

Revised 90 Percent Design Report Trinity River Rehabilitation Site at Oregon Gulch (River Mile 80.9 to 81.7)



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Cover photo: Oblique view of the Oregon Gulch Project Site on the Trinity River, looking downstream. Photo Credit: Ken Decamp, 2013

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CRONYMS AND ABBREVIATIONS

<	less than
>	greater than
≥	greater than or equal to
°C	degrees Celsius
ACD	anastomosing channel design
cfs	cubic feet per second
CGC	clean gravel and cobble
CSB	cobble and small boulders
CY	cubic yards
DTM	Digital Terrain Model
FEMA	Federal Emergency Management Agency
FOS	Factor of Safety
ft	feet/foot
HVT	Hoop Valley Tribe
LAM	large amplitude meander
LOP	limited operating periods
mg/l	milligrams per liter
mm	millimeters
PR	pit run
Project	Oregon Gulch Channel Rehabilitation
RM	river mile
ROD	Record of Decision
USGS	United States Geological Survey
WSEL	water surface elevations
µs/cm	microSiemens per centimeter

1. Purpose and Background

This report presents the final 90 percent design for the Oregon Gulch channel rehabilitation project (Project). The Project is one of the 47 rehabilitation sites originally identified for construction by the 2000 Environmental Impact Statement/Report (USFWS et al. 2000) within the restoration reach. The restoration reach of the Trinity River spans 40 miles from Lewiston Dam downstream to the North Fork Trinity River confluence. The Project will function in concert with restoration flow releases across all water year types to support the fundamental goals of the Trinity River Restoration Program.

1.1 Statutory Mandate

In December 2000, the Secretary of the Interior signed a Record of Decision (ROD) (USDOJ 2000) for the Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Report. This decision recognized that restoration and maintenance of the Trinity River's fishery resources requires rehabilitating the river itself and restoring the dynamic geomorphic processes that maintain an aquatic ecosystem. Consequently, the ROD included five components to ensure long-term restoration and maintenance of the Trinity River (USDOJ 2000).

1. Variable annual in-stream flows ranging from 369,000 acre-feet in critically dry years to 815,000 acre-feet in extremely wet years.
2. Physical channel rehabilitation including removal of riparian berms and establishment of side channel habitat.
3. Sediment management, including the supplementation of spawning gravels below Lewiston Dam and reduction in fine sediments which degrade fish habitats.
4. Watershed restoration projects to reduce fine sediment production in the Trinity Basin and its subsequent delivery to the Trinity River.
5. Infrastructure improvements or modifications, including rebuilding or fortifying bridges and addressing other structures affected by peak in-stream flow releases provided the ROD.

“The ROD represents the culmination of over two decades of efforts aimed at understanding the necessary in-stream flow and physical habitat restoration requirements in order to restore the Trinity River anadromous fishery. Statutory requirements since 1955, based in large part upon the federal governments’ trust obligation to the Hoopa Valley and Yurok Tribes, require the restoration and maintenance of the Trinity River anadromous fishery resources to pre-dam levels. It is clear that restoration must provide for a meaningful fishery, not only for the Tribes, but also for the commercial, sport, and recreational fisherman. These important resources represent both tribal trust and public treasures from which all should benefit – to restore the faith of tribal beneficiaries and to improve the economic well-being of the Trinity Basin and the North Coast as a whole.” (USDOJ 2000, page 8).

2. Project Location, Ownership, Infrastructure, and Access

The project site spans 0.7 river mile of the Trinity River in Junction City, California (Figure 2-1). Land ownership is a mix of public land (Bureau of Land Management) and private land (Figure 2-2). Different sides of the river are referred to as river right and river left from the perspective of looking in the downstream direction. The Federal Emergency Management Agency (FEMA) 100-year flood zone spans the entire valley bottom. No houses are located in the 100-year flood zone, but one house and its well are located in the 500-year flood zone immediately adjacent to the 100-year flood zone boundary. The river flows from left to right on all project figures unless otherwise indicated.

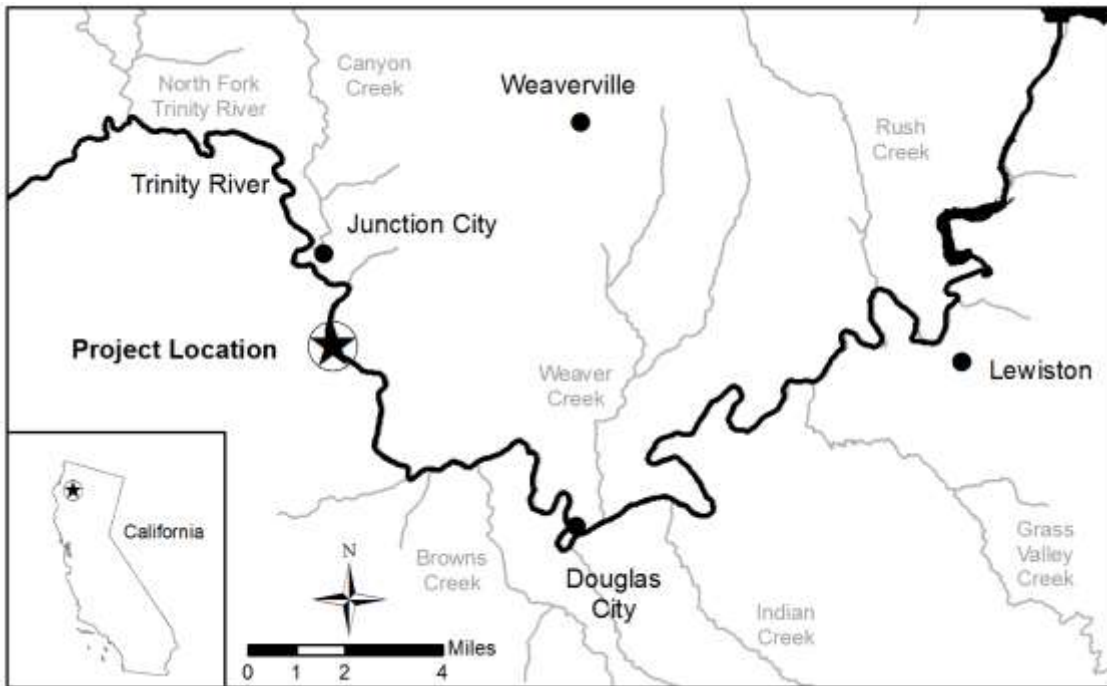


Figure 2-1. Project Location Map. River flow is right to left.

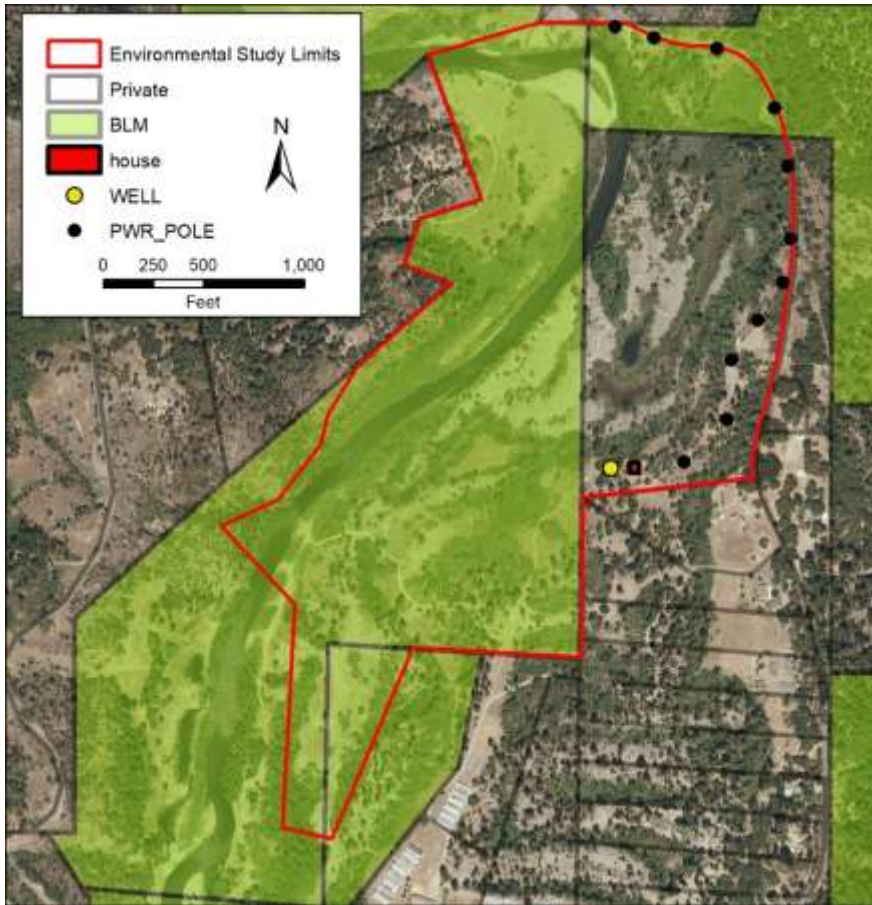


Figure 2-2. Environmental Study Limits and Land Ownership

3. Hydrology and Water Quality

The Trinity River is 180 miles long with a total watershed area of 2,383 square miles is the largest tributary to the Klamath River. Approximately one-quarter of the watershed is located above Lewiston Dam. The watershed is predominately mountainous and forested. The climate is Mediterranean, with hot, dry summers and cool, wet winters. Precipitation averages 30 to 80 inches per year, with 80 percent of the precipitation occurring between November and March. The high elevation northern tributaries experience snowmelt-dominated hydrology while the southern tributaries are predominately rainfall dominated. The largest magnitude floods on the Trinity River are generated by rain on snow events.

Trinity and Lewiston Dams were constructed as part of the Trinity Division of the Central Valley Project. The dams and associated infrastructure create a trans-basin diversion that supplies water from the Trinity River to the Sacramento River in the Central Valley of California. The long-term average annual runoff for the Trinity River above Trinity Dam is 1.25 million acre-feet. Trinity Dam has a storage capacity of 2.4 million acre-feet which is enough to hold 2 full years of inflow. Flow regulation began in 1960 with trans-basins diversions starting in 1963. Flow diversions historically accounted for upwards of 90 percent of the annual inflow to Trinity Dam, virtually eliminated floods, and reduced daily flows to a constant 150 cfs (USFWS and HVT 1999). Flow diversions have

gradually been reduced since the early 1980’s in response to a variety of environmental legislation. Since 2005, flow diversions account for slightly more than half of the annual inflow to Trinity Dam. Environmental flow releases to the Trinity River are conducted as part of ongoing restoration efforts and account for the remainder of the water. The environmental flow releases include spring high flow releases intended to emulate snowmelt runoff, route sediment downstream, and create a dynamic channel. The magnitude of these high flow releases varies by water year type, with the largest being capped at 11,000 cubic feet per second (cfs) (USDOI 2000). Flow regulation has reduced the modern 2-year event (6,000 cfs) by 60 percent compared to pre-dam hydrology at the Lewiston streamgage (USFWS and HVT 1999). The hydrology at the Project site is a mix of dam releases and tributary accretion from several major tributaries.

3.1 Flow Frequency and Duration

Streamflow at the Oregon Gulch site is monitored at USGS gaging station 11526250, Trinity River at Junction City, located at the Dutch Creek Road Bridge about 2 miles downstream from the project site. Oregon Gulch, which has a basin area of 7.8 square miles (about 2 percent of the total basin area downstream from Lewiston Dam at the Junction City gage), is the only significant tributary entering the river between the project site and the gage. The United States Geological Survey (USGS) flow record for the Junction City gage spans WY2003 to the present, and additional flow records existed for WY1995-2002 when the gage was operated by the Hoopa Valley Tribe (Table 3-1).

Table 3-1. The period of record at the Trinity River at Junction City streamflow gage. The gage was operated by the Hoopa Valley Tribe (HVT) prior to USGS operations, which began in WY2003.

WY	Gage Operator	Type of Record
1995	HVT	Partial
1996	HVT	Complete
1997	HVT	Estimated
1998	HVT	Partial
1999	HVT	Complete
2000-2001	HVT	Estimated Partial
2002	HVT	Complete
2003-2019	USGS	Complete

The Junction City gage records include measured peak flows for 19 of the 25 years of record. Peaks reported for 1997 and 1998 were estimated by HVT, and peaks for 2000 and 2001 are absent from the record. Estimated peaks for those years are filled in for this report by correlation with the USGS gage near Burnt Ranch (11527000), approximately 27 miles downstream. The median instantaneous annual peak flow for the full period of record (1995-2019) is 8,590 cfs (Table 3-2).

Table 3-2. Annual peak flows at the Trinity River at Junction City gage, 1995-2017. ^Hpeaks estimated by HVT; ^Bpeaks estimated by correlation with the Burnt Ranch gage.

WY	Date	Peak Discharge (ft ³ /s)
1995	01/09/1995	15,800
1996	02/22/1996	8,800

WY	Date	Peak Discharge (ft ³ /s)
1997	01/01/1997	30,000 ^H
1998	03/23/1998	17,600 ^H
1999	03/25/1999	3,410
2000	no record	4,700 ^B
2001	no record	2,600 ^B
2002	01/02/2002	8,590
2003	12/16/2002	9,170
2004	02/17/2004	14,900
2005	05/09/2005	8,540
2006	12/31/2005	16,700
2007	05/02/2007	4,490
2008	05/09/2008	7,210
2009	05/05/2009	6,500
2010	05/04/2010	7,660
2011	05/04/2011	13,700
2012	05/07/2012	6,290
2013	12/02/2012	6,340
2014	09/19/2014	3,480
2015	02/7/2015	9,740
2016	5/10/2016	11,200
2017	04/28/2017	13,400
2018	04/07/2018	4,500
2019	02/27/2019	18,300

A record of mean daily flows is available only since the water year 2003 when the USGS took over gage operations. Daily mean flow during that period ranges from 280 cfs to 30,000 cfs (estimated peak on Jan. 1, 1997). Table 3-3 shows flow duration exceedance probabilities computed with daily averaged flow at the Junction City gage for the full year and the period between January 1 and April 30 when rearing juvenile salmon in the river.

Table 3-3. Flow Duration Exceedance Probability at Junction City Gage For full year and from January 1 to April 30 (water years 2003 – 2019). Discharge values are given in cfs. Scheduled releases from Lewiston Dam used to predict daily flows for May 9 through September 30, 2019.

	Probability Exceeded								
	90 percent	80 percent	70 percent	60 percent	50 percent	40 percent	30 percent	20 percent	10 percent
Full Year	380	447	485	523	650	850	1150	1800	2840
Jan. 1 to April 30	447	535	620	722	845	1000	1240	1650	2570

3.2 Local Surface Water and Wetlands

Figure 3-1 shows the location of perennial and ephemeral creeks, springs, and wetlands. Perennial local surface water supplies are Oregon Gulch, Mill Creek, and Sky Ranch Road Spring. Oregon Gulch is a fourth-order tributary to the Trinity River and forms a delta that pushes the mainstem towards the west. Oregon Gulch passes through a concrete box culvert under Sky Ranch Road that acts as a fish barrier. Mill Creek is a second-order tributary. Upon reaching the valley floor terrace Mill Creek goes subsurface and does not have a surface water connection to the Trinity River. Two un-named first-order drainages are located on the eastern side of the valley. Sky Ranch Road Spring flows south along Sky Ranch Road for 300 feet before reaching a culvert that passes the flow under the road and into the Oregon Gulch wetland complex. Two additional culverts on Sky Ranch Road pass ephemeral flows into the wetland complex.

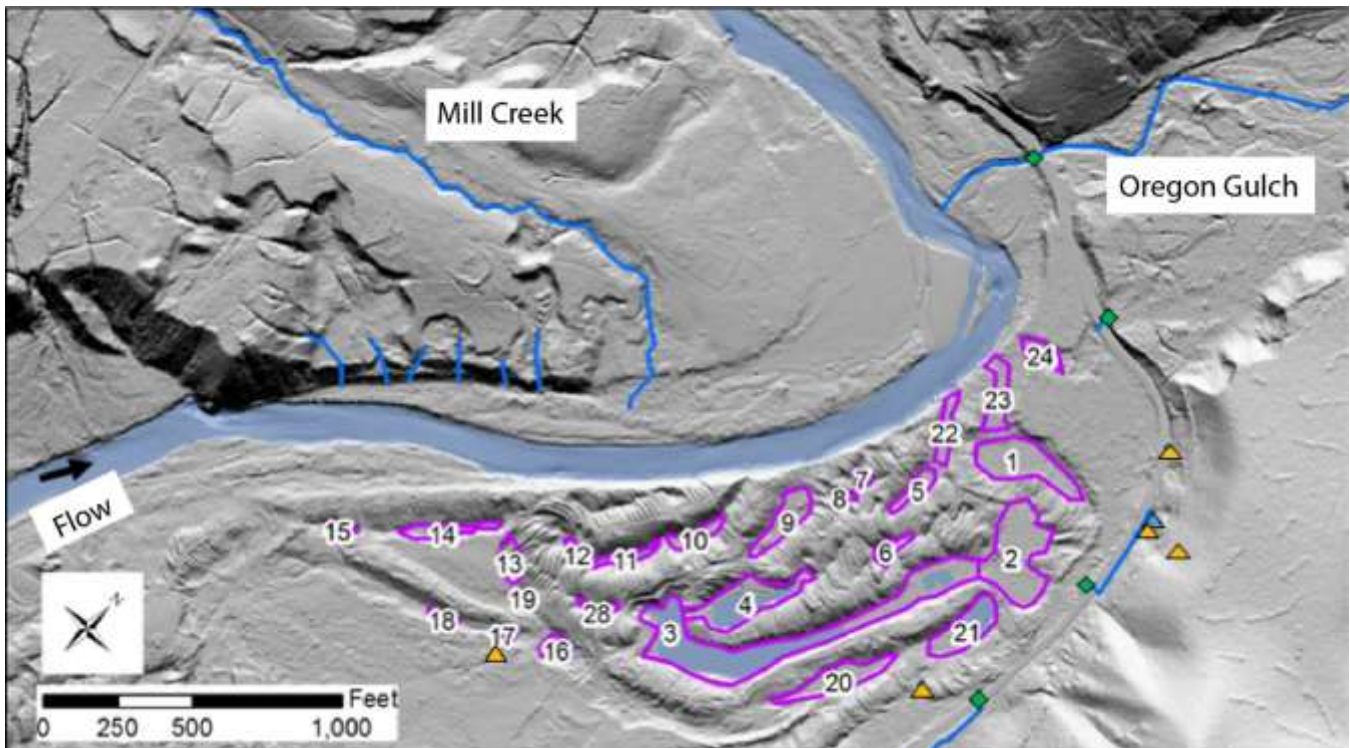


Figure 3-1. Tributaries, Springs, and wetland ponds. Blue line = creek or drainage; blue triangle = perennial spring; orange triangle = ephemeral spring; green diamond = culvert; question mark = potential spring; magenta polygon = wetland pond (with pond ID #).

Dredger mining created a complex of wetlands on the river right (Figure 3-1). Monitoring was conducted throughout 2017 to determine water levels and water quality parameters in the wetlands (Appendix A). The water surfaces of the wetlands closely track the water surface of the Trinity River, indicating good groundwater exchange across the valley bottom. Raising mainstem flows cause the wetlands to fill and falling mainstem flows cause the wetlands to drain (Figure 3-2). The elevation of the bottom of the wetlands relative to the mainstem water surface elevation during low flows determines whether the wetland is perennial (wetland bottom elevation below mainstem low flow water surface) or ephemeral (wetland bottom elevation above mainstem low flow water surface). Wetlands 3, 4, and 11 (Figure 3-1) are perennially inundated, and the remainder are ephemerally inundated. Wet periods affect the wetlands in two ways. First, baseflows in the mainstem increase, raising the

groundwater water table and inundating more wetlands. Second, ephemeral springs and creeks form on the east side of the valley that supply additional water to wetlands. The ephemeral water supply from the valley wall creates positive drainage from the east valley wall to the mainstem. Figure 3-3 shows the inferred surface water and ground water flows paths based on measured water surface elevations during the wet spring of 2017. A beaver dam is located between ponds 3 and 4. During wet periods when positive drainage from the east valley wall towards the river exists, the beaver dam causes the water in pond 3 to back up and be 1 foot higher than in pond 4. During the summer low flow period, the beaver dam is dry and has no hydraulic effect (i.e., ponds 3 and 4 have the same water surface elevation).

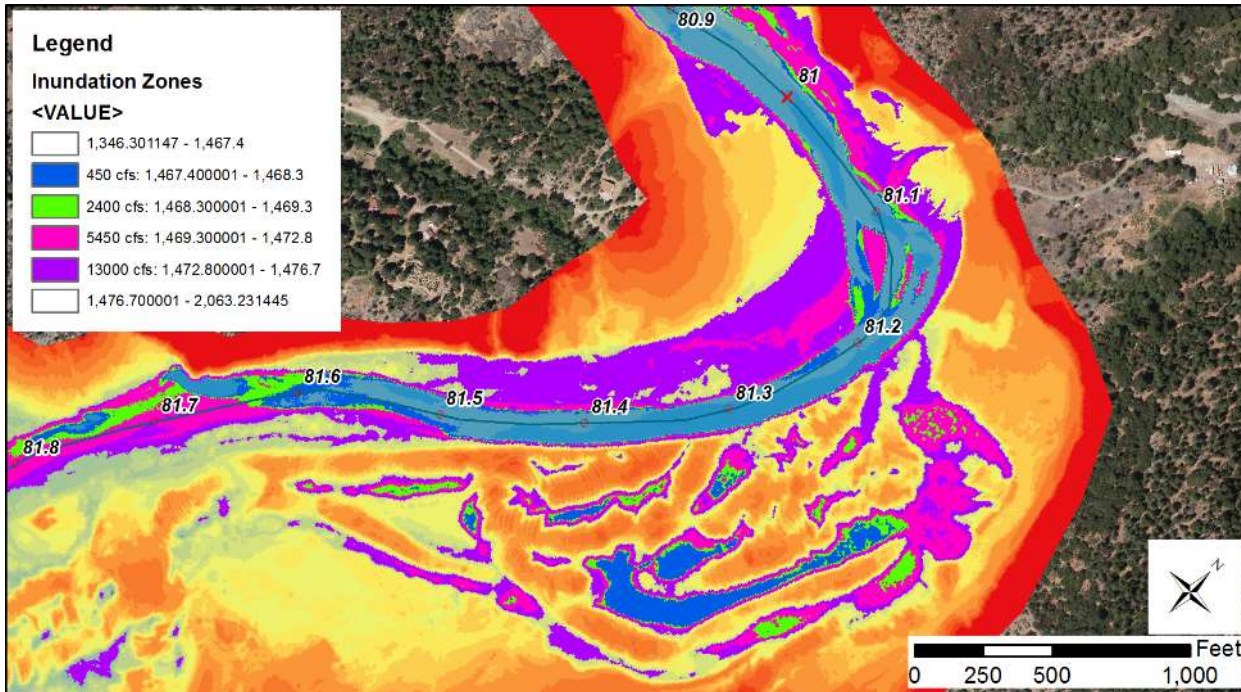


Figure 3-2. Approximate Flow Inundation Zones. Red to Yellow indicates 2-foot elevation intervals in detrended topography.

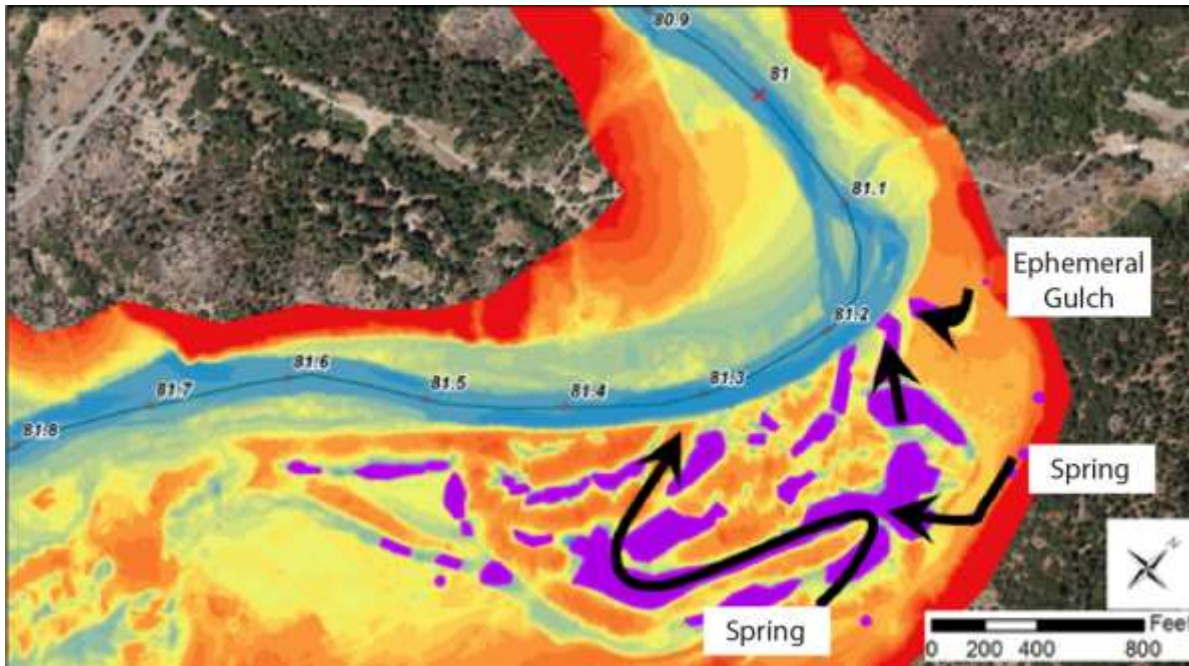


Figure 3-3. Inferred surface water and groundwater flow paths during periods with water supply from the valley wall. Red to yellow show 2-foot elevation intervals in the detrended topography; magenta indicates wetland and springs; black arrows show inferred surface and groundwater flow paths.

3.3 Water Quality

Water temperature, dissolved oxygen, pH, and specific conductance results from monitoring in 2017 are presented in Appendix A.

3.3.1 Water Temperature

Water temperature is highly local and can change dramatically from point to point. The water temperature needs for salmonids vary by species and life stage. The water temperature of the Trinity River typically ranges from 5 degrees Celsius (°C) to 18°C, as measured at the Trinity River above the North Fork streamgage. Reservoir releases from Trinity Dam have flipped the natural temperature regime making the river warmer in the winter and colder in the summer than would have occurred without the dam. The current temperature regime lacks seasonal variability exhibited by undammed streams in the region.

Surface water temperatures were manually measured in shallow water (<1.0 ft) near mid-day to get the hottest water temperatures. The surface water temperature of the wetland ponds typically ranges between 9°C and 16°C except for the August measurements. The hottest surface water temperatures were measured in August and ranged from 14.3°C to 23.4°C, with all but one measurement below 20.2°C. Temperature loggers placed in the ponds several feet below the water surface indicate the deeper area of the ponds (below 2 or 3 feet) is thermally stratified and remains cooler than the surface water temperatures. The pond bottom temperatures never exceeded 16 °C. Air temperature is the primary driver of pond water temperature and plays a significant role in river water temperature (along with the reservoir releases). Pond bottom temperatures generally track river temperatures to within a couple of °C but experience less diurnal variation.

3.3.2 Dissolved Oxygen

Dissolved oxygen concentrations are highly localized and can change dramatically from point to point. Dissolved oxygen levels for salmonids are typically considered good when >6.0 milligrams per liter (mg/L), fair (3.0 mg/L to 6.0 mg/L), and poor to lethal (<3.0 mg/L). The dissolved oxygen in Trinity River typically ranges from 9 mg/L to 16 mg/L, as measured at the Trinity River above North Fork streamgage. Dissolved oxygen in the wetland ponds is good to fair throughout the winter and spring (Table 3-4) when water temperatures are cold, and the ponds are free of aquatic vegetation. Dissolved oxygen levels generally drop in the summer months as water temperatures rise and thick stands of aquatic vegetation cover the pond and reduce atmospheric oxygen exchange. Depending on location, dissolved oxygen levels can drop precipitously in the summer months to lethal levels (near zero). Dissolved oxygen levels in the open water portion of pond 4 remained good throughout the summer. Pond 4 is the only pond that retains enough open water in the summer that is free of aquatic vegetation to maintain good atmospheric oxygen exchange.

Table 3-4. Dissolved Oxygen Measurement Summary

Date	# samples	Min DO (mg/L)	Max DO (mg/L)	Notes
2017-04-13	3	6.55	6.96	Samples limited to shallow pond margin areas.
2017-04-28	15	4.74	12.32	Samples limited to shallow pond margin areas.
2017-05-18	15	1.5	6.5	Samples limited to shallow pond margin areas.
2017-08-10	5	0.7	2.5	Samples limited to shallow pond margin areas.
2017-09-28	15	0.1	8.0	Samples in shallow and deep water areas, mostly located away from the channel margins.

Note: mg/L = milligrams per liter; DO = dissolved oxygen.

3.3.3 Mercury

Mercury sampling conducted by the USGS indicates that the mercury concentrations in dredge pond waters at the Oregon Gulch project area are all very low and comparable to mercury concentrations in Trinity River water at base flow (Rytuba 2018). Concentrations are well below the water quality standards for aquatic life set by the State of California and the U.S. Environmental Protection Agency. Earlier work by the USGS (Rytuba and Goldstein 2012) established that mercury concentrations in sluice sands contained within dredge tailings along the Trinity River are highly variable. Where high levels of mercury are present, it can potentially be released through methylation under anoxic conditions in wet dredge ponds that have accumulated deposits of organic-rich clay. Whether such conditions presently exist at the Oregon Gulch site has not been determined, but the proposed actions are consistent with mercury mitigation. Dredge tailing, including the sluice sands, will be removed from the valley bottom and spoiled in well-drained upland locations where conditions for methylation do not exist. In addition, small quantities of organic-rich fine sediments that currently exist in several low areas among the tailing will also be removed.

3.3.4 Other Water Quality Parameters

Specific conductivity and the potential for hydrogen (pH) in the surface water was measured on September 28, 2017. The specific conductance of the Trinity River was 119 microSiemens per centimeter ($\mu\text{s}/\text{cm}$) and the spring

on Sky Ranch Road measured 216 $\mu\text{s}/\text{cm}$. The specific conductivity of the wetland ponds was higher than the river and spring and ranged from 478 $\mu\text{s}/\text{cm}$ to 823 $\mu\text{s}/\text{cm}$. The pH ranged from 7.4 to 8.7. The wetland ponds all measured pH below 8.0 while the Trinity River and the spring on Sky Ranch Road measured above 8.0.

4. Geology and Geomorphology

4.1 Geology

The Trinity River watershed is located in the southern portion of the Klamath Mountain Province (Irwin 1994). The Klamath Mountain Province is characterized by a complex series of folded and faulted metamorphic rocks, eastward dipping regional thrust faults, and granite plutons. Regional thrust faults generally define the location of the valley walls on either side of the river corridor (CADWR 1980). Pleistocene glaciation occurred in the high elevations of several headwater tributaries but stopped short of reaching the mainstem Trinity River (Sharp 1960). Significant placer gold deposits occur throughout the watershed in Quaternary alluvial deposits located in the modern river valleys and adjacent Pleistocene strath terraces, as well as the Weaverville Formation, a fluvial gold bearing formation likely deposited during the Oligocene (Diller 1902; Anderson 2008). The valley bottom width at the project site is geologically controlled by faults that form the eastern and western valley walls (Figure 4-1).

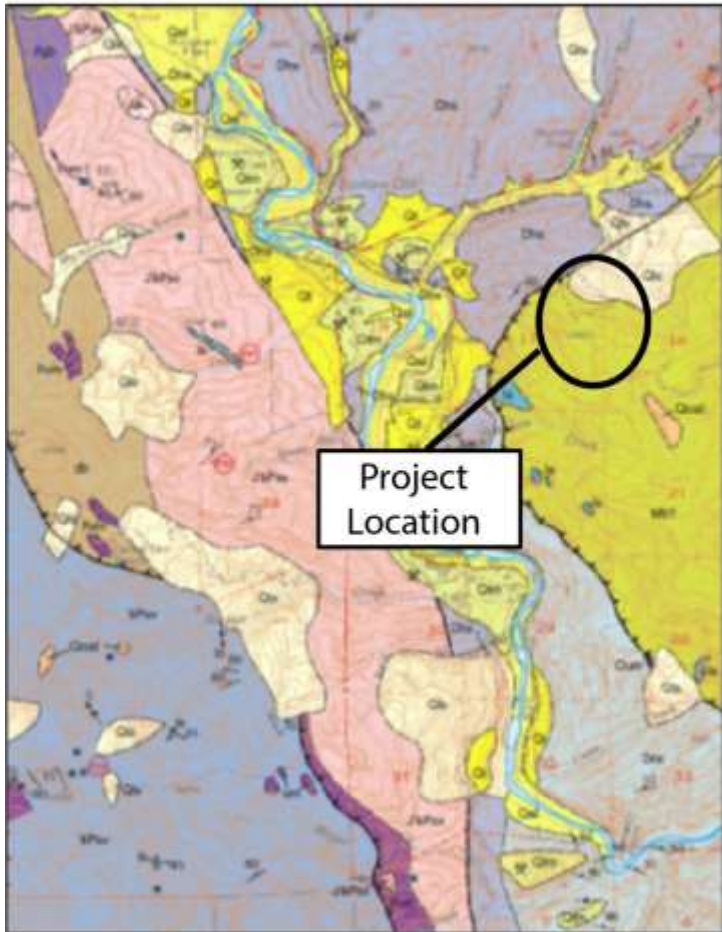


Figure 4-1, Reconnaissance Geologic Map of the Hayfork 15' Quadrangle, Trinity County, CA. Modified from Irwin (2010). Note: see Irwin (2010) for map and symbol legend.

4.2 Valley Scale Geomorphology

The Trinity River is a partially confined, gravel bed river, and is the largest tributary to the Klamath River. The Trinity River has a complex geology and remarkable history of human impacts from mining, logging, and flow regulation. The local mining impacts near the project site are shown in Figure 4-2. Extensive hydraulic mining occurred throughout the Junction City area from the 1860s to the mid 1900s. The sediment discharged from the hydraulic mines caused significant valley aggradation resulting in a large-scale bulge in the longitudinal profile of the Trinity River that extends from about Dutch Creek (RM 86.4) to Lime Point (RM 74.6) (Krause et al. 2010). The apex of aggradation occurs at the Oregon Gulch confluence (RM 81.1). The valley aggradation from hydraulic mining at the Project site is estimated at about 12 feet. The valley aggradation has lowered the valley slope above the Oregon Gulch confluence (0.0016) by about 25 percent compared to the overall 40-mile river slope (0.0022). Extensive dredger mining mechanically mixed and inverted the alluvial material and left remnant tailings piles (up to 40 feet high) that artificially confine the river. The resulting floodplain and terrace sediments are coarse grained with poor capillarity.

Gaeuman et al. (2016) characterized the morphologic attributes that are common to the entire Junction City Valley reach (RM 82.85 to 78.08) as follows: The reach occupies a fairly wide alluvial valley bottom (5th widest

in the restoration reach). The valley is generally straight but has a strong curvature at the Oregon Gulch confluence and near the Dutch Creek Bridge. Incision into the mining sediments and pre-dam bars has produced a canal-like channel that is largely disconnected from the valley bottom under the modern flow regime. The valley disconnection creates the smallest measured functional floodplain width despite having one of the largest valley bottom widths in the restoration reach. The Trinity River is a straight, plane bedded, single-thread channel with a low sinuosity (near 1.0). Channel morphology is generally simple, except where valley curvature forces the channel to interact with the valley wall. Discriminate analysis using the method described by Eaton et al. (2010) showed that the Trinity River favors a single-threaded channel planform at the project location and is unlikely to develop a multi-thread channel. However, smaller scale flow bifurcations around alluvial bars are possible. Natural reworking of the present terraces will require time spans that exceed those normally considered by resource managers.

The Oregon Gulch and Mill Creek watersheds and creek alignments were also dramatically altered by hydraulic mining. Hydraulic mining in Oregon Gulch occurred between 1851 and 1940 and filled the Oregon Gulch valley with a wedge of sediment ranging from 120 feet thick near the headwater to 40 feet near its confluence with the Trinity. Oregon Gulch is slowly incising through the hydraulic mining sediments, which provides a high sediment load. The high tributary sediment load and wide mainstem valley allow for Oregon Gulch to produce a delta. Mill Creek has a small sediment load because it is a much smaller creek, and the majority of sediment was washed out by hydraulic mining.

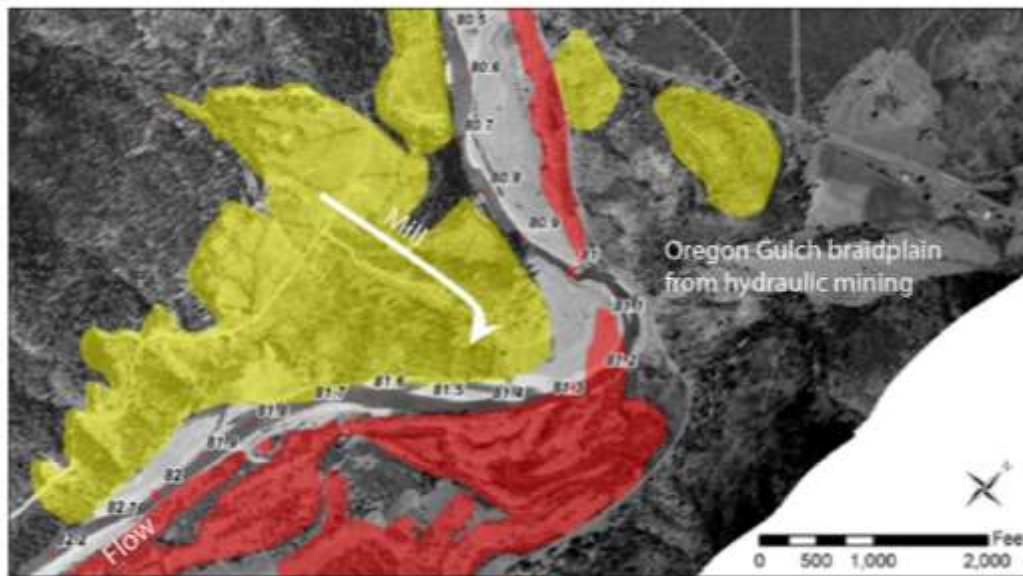


Figure 4-2. Hydraulic and dredger mining impacts near the Project Site. 1960 Photo. Yellow = extent of hydraulic mining; Red = extent of dredger mining 1944-1965.

4.3 Site Scale Geomorphology

Historical mining impacts, large floods, flow regulation, and continued delta building have created the contemporary site geomorphology found today, delineated in Figure 4-3 and summarized in Table 4-1.

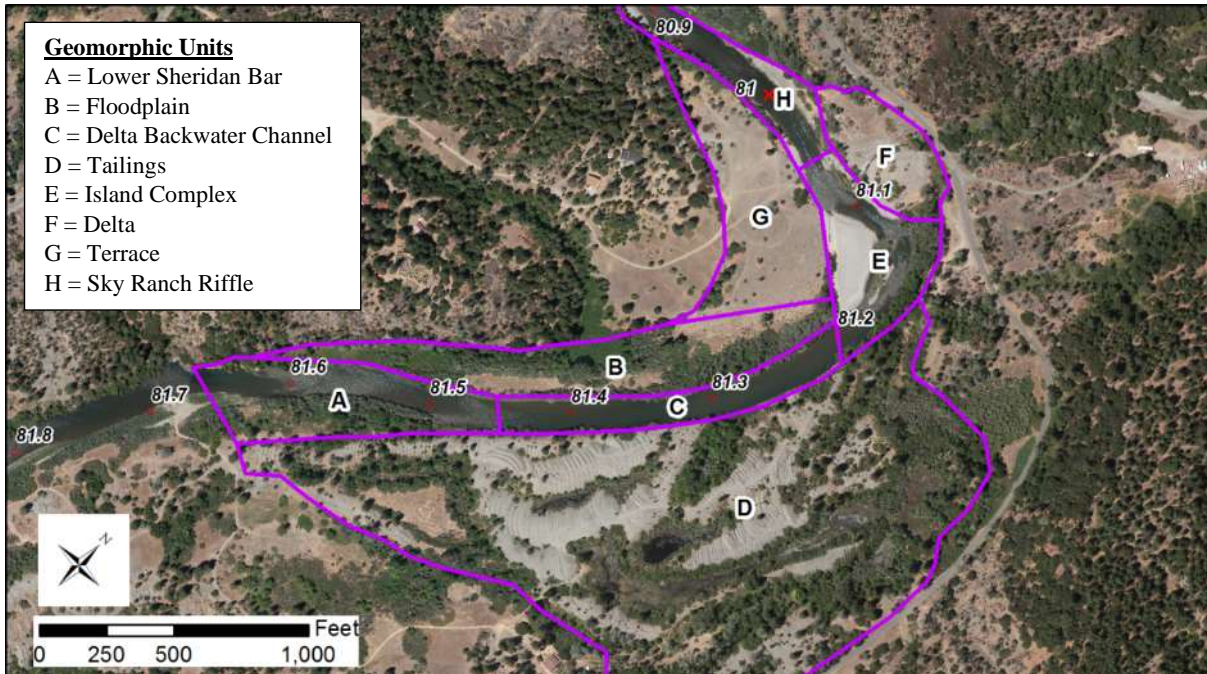


Figure 4-3. Contemporary Geomorphic Units

Table 4-1. Description of Contemporary Geomorphic Units

Unit	Name	Description
A	Lower Sheridan Bar	A vegetated bar with an alcove at the downstream end that periodically fills with sand. Forms a compound riffle downstream of Sheridan Hole that drops 4 vertical feet. The first foot of drop is across a bar downstream of Sheridan Hole on river left between RM 81.67 and RM 81.6. That bar is periodically exposed as it changes in response to floods but the riffle remains relatively stable. A stabilized head cut across the remnant pre-dam bar accounts for the remaining 3 feet of drop.
B	Floodplain	Created by a pre-dam bar whose chute channel slowly filled in with vegetation and sediment, converting it to a contemporary floodplain and terrace.
C	Delta Backwater Channel	A simple channel with a low slope and a plane bed entrenched between tailings and remnant pre-dam bars and backwatered by the Oregon Gulch delta. The channel planform in this area has changed little since flow regulation began.
D	Tailings	A dredger tailings field that occupies upwards of 75 percent of the valley bottom width. The height of the tailings piles ranges from 25 to 35 feet above the river. Large pre-dam floods flattened portions of the tailings piles. Low areas between the tailings have created a large complex of perennial and ephemeral wetlands.
E	Island Complex	A contemporary island complex controlled by the Oregon Gulch delta. The island complex is very dynamic with active deposition and erosion that changes the number of islands and channels.
F	Delta	The delta of Oregon Gulch. The delta was completely evacuated by the 1955 flood. The delta rapidly rebuilt between 1955 and the early 1970's. Delta growth continues today but at a slower pace.

Unit	Name	Description
G	Terrace	A terrace created by the 1955 flood in an area previously occupied by the river. The terrace rises up to 15 feet above the contemporary river and forces the river to the right side of the valley.
H	Sky Ranch Riffle	A steep transition from Oregon Gulch to Sky Ranch through a short narrowing of the valley.

4.3.1 Historical Change

Historical change was assessed using aerial photos from 1944 to 2016 (figures in Appendix B) and comparing changes in mapped channel extents before and after large floods (figures in Appendix C). The alignment and planform of the Trinity River before the start of the Gold Rush in 1848 is unknown. Large-scale hydraulic mining occurred in Oregon Gulch through 1940, contributing vast amounts of sediment to the Trinity River valley. The 1944 aerial photos provide the first available evidence of the channel alignment and planform but were taken after 96 years of intensive hydraulic and dredger mining. In 1944, the Junction City valley had already aggraded by about 12 feet from hydraulic mining sediment inputs, and large portions of the valley bottom were cut off by dredger mining. In 1944 the Trinity River was aligned along the left side of the valley downstream of Sheridan Hole (RM 81.7). The river was presumably pushed to the left side of the valley by the extensive dredger mining upstream of Oregon Gulch and by the high tributary sediment loads from hydraulic mining in Oregon Gulch. Large floods had already sheared off portions of the dredge tailings between RM 81.7 and 81.3. Large bars are present near RM 81.5 and RM 81.1 (the old delta head).

The 1955 flood caused the greatest changes at the project site observed in the historical aerial photo record. The 1955 flood peaked at 172,000 cfs (as measured downstream at the Burnt Ranch streamgage) and was more than twice the size of the next three largest storms on record (1958, 1940, and 1964). The 1955 flood caused significant changes in the channel and valley configuration, as described below. Smaller geomorphic changes occurred in response to later floods and to flow regulation after 1960. These historical changes are summarized below in terms of three response zones: the Delta zone, the Delta Backwater zone, and the Tailings zone.

Delta Zone Changes 1944 – 2016

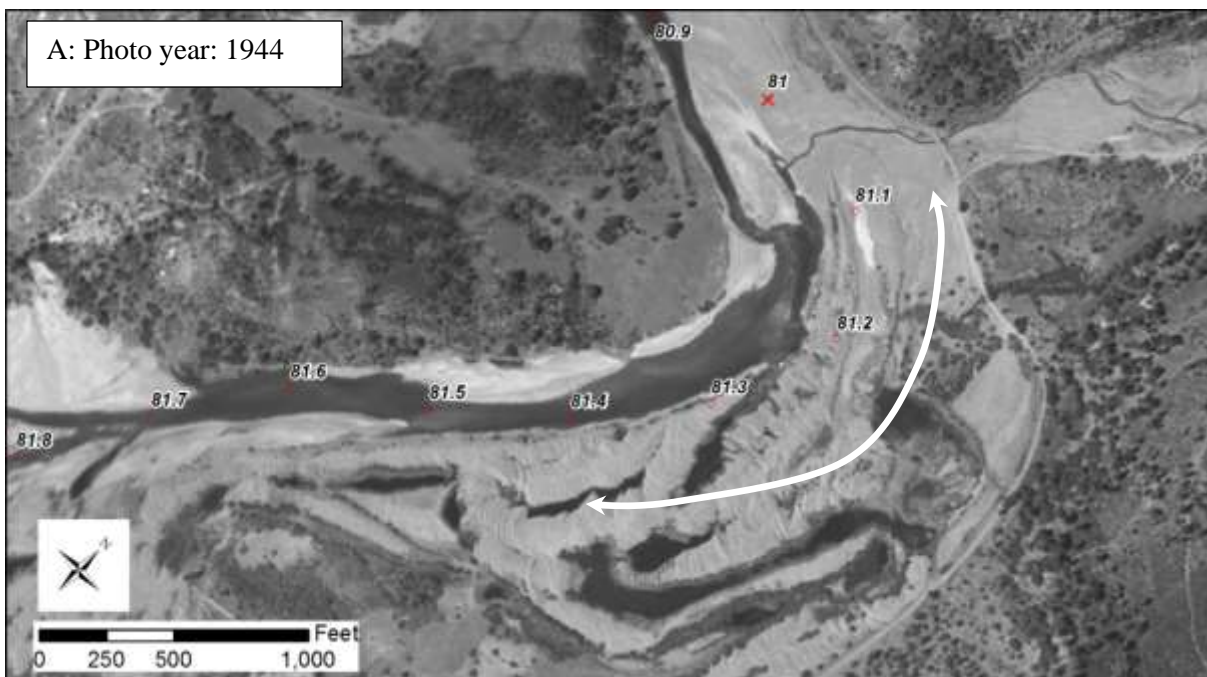
The delta zone encompasses the entire valley bottom between RM 80.9 and RM 81.2 (Figure 4-3; geomorphic units E, F, and G respectively). The 1955 flood removed most of the Oregon Gulch delta as the channel thalweg migrated laterally more than 500 feet toward the north-northwest (Figure 9). The 1955 flood also created a terrace that filled the left side of the valley between RM 80.9 and 81.4 where the channel thalweg was previously located. Oregon Gulch rapidly rebuilt a delta between 1960 and 1971 (Appendix B). The delta continued to grow from 1971 to 2016 but at a slower pace. Delta building between 1960 and 2016 pushed the Trinity River more than 200 feet back toward valley left, laterally migrating into the 1955 terrace deposit, and causing cut bank erosion. The channel of Oregon Gulch migrates across the delta, typically in the upstream half of the delta (i.e., upstream relative to the Trinity River). The 1960 photo shows evidence of mechanical excavation at the end of the terrace downstream of RM 81.0.

The reformation for the Oregon Gulch delta created following flow regulation, an island complex developed immediately upstream of the delta between RM 81.1 and 81.2. The island complex first appeared in the 1971 photographs, was well developed by 1975, and has since remained active within its 1975 footprint as the number

and positions of islands and channels shift. Despite the high level of activity within the delta and island complex, their general locations have been fixed since 1971.

Delta Backwater Zone Changes 1944 – 2016

The delta backwater zone stretches from Sheridan Hole (RM 81.7) to the upstream end of the island complex (RM 81.2) and includes the lower Sheridan Bar riffle, floodplain, and delta backwater channel (Figure 4-3; geomorphic units A, B, and C respectively). The river valley is moderately confined between the river left valley wall and river right dredger tailings. The 1955 flood was the formative event that expanded and connected relatively large bars that existed in this reach in 1944 to create a transverse bar downstream of Sheridan Hole (Figure 4-3). The 1971 photos are the first ones clear enough to delineate the location of the associated riffle, which formed at the lower end of the bar between RM 81.4 and RM 81.3. The crest of the riffle crest appeared to migrate about 0.2 mile upstream between 1971 and 1990 and has since remained fixed in position.



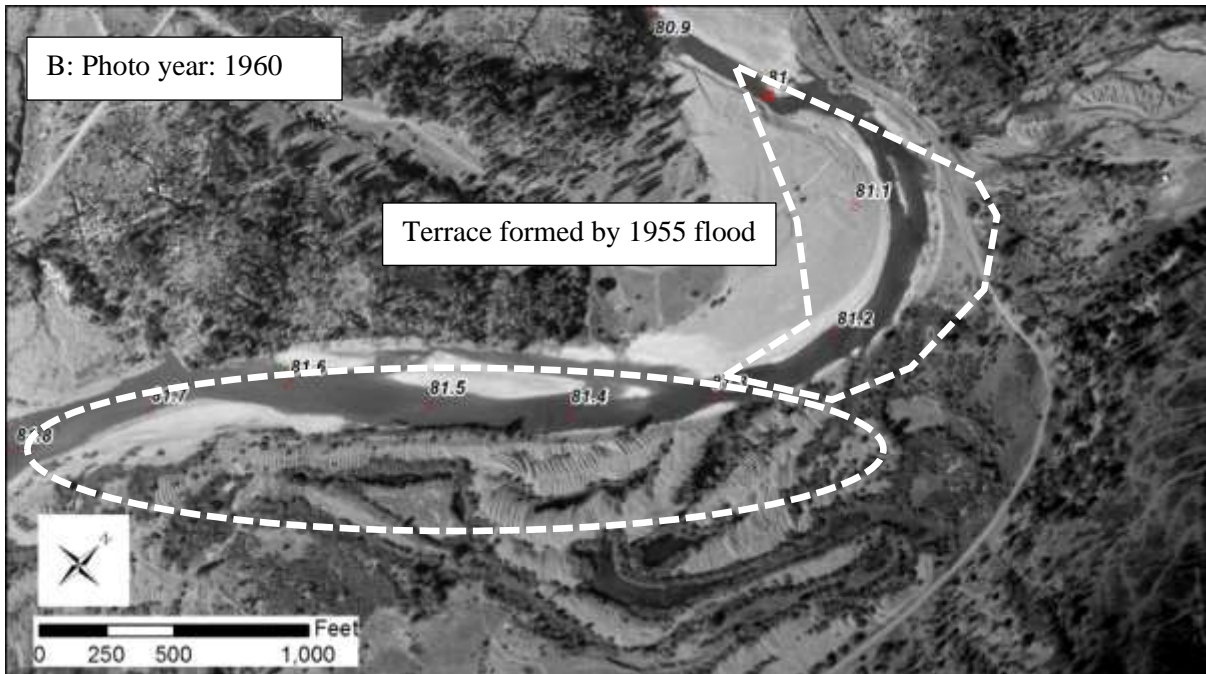


Figure 4-4. Pre-Dam Geomorphic structure and effect of 1955 flood

In 1960, the lower end of the pre-dam bar on the river left was barren with a chute channel between RM 81.3 and RM 81.6. The lower elevation portions of the bar and chute channel began filling in with riparian vegetation after dam construction and flow regulation in 1960. The chute channel remained flowing through 1971 but was subsequently colonized by vegetation and abandoned. The former chute channel is now a heavily vegetated floodplain. The higher elevations of the bar were unable to support riparian vegetation and remain grassy terraces.

Tailings Zone Changes 1944 – 2016

The tailings zone is the field of dredger tailings on valley right between Oregon Gulch delta and Sheridan Hole (Figure 8; geomorphic unit D). A portion of the tailings piles near the channel margin were flattened by large floods prior to 1965. The tailing ponds are present in 1944 aerial imagery but were largely devoid of vegetation. The tailings ponds do not change over time except for vegetation growth around the pond margins.

4.3.2 Contemporary Geomorphology

Valley cross sections are shown in Appendix D. The unconstrained valley bottom width ranges from 600 feet to 1,700 feet. Dredger tailings piles occupy up to 75 percent of that width and eliminate the river's ability to access most of the valley. The river has low sinuosity, with river curvature driven largely by valley curvature near the Oregon Gulch confluence. The river is not in direct contact with the valley walls except at the upstream site boundary (Sheridan Hole, RM 81.68) and a bedrock outcrop on river left at RM 80.9. Hydraulic mining caused significant aggradation, so the depth to bedrock is anticipated to be at least 10 feet or more. The slope upstream of the Oregon Gulch delta ranges from 0.0012 to 0.0018 to which represents a reduction of about 20 – 50 percent as compared to the average river slope of 0.0022 across the entire 40-mile restoration reach. The slope steepens to 0.0039 as the river drops 7 feet in the transition from the upstream end of the Oregon Gulch delta (RM 81.2) into Sky Ranch (RM 80.9).

The channel in the Junction City valley reach is shallow with below average bed relief. Gaeuman et al. (2016) evaluated overall channel complexity based on a cluster analysis of various channel parameters, including depth variation. This analysis indicated the geomorphic units in the project site are longer than average, and the overall vertical channel complexity (i.e., bed relief) ranges from “very low” to “moderately low.” Exceptions occur in short reaches immediately below Sheridan Hole and near the Oregon Gulch Delta where channel complexity ranges from “high” to “moderately high” respectively. Horizontal complexity is also low.

4.3.3 Valley Bottom Materials

Sherer (2010) visually characterized the sediment deposits of the river left terrace at three test pits (Figure 10). Test pits OG-01 and OG-02 were used to characterize the terrace deposit. The terrace deposit surface is 10 to 15 feet above groundwater (elevation 1464.3 ft to 1465.9 ft), and no bedrock was encountered. The terrace deposit consists of poorly graded gravel with sand. The terrace deposits are sometimes overlain with a surface layer (0.7 ft thick) of silty sand to sandy silt.

Test pit TP-OG-10-03-OW was excavated into a channel bar deposit. A thin (0.5-foot-thick) surficial cover of floodplain overbank deposits consisting of silty sand to sandy silt was encountered. Beneath the surficial deposits to a depth of 7.0 feet, there is an old bar deposit consisting of poorly graded sand with silt, gravel, and cobbles. Between 7.0 and 10.0 feet of depth, there is terrace alluvium consisting of silty sand with gravel and cobbles. Between 10.0 And 10.5 feet (total depth), very intensely weathered schist bedrock was encountered. Groundwater was encountered in this pit on top of the bedrock at 10.0 feet (elevation 1464.8 feet). The channel bar deposit is estimated to be comprised of approximately 40 percent spawning size gravel and 60 percent sand, silts, and some cobbles.

The channel substrate size (D_{84}) between Sheridan Hole and the Oregon Gulch delta is generally less than 128 mm (Figure 4-5). The substrate size coarsens to a maximum D_{84} of 254 millimeters (mm) Below Oregon Gulch.

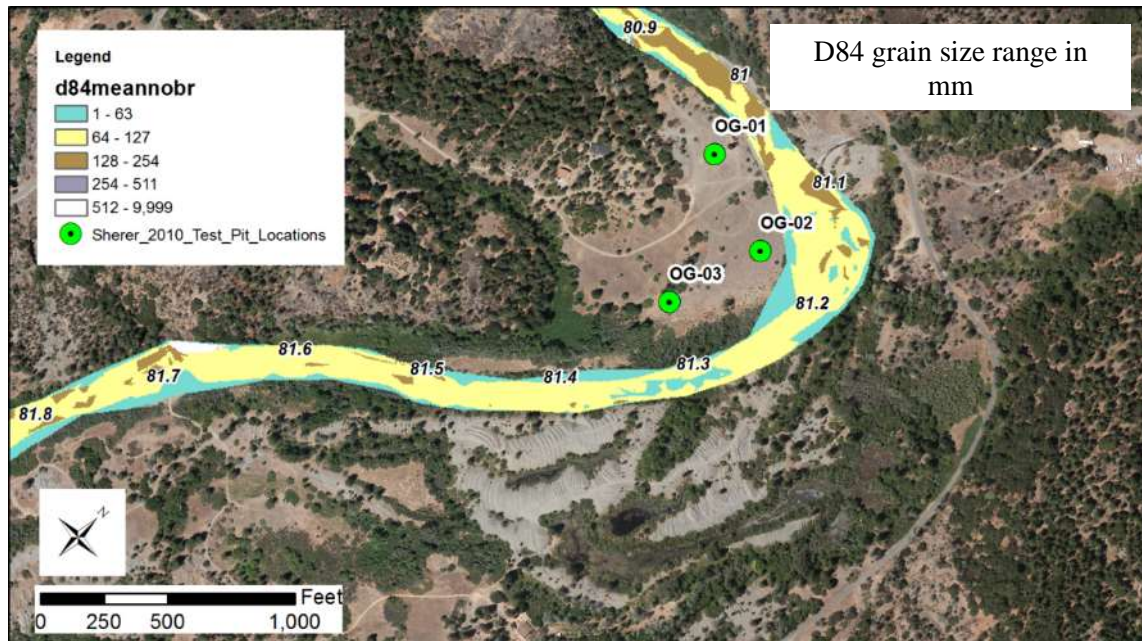


Figure 4-5. Channel Substrate Mean D84 Size and Test Pit Locations. Substrate data collected in 2014 by US Fish and Wildlife Service, Hoopa Valley Tribe, and Yurok Tribe.

4.3.4 Large Wood Dynamics

Existing wood abundance throughout much of the Project reach is low relative to natural conditions due to historic impacts from logging, mining, and dam construction. Wood is often removed from rivers to protect infrastructures such as bridges or pipelines and to facilitate navigation or recreational use. The Oregon Gulch site overall has very little wood. The island complex at 81.2 RM has been a wood racking and storage area in recent years. In moderate-sized rivers such as the Trinity, most of the natural wood is found in logjams (Cardno Entrix and CH2MHILL 2011). However, the 2016 high flows scoured out an entire island and the wood jam that was being racked by the vegetated island. The absence of mature vegetation on the island complex now makes it difficult for wood to accumulate anywhere in the Oregon Gulch site. Also, a buried tree was present for over a decade at 81.45 RM. This too, was washed out during recent high flow events. The only substantial wood presently in the Oregon Gulch site is at the apex of the bend, at the bottom of the island complex on river right, where the bank is being eroded, and trees are collapsing into the channel. Wood densities at the Oregon Gulch site are far less than the recommended 50-60 pieces per 100m of river channel (Cardno Entrix and CH2MHILL, 2011).

5. Biological Significance and Use

5.1 Salmonids

Situated in the lower third of the 40-mile project reach, the Oregon Gulch site is used by the bulk of salmonids that are produced in the Upper Trinity. Adult salmonids migrating upstream arrive as early as May (Spring Chinook). Their numbers peak in September and October when the Fall Chinook and steelhead arrive. Some adult steelhead and Coho salmon may continue to use this reach from December through March. Juvenile salmonids

begin to emerge from the gravel in January for Spring Chinook. Fall Chinook begin to emerge in late February into April and steelhead appear in late March through May. As mentioned above, a large proportion of the juvenile salmonids that are produced in the Upper Trinity River will rear and migrate through the Oregon Gulch site. Native Fall Chinook Salmon dominates spawning in the Upper Junction City reach of the Trinity River. The Sheridan Creek site immediately upstream of Oregon Gulch experiences some of the highest concentration of natural spawners in the 40-mile Project reach. This amplifies the importance of quality rearing habitat directly at the project site (just downstream of Sheridan) across a range of flows. NOAA (2014) identified the Oregon Gulch tributary as having a high intrinsic potential for Coho salmon and ranked removing the fish passage barrier at Sky Ranch Road as a high priority. The Mill Creek tributary has zero intrinsic potential for Coho salmon.

5.1.1 Juvenile Rearing Habitat

Fry and juvenile rearing habitat were estimated for the Oregon Gulch site using outputs from the SRH-2D design hydraulic model results (Figure 5-1). Habitat for existing conditions was estimated using fish capacity. The Fish Work Group recently recommended that juvenile salmonid physical habitat be estimated using capacity in all TRRP work going forward, which is detailed in the meeting summary for 20 April 2020 and a memo from the fish work group to the TRRP Science Coordinator dated 9 May 2020. This marks one of the 1st occasions of it being applied to design habitat evaluations by the Trinity River Design Team. Estimating rearing habitat through fish capacity relies on depth, velocity, and distance to cover outputs provided for each model cell. The capacity metric also accounts for variation in local fish abundances beyond these three physical variables. Cover, such as is associated with in-water vegetation or wood accumulation, is a critical component of habitat. For modeling purposes, the existing distribution of cover at the site was derived from GIS layers depicting the distribution of riparian vegetation and in-water cover at the site.

Fry habitat capacity decreased with increasing flow through the range of frequent flows during the winter and early spring salmon rearing period. The combination of high banks and a terrace on river left and mine tailings on river right confine the channel create some of the poorest rearing habitat observed anywhere in the project reach. It is a primary design objective to eliminate this habitat decrease and to replace it with increasing habitat availability as flows increase. A complete analysis of rearing habitat availability as measured by habitat capacity is presented in a later section of this report.

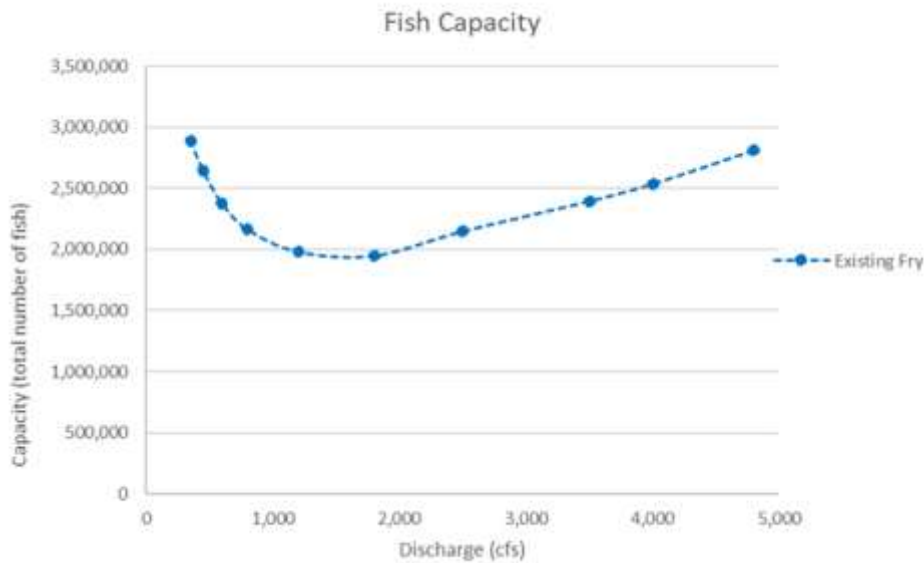


Figure 5-1. Estimated Fry Chinook habitat capacity at a range of flows for the Oregon Gulch design site (2016 existing conditions).

5.1.2 Salmonid Spawning Habitat

Spawning within the Oregon Gulch site is mostly focused around the upstream and downstream ends of the site where areas of greater complexity exist (Figure 5-2). Higher densities of redds are usually observed just below Sheridan Hole at the top of the site, and around the top of the Oregon Gulch delta. The middle of the site (RM 81.4-81.2), which is a mostly plane bed reach, usually has very low spawning densities. As mentioned earlier, the most important aspect relating to spawning at Oregon Gulch is the proximity of this site to the Sheridan riffle just upstream, which experiences some of the highest natural spawning densities in the restoration reach (Figure 5-2).



Figure 5-2. Redd distribution at the Oregon Gulch project site for years 2012-2016.

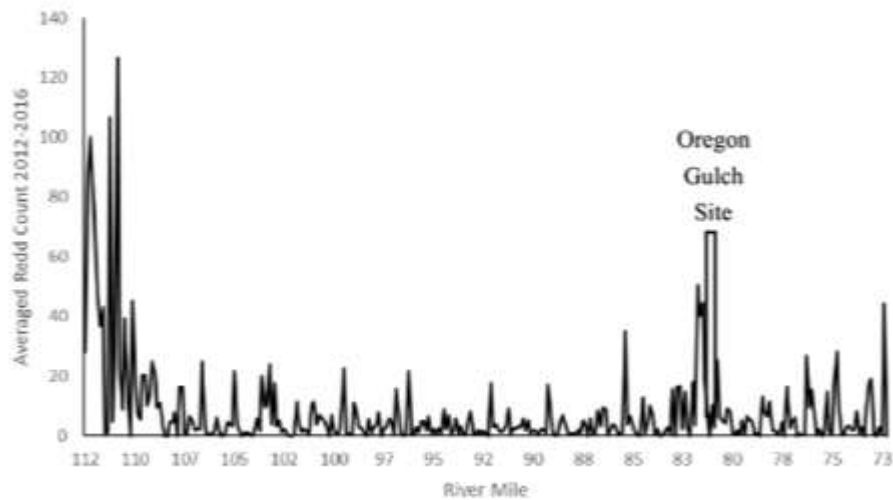


Figure 5-3. Mainstem redd distribution between Lewiston Dam and the North Fork Trinity River.

5.1.3 Salmonid Adult Holding

No Trinity River specific holding habitat depth criteria for adult Chinook Salmon are available. However, there are a few sources in the literature that characterize holding habitat for adult Chinook Salmon, though it is generally understood that “deeper is better.” Raleigh et al. (1986) describes prime adult holding pools in streams greater than 5m wide (16.4 ft) as those that are greater than 2m in depth (6.6 ft.). Wampler (1986) characterizes ideal adult holding habitat for adult spring Chinook Salmon in the Wind River of Washington State as ≥ 14 ft. Moyle (2002) describes adult Spring Chinook selection of pools greater than 6.6 ft deep. It also appears that other factors like stream aspect, hillshade effects, and overhead cover may influence the quality of deep water for holding adult Chinook Salmon. With all this in mind, the Oregon Gulch project site currently has almost no locations where depths exceed 6 feet.

Hampton (1997) identified suitable depths for adult steelhead holding as those greater than or equal to 3.5 feet. On the Trinity, steelhead prefer water between 3-8 ft deep, with medium velocities, and large cobbles, boulders or wood that provide velocity cover. Some sort of surface disruption in the form of riffles or bubbles which provide cover from predators is also desirable. Throughout the Oregon Gulch site, there is almost no area that meets these criteria. In some years, a few steelhead were known to hold in the riffle near the top of the site (upstream of RM 81.5), towards the left bank. On river right at RM 81.45, there was a large tree in 6-7 ft of water where a few steelhead and brown trout were found. High flows in 2017 displaced that tree to an unknown location downstream. The majority of the site (RM 81.45-81.2) is a plane bed channel with simple flow characteristics and is highly undesirable habitat for adult salmon or steelhead. In short, the Oregon Gulch site currently exhibits some of the worst rearing habitat across the critical range of flows anywhere in the Project reach, and it also has very little adult holding habitat.

5.2 Wildlife

5.2.1 Special-Status Wildlife Species

Suitable habitat exists for terrestrial and aquatic special status wildlife (and others) within the Lower Valley ESL. Past TRRP construction has avoided or minimized potential impacts to species of concern by following limited operating periods (LOPs), which avoid impacts at sensitive life history stages (e.g., breeding and development periods). If these LOPs are observed, mobile life stages are expected to avoid construction equipment so that impacts will be minimal at most. The 2009 Master EIR for channel rehabilitation and sediment management for remaining Phase 1 and Phase 2 sites (NCRWQCB and USBR, 2009) provides more details about special-status wildlife species that occur in the along the mainstem Trinity River between Lewiston dam and the North Fork. The federal Action Agencies and the Cooperating Agencies of the TRRP have reinitiated Section 7 consultation with the regulatory agencies that administer the Endangered Species Act (ESA; e.g., the USFWS and NMFS) to ensure that the current habitat restoration activities, design strategies, and the adaptive management process used for implementing the action remains in compliance with the ESA. Biological Opinions (BOs) which address potential Project impacts to federally listed and proposed species (e.g., SONCC Coho Salmon; N. Spotted Owls) will be developed while current BOs remain in effect.

Foothill yellow-legged frog (*Rana boylei*) and western pond turtle (*Actinemys marmorata*) are the only non-fish, special status aquatic species in the area. The island complex at the Oregon Gulch confluence has had successful breeding in the past, but generally, velocities are too swift, and no breeding was observed in 2017 (D. Ashton, pers.comm), and there are no other bars that provide suitable habitat within the Oregon Gulch site. Western pond turtles are frequently observed in the tailings ponds on river right (E. Mattison, pers. comm.).

Riparian and riverine birds are considered special-status species because of their associations with unique and imperiled environments, such as particular types of riparian plant communities. Demographics and abundance of riparian bird communities were monitored in the Trinity River from 2004-2009, including the Oregon Gulch to Canyon Creek reach where this site is located (Miller et al. 2010). Relatively common birds in the reach of river from Oregon Gulch to Canyon Creek include Black-headed Grosbeak (*Pheucticus melanocephalus*), Song Sparrow (*Melospiza melodia*), Tree Swallow (*Tachycineta bicolor*), Yellow-breasted Chat (*Icteria virens*), Yellow Warbler (*Dendroica petechia*), American Dipper (*Cinclus mexicanus*), Belted Kingfisher (*Megaceryle alcyon*), Common Merganser (*Mergus merganser*), Green Heron (*Butorides virescens*), and Spotted Sandpiper (*Actitis macularius*) (Miller et al. 2010).

5.3 Riparian Vegetation Conditions

Land and vegetation cover type were mapped in 2014 within the 2018 Oregon Gulch site ESL and are shown in Figure 5-4. Using the quantitative definition of vegetation zones from HVT and MA (2015), emergent and mesic vegetation zones occupy the bank 0 to 10 ft above the 450 cfs water surface elevation. Of the 114.3 acres in the ESL, 7.65 acres are less than 3ft above the river (i.e., the emergent zone; 7 percent of the ESL) and 24.8 acres were between 3 and 10 ft above the river water surface elevation (i.e., the mesic zone; 22 percent of the ESL). Land and vegetation cover type within the 2018 ESL area was 104.7 acres. Wetland and riparian land cover classes composed 38 percent and invasive riparian land cover classes composed 3 percent of the 2018 ESL area (Figure 5-4). Mature riparian vegetation within the Sheridan Creek site is dominated by narrowleaf willow (14 percent of the ESL), arroyo willow (8 percent of the ESL), and red willow (4 percent of the ESL). Invasive

riparian land cover classes were primarily composed of Himalaya berry (3 percent of the ESL). Tree of Heaven occurs sporadically throughout the site (0.7 acre) and should be prioritized for removal during construction. Over one-quarter of the 2016 ESL area was covered with a combination of disturbance-related habitats, including yellow star-thistle grasslands (13 percent of the ESL) and dredger tailings (11.5 percent of the ESL).

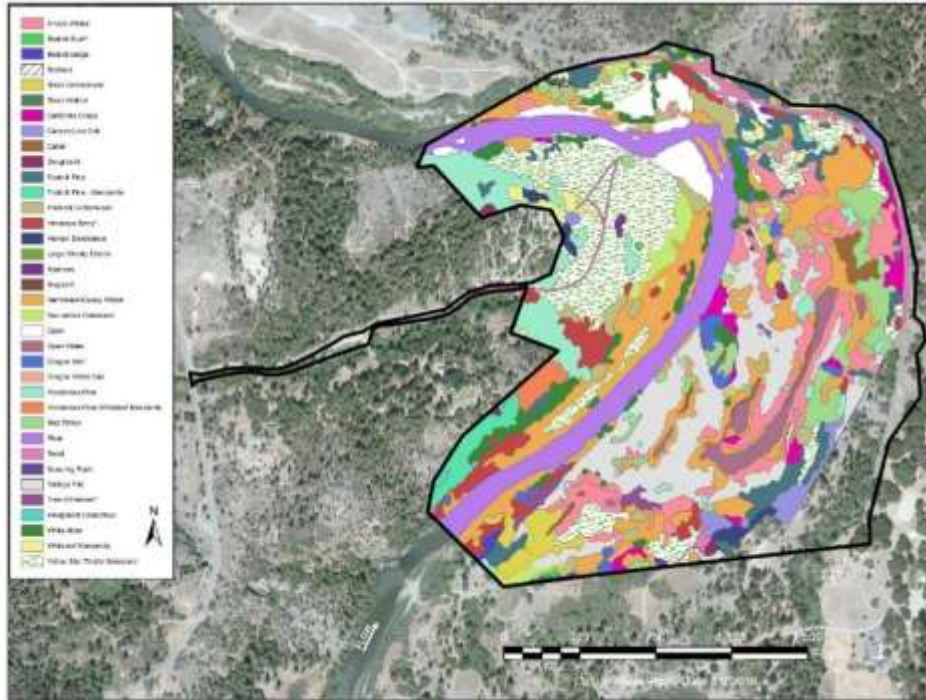


Figure 5-4. Land and vegetation cover type mapped in 2014 within the 114.3-acre project site.

5.4 Site Constraints and Opportunities

The preceding sections documented how mining impacts, large floods, and flow regulation artificially confined the valley, disconnected the river from its floodplain, and created a simplified and stable river channel through most of the site. The site currently exhibits some of the worst rearing habitat across the critical range of flows anywhere in the restoration reach, and it also has very little adult holding habitat. The value of creating rearing habitat at the project site is magnified due to its proximity to Sheridan Riffle, which has some of the highest densities of natural spawning in the restoration reach.

Gaeuman et al. (2016) stressed that planform complexity is dependent on an accessible floodplain and recommended the following general approaches for mechanical rehabilitation of the Trinity River:

- Connect the channel to its valley
- Create obstructions
- Use large wood placements at all scales
- Create functional floodplains
- Natural bar morphology and dynamic construction

Gaeuman et al. (2016) provided additional recommendations for the Junction City valley reach (where the Oregon Gulch project is located) as follows:

“This reach includes some expansive terrace area that could be converted to complex floodplains over the long term. This should be the ultimate end objective for these reaches. In the short term, rehabilitation in this reach should target floodplain development at a scale commensurate with current means, increasing channel complexity through local width variations as described previously, and maintaining existing complexity where the channel interacts with its valley walls.”

The combination of a wide valley bottom, significant amount of public land, and willing landowners provides a unique opportunity to implement the recommendations of Gaeuman et al. (2016) to make significant and badly needed planform and habitat improvements to the site.

6. Design Development

6.1 Project Objectives

At its core, the Oregon Gulch project is a tailings removal project. The magnitude of the disturbance to the site from historical gold mining cannot be overstated. Mining debris washed off the hillslope during upslope hydraulic mining buried the historical valley bottom, and subsequent dredging coupled with fluvial incision left a narrow canal-like channel with almost no functional floodplain area. The result is a section of river with extremely poor rearing, spawning, and adult holding habitat and a pronounced dip in rearing habitat capacity between 450 cfs and 8000 cfs. Therefore, the general project objectives are to increase rearing habitat across all flows, eliminate the rearing habitat dip below bankfull flows, increase the functional floodplain area, and increase topographic and hydraulic complexity throughout the site. The project site is located just below the Sheridan Riffle, which has the highest density of natural spawning in the restoration reach. Therefore, it is important to maximize the rearing habitat gains at the project site to enhance the growth and survival of the fry produced at the Sheridan Riffle immediately upstream. The detailed project objectives are as follows:

- Physical Objectives
 - Remove tailings piles from a riverine valley bottom area spanning 16 acres.
 - Increase the extent and frequency of floodplain inundation.
 - Promote fluvial processes, such as bedform dynamics and channel planform change.
 - Reduce wood storage deficit (wood structures and standing inventory).
- Biological Objectives
 - Ensure that habitat availability continuously increases as discharge increases above baseflow.
 - At a minimum, double rearing habitat capacity across the range of frequent discharges during the period when juvenile salmon are present in the river (350-4,000 cfs).
 - Increase allochthonous production within the aquatic ecosystem.
 - Enhance existing native amphibian habitat.

- Create seasonal surface water connection to off-channel habitats.
- Riparian Objectives
 - Minimize impacts to existing multi-story riparian vegetation and cottonwoods.
 - Increase riparian vegetation biomass and abundance in the tree, shrub and herb layer along design features compared to existing conditions.
 - Increase the number of trees (especially cottonwood) that could supply logs in excess of 24' to the river.
 - Increase native species richness/abundance.

6.2 Design Process and Approach

The Trinity River Restoration Program is a multi-agency program. A technical workgroup called the Design Team is comprised of multi-disciplinary program partners that oversee the design process. The Design Team is broken into four smaller subset teams that are assigned a specific project that they oversee the specific design tasks and become the project lead or the designers of record. The four individual designer teams include Federal, Hoopa Valley Tribe, State of California, and the Yurok Tribe. The designs are reviewed at multiple stages throughout the design process via internal technical review, external technical review (a formal value engineering study), and by the public through the environmental permitting process. The final design deliverables include a design report, design drawings, and Digital Terrain Model (DTM). The Bureau of Reclamation manages the associated environmental permitting process and construction contracting, implementation, and oversight.

6.3 Conceptual Design Alternatives

In 2010, the Trinity River Restoration Program developed conceptual designs for nine project sites throughout the restoration reach, including two concepts for the Oregon Gulch project site (CH2MHill and Entrix, 2010). The current design process started by reviewing two concepts developed in 2010. From there, the Yurok Design Group took a new approach to the design process and solicited conceptual design input from the other design groups prior to developing their concepts. This was done to ensure the conceptual designs represented input from across the TRRP. The input from the other design groups was developed during individual brainstorm meetings with other TRRP design groups. The various brainstorming sessions developed a total of 15 different conceptual ideas. Combining similar design elements reduced the number of brainstorming concepts for 10, including the original two from 2010.

6.4 Thirty Percent Design Alternatives

The 30 percent designs alternatives adopted the design team recommendations to reconnect the river with its valley and maximize the amount of functional floodplain. Two alternatives were developed for the 30 percent design stage, a large amplitude meander alternative, and an anastomosing channel alternative. Both of these alternatives are described in detail in the 30-percent design report (Yurok Tribe 2018).

The anastomosing channel 30 percent design alternative (ACD) combined the “stage-zero” concept described by Cluer and Thorne (2014) with the more familiar concept of an anastomosing channel system consisting of several stable channel anabranches separated by vegetated islands (Knighton 1998). The stage-zero concept refers to a stream condition in which a network of small channels that inundates the adjacent floodplain and wetlands at

relatively frequent discharges provides greater ecological benefits than a single large stream channel. As applied to multiple stream restoration projects in the Pacific Northwest, the stage-zero concept has been implemented by creating a geomorphic grade surface that spans the valley width and has a longitudinal slope defined by the elevation of hydraulic controls at the upstream and downstream ends of the project reach (Powers et al. 2019). This approach is well-suited to low-slope areas where valley and floodplain connectivity can be restored to promote longitudinal and lateral sediment deposition. The Oregon Gulch project site is well suited to this approach due to its low slope, wide valley (accessible with tailings removal), and stable geomorphic control near the Oregon Gulch confluence. However, the necessity to maintain boat passage precludes the implementation of a true stage-zero design.

The large amplitude meander (LAM) alternative focused on increasing sinuosity through the reach by extending the length of the main channel by about 8 percent. It also features side channel and high flow channel creation through existing tailings ponds and extensive tailings lowering to encourage riparian growth.

6.5 The 60 Percent Design

The 60 percent design was a blend of the two 30 percent alternatives. Like the ACD alternative, it was based on the stage-zero concept in that the low-flow stream channel is designed to overtop its banks and inundate an extensive valley bottom area at relatively low discharge levels (approximately 600 cfs). A primary concept in this restoration approach is restoring the valley grade across the valley bottom both longitudinally and laterally. A design valley grade of 0.00065 was developed by defining a geomorphic grade line connecting baseflow water surface elevations at the upstream and downstream ends of the project area. Elevations of the channel and all other design features were then referenced to the designed valley grade. The three low flow channels proposed in the ACD design have been reduced to a single-thread channel that follows an arcuate path along the right margin of the valley bottom, somewhat similar to the LAM alternative. The reduction to a single channel was made to force the river as far across the valley bottom as possible and discourage any easier or shorter paths. Unlike the LAM, however, the 60 percent design channel was too narrow, and its slope too low for it to convey flows greater than about 600 cfs. At discharges greater than 600 cfs, the flow would be conveyed across the valley grade surface, creating abundant slow water habitats used by juvenile salmonids.

7. The 90 Percent Design

The 90 percent design is conceptually and structurally similar to the 60 percent design, in that it retains a large, relatively flat valley grade surface and the single channel along the right valley margin as described above. As with the 60 percent design, the channel is designed to overtop its banks at a discharge near 600 cfs. The 90 percent design differs from the 60 percent in two major ways. First, we removed a large area of terrace lowering on river right at the upstream end of the site because hydraulic modeling indicated that lowering in that area caused significant decreases in high-flow water surface slopes at Sheridan riffle a short distance upstream. The second significant change is a substantial decrease in the size of the constructed landslide feature used to divert the main channel to the right side of the valley. After careful consideration, we concluded that the size of that feature in the 60 percent configuration was unnecessarily large. It would be preferable to keep more of the available valley width at lower elevations that can function as aquatic and riparian habitats.

In addition to significantly increasing juvenile habitat availability at flows typical of the winter fry-rearing period, the 90 percent design is intended to stimulate geomorphic processes that will drive the evolution of a structurally diverse floodplain landscape that offers a wide range of habitats and hydraulic conditions. As discharges increase to magnitudes capable of transporting appreciable volumes of sediment, flow divergence in the valley grade area is expected to result in the deposition of sediment and woody debris in some floodplain locations. At the same time, overbank flows are expected to become concentrated in specific areas, leading to localized scour. When coupled with aggradation within the constructed channel, these processes can produce avulsions and the incision of new channels into the floodplain surface. In summary, the designed low-flow channel is not intended to be a stable or static feature. Temporary effects on low-flow navigation at certain times of the year are possible, depending on geomorphic evolution.

7.1 Access, Contractor Use Areas, and Spoils

Figure 7-1 provides a broad overview of the full Oregon Gulch site and highlights the construction logistics involved in the project, such as access roads and contractor use areas for storing equipment and stockpiling supplies (C-1 through C-8, shown in yellow). Construction access to the site will be gained from Sky Ranch Road using two new access roads. Access within the site will utilize those roads plus an existing road network that will connect the project design features to contractor use areas and upland spoil areas. Restoration of the valley within the site requires moving spoils to off-site locations, one of which is the U-1 spoils area located about 1000 ft to the south of the main rehabilitation area (shown in light blue in Figure 7-1). U-1 will accommodate approximately 143,000 yd³ of excavated material. The rehabilitation features themselves are presented in Figure 7-1 and Figure 7-2.

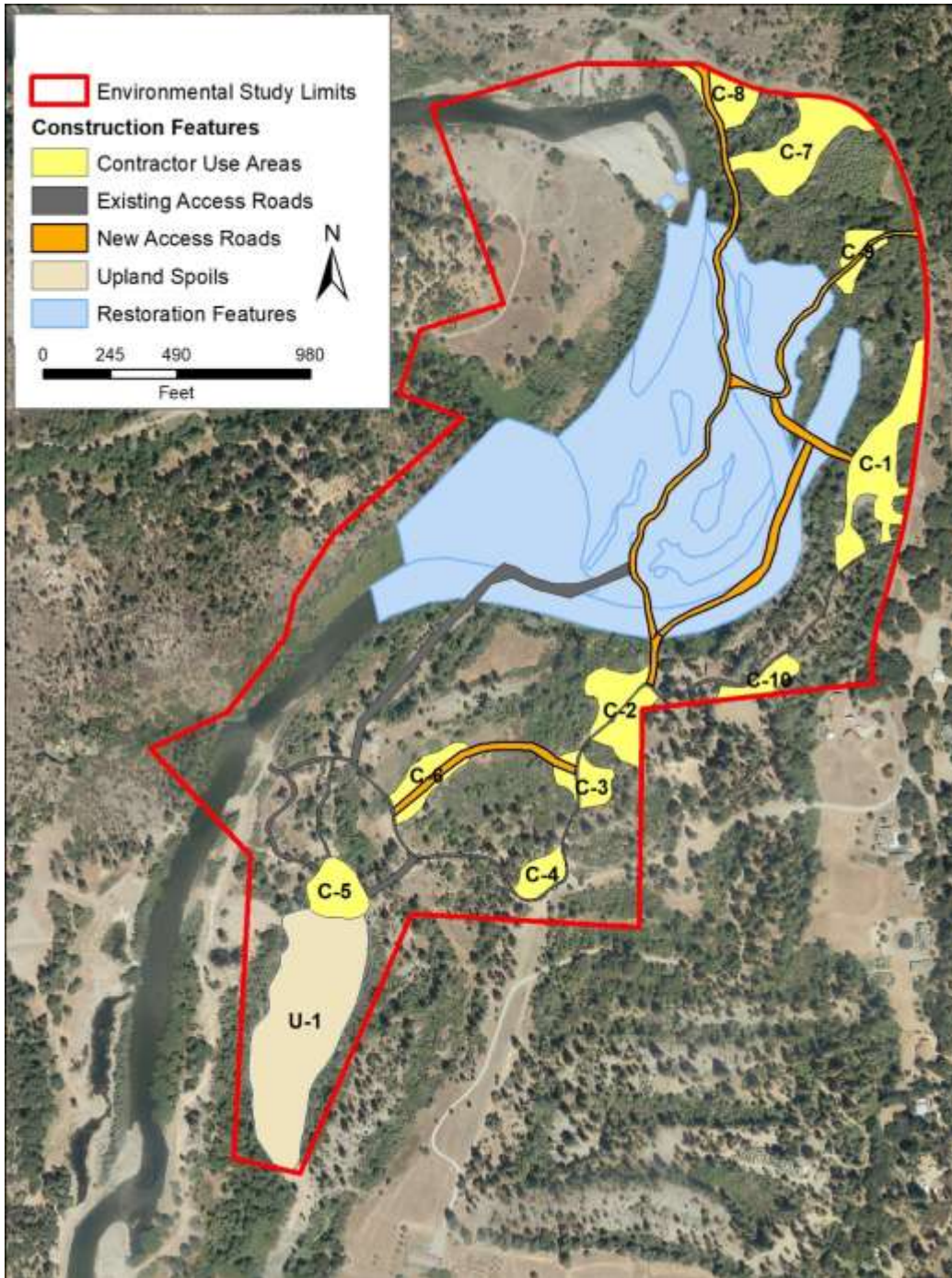


Figure 7-1. Construction access, Contractor use areas, and spoils area

7.2 Oregon Gulch Rehabilitation Design Features

The remainder of this section of the report describes the rehabilitation features included in the 90 percent design and summarizes their intended physical and ecological functions. The feature descriptions also address prospects for the future evolution of the site and uncertainties surrounding those expectations. The next section then presents modeling analyses that demonstrate that the design will immediately produce significant increases in

rearing habitat availability over a wide range of ecologically significant flows and set initial conditions that stimulate the geomorphic processes that support the development of diverse riverine habitats and ecological integrity in the future.

7.3 R-1, R-2, and R-3 Floodplains

Description and Purpose: The R-1, R-2, and R-3 floodplains are separate sections of a single implementation of the valley grade concept that underpins stage-zero restoration design, as described above. The valley grade surface spans the full longitudinal extent of the project site, starting at an elevation of 1469.1 ft at its upstream end. From there, it slopes downstream at a constant slope of about 0.0009 to an elevation of 1467.8 about 1440 ft downstream. The existing surface in the valley grade area contain tailings piles that approach 1500 ft in elevation, as well as some depressions at elevations near the valley grade surface or below it. These depressions, which include one deep open-water pond, are retained in the final floodplain surfaces. The final surfaces will incorporate woody debris, transplanted willow clumps, and preserved patches of desirable existing vegetation to increase hydraulic roughness. In conjunction with the design of the main river channel (IC-1, described below), these three floodplains are designed to inundate at discharges near 600 cfs.

R-1, the largest of the three valley grade sections, extends about 1270 ft longitudinally and about 850 ft laterally at its widest point and encompasses 11.4 acres. R-1 is separated from R-2 and R-3 by the designed main river channel (IC-1), which is located along its right edge (Figure 7-2, Figure 7-3). The area spanned by R-1 currently contains at least four long ridges of tailings. R-2, the smallest of the three sections at 1.4 acres, occupies the footprint of an existing tailings pile about 560 ft long and 100 ft wide on the right side of the valley. Removal of that pile will connect existing depressions on either side of it that are at elevations near the design valley grade. R-3 spans 3.2 acres of existing tailings piles between the designed main river channel and some existing depressions in the downstream right corner of the project site. Together, R-1, R-2, and R-3 represent 16 acres of new floodplain that will provide abundant high-quality juvenile rearing habitat at discharge levels that are frequently exceeded during the months when juvenile salmon are in the river. Construction of these floodplains will require a total excavation volume of 334,600 yd³.

Expected Evolution: Due to their low elevation and large width, the R-1, R-2, and R-3 floodplains are expected to be depositional in some areas and experience scour in other areas. We expect deposition to be the dominant geomorphic process in the upstream third of R-1, whereas local scour, possibly involving the incision of new secondary channels, is more likely toward the downstream end. Overbank deposition is likely in R-2 and R-3, whereas scour is unlikely in those areas due to their positions along the right valley margins. The low elevation of the valley grade surface will also encourage rapid colonization of riparian vegetation. This will increase both trophic production and rearing habitat quality in the area. See the discussion of the expected evolution of U-2 and IC-1 below for more on how these features are expected to co-evolve.

Assumptions/Uncertainties: Uncertainties in the co-evolution of the R-1 floodplain, the U-2 constructed landslide deposit, and the IC-1 channel are discussed in the next section.

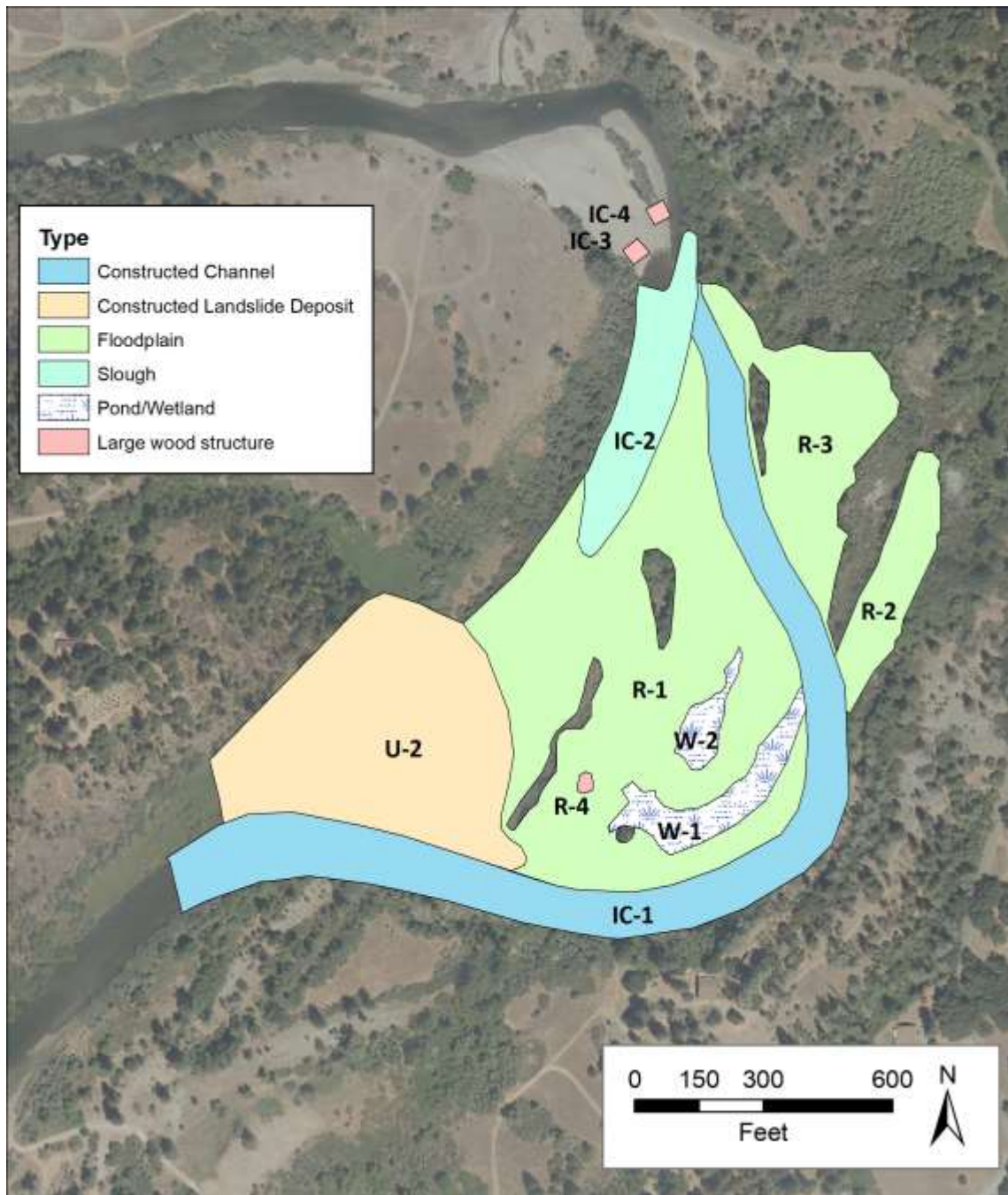


Figure 7-2. Oregon gulch Design Features. The Open holes in the R-1 and R-3 floodplains indicate “no-action” areas where existing topography can vegetation will be retained.

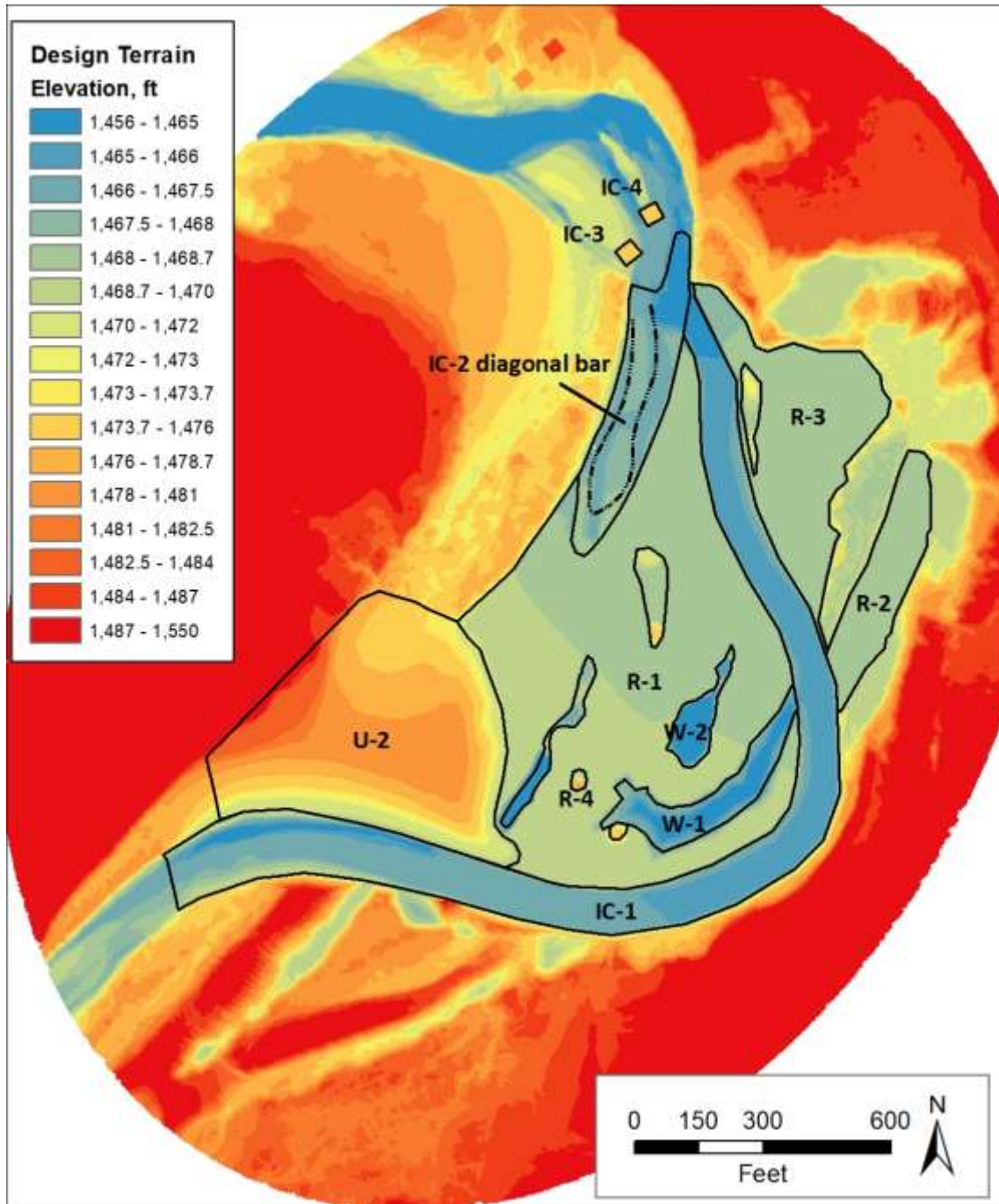


Figure 7-3. Oregon gulch Design topography. Unlabelled polygons indicate no-action areas where existing terrain and vegetation is preserved.

7.4 U-2 Constructed Landslide Deposit

Description and Purpose: The primary purpose of the U-2 constructed landslide is to divert the Trinity River from its existing channel into a new alignment (IC-1 described next) along the right margin of the valley. The U-2 feature consists of a large mound of well-graded alluvium that rises gradually (12:1 slope) from river level (about

1470 ft) at the upstream edge of the R-1 floodplain to about 1480 ft at its crest. That crest elevation was selected so that only floods larger than 16850 cfs (about the 8- to 10-year event) will overtop it. The crest itself is oriented roughly perpendicular to the incoming flow, with a maximum crest width of about 200 ft located approximately on top of the pre-existing channel alignment and a minimum crest width of 130 ft located to the left of the pre-existing channel alignment. This difference in crest widths results in a lee slope with a ridge projecting to the north. The shape of the crest and lee slope is such that any flow overtopping the feature during rare floods will mostly be directed either to the east onto the R-1 floodplain or the heavily vegetated terrace west of the existing channel. The structure is about 530 ft thick in the streamwise direction at its base. It also features a relatively small projection on the east end of its upstream face. That projection, which rises about 4 ft above the valley grade, is intended to direct moderate flow farther to the right before spilling out onto the R-1 floodplain and serve as a small stockpile of coarse sediment that can be redistributed on the R-1 floodplain during larger flow events. In total, U-2 covers an area of 6.6 acres and requires a net fill of about 41,000 yd³.

The bulk of the material used to construct U-2 will be pit run (Table 6). Some portions of U-2, however, are expected to experience relatively high shear stresses during floods and so will incorporate varying amounts of additional cobble through small boulder materials and large wood. To better describe how materials will vary in different parts of U-2, we divided the feature into four regions as shown in Figure 7-4. The east half of the upstream face of U-2 (U-2a) is expected to experience shear stresses exceeding 2 lb/ft² during floods in the range of 9000 to 11500 cfs (about the 2.5- to 5-yr events), which has the potential to entrain sediments with median particle sizes approaching 8 inches in diameter. Likewise, the crest (U-2b) and upper part of the concave downstream face of the feature (U-2c) may experience shear stresses up to 1 lb/ft² during overtopping events like the maximum fisheries flow of 21900 cfs, and so will require materials with a median particle size of nearly 4 inches. The sediment gradations used to construct different parts of U-2 are discussed in greater detail later.

7.5 IC-1 Channel

Description and Purpose: The IC-1 channel will provide baseflow water conveyance and boat passage through the R-1 floodplain area following project construction. The bottom of the IC-1 channel will be set to an elevation 3 feet below the elevation of the adjacent R-1 floodplain surface throughout its length. The channel will be relatively wide at its upstream end, with a bottom width of about 95 ft and a top width as large as 200 ft. This portion of the channel is intended to efficiently convey flow through a bend to the right forced by the U-2 constructed landslide deposit to help mitigate the potential for the bend to create backwater conditions farther upstream. Upon reaching the right edge of the R-1 floodplain and bending to the left to flow straight down-valley, the channel gradually narrows to bottom and top widths of about 50 ft and 70 ft, respectively. The moderately sinuous path of the channel relative to the valley grade (sinuosity equal to about 1.3) gives it a mean slope of approximately 0.00066. Together with this low slope, the narrow downstream section serves to limit the discharge conveyed through the R-1 area to about 600 cfs. Flows greater than about 600 cfs will spill over the channel banks and inundate the R-1 floodplain, generating large increases in wetted area and rearing habitat availability as flows increase through the range of flows typical of the period when juvenile salmon are in the river. Excavation of the IC-1 channel will require 181,900 yd³ of excavation.

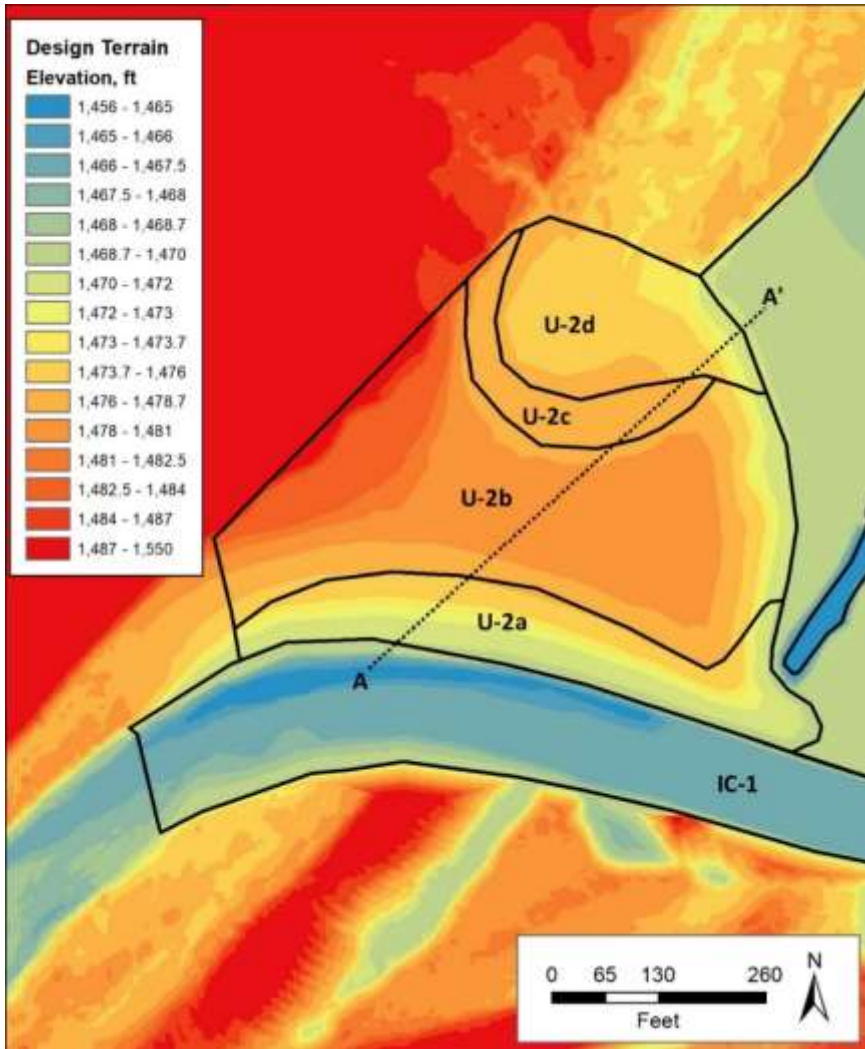


Figure 7-4. Materials regions defined for the U-2 constructed landslide deposit. The location of profile A-A’ shown in Figure 7-5 is indicated.

Expected Evolution: Because the IC-1 channel is designed to overtop its banks at relatively small discharges, the majority of the water passing through the site during floods will be conveyed over the R-1 floodplain. Spreading the flow over a wide area will greatly reduce unit stream power and sediment transport capacity in the R-1 area. Therefore, we anticipate sediment deposition on all three floodplain features, especially in the upstream half of R-1 and within the IC-1 channel itself. Deposition on the channel bed may further reduce channel capacity, forcing more water onto the floodplains. Simultaneously, irregularities in the floodplain surface may cause the flow to concentrate into defined flow paths that evolve into alternative channels. The net results could range from avulsion of the channel to a new location on the floodplain, or the formation of an anabranching delta-like channel network. The precise outcome cannot be accurately predicted, but the as-built terrain is, by intention, almost certain to evolve dynamically in the years following construction.

Assumptions/Uncertainties: It is not possible to predict the course of post-construction evolution in the R-1/IC-1 area in detail. We can confidently predict that one or more relatively stable channels will eventually establish themselves and that the R-1, R-2, and R-3 areas will continue to be flooded at relatively small discharges well into

the future. However, the project site may undergo an evolutionary stage in which boat passage may become difficult. Such a situation would be unlikely to persist for more than a few years under normal flow conditions, but in the event of a prolonged drought, boat passage could remain an issue until larger floods return.

7.6 R-4 Large Wood Structure

Description and Purpose: The R-4 large wood structure uses an unusually large cottonwood tree that currently exists at the project site and must be removed to accommodate necessary excavation. The trunk and rootwad of that tree will form the core of the R-4 structure, which will incorporate additional wood and about 150 yd³ of coarse fill. This structure is intended to increase hydraulic roughness and topographic and ecological diversity on the R-1 floodplain.

Expected Evolution: We anticipate that R-4 will bifurcate overbank flow streamlines, creating hydraulic variability and local scour and deposition. Interactions between R-4 and overbank flows will increase topographic and ecological diversity on the floodplain and, if fully developed, could take the form of a vegetated island between two channel anabranches.

Assumptions/Uncertainties: Future magnitudes and spatial distribution of deposition and scour around the R-4 large wood structure cannot be predicted with confidence.

7.7 IC-2 Slough

Description and Purpose: The IC-2 slough occupies a 600-ft-long section of the pre-existing Trinity River channel downstream from the U-2 constructed landslide deposit. This section of the channel, which covers about 1.9 acres, will be partially filled with about 5,050 yd³ of clean gravel and cobble (Table 7-1) to construct a diagonal bar that crosses the slough from right to left (dashed black outline in Figure 7-3), and supplied with large wood and slash. The slough will contain slackwater when mainstem flows are less than about 600 cfs, with the hyporheic flow coming from Mill Creek on the downstream flank of the U-2 landslide deposit and through the base of U-2. However, at flows greater than 600 cfs, the slough will receive discharge conveyed across the R-1 floodplain. At lower discharges, the placed bar within the slough decreases the channel cross section compared to the pre-project cross section so that the velocity of through-flow is increased. On the other hand, at somewhat higher discharges, the diagonal bar functions as a hydraulic control that limits flow velocities. As a result, the slough will maintain flowing water with velocities suitable for juvenile Chinook rearing (<2 ft/s) over at least half its area at flows up to 4000 cfs.

Expected Evolution: The fate of the IC-2 slough will depend on the development of primary flow paths that develop in the R-1 floodplain. If the floodplain develops a channel that delivers significant flood flow to the upstream end of the slough, the slough may once again function as a primary channel pathway. In that case, the slough could be replaced by abandoned or inactive channels elsewhere on the floodplain. If the floodplain develops channels that convey flow back to the existing channel farther downstream, the slough would likely remain a slackwater environment or even accumulate fine sediment.

Assumptions/Uncertainties: As the future channel configuration that will develop on the R-1 floodplain cannot be predicted with confidence, neither can the future fate of the IC-2 slough.

7.8 W-1, W-2 Wetlands

Description and Purpose: Wetlands W-1 and W-2 are features that already exist on the landscape. W-1 currently consists of a shallow wetland covering about 1 acre, and W-2 is a 0.35-acre deep water pond. These two wetland features will be left intact to preserve over-summer salmon rearing habitat and habitats used by frogs, turtles, and other riverine species. Both wetland features are surrounded by desirable vegetation that will also be preserved as much as possible. The current design calls for the existing wetland at W-1 to be connected directly to the IC-1 channel at its downstream end, whereas the pond in W-2 will have a surface water connection to the main channel only when discharge exceeds 600 cfs.

Expected Evolution: The basis of the Oregon Gulch design is to allow the river access to as much of the valley as possible. As the existing wetlands are topographically low, they represent areas that the main river flow can easily occupy. This could potentially contribute to the development of an anastomosing channel pattern. However, such details cannot be predicted with confidence at present.

Assumptions/Uncertainties: Poor water quality and dissolved oxygen levels in the ponds are linked to the amount of in-water aquatic vegetation and limited connectivity to river. We assume that greater connectivity to surface water will reduce the density of aquatic macrophytes increase water exchange rates and thereby alleviate any water quality issues.

7.9 IC-3, IC-4 Large Wood Structures

Description and Purpose: IC-3 and IC-4 are two wood features planned for construction on the Oregon Gulch delta at the downstream end of the project site. These structures are intended to increase topographic and hydraulic diversity and to promote roughness and vegetation establishment. The location of the structures was chosen to encourage temporary and long term and wood recruitment for racking and wood storage in the system. Recently, the delta area has been losing vegetation due to scour and natural erosion and currently exhibits a single thread low flow channel. Historically this area has had more diversity, splitting the flow into two or three channels.

Expected Evolution: Hydraulic modeling shows increased velocities and shear stresses near the proposed wood structures. Based on the modeling, the wood structures should increase scour along each side and promote deposition of fines, allowing vegetation to recover. The position and design architecture of IC-4 will provide a good opportunity to rack and store wood moving through the system.

Assumptions/Uncertainties: Vertical piles will be critical for wood racking at IC-4 and potentially at the IC-3 structure. Geomorphic evolution for both scour and deposition will be directly dependent on the natural accretion and shedding (mobility and retention) of wood materials onto the IC-3 and IC-4 structures. Long-term function of the wood structures is conditional on the project's hydraulic response upstream and the longevity of the vertical piles. Post-construction persistence beyond 5-10 years is uncertain.

7.10 Materials and Quantities

Three basic classes of geological materials will be used for constructing the design features (Table 7-1). Clean gravel and cobble (CGC) will be used to construct the submerged portions of U-2 and IC-2 when river turbidity is a potential problem during material placement, whereas pit run (PR) will be used as above-water fill in situations when turbidity is not a concern. Cobble and small boulders (CSB) will be added to pit run or CGC as needed to coarsen the grain size distribution of the fill placed in areas where greater resistance to erosion is required.

Pit run is simply the raw alluvial material obtained from an excavation at the Oregon Gulch site. CGC is obtained by sieving pit run to remove oversize material (>5 inches in diameter) and fines (<0.5 inch), whereas CSB is simply the oversize material excluded from the CGC during the sieving process. We anticipate using several different materials mixtures to meet the requirements for turbidity control and resistance to erosion is different portions of U-2. The planned internal architecture of U-2 with the associated mixtures of the three basic sediment classes is illustrated in Figure 7-5, and the sediment mixtures are defined in Table 7-2. The proportions specified in the table are preliminary estimates and will be modified as needed in the field when the actual gradation of the source material is more precisely known.

Table 7-3 displays the cut and fill quantities, fill types, and numbers of large wood pieces required for the various design features. Excavation of R-1, R-2, R-3, and IC-1 will involve upwards of 516,500 yd³ of cut. Up to about 52,000 yd³ of that total can be used as fill in the construction of other design features, and about 143,000 yd³ can be spoiled the U-1 spoils area within the project ESL. The remaining 321,500 yd³ of spoils will be transported off site for disposal. Quantities of wood needed are discussed in more detail in a later section of this report.

Table 7-1. Specifications for geologic material types referred to in feature descriptions. fines are defined as particles less than 0.5 inch in diameter.

Material	Description	D50 (inches)	D90 (inches)	Dmax (inches)	Percent Fines
Pit run (PR)	Excavated tailings	2-3	5-6	10-12	<30
Clean gravel and cobble (CGC)	Gravel and cobble between 0.5 and 6 inches intermediate diameter	2	5	6	0
Cobble and small boulder (CSB)	Cobble and small boulders between 5 and 12 inches intermediate diameter	7-9	10-12	14	<5

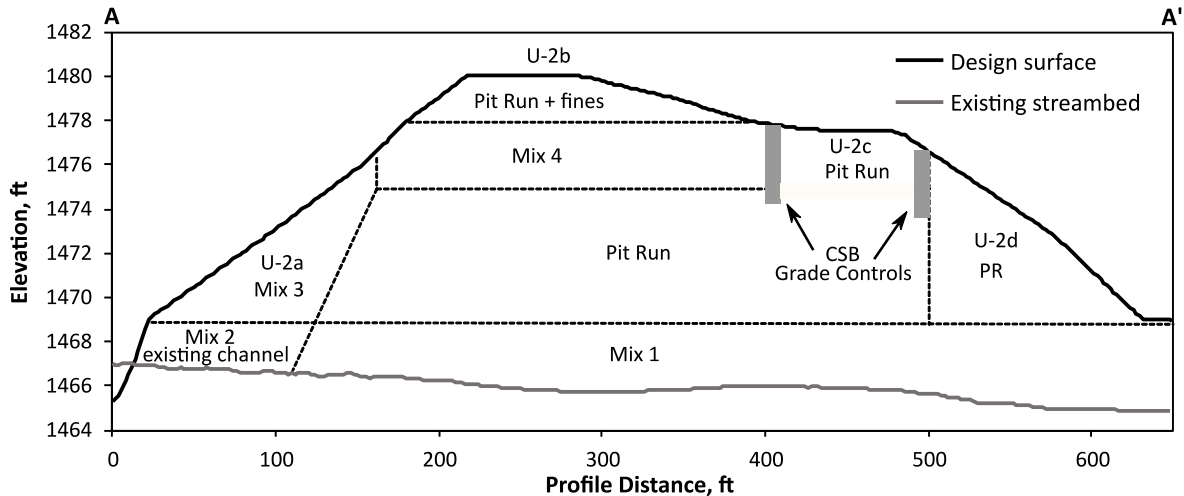


Figure 7-5. Internal architecture of the U-2 constructed landslide deposit along the profile A-A' shown in Figure 7-4.

Table 7-2. Approximate Sediment Mixtures used in U-2. Actual proportions of CSB in mixtures depends on gradation of native material and will be adjusted during construction.

Material Zone	Description
U-2a, existing channel	Material Mix 2: Ratio CGC:CSB = 1:3, plus large wood, ~2 ft thick
U-2a, subaerial	Material Mix 3: Ratio Pit Run:CSB = 1:3*, plus large wood, variable thickness up to 5 ft
U-2b,c,d, existing channel	Material Mix 1: Ratio CGC:CSB = 12:1, 2-4 ft thick
U-2b, top layer	Pit Run + fines (fraction of fines to be determined in field), 1.5-2 ft thick
U-2b, 2 nd layer	Material Mix 4: Ratio Pit Run:CSB = 2:1, 3-4 ft thick
U-2b,c, interior	100 percent PR, 6-7 ft thick
U-2c, top layer	Material Mix 4, 3-4 ft thick, plus two CSB grade control bands
U-2d	100 percent PR, variable thickness up to 9 ft

Table 7-3. Geologic Materials Quantities by feature. Volumes in cubic yards; wood in numbers of pieces 30 ft long or more. See the wood design section and appendix H for detailed wood specifications.

Feature	Cut	Fill (PR)	Fill (CGC)	Fill (CSB)	Fines	Large Wood
R-1	233,070	2,070	4,140			120
R-2	32,640					20
R-3	68,880					40
R-4				150		10
U-2		21,010	5,200	12,350	2,390	55
IC-1	181,890					75
IC-2		1,260	3,790			35
IC-3				225		16

Feature	Cut	Fill (PR)	Fill (CGC)	Fill (CSB)	Fines	Large Wood
IC-4				275		13
W-1						60
W-2						20
U-1 Spoils Area		143,000				
Totals	516,480	24,340	13,130	13,000	2,390	464

8. Design Assessment and Performance

8.1 Hydraulic Model Description

Hydraulic models were developed to evaluate hydraulic and habitat conditions for both the existing and design conditions within the Oregon Gulch project area. In addition, the potential for geomorphic change after project construction was assessed using hydraulic parameters drawn from the hydraulic models, as well as with direct simulation of geomorphic change using morphodynamic models representing the existing and design conditions. Both types of analysis are performed using the Bureau of Reclamation’s Sedimentation and River Hydraulics model (SRH-2D). SRH-2D solves the depth-integrated, dynamic wave approximation of the Navier-Stokes fluid flow equations with a finite-volume numerical method. More information about SRH-2D can be found at <http://www.usbr.gov/pmts/sediment/model/srh2d/>.

The model domain extends from about 400 ft upstream of Sheridan Hole to about 1,800 ft downstream of the Oregon Gulch delta (Figure 8-1). On the river left, the model domain extends well above the river level and includes the terrace across from the delta. To the east, the model domain extends to Sky Ranch road.



Figure 8-1. The model domain is outlined in orange. The region in which inundation areas and habitat capacity are evaluated is outlined in red. Rehabilitation features are shown in grey. North is up.

SRH-2D requires the development of meshes that represent the topography and hydraulic roughness of the stream reach. These meshes consist of nodal points with terrain elevations and triangular or quadrilateral elements defined by the nodes at their corners in which hydraulic parameters are computed. The meshes, therefore, define the spatial resolution of the output. The existing and design hydraulic models are based on very fine meshes with elements in and near the channel with areas of about 8 ft² (4 ft wide by 2 ft long). Mesh elements in upland areas that are rarely inundated are somewhat larger, with a median area of about 20 ft². The small size of these elements means that very large numbers of elements comprise the meshes. For example, the design mesh contains nearly 390,000 elements. The computational load associated with morphodynamic modeling, however, makes the use of such large meshes impossible. The meshes developed for that purpose, therefore, consist of fewer elements of larger size. Both morphodynamic meshes contain 11,600 elements with an average area of about 450 ft² (about 21 ft by 21 ft).

The bed roughness of the existing terrain is based on a 2014 map of the 84th percentile of sediment grain size on the bed surface (D_{84}) developed by the Trinity River Habitat Assessment Team in (Alvarez et al. 2015) with grain sizes converted to Manning's n according to:

$$n = \frac{C_m(2.8D_{84})^{\frac{1}{6}}}{(8.1\sqrt{g})}$$

where C_m is the unit conversion factor in the Manning equation, equal to 1 for SI units, g is the acceleration of gravity, and D_{84} is in meters (Bradley 2018). Roughness in overbank areas was assigned using a 2014 map of riparian vegetation [HVT and McBain Associates, 2015], where Manning's n values of 0.025, 0.045, 0.06, or 0.08 were assigned to different types of mapped vegetation. Unaltered portions of the design mesh retained the existing roughness values. Within design features where the existing surface is removed roughness was assigned as follows: low-flow channel areas were assigned $n = 0.035$, sparsely-vegetated upland areas were assigned $n = 0.045$, and floodplain areas where placed roughness elements and riparian recolonization is planned n are set to 0.06 to 0.065. The downstream boundary condition for all models consists of a stage-discharge relationship at the model outlet. That condition was satisfied by extracting water surface elevations at the outlet location from a pre-existing calibrated model developed for the full 40 miles of the Trinity River from Lewiston Dam to the North Fork Trinity River (Bradley 2018).

Output from hydraulic models is evaluated in several ways. Flow depths and the extent of valley inundation at different discharges are used to assess whether the design is wetting the terrain as intended, and comparison with existing patterns of inundation quantify the expected increases due to project construction. Changes from the existing condition are summarized in terms of the ratio of the wetted area at discharge level i under design conditions (W_{di}) to the wetted area of the existing channel at the same discharge (W_{ei}):

$$W_{ri} = W_{di} / W_{ei}$$

Examination of flow velocity magnitudes provides a qualitative assessment of extent to which the design is successful in creating low velocity regions. The combination of flow depth and flow velocity are critical components for quantifying the availability of rearing habitat for juvenile salmonids over a range of discharges. Expected increases in rearing habitat availability due to project construction is directly assessed using fish capacity (C), which TRRP recently adopted as the preferred metric for quantifying juvenile habitat in the Trinity River.

Potential geomorphic changes are evaluated in two ways. First, regions that are prone to erosion or deposition are identified by evaluating shear stress gradients output by the hydraulic model. Raw shear stress values reported by the model (τ) are converted to a somewhat more intuitive dimensionless form given by:

$$\tau^* = \tau / (\rho g R D)$$

in which ρ is the density of water, g is gravitational acceleration, R is the submerged specific weight of the sediment, and D is a representative grain size. The value of τ^* needed to mobilize the representative sediment grain size ranges from 0.03 to 0.06, where 0.03 corresponds to the initiation of small sediment transport rates involving just a few particles and 0.06 corresponds to a large transport rate involving the entire surface of the stream bed. Here, we compute τ_{50}^* using a sediment grain size of 50 mm to represent gravel sizes that tend to be mobile during frequent flood events. Although the magnitudes of τ_{50}^* are of interest, spatial gradients of τ_{50}^* are at least equally informative for assessing potential geomorphic change. Regions in which τ_{50}^* decreases in the downstream direction can be interpreted as areas in which sediment depositional is likely, whereas increasing values of τ_{50}^* suggest the potential for erosion.

The second approach to assessing possible geomorphic evolution is a direct simulation using the morphodynamic module of SRH-2D. That module simulates sediment entrainment and transport to predict where erosion and

deposition are likely to occur. Because the factors that affect sediment transport are numerous and often extremely subtle, no existing numerical model can reliably predict channel evolution. Comparing the results of simulations of the design condition to simulations of the existing condition can help identify the potential geomorphic effects of project construction. In addition, morphodynamic results can be compared to the spatial distribution of τ_{50}^* values computed from the hydraulic model output to potentially corroborate interpretations derived from that source.

Due to the computational load associated with morphodynamic modeling, a much coarser mesh with triangular elements averaging about 300 ft² in area was used for that analysis. Mannings n was set to 0.03 in the main channel area, 0.045 in floodplain areas with scattered vegetation, and 0.06 in areas with dense riparian vegetation. Five substrate materials were defined for this simulation. Two bed surface materials were defined to represent relatively fine part of the channel with bars composed of gravel and small cobble (surface 1) and coarser parts of the channel that are armored with cobble (surface 2). A single subsurface material was defined to represent bed composition beneath the surface throughout the model. The particle size distributions of those materials are shown in Figure 8-2.

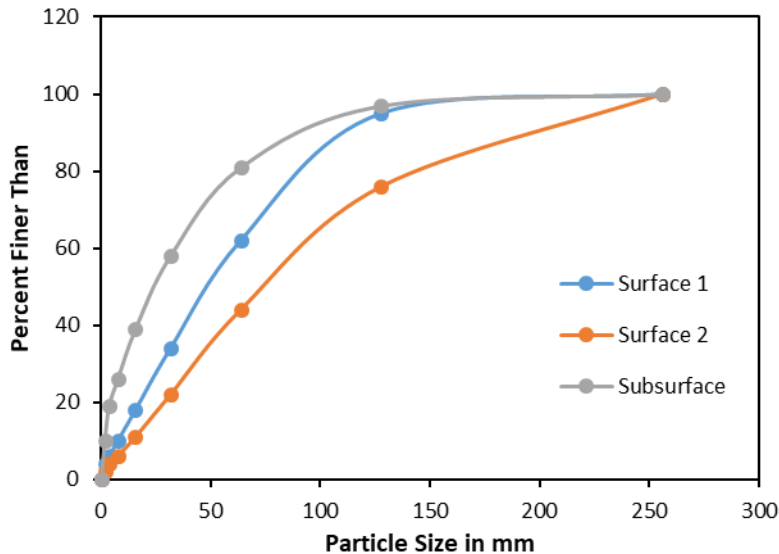


Figure 8-2. Particle size distribution used for morphodynamic modeling.

The remaining two bed material type regions are a “non-erodible” region used in areas outside of the main channel to minimize model artifacts connected to unrealistic bank erosion processes and a region containing the surface 2 material type flagged to allow no changes in bed elevation at the upstream boundary of the model to support computation of the incoming sediment load. Bedload transport capacity was computed using the Wilcock-Crowe (2003) bedload equations with a hiding function modified for the Trinity River (Gaeuman et al. 2009). The model run was performed using an input flood hydrograph that peaks at 11000 cfs and simulates the largest of three peaks released in the spring of 2019 (Figure 8-3).

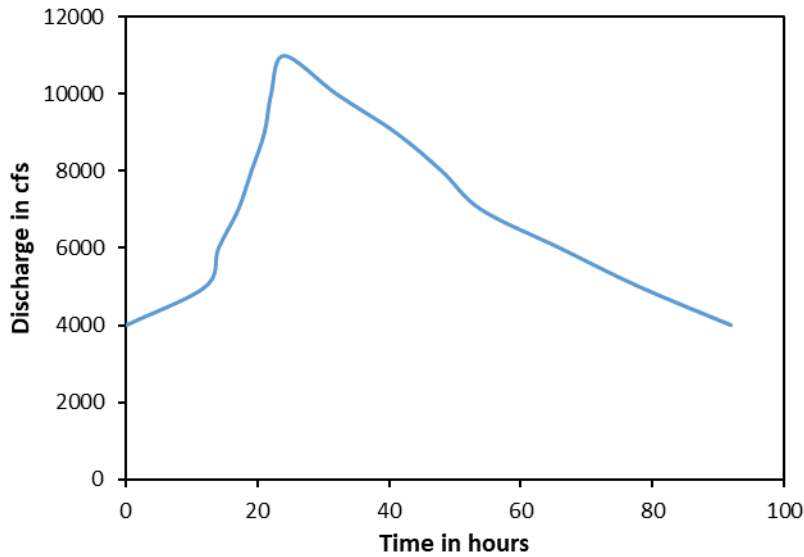


Figure 8-3. Flood hydrograph used for morphodynamic modeling.

8.2 Hydraulic Modeling Results

8.2.1 Inundation and Flow Velocity

Results of seven modeled flows are presented below: 450, 600, 1200, 3500, 9000, 16850, and 21900 cfs. The 450 cfs run represents a small discharge level that is exceeded most (90 percent) of the time during the January through April period when juvenile salmon are in the river, whereas the 600 cfs run represents a more typical winter discharge (exceeded more than 70 percent of the time) during those months. Flows of 1200 cfs are exceeded more than 30 percent of the time during that time period, and 3500 cfs are exceeded more than 5 percent of the time. The 9000 cfs model run is slightly larger than the median annual peak flow representing something akin to a geomorphic design discharge for the site. The 16850 cfs run is approximately an 8-year event as estimated from the 25 records in the annual peak series from the Junction City gage. The 21900 cfs run equals the Maximum Fisheries Flow used by TRRP to identify infrastructure improvements required to implement the restoration program. It represents a very large but not exceedingly rare (at least a 15-year return interval) event.

Under existing conditions, flows remain confined to the bankfull channel throughout the range of flows that occur for significant durations during the winter and early spring. As a result, flow velocities increase rapidly with discharge and greatly exceed the thresholds deemed to be suitable for rearing salmon (1-2 ft/s) throughout most of the channel (Figures 8-4 through 8-9). The flow remains mostly confined to the channel even at 9000 cfs (Figure 8-9) due to confinement by the tailings piles on the right bank.

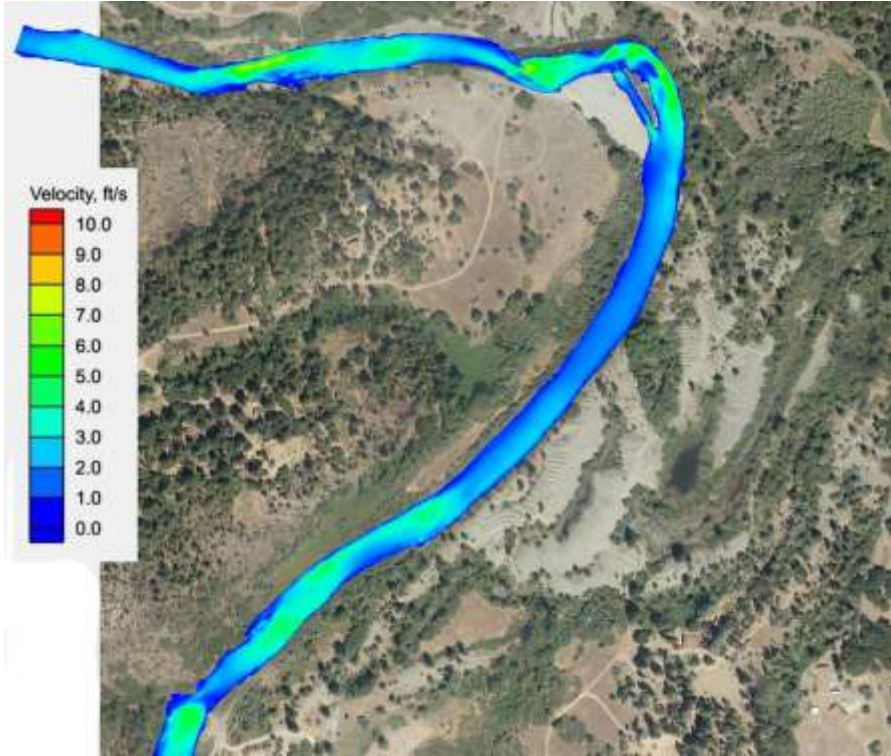


Figure 8-4. Existing Conditions MODELED inundation extents and WATER velocities AT 450 CFS

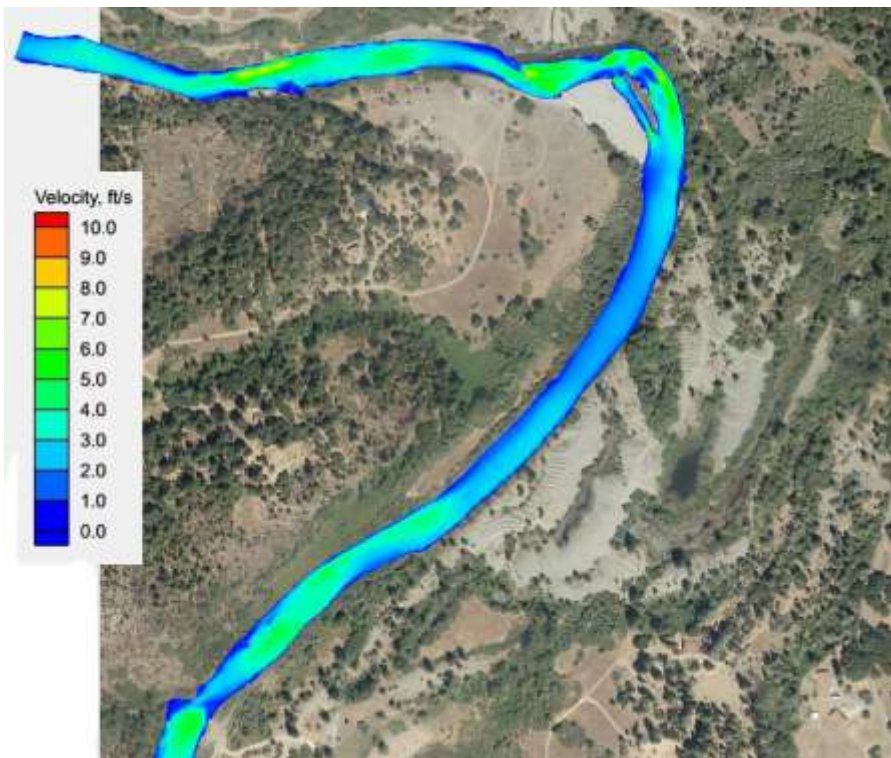


Figure 8-5. Existing Conditions MODELED inundation extents and WATER velocities AT 600 CFS

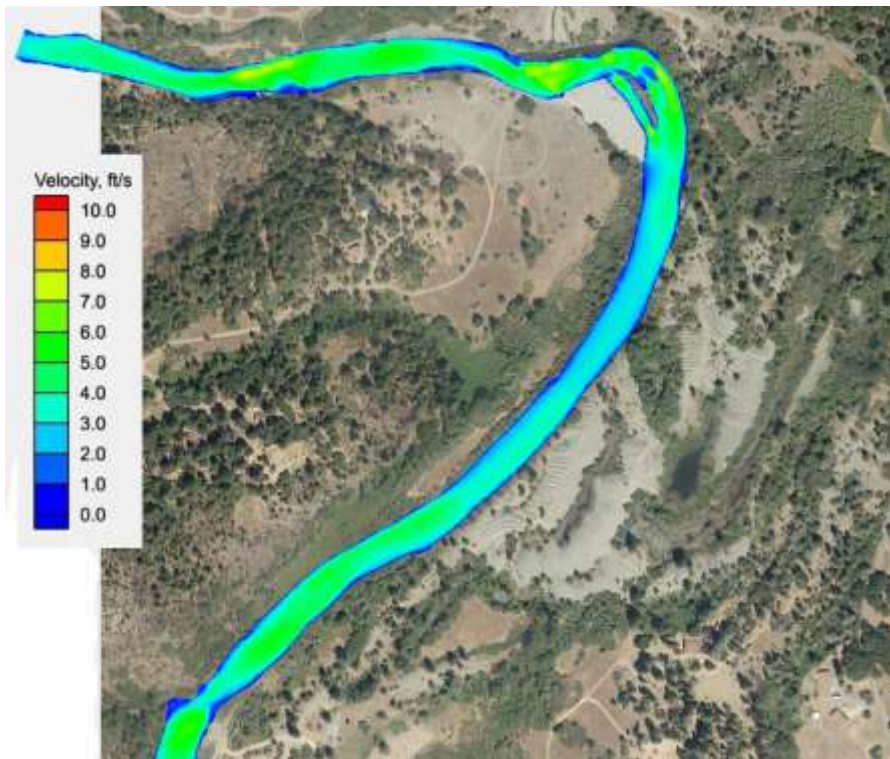


Figure 8-6. Existing Conditions MODELED inundation extents and WATER velocities AT 1200 CFS

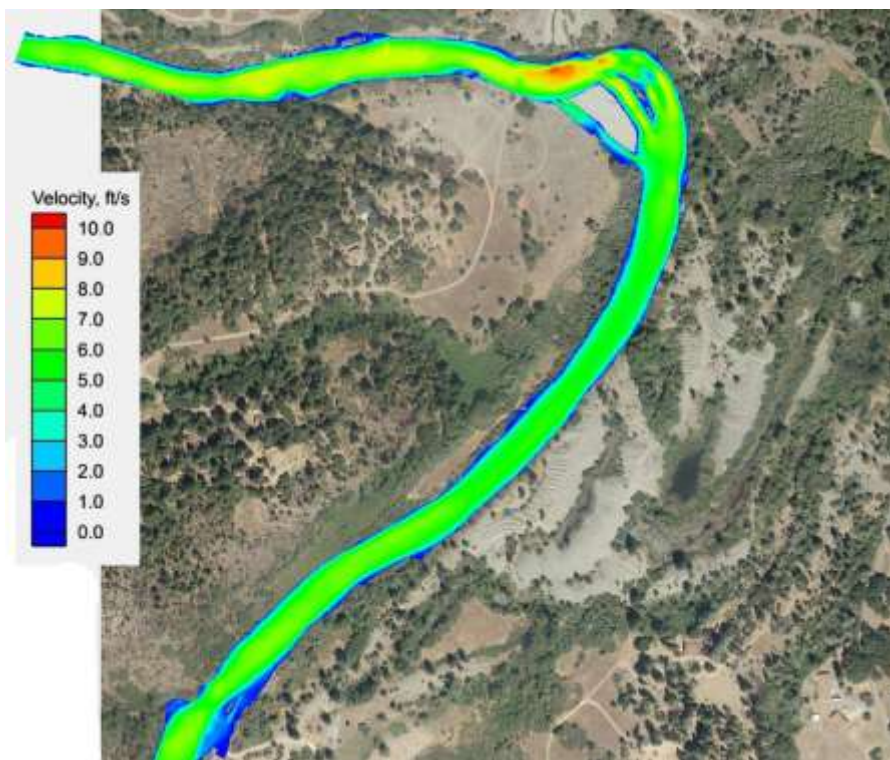


Figure 8-7. Existing Conditions MODELED inundation extents and WATER velocities AT 3500 CFS

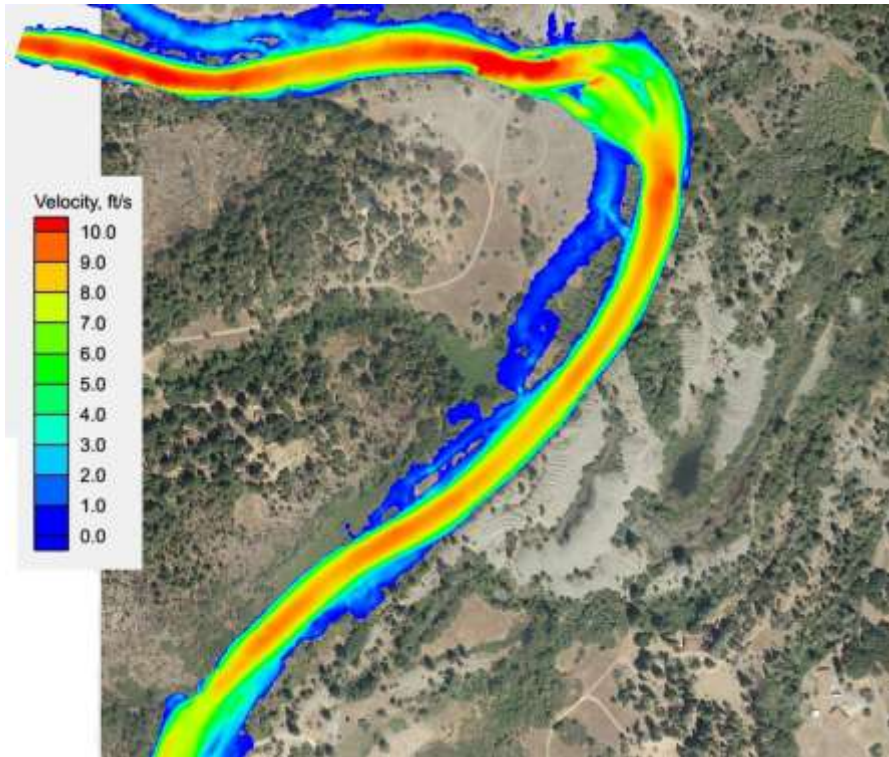


Figure 8-8. Existing Conditions MODELED inundation extents and WATER velocities AT 9000 CFS

Figures 8-9 through 8-13 show modeled flow velocities at 450, 600, 1200, 3500, and 9000 cfs under design conditions. At 450 cfs flow is confined to the IC-1 channel and water velocities are similar to velocities at the same flow under existing conditions. At that flow, only the IC-2 slough displays a large area with low velocities. However, at 600 cfs, water begins to spill out of the channel and inundates most of the valley grade surface (the R-1, R-2, and R-3 floodplains). Inundation extents increase slightly as flows increase to 3500 cfs and flow velocities remain relatively small, with most of the project area showing depth-averaged velocities less than 2 ft/s. Even at 9000 cfs, when the valley floor is almost entirely inundated, flow velocities outside the baseflow channel area are almost exclusively between zero and 2.5 ft/s. The magnitude of the increase in inundation over existing conditions is quantified by W_{ri} , which indicates a more than 4-fold increase in wetted area over a discharge range spanning more than 6000 cfs (Figure 8-14). The smallest increase in wetted area, at 350 cfs, is still 67 percent larger than for pre-project conditions. Inundation of these surfaces generates a rapid increase in the area of low flow velocities throughout the full range of flows. The effect of these large increases in wetted area and low velocity flow on rearing habitat availability is quantified in a later section of this report.

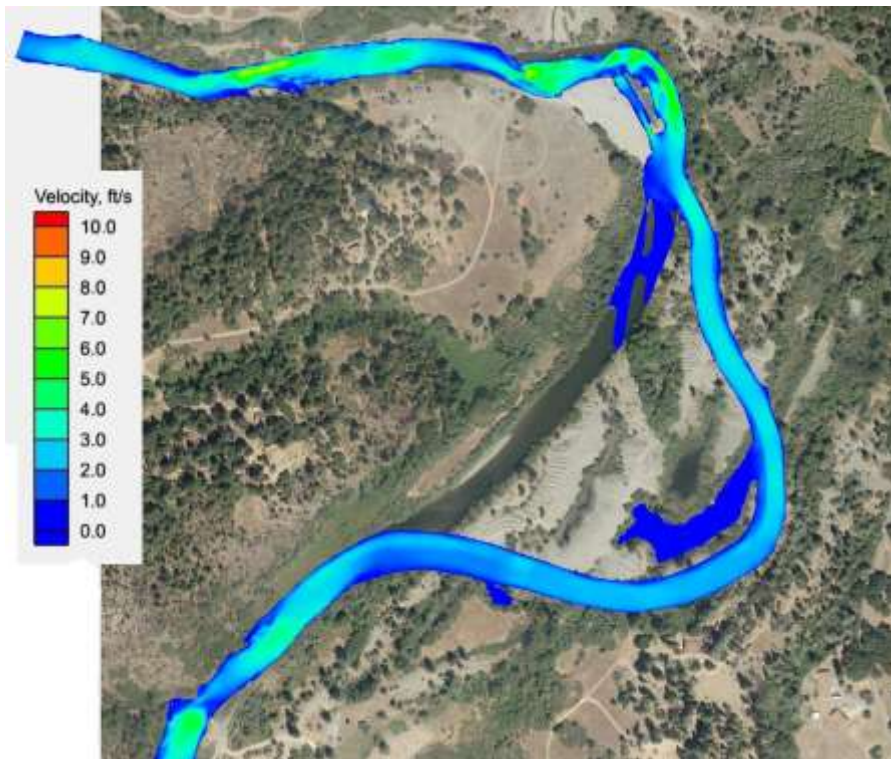


Figure 8-9. Design Modeled inundation extents and Water velocities at 450 cfs

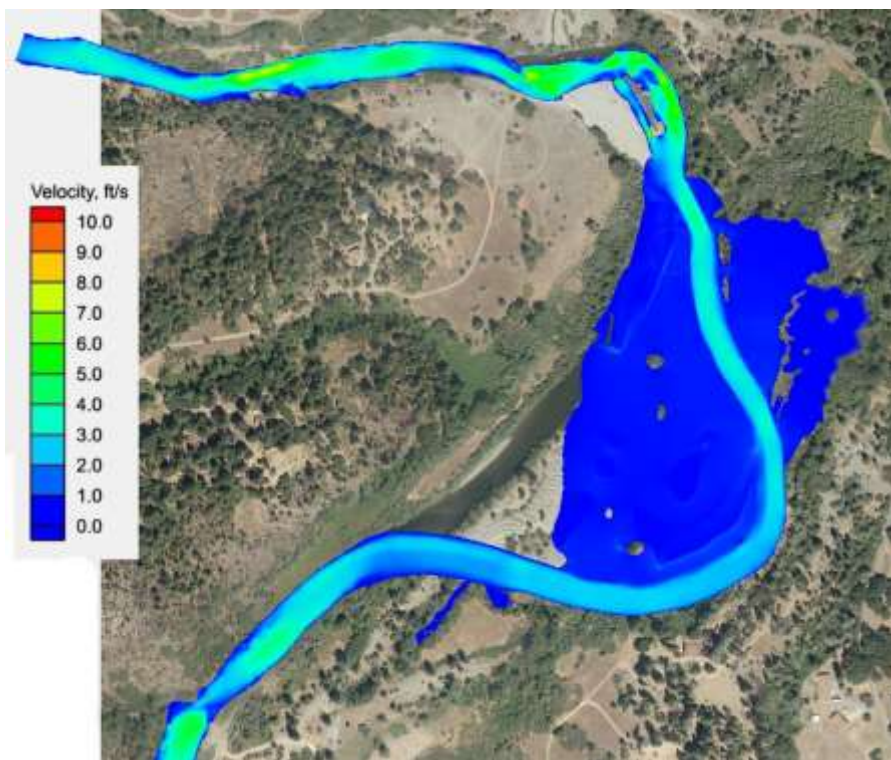


Figure 8-10. Design MODELED inundation extents and Water velocities AT 600 CFS

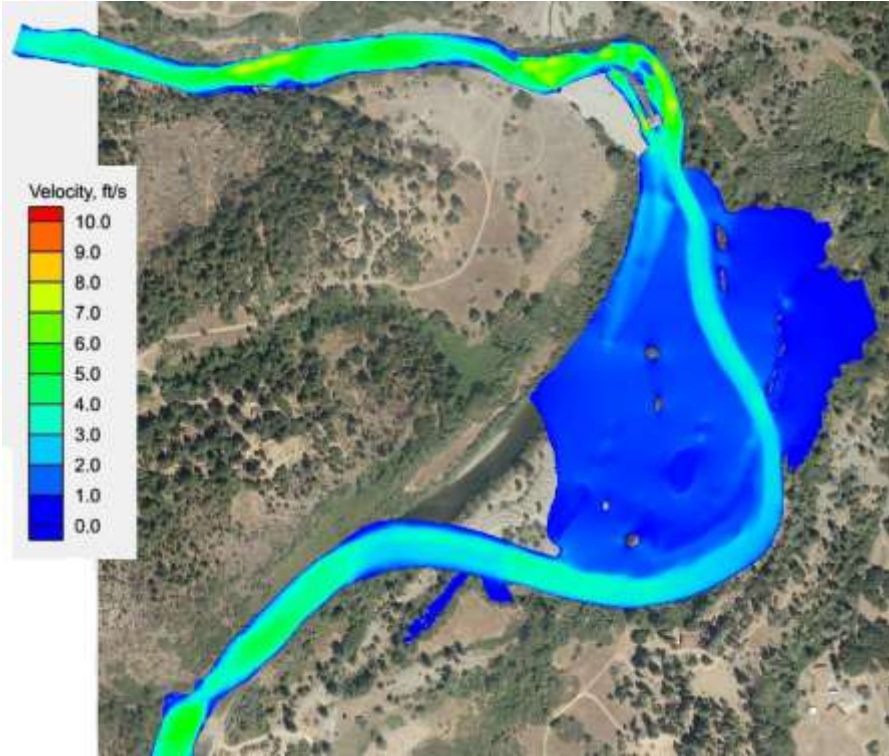


Figure 8-11. Design MODELED inundation extents and Water velocities AT 1200 CFS

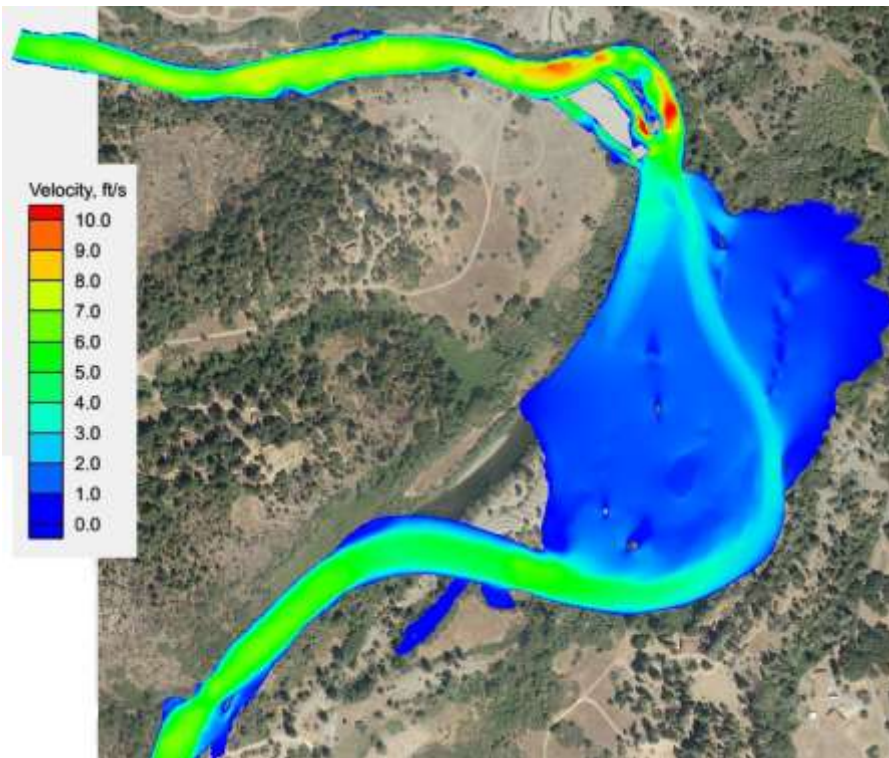


Figure 8-12. Design MODELED inundation extents and Water velocities AT 3500 CFS

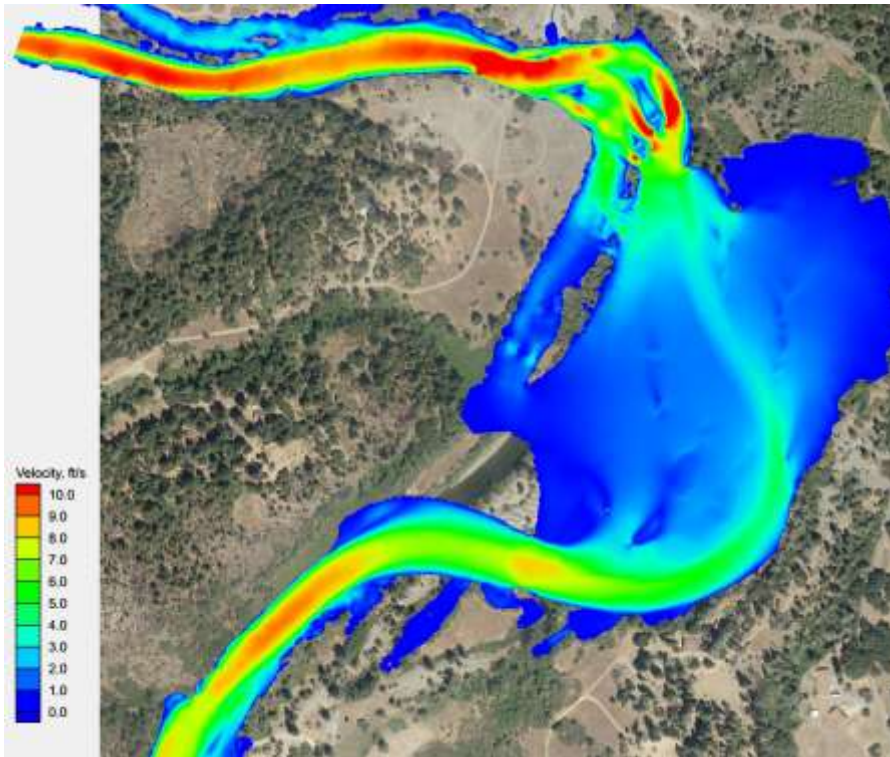


Figure 8-13. Design MODELED inundation extents and Water velocities AT 9000 CFS

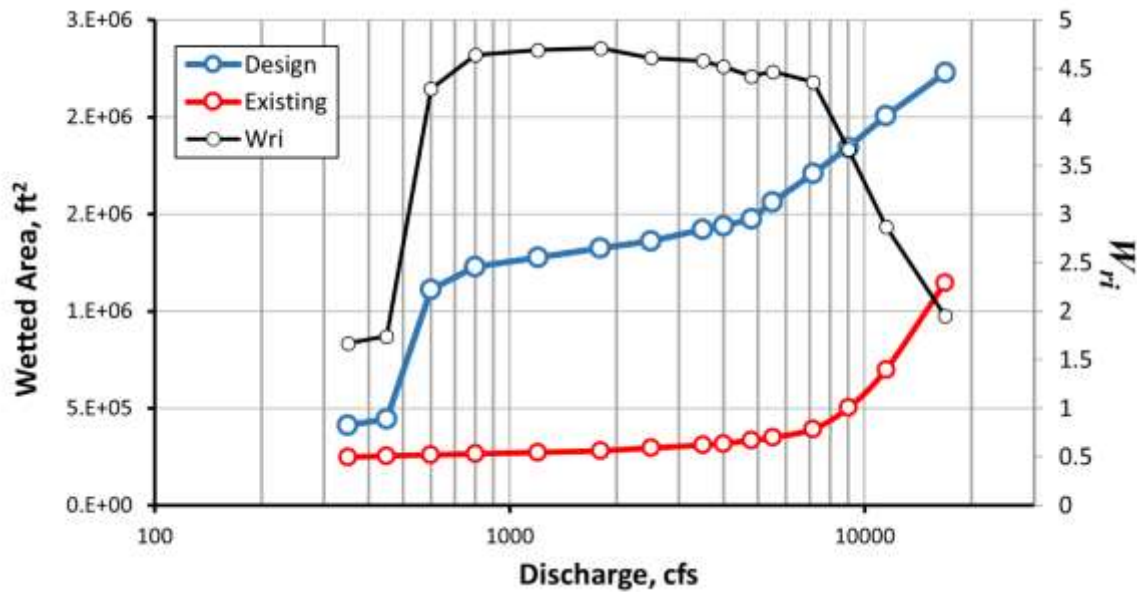


Figure 8-14. Wetted area and W_{ri} for each condition at each modeled flow.

Modeling results for the two largest flows, 16850 and 21900 cfs, are displayed in flow depth rather than velocity. Under existing conditions, some water spills into depressions between the tailings piles during these very large floods, but inundation is otherwise restricted to a region that is typically only about three to four times as wide as the active channel bed (Figure 8-15; Figure 8-16). However, under design conditions, the entire valley bottom

within the work footprint is inundated (Figure 8-17; Figure 8-18). Of particular significance, however, is that the crest of the U-2 constructed landslide deposit is barely wetted at 16850 cfs (Figure 8-17). The modeled depth over most of the crest at that discharge level is less than a tenth of an inch, and a portion of the crest area even shows zero depth. Thus, U-2 can be overtopped only by relatively large and infrequent flood events. At the maximum fishery flow of 21900 cfs, water depth at the crest of U-2 about 1 ft or less. Model results indicate that at 21900 cfs flow energy down the lee side of U-2 is quickly dissipated in a backwater zone downstream from the structure.

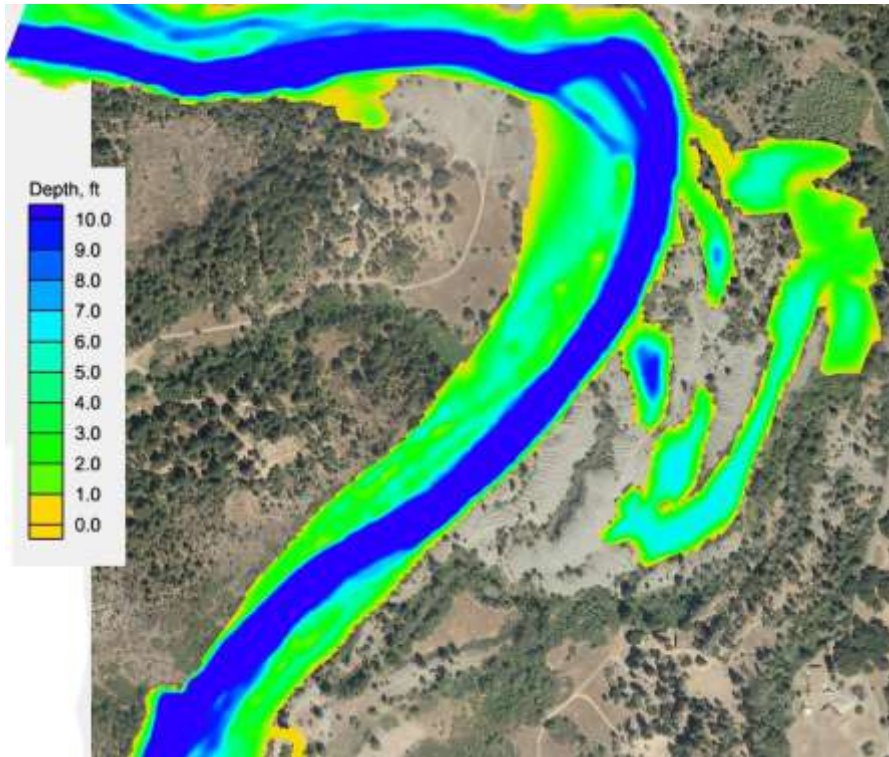


Figure 8-15. Existing Conditions MODELED Depth AT 16850 cfs.

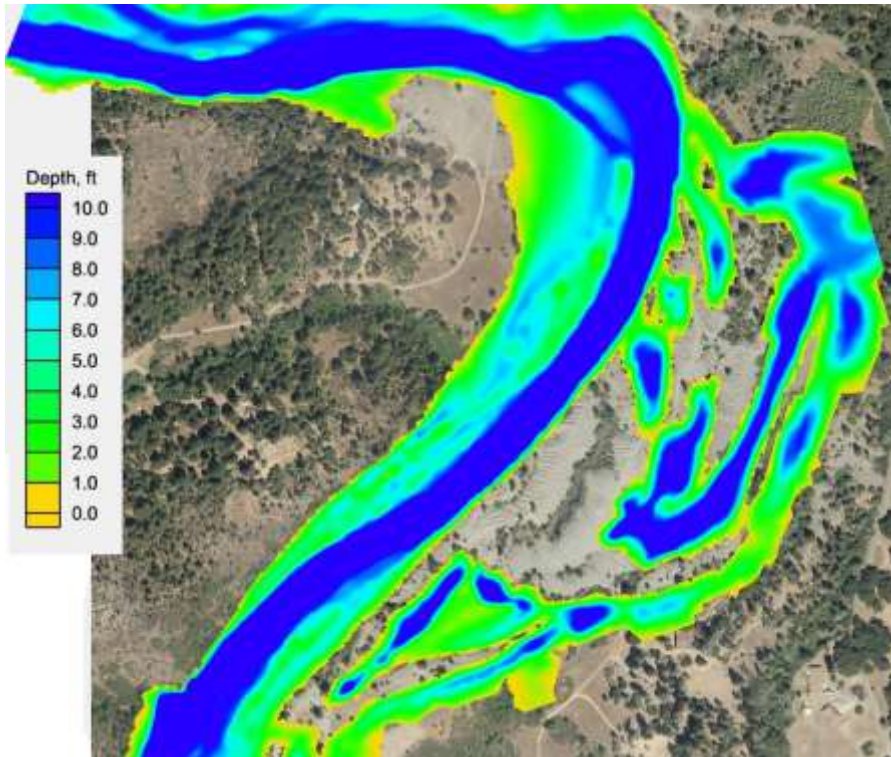


Figure 8-16. Existing Conditions MODELED Depth AT 21900 CFS.

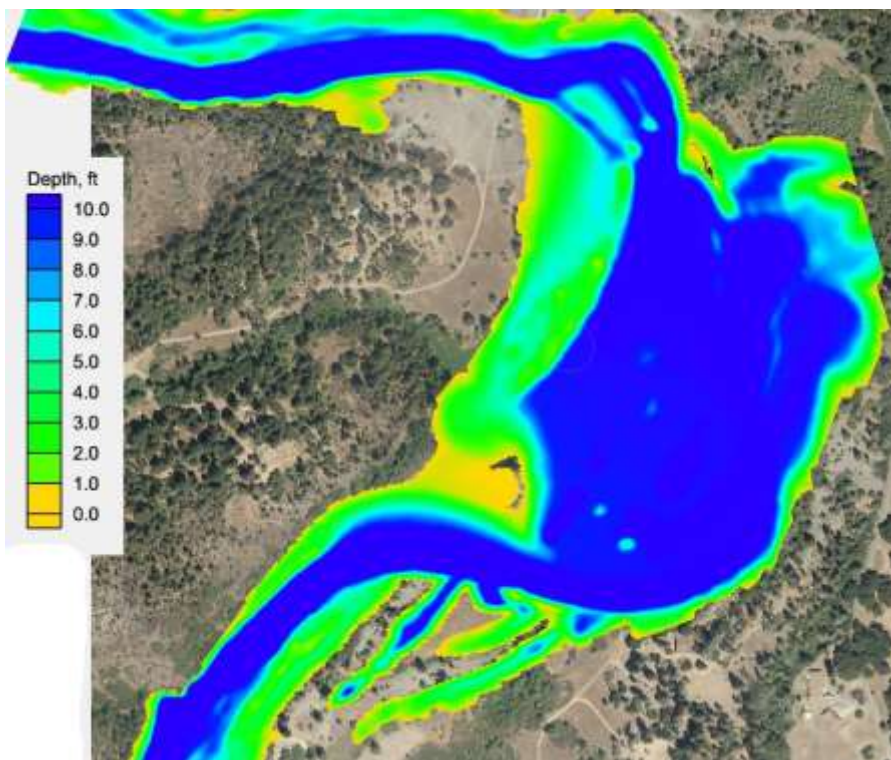


Figure 8-17. Design Conditions MODELED Depth AT 16850 CFS.

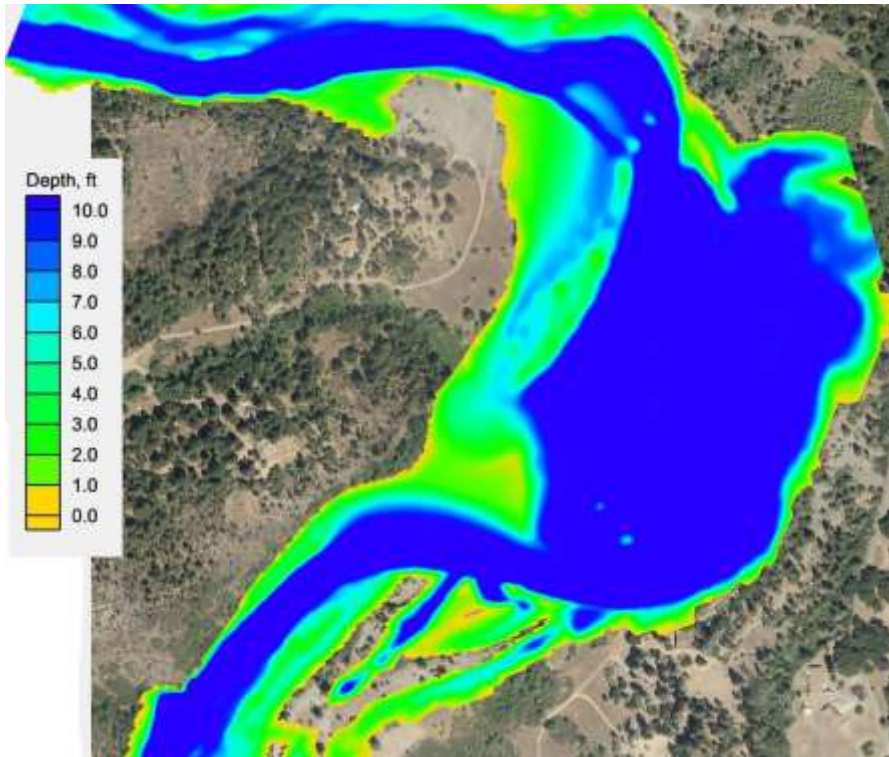


Figure 8-18. Design Conditions MODELED Depth AT 21900 CFS.

8.2.2 Shields Stress

Figure 8-19 shows τ_{50}^* (Shields stress computed for 50 mm gravel) for the design condition at a discharge of 9000 cfs, and Figure 8-20 shows τ_{50}^* at 16850 cfs. The maps indicate that during these moderately large to large floods, values of τ_{50}^* are too small to entrain 50 mm gravel throughout the majority of the floodplain areas. At 9000 cfs, the region of gravel mobility is concentrated along the left bank of the IC-1 channel at the upstream end of R-1 and on the downstream leading edge of the U-2 constructed landslide deposit. Large values of τ_{50}^* are far more widespread both upstream and downstream from the project site, indicating large areas of full gravel mobility in those areas. This distribution suggests that at 9000 cfs it is likely that gravel bedload transported to the site from upstream will initially tend to deposit near the upstream end of IC-1 just beyond where it bends to the right. It also suggests that any bedload that passes the bend entrance or is eroded from the left bank area at the upstream end of R-1 will initially deposit in the upstream half of R-1. The distribution of τ_{50}^* at 16850 cfs leads to similar conclusions, except that the region of high Shield stress (> 0.06) at the downstream leading edge of U-2 spans the entire width of the IC-1 channel and stresses that support nearly full mobility of 50-mm gravel extends nearly to the apex of the bend in the channel. Gravel deposition may therefore be concentrated near or even downstream from the bend apex during larger floods. In addition, a large region of full gravel mobility at the upstream end of R-1 suggests a strong tendency to erode the upstream end of that floodplain. The persistent low values of τ_{50}^* in the interior of R-1 indicate that the eroded material will initially deposit in that area. When considering these results, it is important to recognize that the shear stress patterns output by the hydraulic model represents potentials for initial changes only. Once the initial erosion and deposition occur, the distribution of shear stresses will change in accordance with the evolved topography, and the locations of the areas prone to future scour or fill will shift.

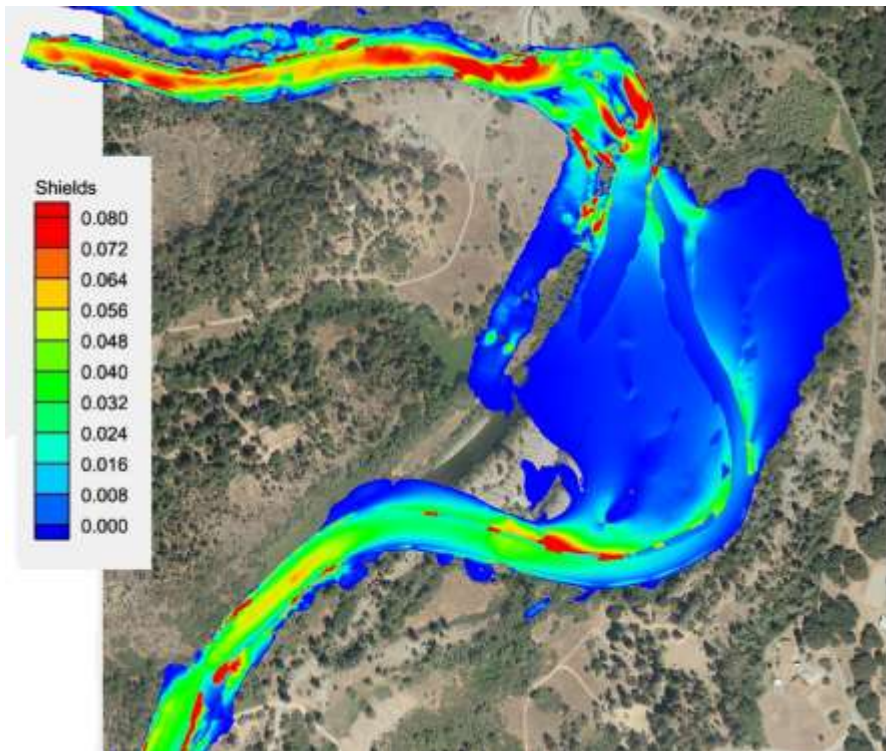


Figure 8-19. Design MODELED τ_{50}^* AT 9000 CFS

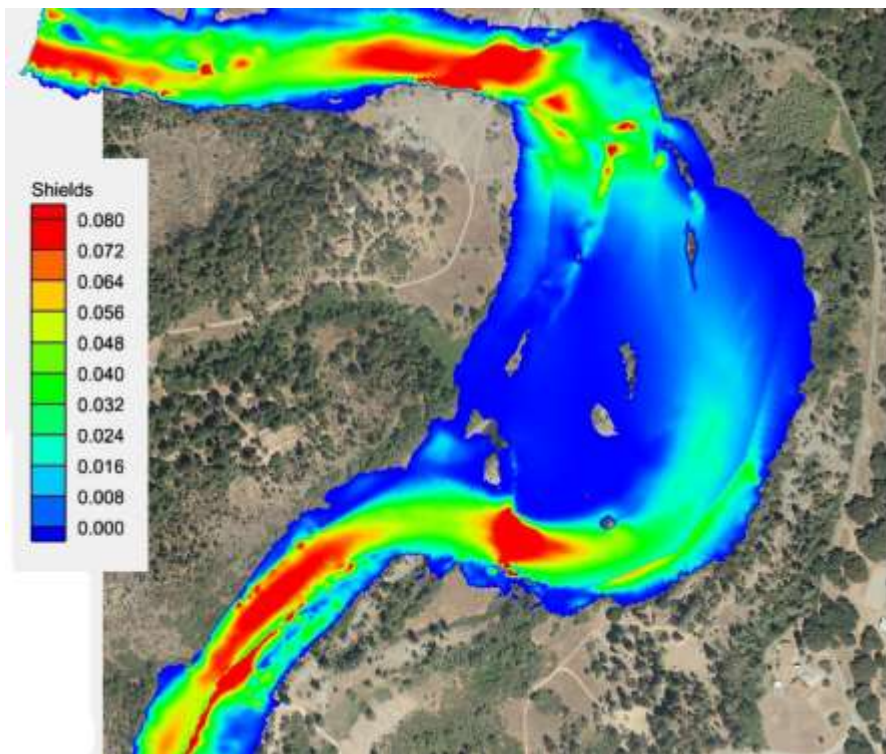


Figure 8-20. Design MODELED τ_{50}^* AT 16850 CFS

8.2.3 Morphodynamic Model Results

Figure 8-21 shows the spatial distribution of erosion and deposition thicknesses predicted by morphodynamic modeling where absolute values of erosion are shown in warm colors, and absolute values of deposition are shown in cool colors. The morphodynamic modeling results reinforce the interpretations drawn from the τ_{50}^* distribution that initial post-construction flood events are likely to produce deposition at the entrance to the IC-1 channel where it bends to the right, erosion at the toe of U-2 where it projects to the east, and deposition near the southern edge the R-1 floodplain. The predicted deposition thicknesses rarely exceed 3 ft, whereas erosion of up to 5 ft is predicted along the upstream face of U-2. This relatively deep erosion prediction was obtained assuming a bed surface size distribution with a median particle size of only about 75 mm. These model results indicate where a larger proportion of coarse bed material (CSB) will be incorporated into the U-2 substrate, that is, the portion of U-2 shown in red in Figure 8-21. Virtually no change is indicated elsewhere within the Oregon Gulch project site. Substantial erosion along the channel margins and deposition within the channel downstream from the project site is considered to be unrealistic model artifacts related to abrupt changes in elevation and roughness parameters and have negligible effect on morphodynamic processes in the upstream project site.

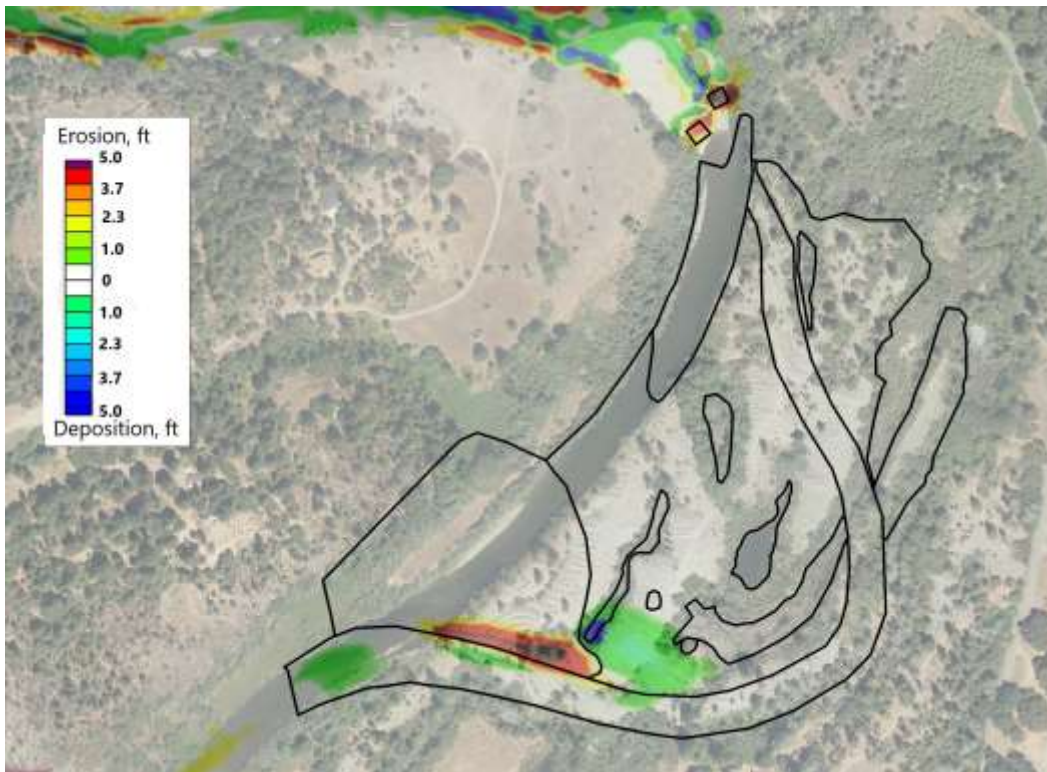


Figure 8-21. MODELED absolute values of erosion and deposition during a large post-construction flood. Erosion/Deposition values indicate a change in bed elevation in feet.

Together with the distribution of τ_{50}^* values, the morphodynamic modeling suggests that the upstream end of the Oregon Gulch site may evolve much like an alluvial fan. That is, the R-1 floodplain is likely to develop a concave-up longitudinal profile as incoming sediment and sediment eroded from its upstream edge deposits on the upstream third of the floodplain. Deposition in that area could contribute to developing multiple shifting channels that coalesce into fewer well-defined channels toward the downstream end of R-1. Over a longer timescale, the

regions of erosion and deposition on the floodplain could very well migrate downstream as the valley and channel morphologies co-evolve.

8.2.4 Flood Water Surface Elevations

Several aspects of the water surface elevations (WSELs) attained by large floods are critical to the design. Design-induced changes in flood elevations at Sheridan Hole are considered to assess whether the U-2 constructed landslide deposit and the channel curvature it creates backwater conditions upstream from the project site. This possibility is of interest because increased backwater conditions in that area could encourage deposition in and around Sheridan Hole or alter the substrate upstream from Sheridan Hole, which is a heavily used spawning area. WSELs just upstream from Sheridan Hole corresponding to flows ranging from 4800 to 21900 cfs for existing and design conditions are displayed in Figure 8-22. Rather than creating a backwater during large floods, the design is predicted to produce a slight decrease in WSELs near Sheridan Hole during relatively frequent floods. The maximum decrease, 0.17 ft, is predicted for a discharge of 11500 cfs, roughly corresponding to the largest flow release permitted from Lewiston Dam. A slight backwater effect of less than a tenth of an inch is predicted for larger, rare floods. This magnitude of change is negligible and well within the model uncertainty. We, therefore, conclude that the model results indicate that the as-built design is unlikely to alter conditions at Sheridan Hole significantly.

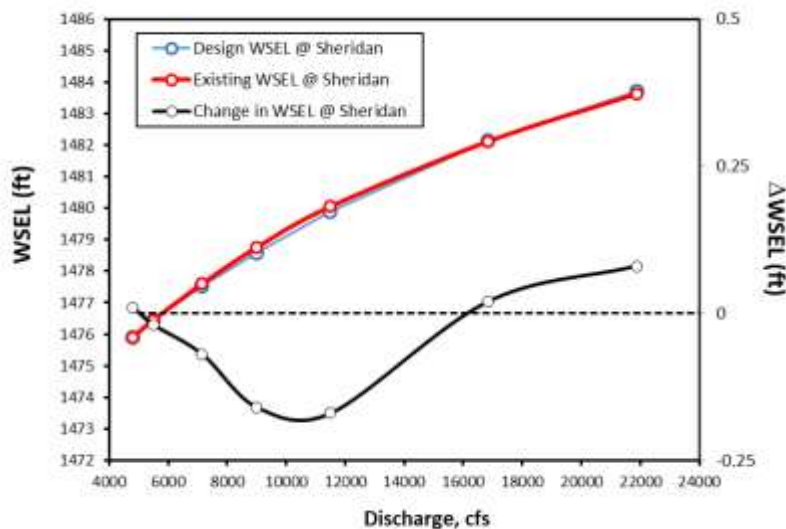


Figure 8-22. Design and existing water surface elevations at a range of flood flows near Sheridan Hole.

8.3 Salmonid Rearing Habitat Model Results

Fry and juvenile rearing habitat were estimated for the Oregon Gulch site using outputs from the SRH-2D 90 percent design hydraulic model results. Habitat for the 90 percent design was estimated using fish capacity. Estimating rearing habitat through fish capacity relies on depth, velocity, and distance to cover outputs provided for each model cell. The capacity metric also accounts for variation in local fish abundances beyond these three physical variables. Cover, such as is associated with in-water vegetation or wood accumulation, is a critical component of habitat. For modeling purposes, the existing distribution of cover at the site was derived from GIS layers depicting the distribution of riparian vegetation and in-water cover at the site. In contrast, the cover layer

for post-construction conditions was developed using professional judgment. See Appendix E for maps showing the distribution of cover used for habitat modeling.

The fish capacity equation is relatively new. It utilizes a robust dataset designed to feed critical fish density inputs for estimating fish production on a systemic scale in a Stream Salmonid Simulator model (Perry et al. 2018) developed specifically for the Trinity River. The fish capacity metric estimates the upper bounds of individual fry or presmolt abundance that could be present in a specified area over relatively short periods of time (Som et al. 2017), such as periods of a day to entire days. The capacity metric that resulted from the well-designed data collection and extensive model-fitting process weights the effects of depth, velocity, and distance to cover differently than traditional WUA metrics. In the capacity metric, depth acts to mitigate the adverse effects of velocity on capacity. For example, very deep areas with mid-column velocities equal to shallow sections would be predicted to have higher capacities. This makes sense when considering that deeper sections contain more wetted volume to hold fish, and even more specifically, deeper sections with elevated mid-column velocities will contain sections of slower velocities closer to the riverbed. Capacity calculations occur for each mesh cell in the model but can be aggregated over larger areas, for instance, within the boundaries of designated habitat units or for the entire design boundary.

The Fish Work Group recently recommended that juvenile salmonid physical habitat be estimated using capacity in all TRRP work going forward, which was detailed in the meeting summary for April 20, 2020, and a memo from the fish work group to the TRRP Science Coordinator dated 9 May 2020. This marks one of the 1st occasions of it being applied to design habitat evaluations by the Trinity River Design Team. The design habitat estimates were then compared to the existing condition modeling results. Examples of capacity habitat maps are presented in Appendix E.

Fish capacity results are displayed in Table 8-1, and Figure 8-23. Capacity increases for the 90 percent design reflect the scale of this proposed valley rehabilitation. As detailed in the hydrology section, flows at Oregon Gulch during the critical rearing period (Jan-April) typically range from 600-1800 cfs. Capacity increases estimated for those flows range between 900-1041 percent for fry and 496 percent-673 percent for presmolt. Increases of this magnitude (10-fold) have never before been demonstrated for a TRRP rehabilitation design. The valley restoration approach and low flow capacity channel specifically target increasing habitat at discharges that matter most to juvenile fish during the critical rearing period. An estimated increase of 900 percent in fry rearing capacity at 600 cfs supports this approach. A drop in the estimated gains in fry capacity is evident between 800 and 4800 cfs (1040 percent -623 percent). By design, the floodplain surface is completely inundated at 800 cfs. At higher flows, velocities begin to increase across the floodplain which explain the smaller (albeit still very large) increases. Presmolt capacity continues to increase throughout the flow range as these larger fish tolerate higher velocities.

Differences in how the capacity metric relates the physical variables to habitat quality leads to different patterns in the traditionally considered flow-to-habitat graphs than commonly were displayed for WUA calculations on the Trinity River. It is important to note that the actual pattern of changes in capacity as a function of discharge will be driven by the physical characteristics of the river section. Still, one of the most notable differences in these patterns for the capacity metric is the absence of a marked decrease in habitat quality at intermediate discharges (commonly referred to as the "habitat dip"). Reasons for this different flow-to-habitat pattern include the very robust data set used to generate the model, the fact that the capacity model accounts for imperfect detection, and

the variation in fish abundance beyond the variables of depth, velocity, and cover, which includes biotic and abiotic factors.

As mentioned, this is one of the first times fish capacity has been used to evaluate a design on the Trinity. This evaluation exhibits the largest increases (at the critical habitat flows) that have been predicted for a Trinity River design to date. These increases are not predicated on a side channel remaining open or off-channel habitats staying connected. Instead, they are based on valley-wide restoration that creates floodplains that are inundated for the vast majority of the winter/spring rearing time. With this approach, scour and fill on the floodplain is expected. Change is encouraged. Available habitat will change, but with such a large area being lowered and such large habitat gains, long-term gains in available habitat at the critical range of flows are expected to persist, making this one of the best examples of process-based restoration to date on the Trinity River.

Table 8-1. Estimated fish capacity (total number of fish) for the Oregon gulch rehabilitation site at existing and 90 percent design conditions. Percent increase is computed as = (Design-Existing)/ Existing*100

Discharge	Existing Fry	Existing Presmolt	Design Fry	Design Presmolt	Percent Increase Fry	Percent Increase Presmolt
350	2,066,426	542,251	4,415,513	1,052,714	114	94
450	1,898,467	528,892	4,740,872	1,159,337	150	119
600	1,696,684	510,465	16,959,808	3,041,313	900	496
800	1,542,588	498,925	17,590,396	3,327,916	1,040	567
1,200	1,397,962	490,081	15,350,484	3,384,612	998	591
1,800	1,337,247	484,635	14,054,960	3,744,610	951	673
2,500	1,387,653	501,426	13,404,804	4,219,898	866	742
3,500	1,513,884	555,522	13,174,571	4,887,795	770	780
4,000	1,611,942	585,747	12,990,963	5,236,235	706	794
4,800	1,791,810	633,893	12,951,779	5,825,820	623	819

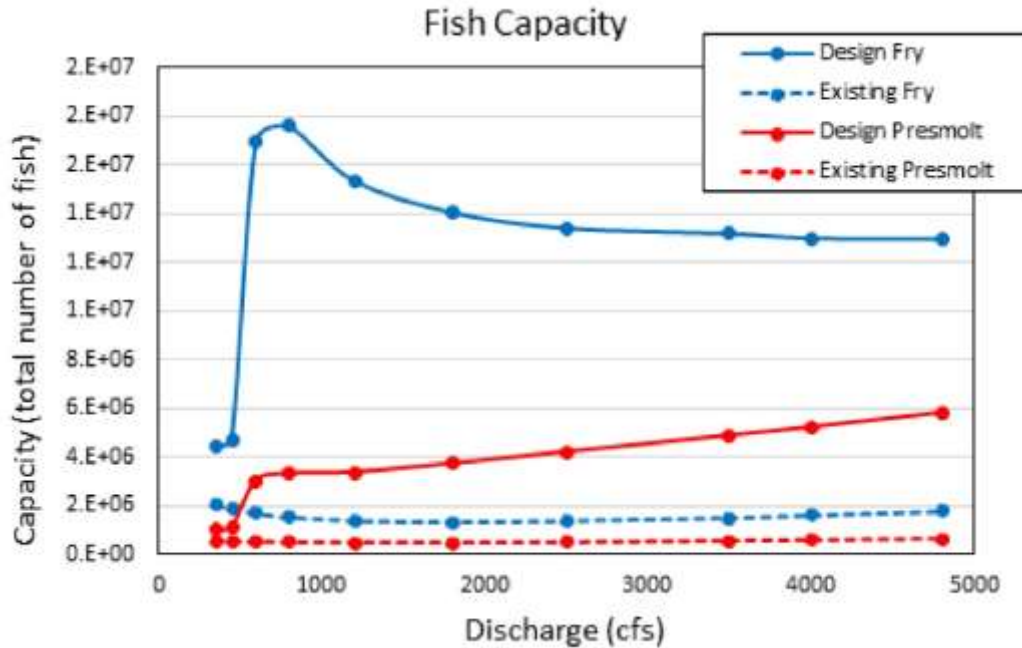


Figure 8-23. Total fish capacity calculated for chinook fry and presmolt for the Oregon gulch rehabilitation site at existing and 90 percent design conditions.

9. Revegetation Design

The Oregon Gulch revegetation design is a critical component of the Oregon Gulch rehabilitation project. The removal of mine tailings and subsequent reconstruction of the 33.7-acre site will result in several new landforms that require revegetation; a new large upland feature (6.6 acres) and new floodplain landforms (18.1 acres) that include existing ponds, wetlands, and forested islands. The remaining 9.0 acres do not require revegetation as they will become in-channel features.

Although most of the pre-construction site is denuded of vegetation because of the deep layers of mine tailings, the reconstruction of the floodplain will remove ~12 acres of vegetation. Most of the vegetation to be removed occurs on mine tailings between 4-30 feet above the historic floodplain elevation. Existing vegetation at or below the final constructed elevation will remain in place. The new floodplain will be quite different from the existing conditions. Monthly mean flows will inundate the entire 18-acre floodplain until July during the first few years after construction, until the river reconfigures the site, increasing surface heterogeneity over time. The water table will be readily available for much of the growing season. The surface elevation of the new floodplain will be <1 ft above the water surface elevation at 450 cfs. The ideal vegetation to plant into the new floodplain will be live-stakes of willows, cottonwoods, and red-osier dogwoods. Oregon ash will also be planted in select areas. The upland landforms will be planted with species suited to dry, hot conditions. We will also install willow clumps (rooted clumps of willow excavated from the project site) along wood features designed to resist erosion and cottonwood poles in deep layers of fill material used to construct the upland plug. In addition to the woody plantings, native herbaceous plants (forbs and graminoids) will be seeded to provide additional native plant diversity, cover, and prevent invasive, exotic species colonization. We will seed an upland seed mix and a riparian

seed mix for the floodplain. This revegetation design is meant to represent the surrounding vegetation communities and provides a buffer to complement and protect remnant riparian vegetation. The broad new floodplain will provide high-quality riparian habitat and cover more area than the existing linear floodplain vegetation that currently exists on-site.

The revegetation design prescribes revegetating 15.3 acres with tree and shrub plantings and seeding 28 acres. Revegetation will be achieved using a combination of bareroot trees and shrubs, some nursery container stock, live cuttings, and poles, and native seed (including acorns). Irrigation and mulch may be used to increase plant survival in the uplands. Plant installation will vary. Willow clumps will be installed during construction of U-2 during the summer months. Live-stakes and poles will also be installed during floodplain construction. River right floodplain landforms will be planted later in the fall to increase live-stake survival. Planting of bareroot and container stock will occur after construction during the winter dormant season. Seeding will occur in the fall on the upland plug and in late spring/early summer after flows subside on the floodplain. Descriptions, maps, and diagrams of the various revegetation prescriptions are available in Appendix F.

9.1 Willow Clumps and Cottonwood Poles

Willow clumps are rooted willows salvaged from areas subjected to construction activities and will be installed with large wood at the upstream end of the upland landform. Willow clumps are the most valuable revegetation tool for installing willows. If more clumps are available, we will plant them in other high priority locations such as the large wood jams and the upland plug's back slopes. All willow species (except narrow leaf willow) are acceptable for willow clump installations.

Cottonwood poles will be installed above the willow clumps in the upland plug during construction. This area will be subjected to significant flow intensity during high floods. The cottonwood poles must be long enough to reach the water table. The location is between 4-8 ft above the WSE at 450 cfs. Poles will be a minimum of 10 ft long. The target density in the polygon will be one cutting for every 20 square ft (2,178 per acre). However, the final density will depend on how many can be obtained at the site. This polygon will be the priority for pole cuttings.

9.2 Willow and Cottonwood Clusters

Willow and cottonwood clusters will be the primary revegetation installation on the new floodplain surfaces. We will install 5,146 clusters at a density of approximately 300 clusters per acre. Each cluster is a single excavator hole approximately 5 ft in diameter planted with a minimum of seven live stakes from three Salicaceae species. This will require 36,019 live stakes. There will be two types of clusters installed in the floodplain. Willow-Cottonwood clusters will contain more willow than cottonwood, while the ratio is reversed for Cottonwood-Willow clusters. The diversity and density are designed to mitigate low rates of survival which may occur when installing in summer and to account for the variable substrate texture and depth to water table likely to occur across the large area. For detailed cluster specifications, species lists, and notes—see Appendix F.

9.3 Cottonwood Upland Plantings

The Cottonwood-Upland planting polygon will contain a combination of long cottonwood poles, bareroot/container plantings, and acorn plantings. Cottonwood poles will be carefully installed during construction because the substrate will be coarse and deep, requiring long poles. Bare root and container plantings

will be installed after constructing the landform in the fall or winter, when bare root stock is delivered. Planting in late fall or winter should improve plant survival compared to planting in summer. For detailed specifications, species lists and notes—see Appendix F.

9.4 Upland Plantings

The Upland planting polygon covers 3.6 acres and will be planted with bareroot/container plantings and acorn plantings installed after construction of the landform in the fall or winter when bare root stock is delivered. *Quercus* species would preferably be planted as acorns to reduce the risk of phytophthora introduction to the site. However, *Quercus* species do not reliably fruit every year as they tend to be mast seeders. We will track seed production, and if masting years precede planting by 2 years, we may collect acorns to propagate in a nursery. Container stock will be tested for phytophthora before out-planting. Planting density will be approximately 3,000 plants per acre (1,100 tree per acre and 1,900 shrubs per acre). The higher density serves two purposes; it provides extra plants to mitigate high rates of mortality, and high-density plantings may facilitate higher survival rates by creating a more favorable microclimate through wind protection and reduced evapotranspiration rates attained by close proximity to other plants (Callaway 1995, Chenoweth et al. 2011). Planting in late fall or winter should improve plant survival compared to planting in summer. For detailed specifications, species lists, and notes, see Appendix F.

9.5 Seeding

The uplands will be seeded with a species mix of native herbaceous forbs and grasses suited to dry, hot conditions. Seeding density for all areas will be 80 seeds per sq ft. Seeding will occur in the fall after the construction of the upland plug. Seeding will be accomplished by hand using belly grinders or other manual seeding tools. The floodplain will be seeded with an erosion control mix available from Hedgerow Farms or another appropriate source. The mix will contain the species best suited to rapid germination and establishment and is intended to provide temporary cover to prevent invasive exotic species colonization. The floodplain will be seeded after the spring flows subside and expose the surface. For detailed specifications, species lists, and notes, see Appendix F.

10. Large Wood Design

10.1 Large Wood Objectives and Design Philosophy

Large wood objectives for the Oregon Gulch design can be summarized into three categories: hydraulic, habitat, and roughness elements. The preferred strategy to accomplish these objectives is to design and build wood features that emulate natural wood jams that are deformable, evolve over time, and perform as dynamic features in the landscape. For this reason, artificial fasteners and boulders larger than 14 inches in diameter have been excluded from this design. The traditional approach of using vertically driven wood piles that use specialized equipment for installation below the bed of the river has also been excluded from this project. This approach provides a unique opportunity to implement large wood features that balance physical process and ecosystem services and evolve over time. This approach does, however, have the potential to shorten the design life of the structures. Natural river processes and channel evolution that can cause physical instability are supported by the

TRRP and Bureau of Reclamation and are consistent with the Record of Decision (ROD, USDOJ 2000) framework.

Habitat wood and slash will be scattered along the both banks of the IC-1 channel, and in the wetlands for in-water cover. Wood and slash will also be heavily utilized on the floodplain to provide roughness and high-quality cover for fish. Large wood will be incorporated in the face and upstream portion of U-2 to provide roughness, habitat, and structural stability along the newly constructed bank. Whole trees buried within the bank will slowly be exposed if/when the upstream face of U-2 erodes. Smaller wood, slash, and willow clumps will also be added to the upstream face of U-2. R-4, a wood structure located on the R-1 floodplain, will incorporate two large keypiece trees, including a 5’-6’ dbh (diameter at breast height) cottonwood tree that needs to be removed to construct the IC-1 channel. The R-4 keypiece jam is located in an area the river could potentially establish a new channel, in which case it would be likely to force a channel bifurcation. Design features IC-3 and IC-4 are intended to bifurcate flows and encourage geomorphic evolution on the Oregon Gulch delta. Table 10-1 shows estimated wood loading by feature. The numbers are approximate and may change according to wood availability and conditions on the ground. The availability of whole trees on-site will determine the final number of 30-ft logs with root wads that will be harvested from off-site locations.

Table 10-1. Estimated wood loading by feature. Whole trees will be sourced on-site; 30’ sections with root wads will be harvested off-site.

Feature	Whole Trees	30’ with Root Wad, > 18” dbh	30’ with Root Wad, 12”-18” dbh
R-1	50	40	30
R-2	5	0	15
R-3	10	5	25
R-4	2	4	4
U-2	15	30	10
IC-1	15	30	30
IC-2	10	15	10
IC-3	4	12	0
IC-4	2	11	0
W-1	25	15	20
W-2	10	5	5
Totals	148	167	149

Note: dbh = diameter at breast height.

10.2 The Design Process

The design of these features integrates a host of tools and techniques to evaluate, analyze, and design the large wood structural features of this project, including topographic digital terrain models, two-dimensional hydraulic models, engineering force balance calculations, scour calculations, computer-aided drawing software, and other related technologies. The design process for developing wood structure is described below.

10.2.1 Step 1: Hydraulic Modeling

The hydraulic model used for the habitat evaluation of this project is referred to as the Sedimentation and River Hydraulics (SRH-2D) model that the Bureau of Reclamation developed. For more information on how this model simulates river flows, see the following link: https://www.usbr.gov/tsc/techreferences/computer_percent20software/models/srh2d/index.html. Bradley (2018) describes how the SRH-2D model for the Trinity River was developed, including calibration and validation results. The hydraulic model incorporated the large wood structural features in the model mesh giving specific hydraulic results at each wood structure. The hydraulic results provide key information regarding hydraulic attributes, including flow depths, velocity, sheer stress, flow vectors, and other information. Through this modeling effort and corresponding refinements, a preferred design alternative is chosen that represents the best physical and biological option for this river reach. This design condition DTM is carried forward to the following steps. A summary of hydraulic modeling output and maps showing inundation extents and flow velocities are located in the Hydraulic Modeling Results section of this report.

10.2.2 Step 2: Design Flow Evaluation

Knutson and Fealko (2014) recommend using the 10-year storm flow for designing stable wood structures that have “LOW” risk to public safety and property damage, as is the case for this project. However, the 2.5-year return interval storm (9,000 cfs) was chosen as the large wood structure design for the following reasons:

1. It is consistent with the design flow used for the overall site design.
2. The 2.5-year storm is slightly greater than bankfull and overtops both wood structures, maximizing the hydrostatic forces applied to the structure.
3. It is consistent with the restoration strategy and objectives to design and build the structures to emulate natural wood jams that are deformable, evolve, and perform as dynamic features in the landscape.

Flow depths and velocities near IC-3 and IC-4 were extracted from SRH-2D model results, and maps showing inundation extents and flow velocities for various flows, including the 9,000 cfs design flow, can be found in the Hydraulic Modeling Results section of this report.

10.2.3 Step 3: Large Wood Architecture

The general location and dimensions of the large wood structures were established during the initial 30 percent design phase. The hydraulics around the wood structures was evaluated during all phases of the design process. Various types of architecture arrangements can be used to build large wood structures depending on constructability aspects, material availability, heavy equipment, environmental conditions, etc. A combination of whole trees harvested on-site, and rootwad logs from both on-site and off-site staging will be used. Using drawing tools in AutoCAD Civil 3D, a conceptual 2-Dimensional (2-D) model of the wood architecture is developed in layering sequence. The arrangements of various sized materials are strategically fit together to correspond to the design-condition DTM. Drawings are developed in plan-view and cross-section to graphically represent the design architecture in relation to the existing and design condition DTM surfaces. The 2D architectural models show specific geometries of the large wood structure, average material sizes, location of embedment into the bank

or bed of the river, and location of ballast materials. A complete set of architectural design drawings are located in Appendix I of this report.

10.2.4 Step 4: Force Balance Analysis

To evaluate forces acting on the large wood design features, a combination of force balance calculations has been analyzed to determine potential failure mechanisms and determine structural stability. These equations have their origin of application structural engineering for bridge designs and have been re-developed to evaluate large wood stability. The Yurok Design Group has worked closely with industry professionals and has incorporated the latest calculations tools for force balance calculations. The force balance results are then used to evaluate the Factor of Safety and determine if the structure will be stable. See information below summarizing the forces balance results and further in Appendix H for all supporting calculations.

10.3 Material Sources and Types

Large wood materials to construct this project will be supplied from within the project boundary and off-site locations. Full-length trees will primarily be sourced from the Oregon Gulch right bank feature boundaries. There are approximately 464 trees that will be used for both structural and habitat placements. Additional full-length trees may come from other parts of the Yurok Tribe’s property at Oregon Gulch.

Several hundred non-full-length trees will be needed for the project. These logs are a maximum of 35 ft long, some with rootwads and others without rootwads. These logs will be harvested off-site and be transported to the project via haul trucks. Additional pin logs, prow logs, and slash will come from a combination of on-site and off-site locations.

A strategic combination of various wood materials will be used at each project location to meet individual feature objectives. The exact size, quantity, and quality of wood materials will be dependent on availability and may need to be adjusted to accommodate site-specific constructability needs and source availability. Structural members used to construct the main architectural components will only use Douglas Fir wood in good condition. The structural wood materials breakdown is listed in Table 10-2. Whole trees will be cut to limit the maximum length to 80 feet.

Table 10-2. Structural Wood Materials

Wood Type	Length	Diameter (dbh)
Whole Trees with Rootwad	Max. = 80 ft.	18”-24”
Cut Log with Rootwad	Minimum = 35 ft.	18”-24”
Excavated Posts, with Rootwad	Minimum = 25 ft.	20”-24”
Driven Posts, no-Rootwad	Minimum = 25 ft.	12”-18”
Prow Logs, no-Rootwad	Approx. = 25-35 ft.	8”-12”
Oblique Pin Logs, no-Rootwads	Approx. = 15 ft.	8”-12”
Spacer Logs, no-Rootwads	Approx. = 20 ft.	12”-15”
Slash Material	N/A	Less than 2”

Notes: Revegetation materials will also be incorporated into the structures – see revegetation/ dbh = diameter at breast height.

10.4 Structural Characteristics

The structures listed below are a matrix of large wood materials woven together into layers and embedded into the river bed and bank. Summaries of large wood structure material characteristics used for IC-3 and IC-4 are listed in Table 10-3 and Table 10-4, respectively.

Table 10-3. Oregon Gulch (IC-3) – Large Wood Structural Characteristics

Description of Materials	Quantity	Length (feet)	Avg. Diameter (inches)
Layer-1: Rootwad Logs - Parallel to Flow	1	35	20
Layer-2: Rootwad Logs - Perpendicular to Flow	2	35	20
Layer-3: Rootwad Logs - Parallel to Flow	3	35	20
Layer-4: Rootwad Logs - Perpendicular to Flow	2	35	20
Layer-5: Full Tree + Rootwad - Parallel to Flow	2	80	20
Layer-6: Full Tree + Rootwad - Parallel to Flow	2	80	20
Posts-E: Vertical Rootwads Excavated in-place	4	25	22
Pin Logs: Logs driven in at an oblique angle	8	15	12
Racking Wood (Materials on Front of Structure)	20	20	6
Total (without racking wood)	16		
	Structure Location	Upstream	Downstream
Total Width of Structure – ft. =	37.0	NA	NA
Total Length of Structure – ft. =	60.0	NA	NA
Total Height of Structure – ft. =	7.5	NA	NA
Top of Structure Elevation – ft. =	1475	NA	NA
Velocity (9,000 cfs) – ft./sec =	8.5	7.5	3.3
Flow Depth (9,000 cfs) – ft. =	8.3	7.5	2.3
River Bed Channel Elevation – ft. =	1466.9	1467.5	1471.1
Water Surface Elevation (9,000 cfs) – ft. =	1475.2	1475.3	1473.4
Channel Width (450cfs Wetted Width) – ft. =	134.0	103.0	134.0

Table 10-4. Oregon Gulch (IC-4) – Large Wood Structural Characteristics

Description of Materials	Quantity	Length (feet)	Avg. Diameter (inches)
Layer-1: Rootwad Logs - Parallel to Flow	3	35	20
Layer-2: Rootwad Logs - Perpendicular to Flow	1	35	20
Layer-3: Rootwad Logs - Perpendicular to Flow	2	35	20
Layer-4: Rootwad Logs - Perpendicular to Flow	1	35	20
Layer-5: Full Tree + Rootwad - Perpendicular to Flow	1	80	20

Description of Materials	Quantity	Length (feet)	Avg. Diameter (inches)
Layer-6: Full Tree + Rootwad - Perpendicular to Flow	1	80	20
Posts-E: Vertical Rootwads Excavated in-place	4	25	22
Pin Logs: Logs driven in at an oblique angle	8	15	12
Racking Wood (Materials on Front of Structure)	20	20	6
Total (without racking wood)	13		
	Structure Location	Upstream	Downstream
Total Width of Structure – ft. =	35.0	NA	NA
Total Length of Structure – ft. =	54.0	NA	NA
Total Height of Structure – ft. =	6.9	NA	NA
Top of Structure Elevation – ft. =	1474.0	NA	NA
Velocity (9,000 cfs) – ft./sec =	8.1	8.1	2.7
Flow Depth (9,000 cfs) – ft. =	7.9	8.1	1.1
River Bed Channel Elevation – ft. =	1466.8	1467.1	1471.6
Water Surface Elevation (9,000 cfs) – ft. =	1474.7	1475.2	1472.7
Channel Width (450cfs Wetted Width) – ft. =	103.0	95.0	98.0

10.5 Ballast Characteristics

Each of the large wood structures will be constructed with ballast materials to counteract bouncy forces and help stabilize the structure. The ballast materials are broken into categories of pit run (sand/gravel matrix) found on-site at the project and CSB ranging from 4-14 inches in diameter. A portion of the ballast material will be used below the river's bed to specifically provide resistance to scour and undermine the structure's foundation around the vertical rootwad posts. Table 10-5 provides a breakdown of the ballast materials for each structure.

Pit run ballast is defined as sand/gravel well graded mixture with less than 20 percent fines. This material will be used in the lower elevations of the large wood structures to provide a growing medium for plant materials to support revegetation within the structure. More information on revegetation components can be found in the subsequent section. CSB ballast is defined as a well-graded mixture of cobbles and small boulders ranging from 4 inches minimum to 14 inches maximum diameter size class. This material will be used to provide structural integrity and weight for the stabilization of the structures. The on-site design representative will determine the exact location, depths, and transition between pit run vs. cobble ballast.

Table 10-5. Ballast Materials in cubic yards (CY)

Structure ID	Pit Run (Above River Bed)	Cobble & Small Boulder (Above River Bed)	Cobble & Small Boulder (Below River Bed)
IC-3	110	130	95
IC-4	115	160	54
Total	225	290	149

10.6 Integration of Vegetation

Vegetation materials integrated into the large wood structures provide critical ecological function and influence the structure's physical processes and overall success. Woody riparian vegetation materials provide structural root cohesion and general stability of the structure to withstand erosive forces acting on the structure during discharge events. Woody materials provide a key biological interface and food web services by trapping fine sediment, nutrient loading, cover for aquatic species, and many other biological components that benefit from this interaction. Riparian plant growth can also produce trees that, over time will help supply wood material back into the riverine system allowing for a full cycle of ecological evolution.

The Oregon Gulch Large Wood Design will utilize two methods of riparian revegetation during construction activities. Method 1 will use live clump plantings (willows) harvested on-site and placed strategically into each Large Wood Structure. The clumps will be harvested within 1 day of placement, and their root ball will be wrapped with burlap and secured, allowing for transport and placement internally into the structure. Pit run ballast material will be placed surrounding the clump planting to provide a critical growing medium. Method 2 will use live cuttings (willow/cottonwood) harvested on-site and hydrated from 1 to 7 days, depending on construction logistics and sequencing constraints. Cuttings will be placed along the interface of the large wood vertical posts into the groundwater. Each cutting will be 10-15 feet tall and secured to the large wood post using twine or similar material. Both clumps and cuttings will be watered daily to maintain hydration until the cooler and wetter months post construction and pruned to encourage root growth over leaf growth. Details of these revegetation methods can be found in Appendix F. Lastly, 3 to 5 years post-construction, logs with moderate decay should be drilled and planted with tree plugs such that decaying logs serves as nurse logs.

10.7 Scour Assessment

Scour is a function of the structure geometry, flow depth and velocity, and channel substrate. Scour around the wood structures is desirable to develop complex aquatic habitat. Scour can also undermine the structure, causing weakness, deformation, and structural failure. Contraction scour, pier scour, and abutment scour were calculated using a variety of equations from the bridge design literature for each scour type. The scour equations are empirically derived and conservatively estimate the maximum scour depth. Results from the different scour equations vary widely for each scour type, so an average for each design flow was taken (excluding the minimum and maximum values). Scour depths were estimated for bankfull conditions (9,000 cfs; return interval of 2.5 years). The largest scour estimated for any of the wood structures is 9 feet but is primarily caused by abutment scour, which is not applicable for this type of design. Therefore, a comparative assessment was used for the design based on similar structures installed at other restoration projects on the Trinity River. Comparative assessment results found scour depth is approximately 4 feet for structures with similar architecture.

10.8 Force Balance Analysis

Wood structures are subject to a variety driving forces that act to destabilize the structure and resisting forces that act to stabilize the structure. These forces are summarized in Table 10-6 and described below. A force balance sums the resisting and driving forces acting on a wood structure in both the horizontal and vertical directions (USBR 2016; Knutson and Fealko 2014). If the resisting forces exceed the driving forces, the structure will remain stable. Appendix H provides detailed force calculations and results.

Table 10-6. Forces Acting on Wood Structures.

Floatation (Vertical Forces)	
Driving Forces (Destabilizing)	Resisting Forces (Stabilizing)
Buoyance	Large Wood Material (dry weight)
Lift	Boulder Ballast [A]
	Soil Embedment
	Pile Skin Friction
	Artificial Anchors
Sliding, Rotation, and Overturning (Horizontal Forces)	
Driving Forces (Destabilizing)	Resisting Forces (Stabilizing)
Hydrostatic	Friction
Drag	Passive
Impact	Lateral Resistance from Piles

10.8.1 Floatation (Vertical Forces)

Floatation can destabilize wood structures causing the wood to disaggregate and float away in individual pieces or as rafts of wood. Floatation is caused by the buoyant force and the lift force acting on the wood material. The buoyant force is the force due to the volume of water displaced by the placement of wood. Most wood has less density than the density of water, which causes it to float. The lift force is caused by water passing over the wood structure in the same manner as the lift is created when air passes over an airplane wing. Lift forces are a function of the wood area and approach velocity. Floatation is resisted by weighing the structure down using ballast placement, native backfill, and wood above the water surface elevation. Floatation is also resisted by using embedment and piles to increase skin friction. In this design, large boulders, piles, and artificial anchors are all excluded.

10.8.2 Sliding, Rotation, and Overturning (Horizontal Forces)

Hydrostatic, debris, and impact forces are horizontal driving forces acting to push the wood structures downstream. The horizontal resisting forces include friction, passive, lateral resistance from piles. If the horizontal driving forces exceed the resisting forces, the wood structure is subject to sliding. Asymmetry in the horizontal driving and resisting forces can also destabilize the wood structure by creating moment forces that cause rotation and overturning.

The principal driving forces acting on large wood structures from river flows are referred to as hydrostatic forces. The hydrostatic force is created when the water surface elevation upstream and downstream of the structure are unequal, creating a pressure differential. Large wood structures block a portion of the channel cross-section creating a constriction that forces water over and around the structure and cause turbulence. Under certain circumstances, the flow can become unstable and form a hydraulic jump, causing a rapid change in the water surface elevation and maximizing the hydrostatic forces acting on the wood structure. This situation often occurs when the wood structure has shallow overtopping flows.

Drag forces on large wood structures are a function of the flow velocity and cross-sectional area subject to flow. The large wood structures are pushed in the downstream direction by the fluid drag forces acting upon the wood by the flowing water. The drag force can increase substantially by material racking at the head of structures. When the structure acts as a blunt body, the drag forces can be compounded, causing structural instability. Lastly, impact forces are created when floating debris causes (typically woody debris from upstream) hits the large wood structure and decelerates, potentially getting lodged in the wood structure.

Frictional resistance is developed from the interaction of the wood structure and the channel bed and depends on the surface area and internal friction angle of the bed material. The soil behind the wood structure also acts to resist the driving forces. Lastly, piles embedded below the scour depth impart lateral resistance to counteract the horizontal driving forces.

The rotational moment force occurs when the asymmetrical flow forces occur near the end of the structure, causing rotational failure. Rotation is typically associated with structures that are adjacent or buried into a bank. Bar apex type structures or structures placed in the middle of the channel are typically loaded in a reasonably uniform manner, and rotation is typically not a significant factor. The structure's stability in relation to rotation is calculated by summing up all the moments associated with each force acting on the structure from flows.

Overturning moment forces acting on a large wood structure is how a structure can rotate in the downstream direction. Overturning is potentially an issue when a wood structure is broad laterally, tall vertically, short longitudinally (in the direction of flow), and experiences deeper flow depths. Typically, a wood structure would fail by sliding rather than overturning when their width to depth ratios are less than 10. The wood structures in this report are longer than they are wide, so they are not prone to overturning.

10.9 Factor of Safety Analysis

Large wood structural stability is measured using ratios of resisting forces compared to driving forces acting on the structure, referred to as the Factor of Safety (FOS). Because there is high uncertainty in computations of hydrostatic forces and resisting forces associated with large wood structures, safety factors are selected to accommodate the level of uncertainty and risk Knutson and Fealko (2014).

A minimum factor of safety of 1.25 is recommended to be applied to sliding, overturning, and rotation, while a minimum factor of safety of 1.5 is applied to floatation (D'Aoust and Millar 2000). When the level of risk increases, the factors of safety should increase as well. Table 10-7 provides minimum recommended factors of safety based on public safety and property damage risks Knutson and Fealko (2014). The wood structures described in the report have a "LOW" risk to public safety and a "LOW" risk for property damage (see the Risk Assessment section for details). Consequently, the factor of safety requirements for this project correspond to the last row in Table 10-7 (outlined in bold text). Based on force balance calculation results, all wood structures designed for this project meet the minimum factor of safety requirements (Appendix H).

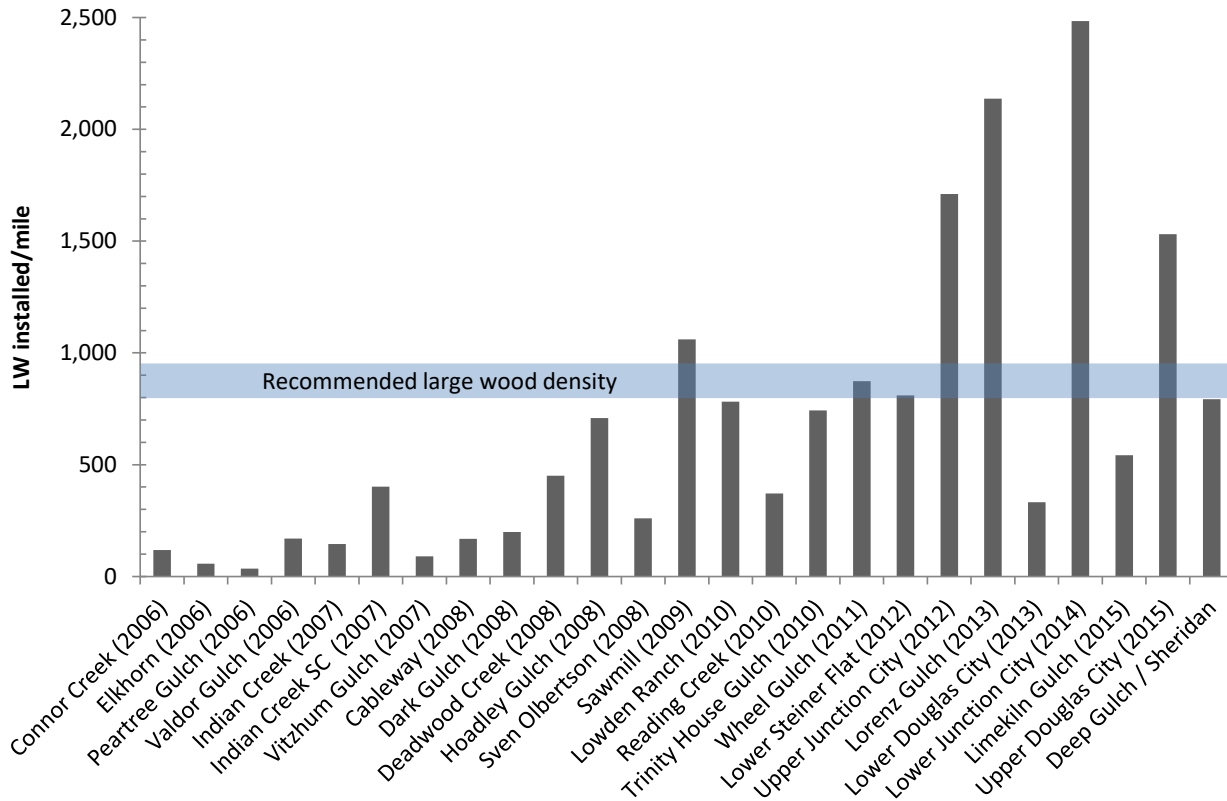
Table 10-7. Minimum Design Factor of Safety

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	FOS sliding	FOS buoyancy	FOS rotation FOS overturning
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

Source: Knutson and Fealko (2014).

10.10 Wood Loading Criteria

The Trinity River Chanel Design Guide (HVT et al. 2011) recommends a target large wood loading of 5-35 pieces/300 ft, with per piece minimum volumes ranging from 70-530 ft³, and a corresponding Key Piece loading of 0-2 pieces/330 ft, with a per piece minimum volume of 370 ft³. These ranges are based upon observations from Fox (2001) and Fox and Bolton (2007) for waterways in Douglas Fir and Ponderosa Pine forests of eastern Washington with bankfull widths similar to the Trinity River. The Trinity River Large Wood Analysis and Recommendation Report (Cardno ENTRIX and CH2MHILL 2011) recommends a target large wood loading of 50-60 pieces/330 ft (800 to 960 pieces per mile), with no separate recommendations for Key and non-Key Pieces. Approximately 464 pieces of wood will be used to construct the project's structural and habitat wood features. This translates to 773 pieces of wood per mile which is near the recommended wood loading range (Figure 10-1). This does not account for a small amount of natural wood already existing on the project site. Several wood structures are designed to rack and retain additional wood supplied from upstream (typically during storm events).



Source: modified from USFWS et al. 2016.

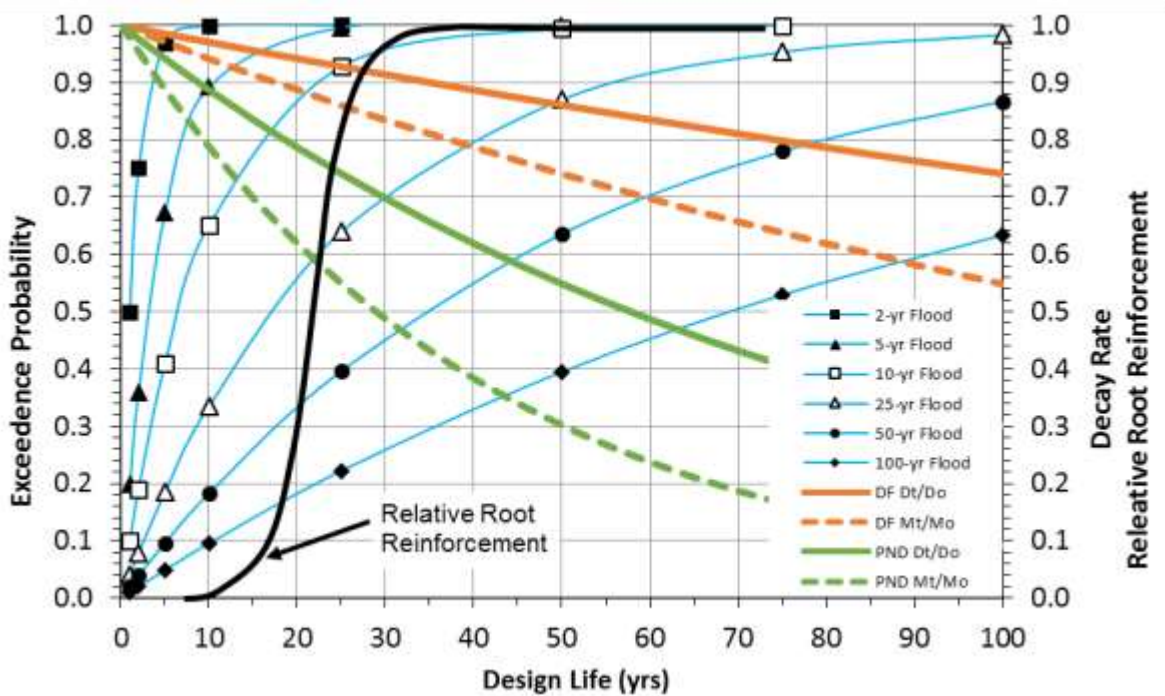
Figure 10-1. Wood Loading for Channel Rehabilitation Projects on the Trinity River (2002 - 2015)

10.11 Stability and Life Expectancy

Figure 10-2 is a conceptual diagram that compares design life against flood recurrence intervals, wood decay rates, and the rate of vegetation establishing relative root strength. The flood recurrence interval is shown as an exceedance probability for different magnitude floods (e.g., 2-year flood to 100-year flood). The probability of a wood structure experiencing floods of any magnitude increases over time. As the wood used for construction ages it decays and loses its material strength, the large wood structure becomes more prone to failure during flood events. Wood decay rates are shown in terms of log diameter (D_t/D_o) and mass (M_t/M_o) for two tree species - Douglas Fir (DF) and Ponderosa Pine (PND). D_o = log diameter at construction; D_t = log diameter at time t ; M_o = log mass at construction, and M_t = log mass at time t . Wood species strongly affect decay rates. Ponderosa Pine decays nearly twice as fast as Douglas Fir. The decay rates shown in Figure 10-2 are based on literature values for wood in forested conditions. The wood structures in the project are located in a riverine setting which is harsher than forested conditions (less shade, more frequent wetting and drying), so the actual decay rates are likely larger than shown.

The tendency for the structure to lose strength as the structural wood elements decay is counterbalanced through the establishment of vegetation within the structure, which builds a root network that binds the soil and wood in the structure together and more firmly attaches it to the surrounding channel bed and banks. The relative root strength is a measure of the structural strength gained over time as vegetation establishes. Like the decay rates, the relative root strength shown is based on literature values that are not specific to constructed wood structures in

riverine settings. Taken as a whole, Figure 10-2 indicates that (1) Douglas Fir should be used for all key members, and (2) wood decay limits the design life of wood structures to about 15 years without successful revegetation.



Source: Fiori GeoSciences. DF = Douglas Fir; PND = Ponderosa Pine; Dt/Do = Relative Log Decay (diameter); Mt/Mo = Relative Log Decay (mass)

Figure 10-2. Design Life vs. Decay and Flood Exceedance Probability.

The design objectives for these wood structures include increasing channel dynamism and complexity to create geomorphic and habitat benefits (no infrastructure or bank protection objectives exist). Reclamation has indicated the preferred strategy to accomplish these objectives is to design and build the structures to emulate natural wood jams that are deformable, evolve over time, and perform as dynamic features in the landscape. To accomplish this design strategy and meet project objectives, Reclamation has requested the design exclude the use of (1) piles, or (2) ballast material that is not ultimately transportable by the river (i.e., boulders >14 inches in diameter).

Reclamation has also indicated that a secondary objective of omitting traditional piles and large boulders is to test the performance of such wood structures in an attempt to reduce construction costs for future projects.

A typical engineering standard of practice is to design for structural stability over a reasonable design life. Designing structures to be deformable and evolve over time is atypical and reduces the design life. Estimating the design life of wood structures in riverine environments is a complicated and often uncertain science. The decay of exposed wood limits the maximum design life for wood structures on the Trinity River to about 15 years and depends on the intensity and duration of flows. Design calculations indicate the wood structures are vulnerable to undermining by scour. Scour around the wood structures is desirable to develop complex aquatic habitat. Scour can also undermine the structures causing weakness, deformation, and structural failure. A standard engineering approach would be to utilize piles and large boulders to help stabilize the structure and protect against scour. Omitting piles and large boulders will reduce the rated design life to between 2 and 10 years. The shorter design life may affect the ability of the wood structures to revegetate or provide intended geomorphic and habitat benefits successfully. The life expectancy for both IC-3 and IC-4 is anticipated to be low due to the reduction of

ballast, piles, vegetation establishment, and natural decay (Figure 10-2). The design life has been estimated to be 6 years based on geomorphic evolution related to flow and deformity related to anticipated scour depths of 4 feet (Table 10-8).

Table 10-8. Estimated Scour Depth and Design Life

Structure	Estimated Scour Depth (ft)	Estimated Design Life (Years) without Piles (only using posts)
IC-3	4	6
IC-4	4	6

10.12 Infrastructure and Private Property Impacts

The project site is predominately public land with some private land. The Dutch Creek Road Bridge is located approximately 1 mile downstream of the Project site. The overall infrastructure and property risk for each designed large wood structure was assessed following the method described by Knutson and Fealko (2014). The method considers both the stream response potential (stream type, hydrologic regime, bank erosion and scour, etc.) and the infrastructure/property characteristics (in-stream and floodplain infrastructure, land use). The infrastructure and property risk scored “LOW” for all large wood structures.

10.12.1 Flood Risk

Placement of large wood materials in the channel may impact the inundation patterns on adjacent private and public properties. The Bureau of Reclamation has completed an assessment of flood impacts due to the proposed project as part of the application for a Conditional Letter of Map Revision to the FEMA. The Bureau of Reclamation has assessed that project implementation will not affect the flood risk of structures in the area. Therefore, the risk of flooding of neighboring properties due to the project implementation is low.

10.12.2 Erosion

Placement of large wood material is expected to initiate natural scour and erosion processes within the immediate vicinity of the material. Since the material will be placed within the project area and not immediately adjacent to any private properties or infrastructure, the risk of erosion to these properties due to the project is low. Hydraulic modeling output indicates that significantly increased shear stresses, which may be associated with increased scour and erosion, are isolated to the immediate vicinity of the large wood placements.

10.12.3 Mobilization of Large Wood

The wood structures are designed with interlocking logs up to 80 ft long, many with root wads still attached. The wood structures are designed to be deformable and will both accrete and shed wood over time. The large wood structures are designed specifically to avoid using artificial fasteners (e.g., cables, bolts, and anchors) to reduce risks to public safety and infrastructure. Omitting artificial fasteners means that any wood dislodged from the structure during floods will break apart and wash downstream as individual pieces rather than as a large raft, thereby significantly reducing risk to the downstream property and infrastructure.

Dutch Creek Road Bridge is a County bridge that crosses the Trinity River approximately 1 mile downstream of the project site. The bridge has two piers with a minimum span of 81.9 feet and maintains a minimum freeboard of 5.4 feet during the 100-year flood event (Table 10-9). Significant wood loading on the bridge piers is not expected because the maximum log length is capped at 80 feet to remain shorter than the minimum bridge span. Significant wood loading on the bridge deck is also not anticipated. The Federal Highway Administration guidelines for adequate freeboard (the distance between that river water surface during a flood the bottom of the bridge deck) to protect bridge decks from floating debris range from 2 feet where the potential for floating debris is “high”, and 3.3 to 3.9 feet where the potential for floating debris is “abundant and known debris problems exist” (USDOT-FHWA 2005). The freeboard at Dutch Creek Road Bridge during the 100-year flood event is 5.4 feet, exceeding the most conservative recommendation for abundant wood loading.

Table 10-9. Dutch Creek Road Bridge

Attribute	Value
Location	River mile 79.6
Built	1982
Q100	63,620 cfs
Q100 – WSE, inside bridge, upstream face	1471.9 ft
Deck thickness	6.7 ft
Piers	2 cylindrical piers, each 2.5 feet wide
Opening width at Q100 WSE – Left span	81.9 ft
Opening width at Q100 WSE – Center span	117.5 ft
Opening width at Q100 WSE – Right span	91.3 ft
Minimum freeboard at Q100	5.4 ft

Source: Trinity County 1982.

10.13 Public Safety and Use Impacts

Large wood in rivers is a common and important component of the natural river ecosystem, providing a variety of physical, habitat, and recreational benefits. Wood structures provide multiple recreational benefits, from increasing fishing and swimming opportunities to attracting birds and mammals. Wood in rivers, whether natural or placed, also increases channel complexity and potential safety hazards, including entrapment, injury, and in extreme cases, death. The proposed large wood placements are designed to emulate natural processes and stable log jams in rivers. The proposed wood placements will increase the quantity of wood in the river to replicate more natural conditions and increase the channel complexity. The increased channel complexity will complicate but not impede navigation. Increasing the quantity of wood in the river increases the likelihood of recreational users encountering wood elements but should not increase the risk to recreational users. The placed wood possesses similar hazards to natural and placed wood already in the river and should not increase risk to recreational users who are aware and consider the current condition of natural hazards in dynamic river. Large wood has been placed in constructed side channels of the Trinity River since the early 1990’s with mainstem placements starting in 2006. There have been no reports of adverse public encounters with placed wood structures on the Trinity River to date.

Recreational use includes fishing (boat-based and wading), boating, swimming, and some walking trails. Boat-based fishing is by far the most popular recreational use of the site. Recreational use occurs at high frequency throughout the year, at flows less than 1,000 cfs (Table 19). Public access to the site via land routes is very low because the site is entirely surrounded by private land. Limited access keeps the frequency of use low except for boat-based fishing (high use) which can access the site from upstream. The closest official public river access point and boat launch is located approximately 1 mile downstream of the site.

Table 10-10. Recreational Use

Public Use	Use period	Frequency of Use	General Skill Level	Recreational Flow Range (cfs)
Fishing	All year	High	Intermediate	< 1,000
Boating	Summer	Low	Intermediate	~ 450
Swimming	Summer	Very Low	Intermediate	~ 450
Walking on nearby trails	All Year	Low	N/A	N/A

Note: Ratings based on majority user group.

The large wood structures are located in an alluvial reach of the river in mellow Class I and Class II stream reaches. The structures are placed in a manner that provides for navigational safety. The minimum site distance for the large wood structures is 320 ft. Hydraulic modeling indicates mean water velocities are approximately 1.6 ft/s at 450 cfs (the prime recreational use time) and approximately 8 ft/s during bankfull conditions between 7,000 to 9,000 cfs. This equates to a reaction time of over 2 minutes during recreational flows and 40 seconds during bankfull flows, which is adequate to identify and safely avoid the structures.

The public safety risk for each designed large wood structure was assessed following the method described by Knutson and Fealko (2014). The method considers both recreational use characteristics (frequency of use, skill level, access, etc.) and the structure characteristics (channel type, structure location, egress potential, sight distance, etc.). Individual scores for each of these characteristics are shown in Appendix D. The public risk score is “LOW” for all large wood structures. Public risk is further mitigated by limiting construction to natural materials (wood and sediment) and specifically avoiding the use of artificial fasteners (cables, bolts, and anchors). Artificial fasteners are often used to increase the short-term stability of large wood structures but pose a significant public safety risk in the long run. Artificial fasteners create a dangerous tangle of cables and sharp points as the large wood structure slowly degrades.

Public education is another component of managing public risk. The Trinity River Restoration Program created a public brochure to educate the public on the benefits and large wood structures. The Restoration Program also held a public workshop in 2011 to discuss both the benefits of large wood and associated public safety concerns with the local community. Lastly, project-specific public meetings are held throughout the design process to educate the public about the proposed project and receive public input.

10.14 Construction Safety

Implementation of large wood features is logistically complex and involves a series of calculated steps to ensure safety of everyone within the radius of the construction activities. Because the structures are installed on the Trinity River, which is designated as a Wild and Scenic, boater navigation must remain open during construction

activities. Safety above everything is the highest priority, which includes safe passage for boaters, and a safe work zone for the construction crew. The contractor must have proper signage in the river to provide ample warning of construction activities ahead. A spotter and radio communication is used when equipment may be actively crossing the river with large material loads. The protocol is that all heavy equipment is shut down completely while boaters are passing by the work zone.

A job hazard analysis is completed for each construction activity on the river, including operating chainsaws or installing wood features. All construction sequencing steps are outlined and take into consideration everything from radio communication, personal protective equipment (eye/ear protection, chaps, etc.), swing radius of specific machines around existing objects, and many other related steps. An emergency action plan is also in place in case of an injury outlining protocols for communication and extrication.

Because the materials are often variable in size and integrity, the contractor should consider specific installation techniques depending on the materials being used to ensure that the materials do not break when handling them with heavy equipment.

10.15 Environmental Compliance

Installing large wood features in the active river poses an environmental risk for water quality concerns with oil spills and turbidity. To ensure environmental compliance, the contractor must isolate the work zone for any structure where there is excavation below the bed of the river. Isolation is performed by installing pre-cast concrete barriers, impervious plastic sheeting, turbidity curtains, and other techniques to ensure that all turbidity and potential spills are contained in the work area. As a second layer of precaution, oil booms are strategically placed downstream of the structures to capture any hydraulic oil spills that could occur to protect water quality.

10.16 Adaptive Management

The Trinity River Restoration Program is a science-based adaptive management program. Adaptive management is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and rapidly improving management. River systems are very complex, and while our level of understanding of river ecosystems is improving, managing the Trinity River will always face varying levels of scientific uncertainty. The adaptive management program promotes responsible, science-based progress in the face of this uncertainty.

There are significant uncertainties associated with the design, construction, and evolution of wood structures. Addressing these uncertainties is one of the many aspects to be addressed by the adaptive management program. The wood structures have been designed to act like natural wood jams that deform and evolve, which may increase the public safety risk over time. It is recommended that the adaptive management program provide continued monitoring to ensure the wood structures provide for public safety after construction. Secondly, adaptive management should be used to reduce the uncertainty associated with (1) scour calculations and associated use of piles and other scour protection measures, (2) wood structure architecture and construction techniques that best promote short and long term biological and geomorphic objectives on the Trinity River, and (3) revegetation and plant establishment performance with the large wood structures.

11. Summary

The Oregon Gulch project site is currently characterized by a straight, simple channel entrenched between tailings piles with heights up to 40 ft above the river bed. The proposed design primarily involves the removal of tailing piles to create one large frequently inundated floodplain. The floodplain is designed as a valley-grade surface characterized by a relatively flat surface with a mild down-valley slope. A single low-flow channel traverses the floodplain in an arcuate path along the right margin of a low-elevation floodplain designed to begin to inundate at flows as low as 600 cfs. The channel is intentionally too small to contain typical winter and early spring flows, so that frequent flooding will provide abundant rearing habitat for juvenile salmonids.

Inundation of these floodplains results in more than a 4-fold increase in the valley bottom areas inundated by flows ranging from about 600 to 8000 cfs. Flow velocities in these inundated areas are generally low, leading to large increases in rearing habitat as measured by fish capacity. The design produces increases in fry rearing habitat availability of 900-1040 percent over existing conditions over the range of habitat critical flows (600 to 1800 cfs). Design increases in presmolt habitat over the same range of flows are 496-673 percent. These are by far the largest increases in rearing habitat ever predicted for a rehabilitation project on the Trinity River.

In addition to greatly increasing rearing habitat availability, the design is expected to stimulate geomorphic processes that will drive the evolution of a structurally diverse floodplain landscape that offers a wide range of habitats and hydraulic conditions. Initial changes during the first few floods following construction include bed deposition at the upstream end of the constructed channel and erosion along the left bank of the channel where it traverses the valley width from left to right, coupled with deposition on the floodplain surface immediately downstream. Aggradation within the constructed channel has the potential to produce avulsions and the formation of new channels elsewhere on the floodplain surface.

Rather than focusing on channel morphology, the objective of the Oregon Gulch design is to restore the entire valley bottom. The quantities of earthwork involved are therefore very large. Excavation of the tailings pile will involve upwards of 516,500 yd³ of cut. About 52,000 yd³ of that total could potentially be used as fill in the construction of other design features, and about 143,000 yd³ can be spoiled in a designated spoils area within the project ESL. The remaining 321,000 yd³ of spoils will be transported off the site.

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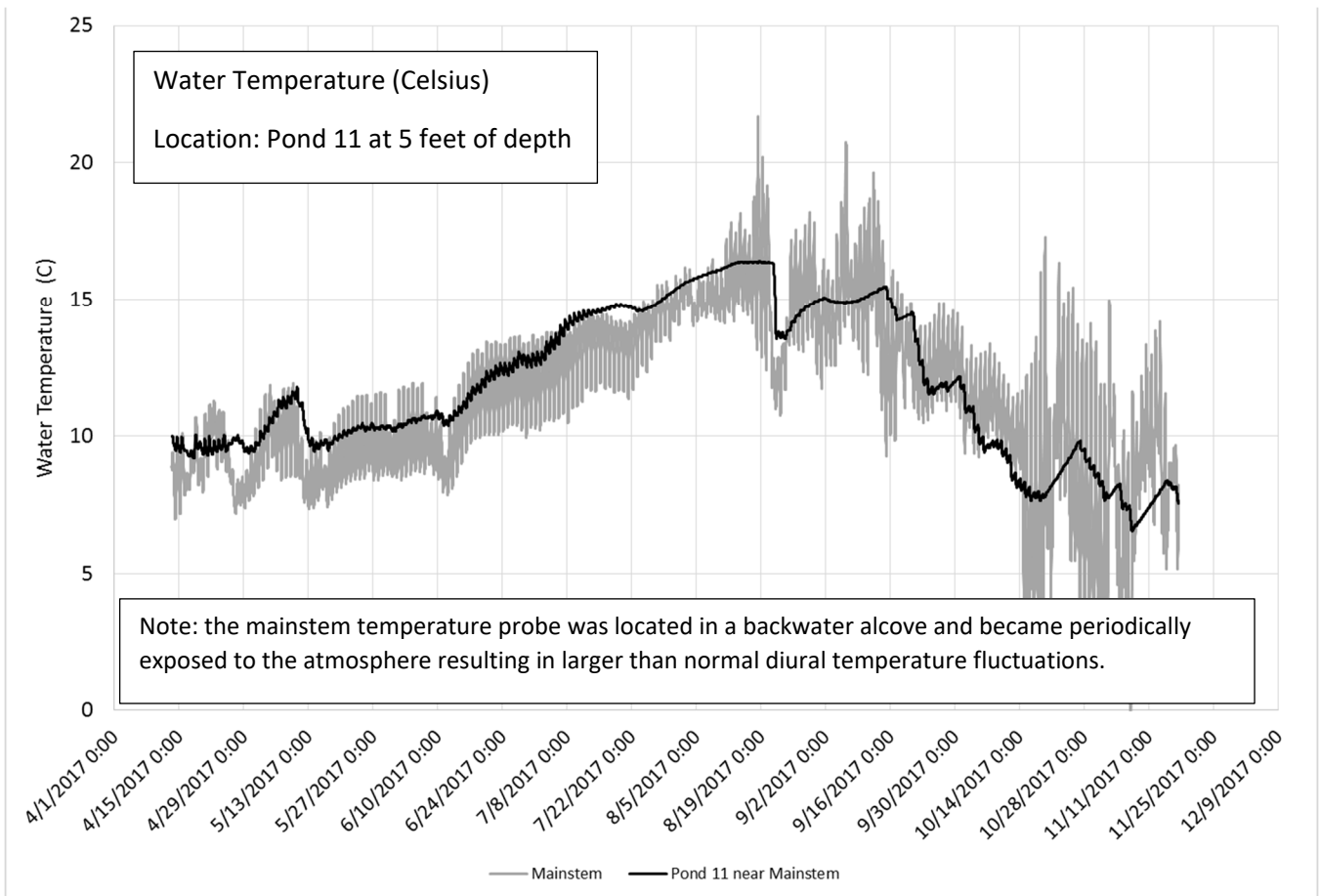
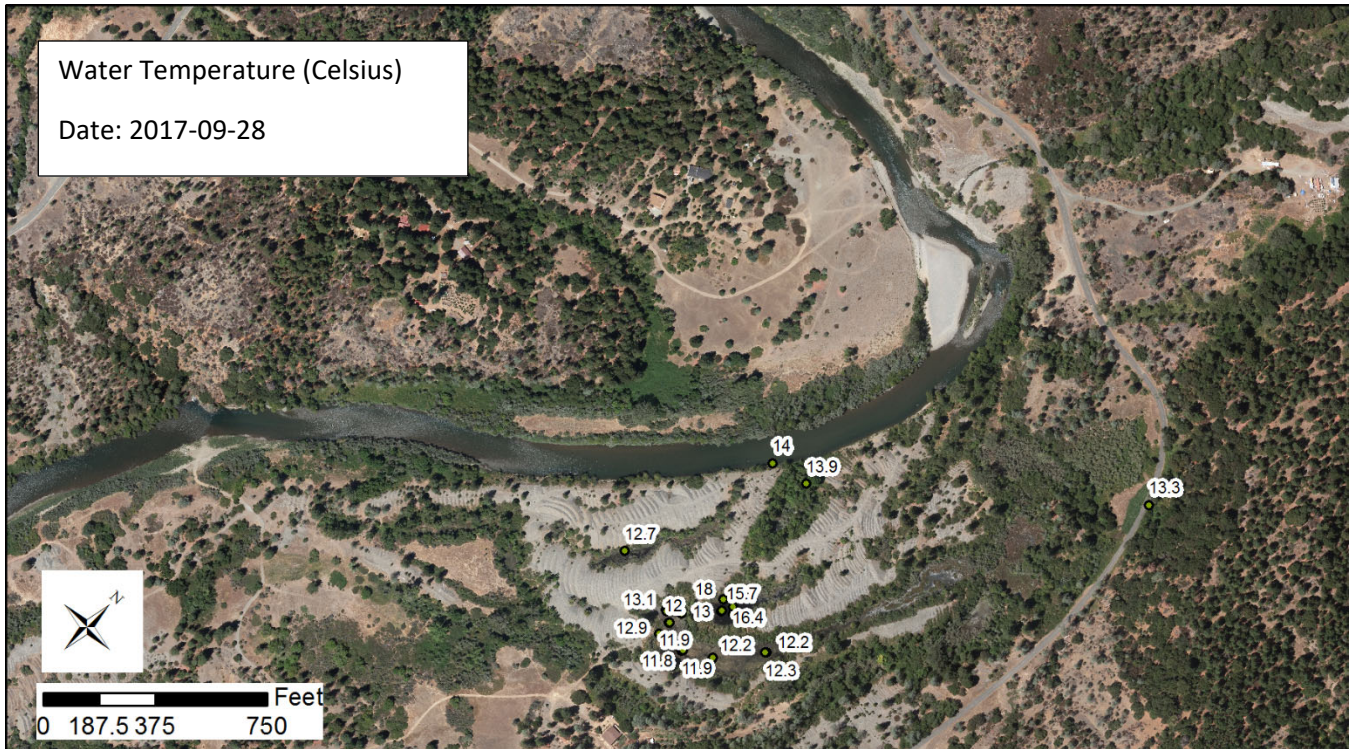
Appendix A: Water Quality Monitoring Results

Water quality monitoring was conducted for water temperature, dissolved oxygen, pH, and specific conductance. A result of zero indicates the water quality parameter was not measured at the indicated location.

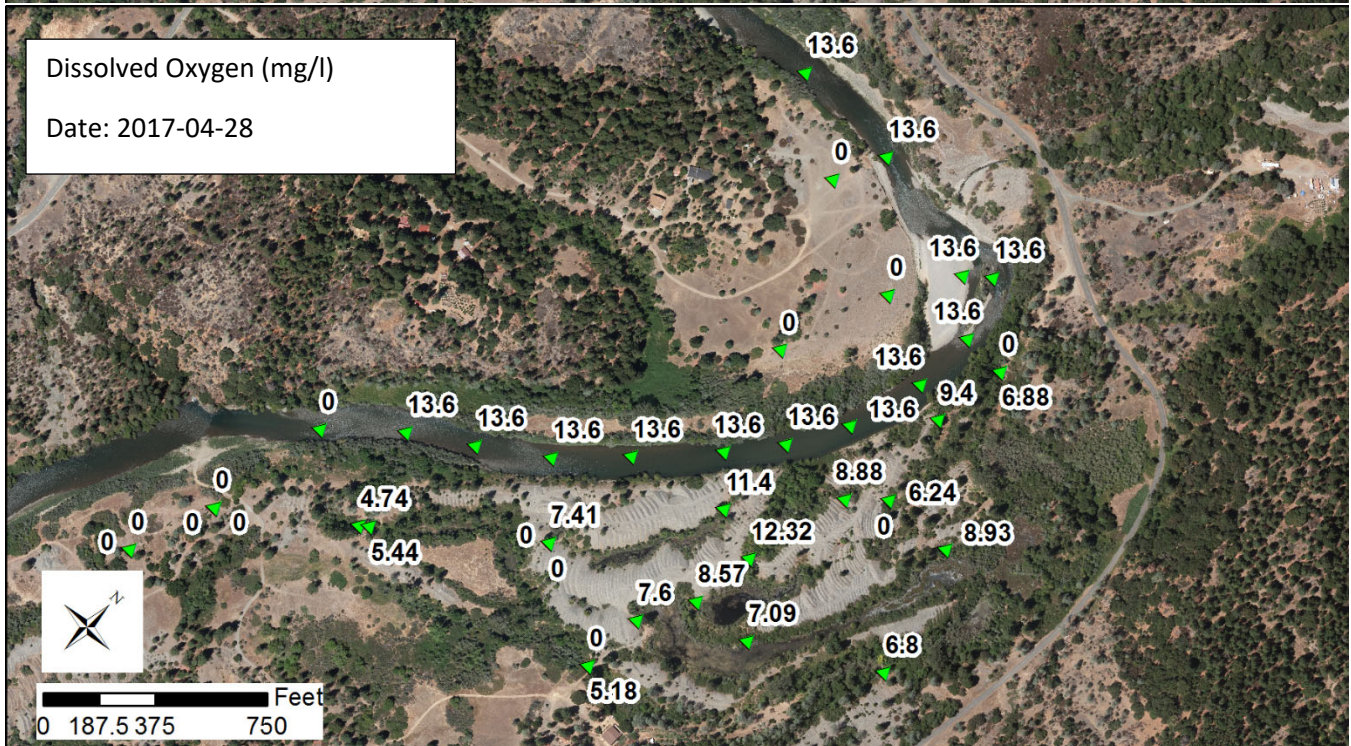
Water Temperature Monitoring Results



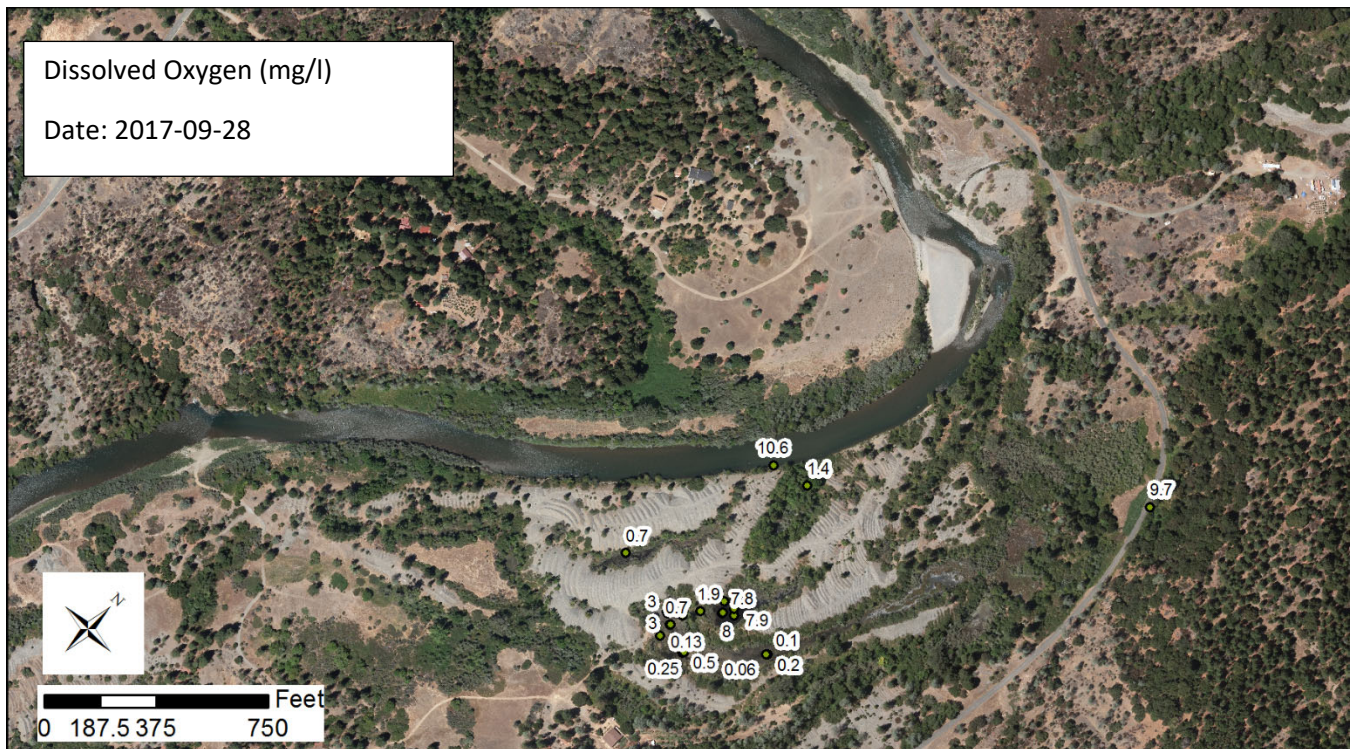




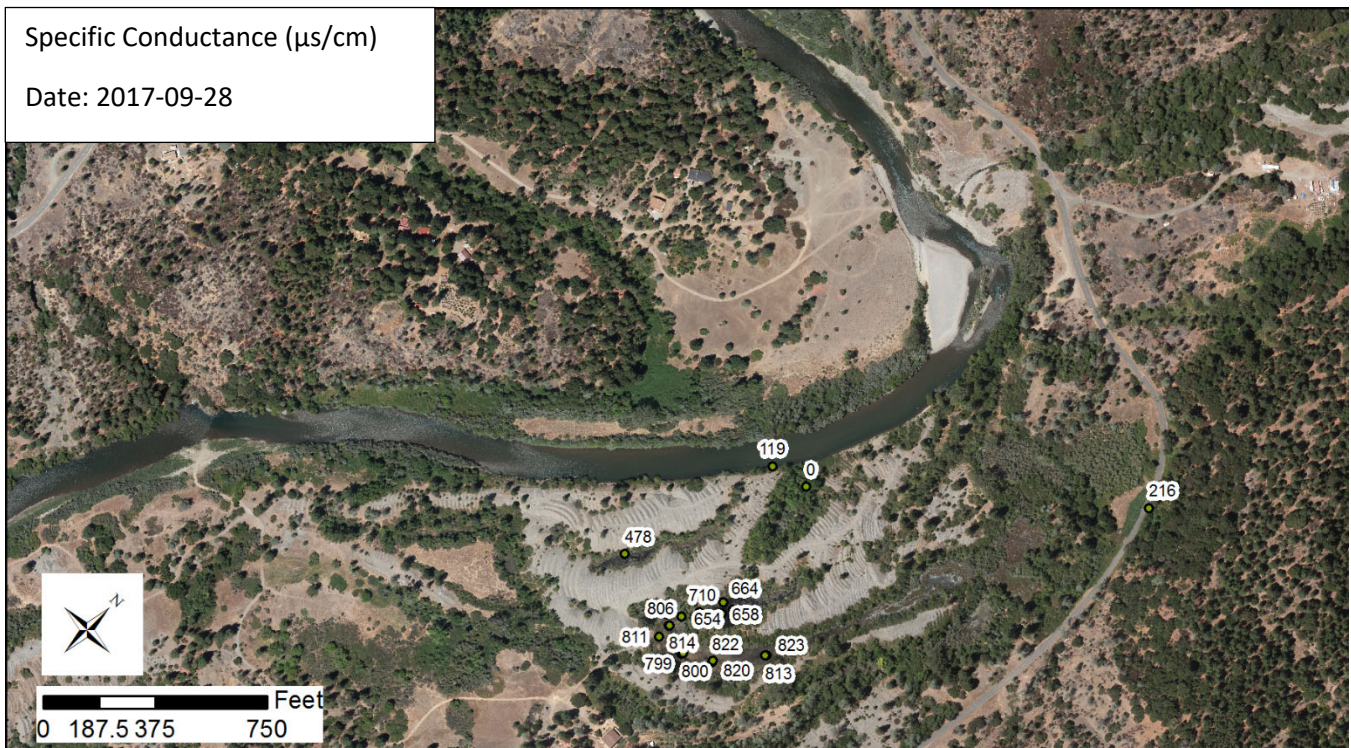
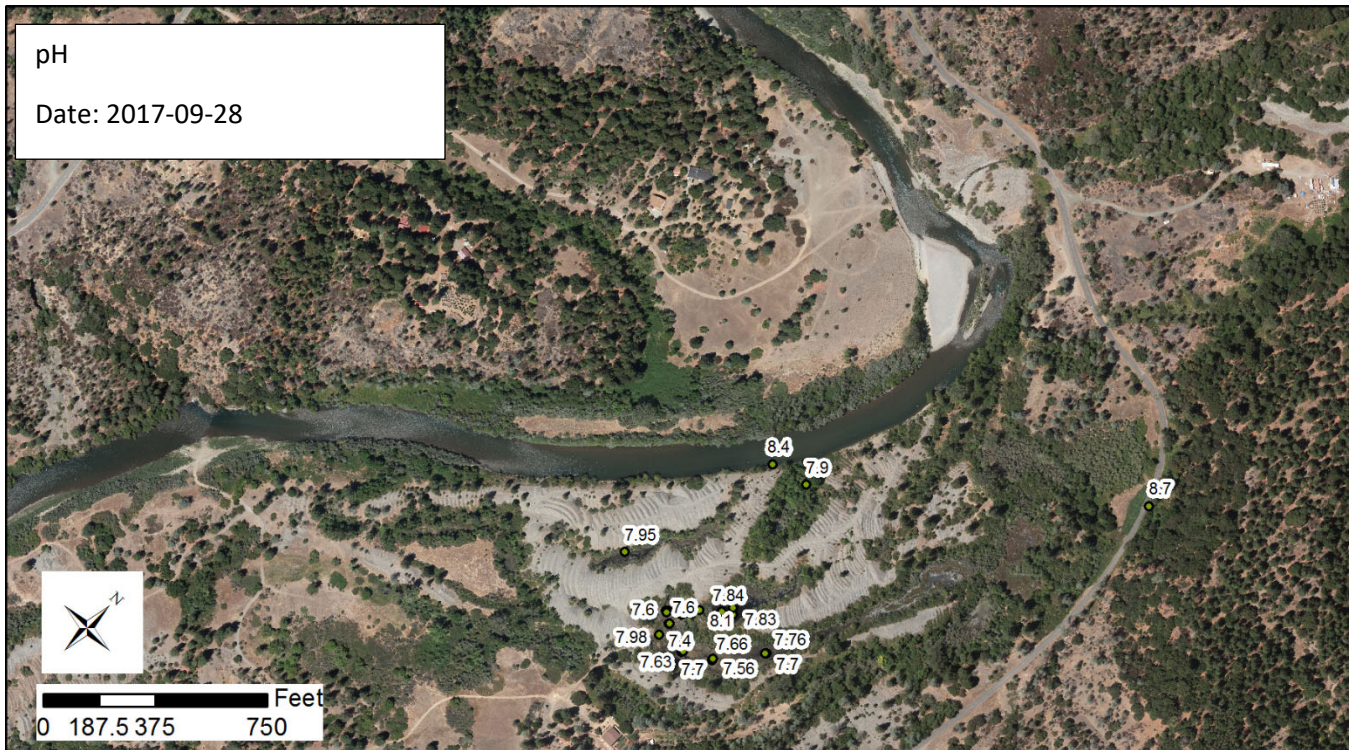
Dissolved Oxygen Monitoring Results





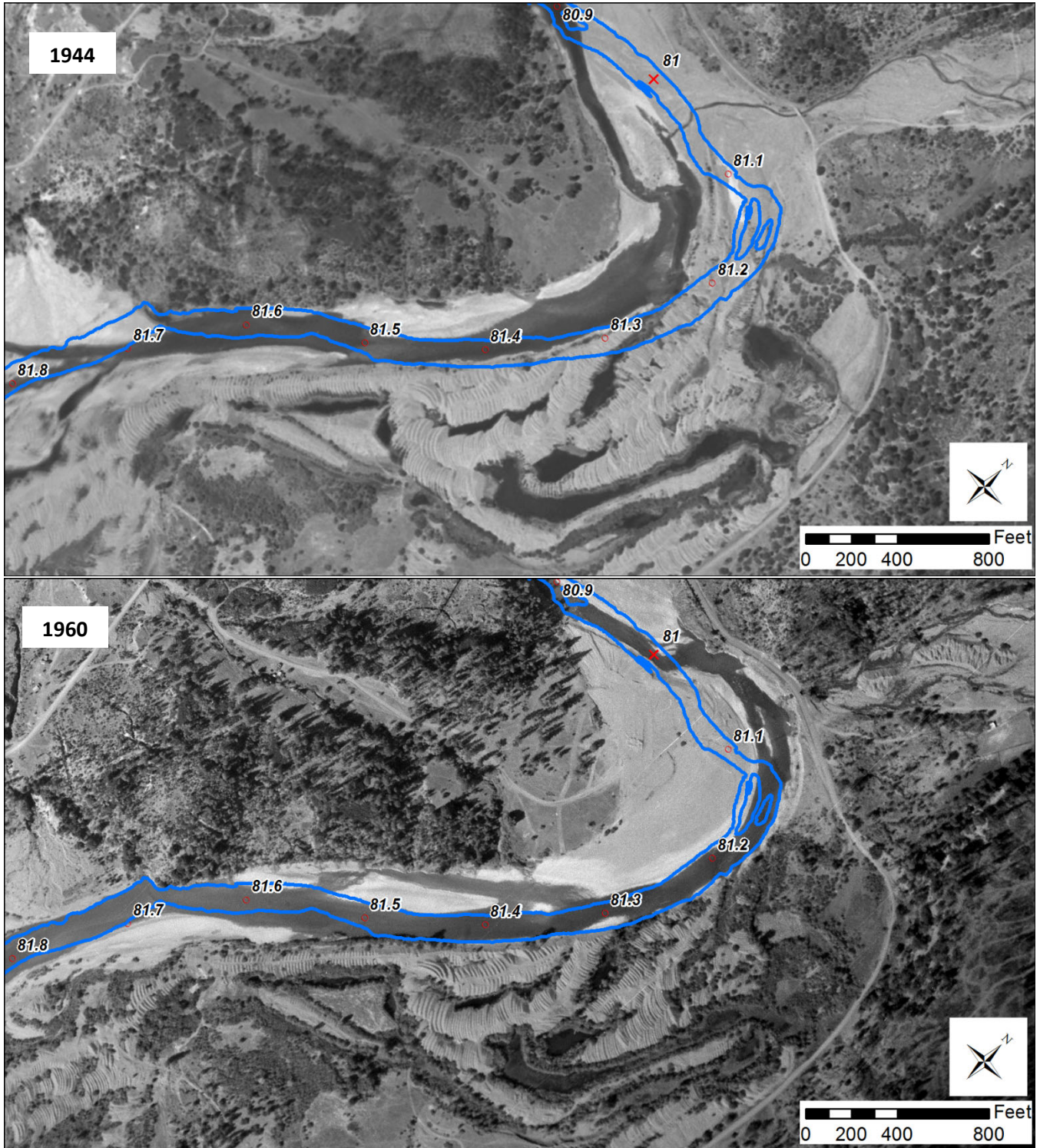


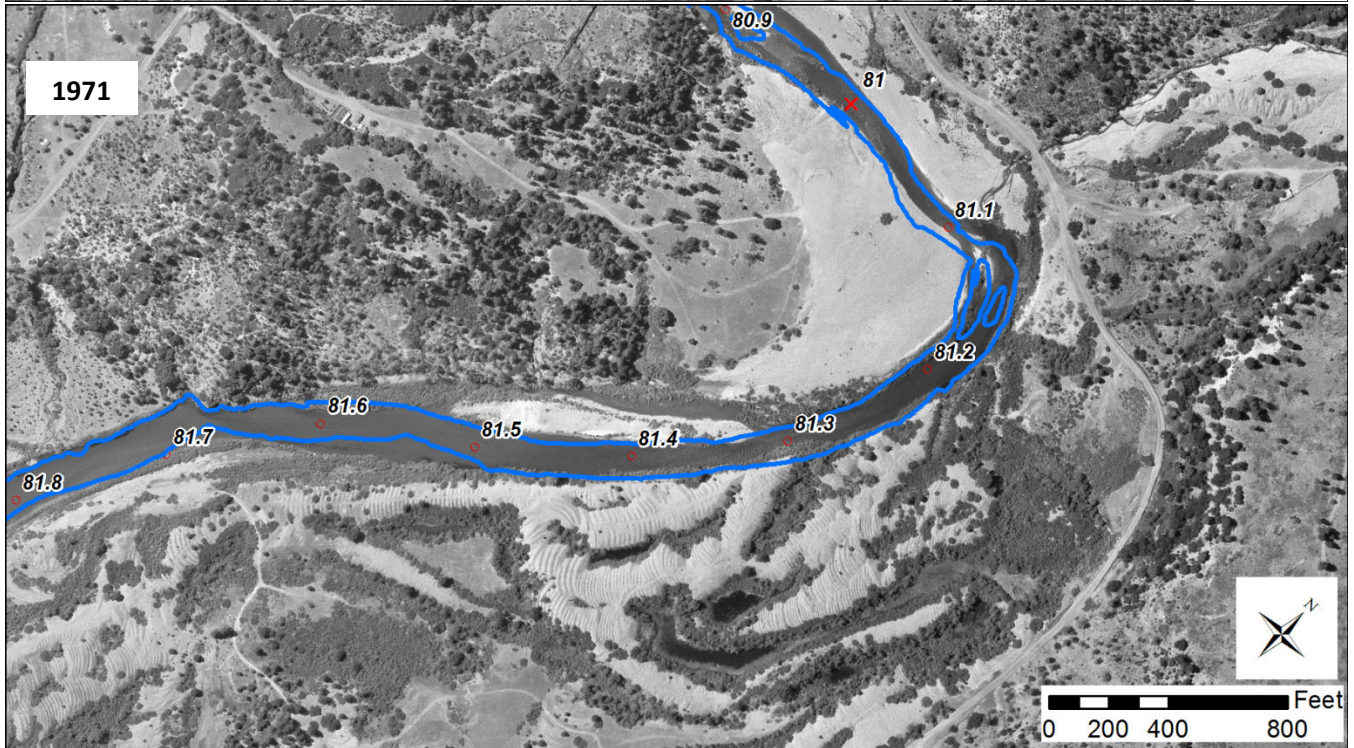
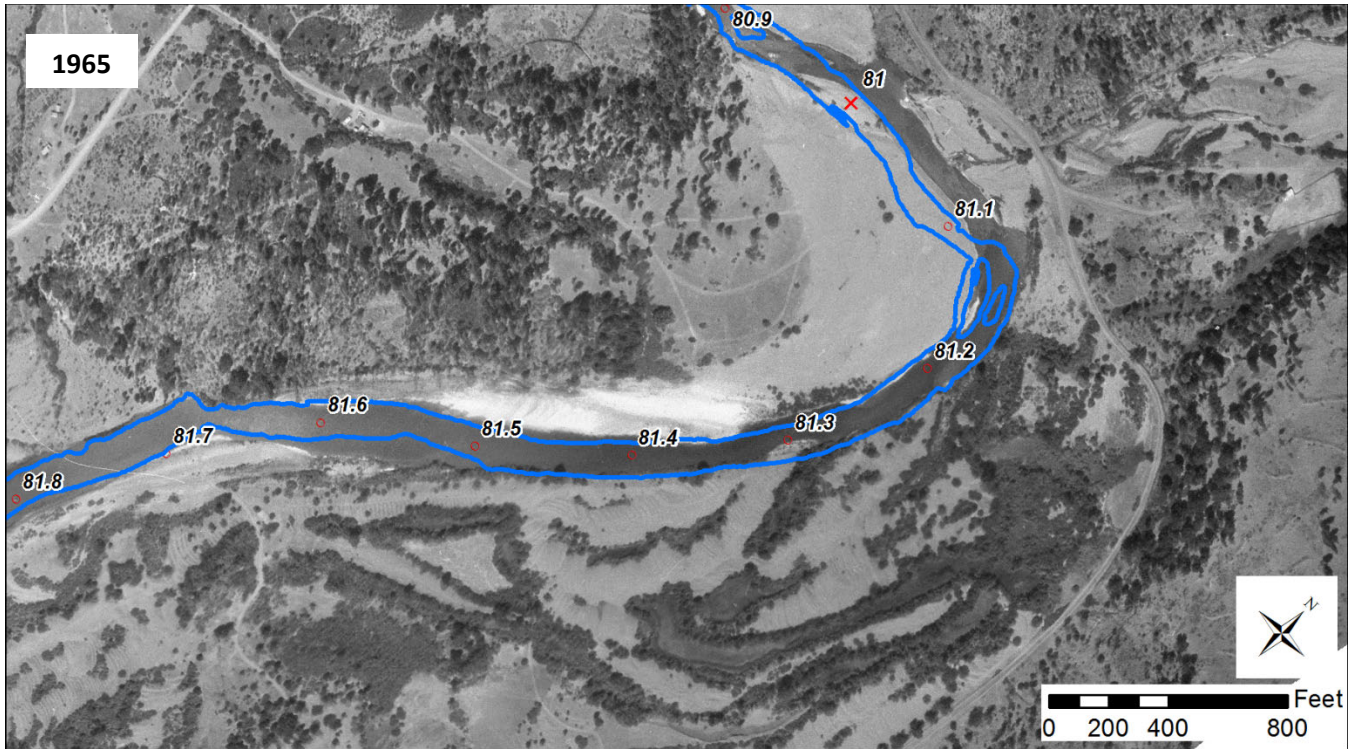
Other Water Quality Monitoring Results



Appendix B: Historical Aerial Photos

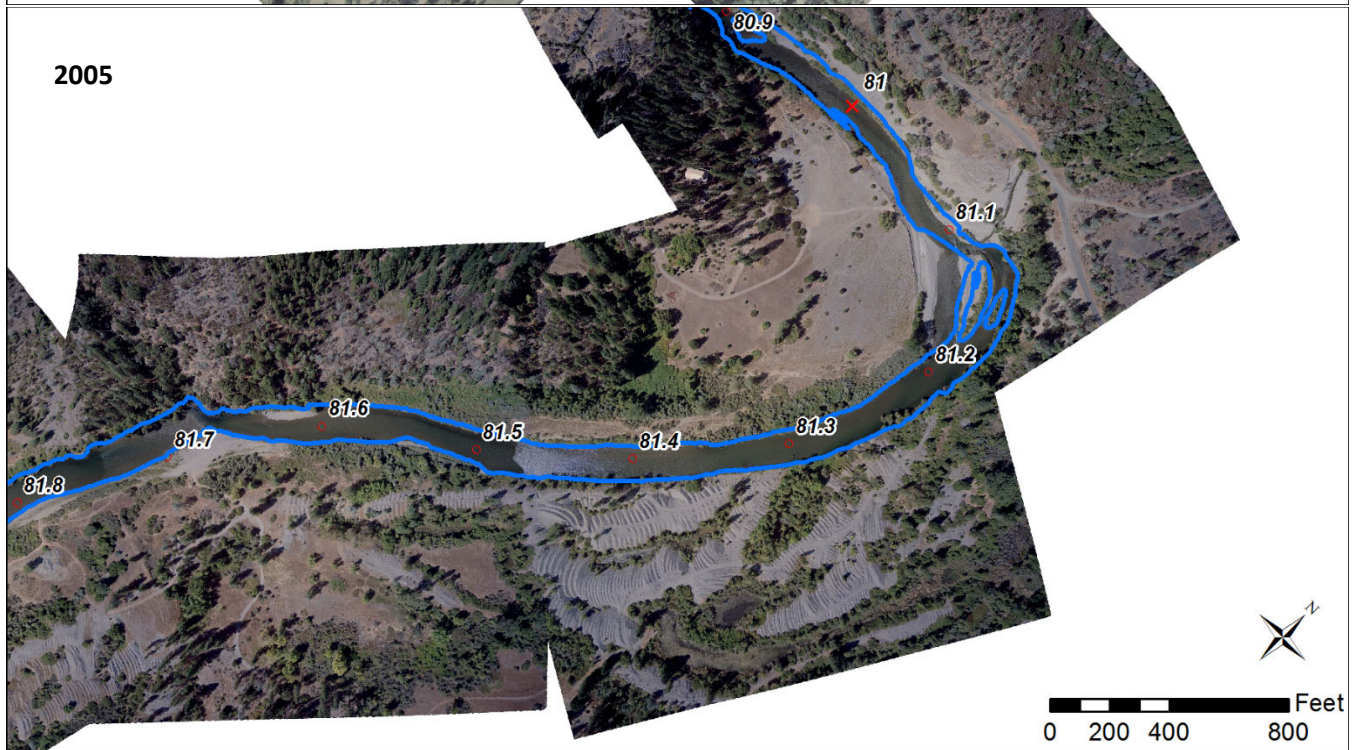
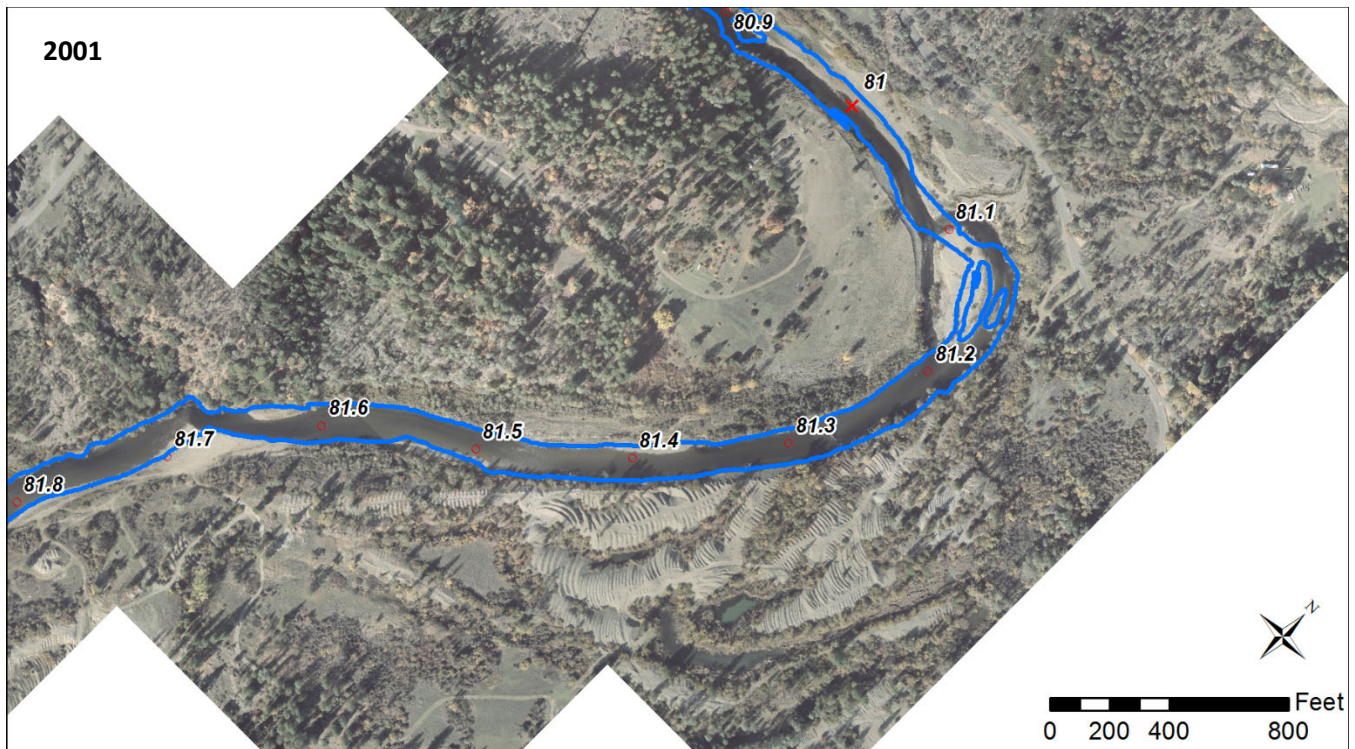
Aerial photos from 1944 to 2016. Blue line shows 2011 low flow inundation boundary from for reference.

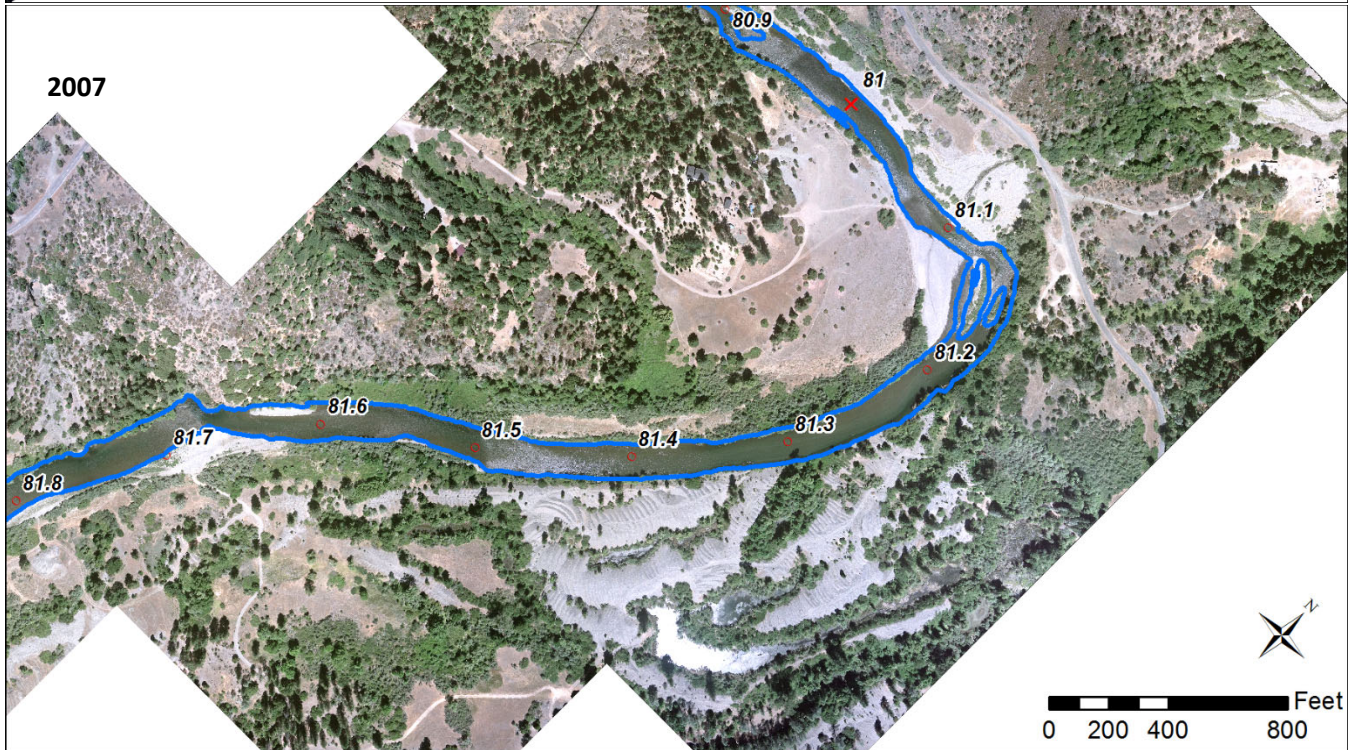
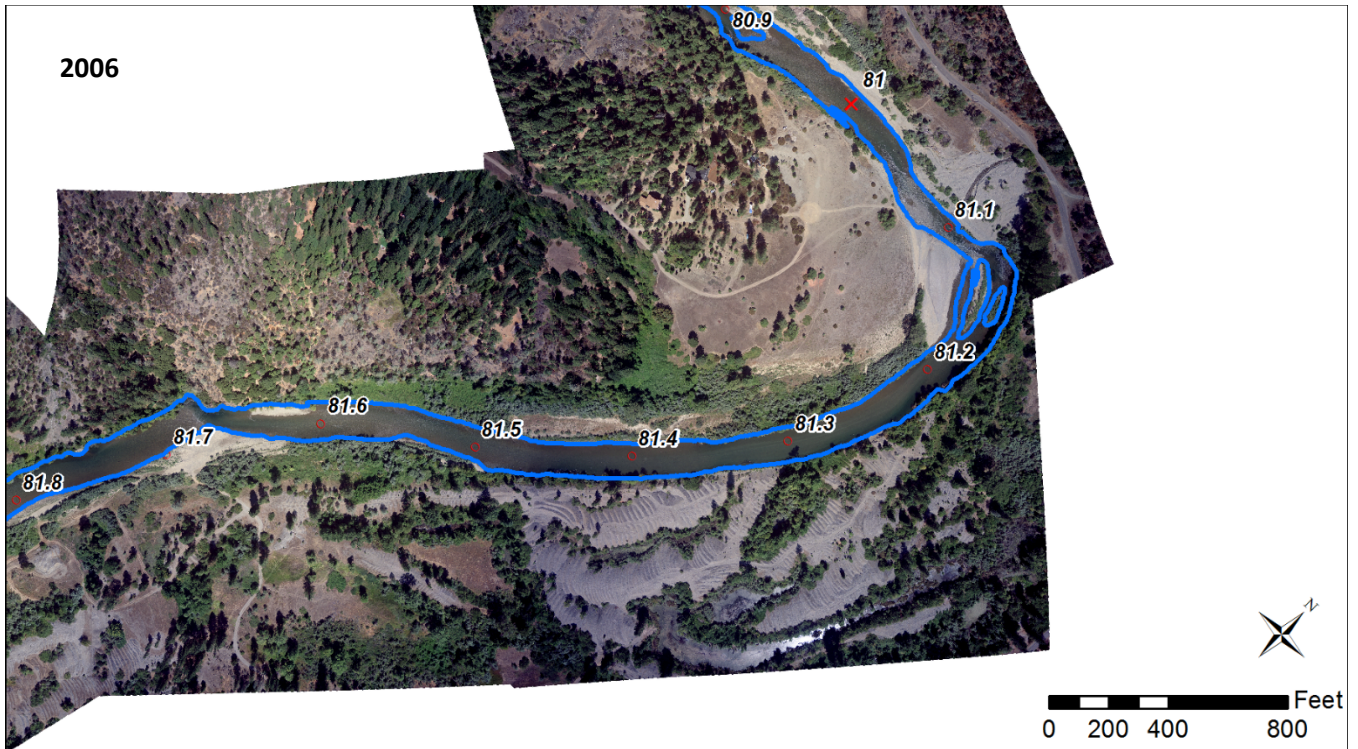


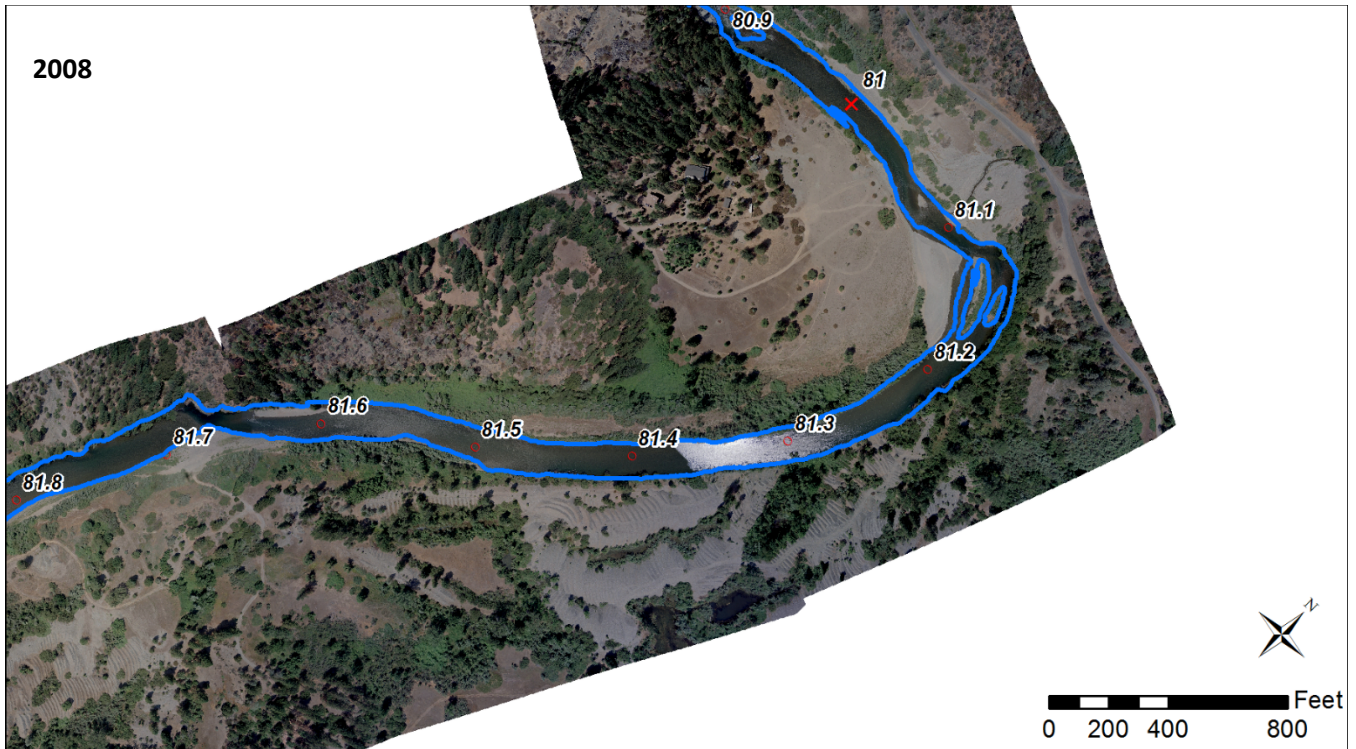










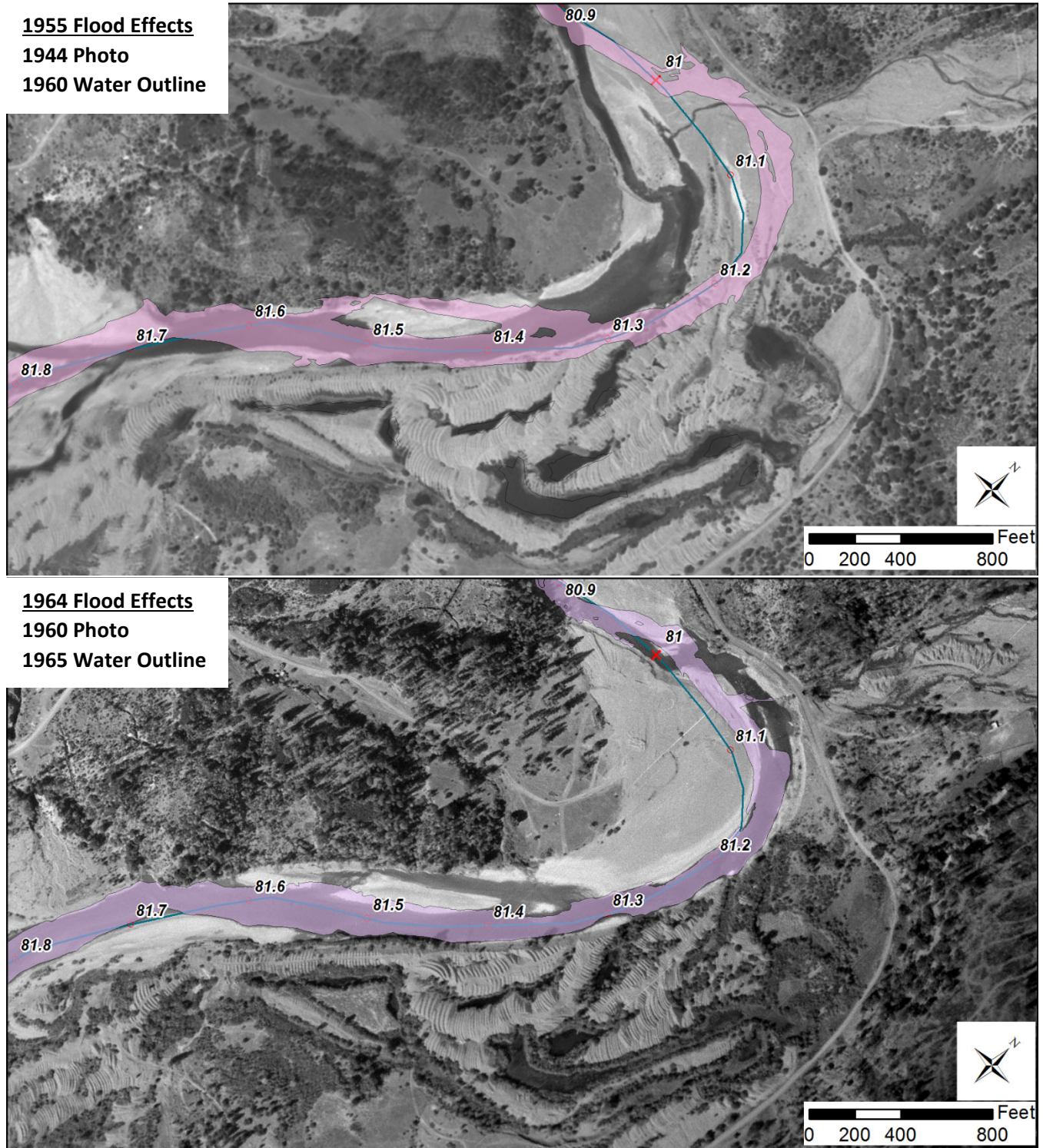




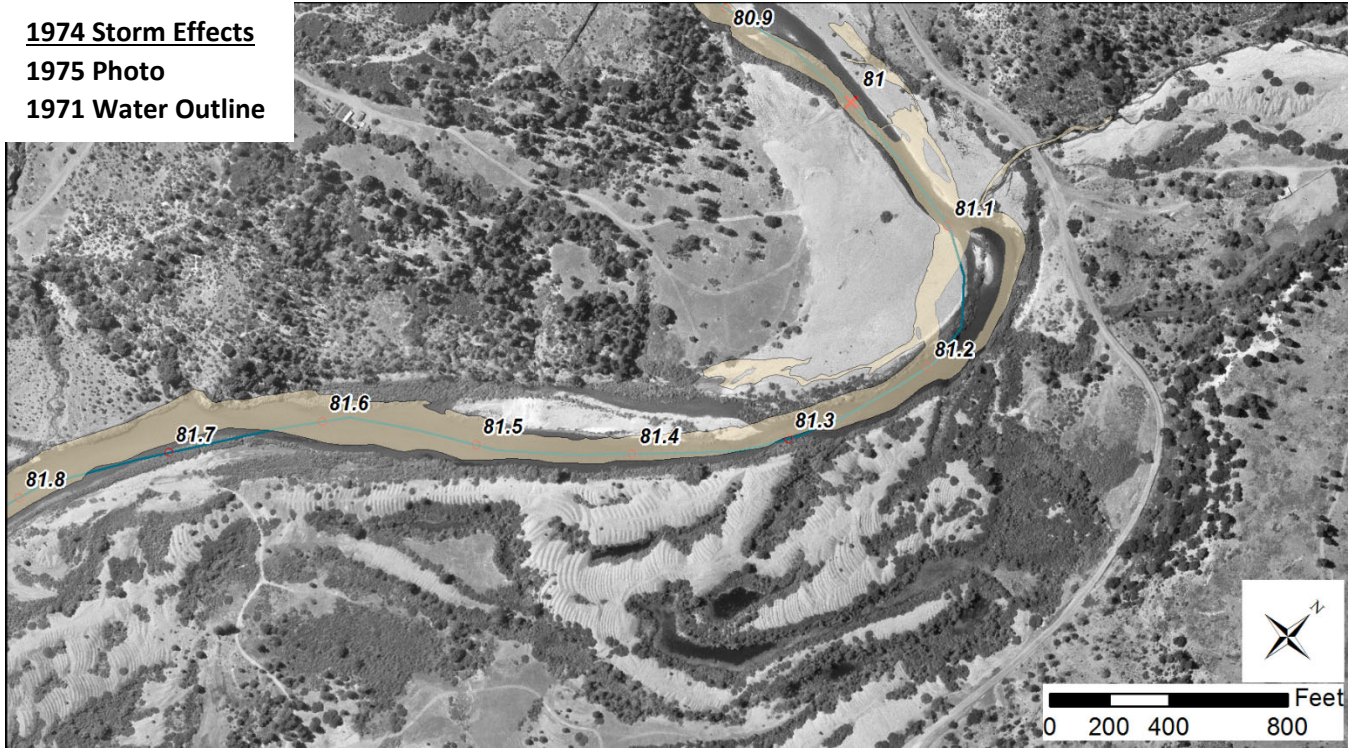




Appendix C: Aerial Photos Showing Channel Planform after Major Floods



1974 Storm Effects
1975 Photo
1971 Water Outline



1997 Storm Effects
1997 Photo
1990 Water Outline



Channel Change 1944 - 2011

Base Photo = 1960

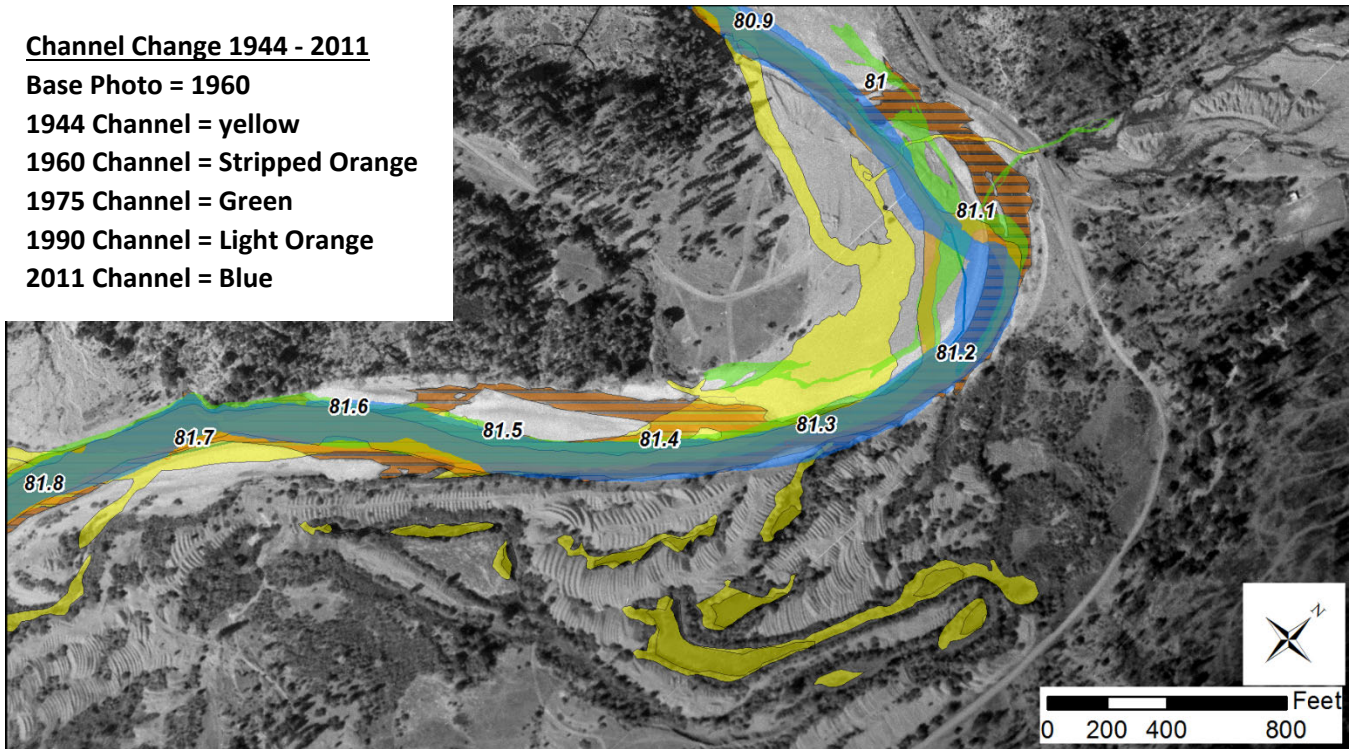
1944 Channel = yellow

1960 Channel = Stripped Orange

1975 Channel = Green

1990 Channel = Light Orange

2011 Channel = Blue



Channel Change 1960 - 2011

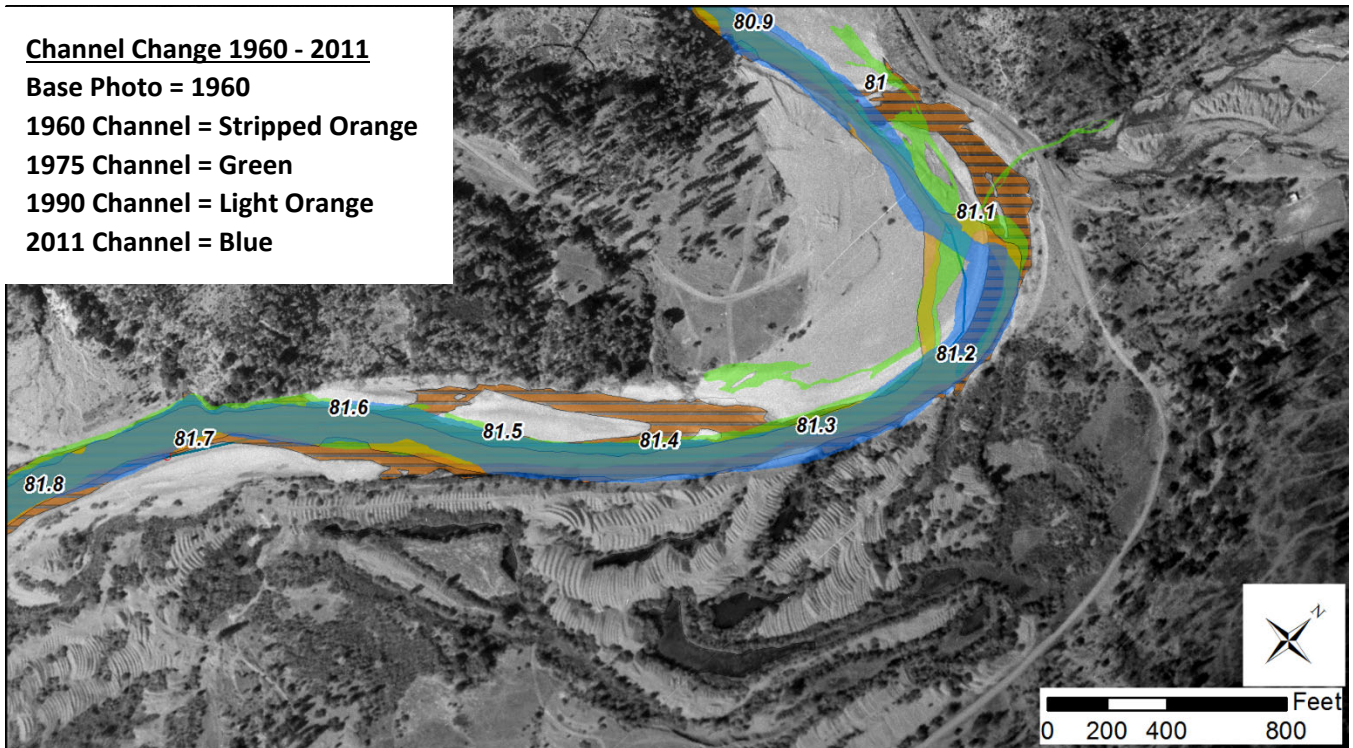
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1960 Channel = Stripped Orange

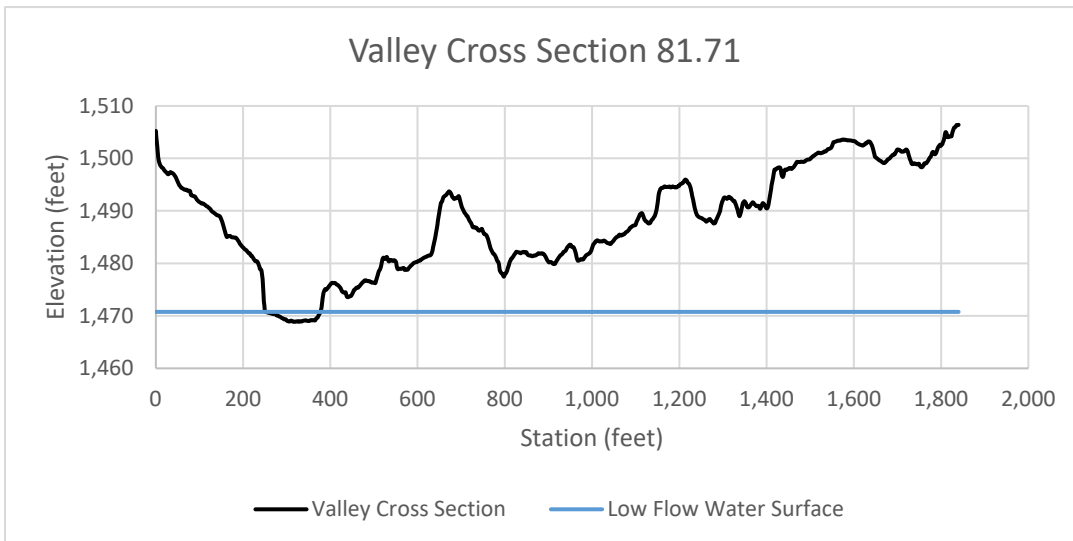
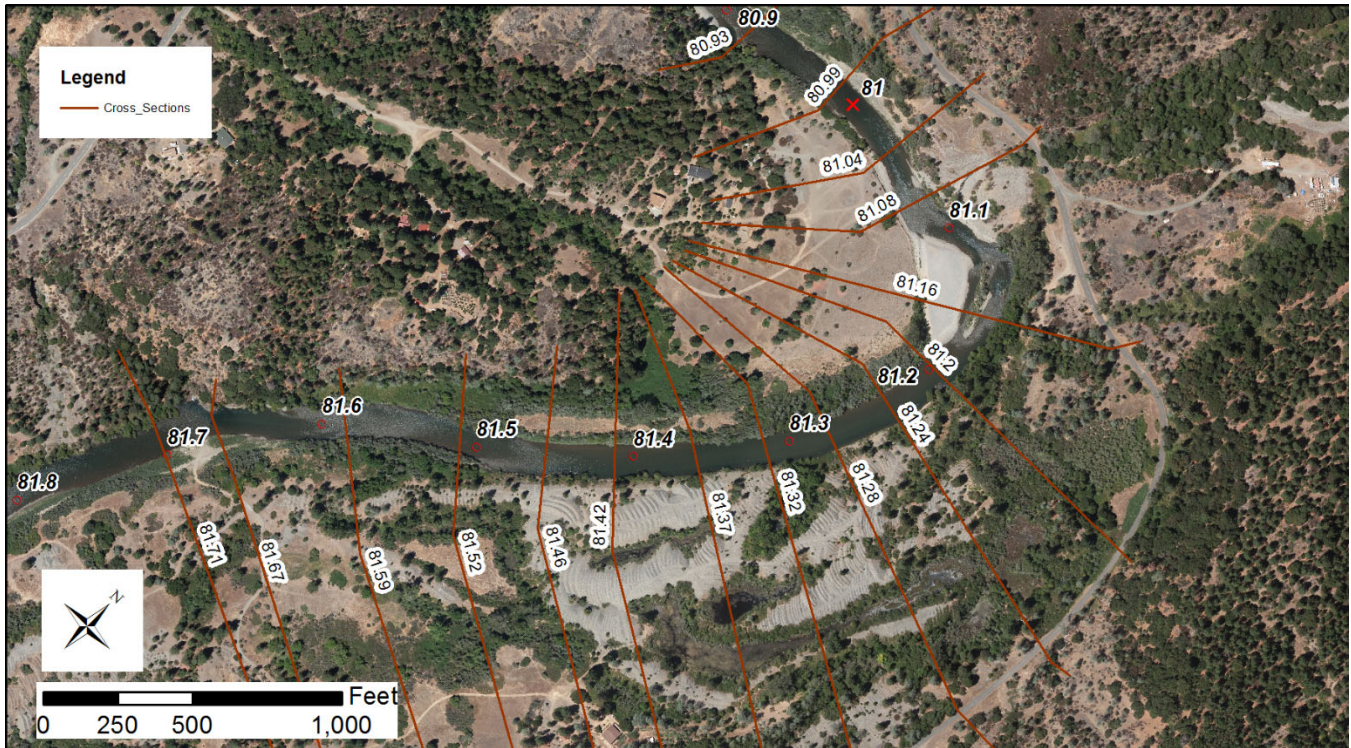
1975 Channel = Green

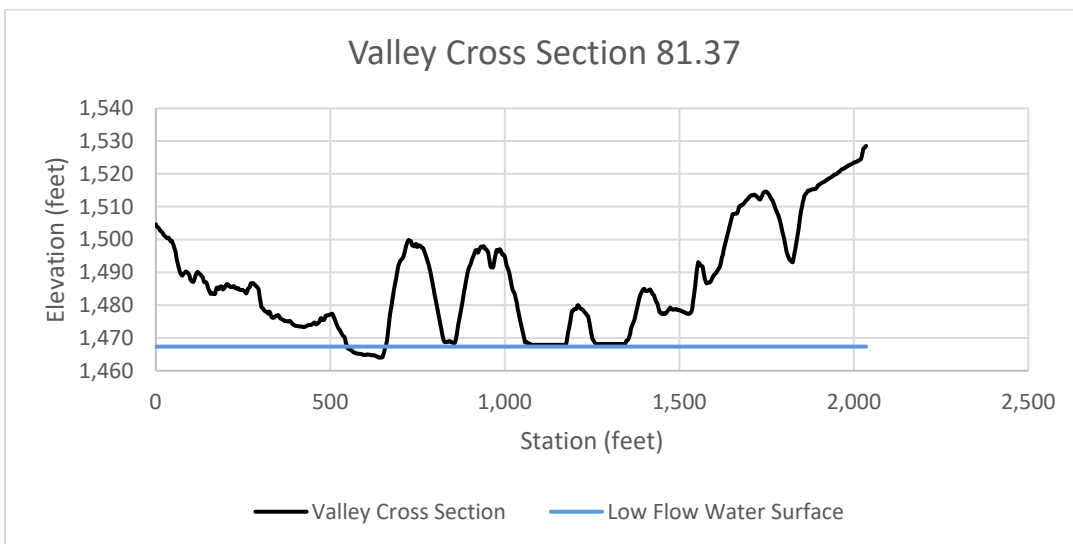
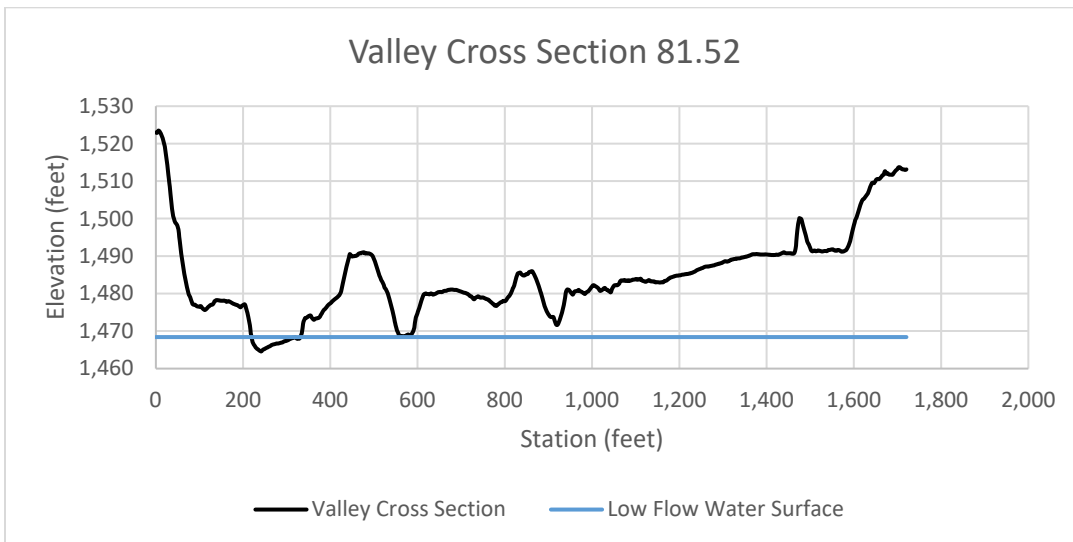
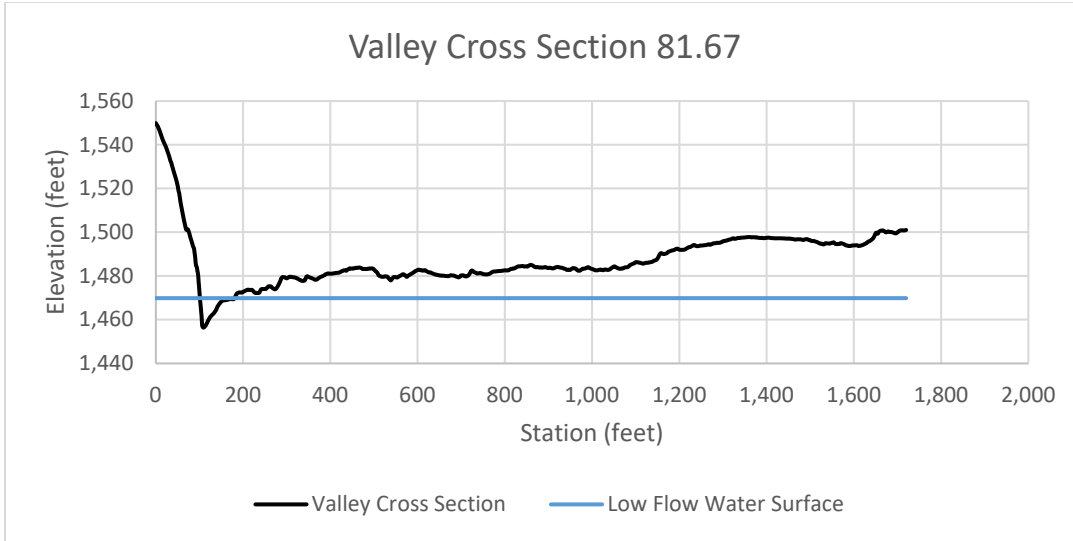
1990 Channel = Light Orange

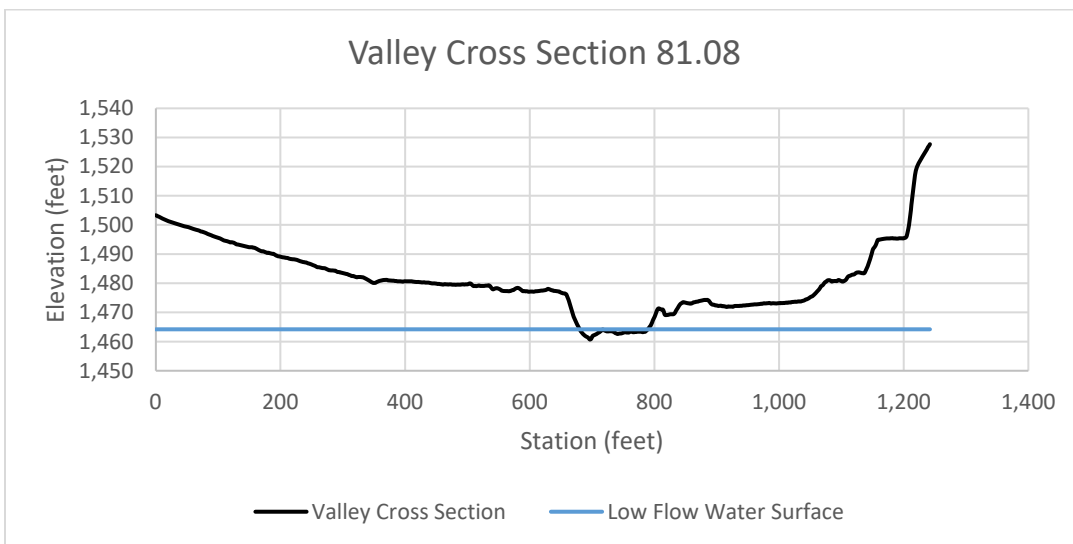
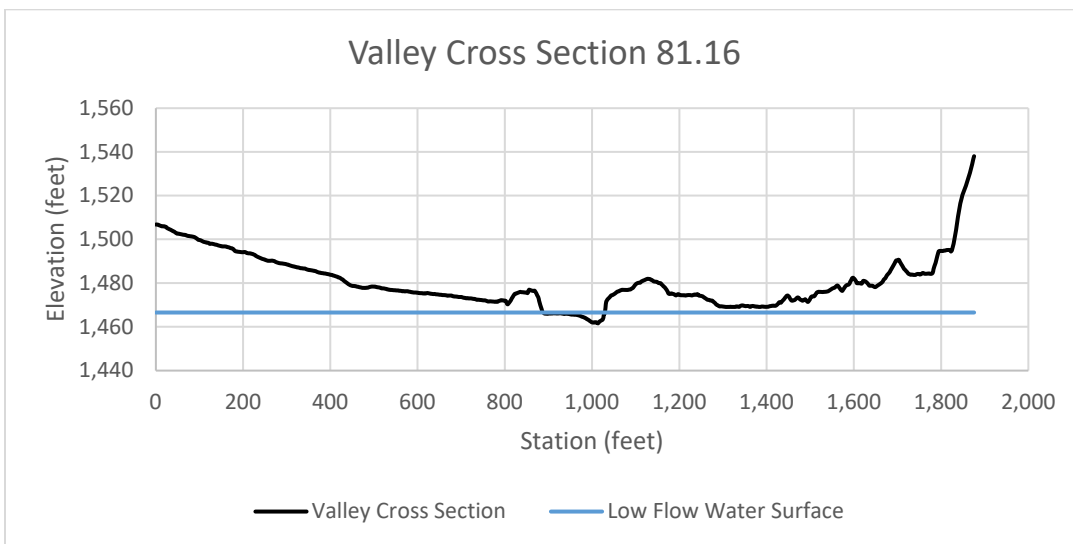
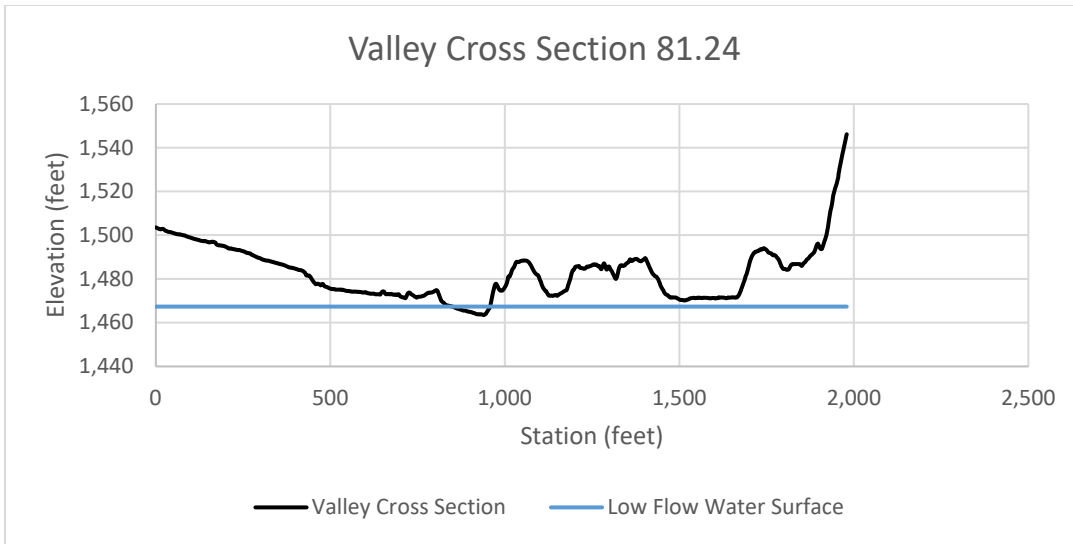
2011 Channel = Blue

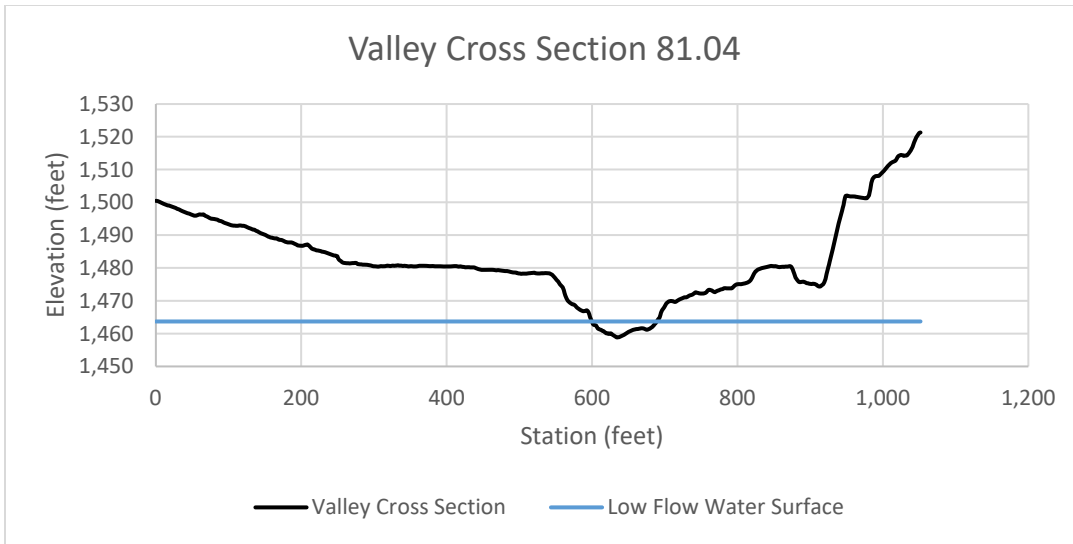


Appendix D: Valley Cross Sections



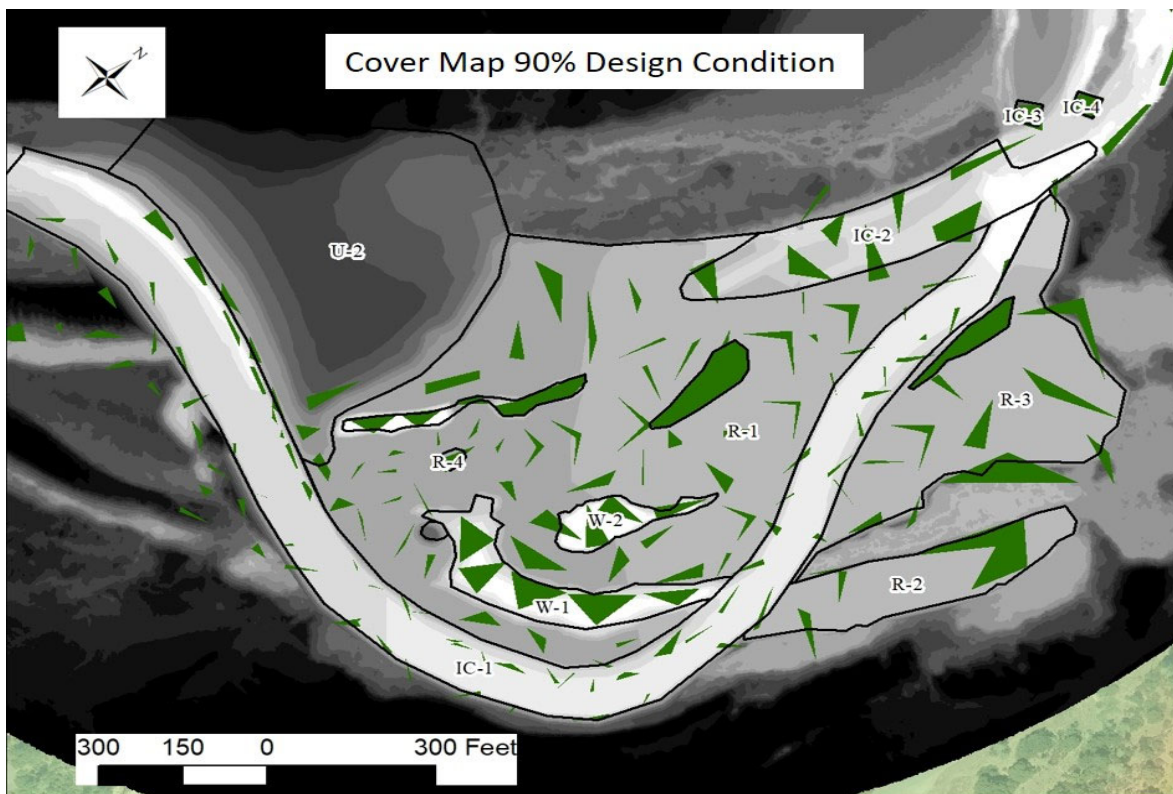
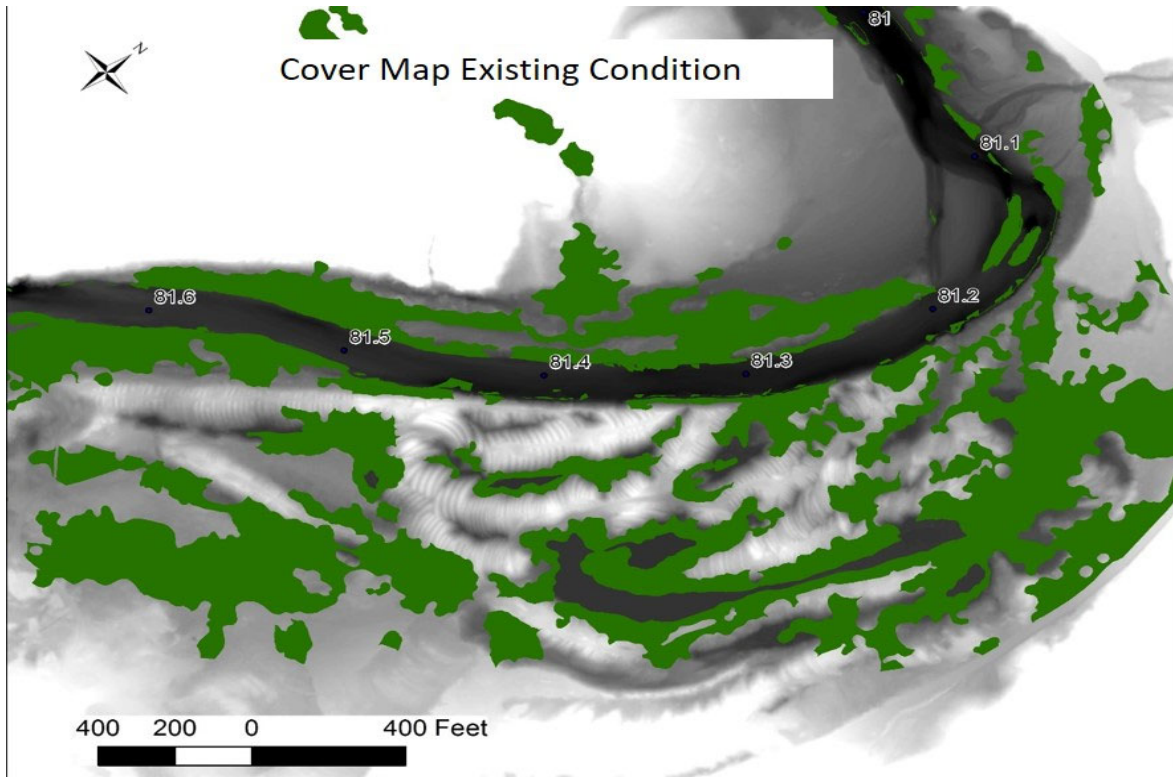






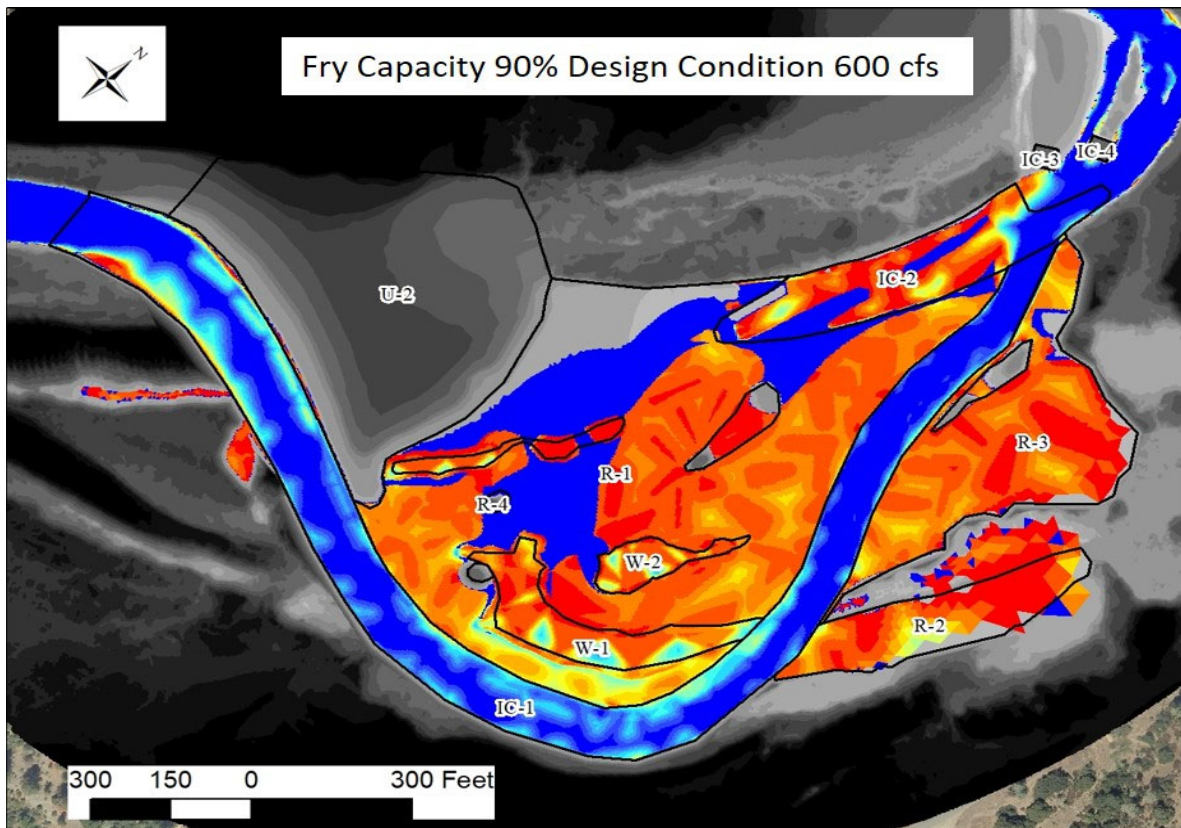
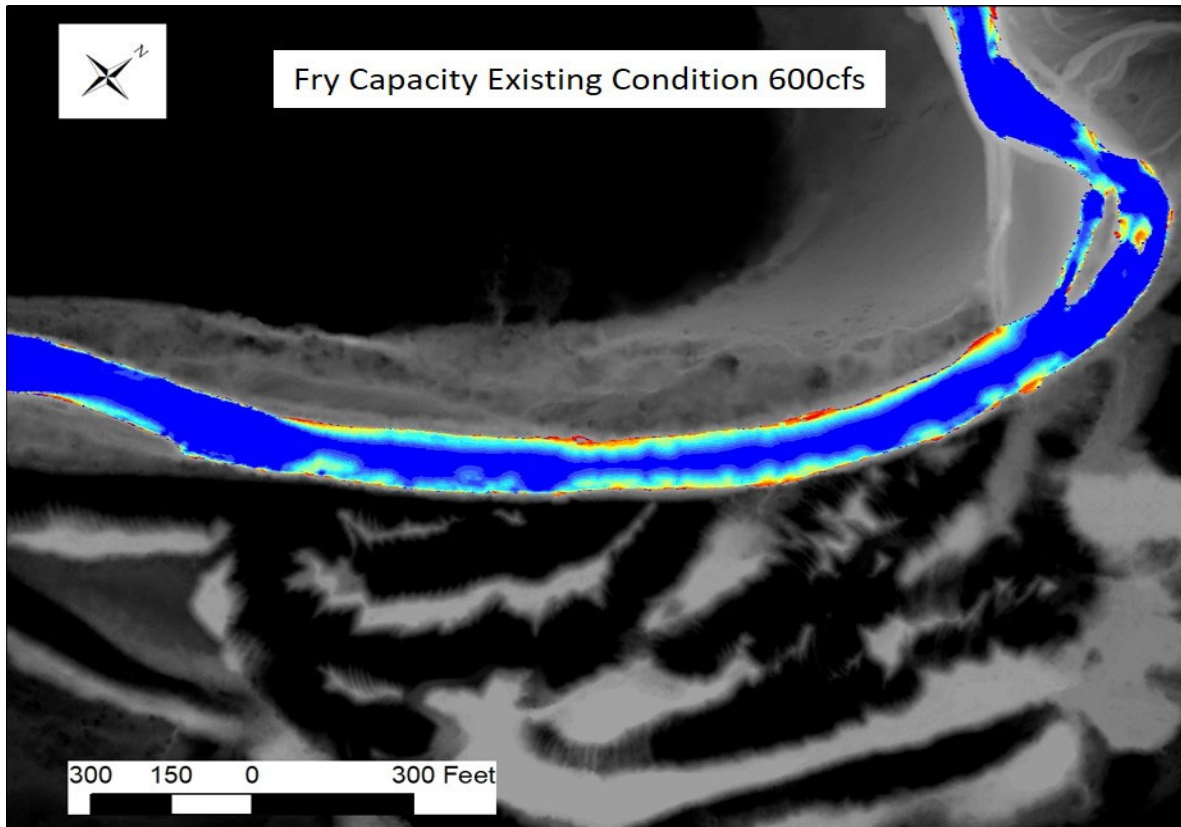
Appendix E: Habitat Modeling Maps

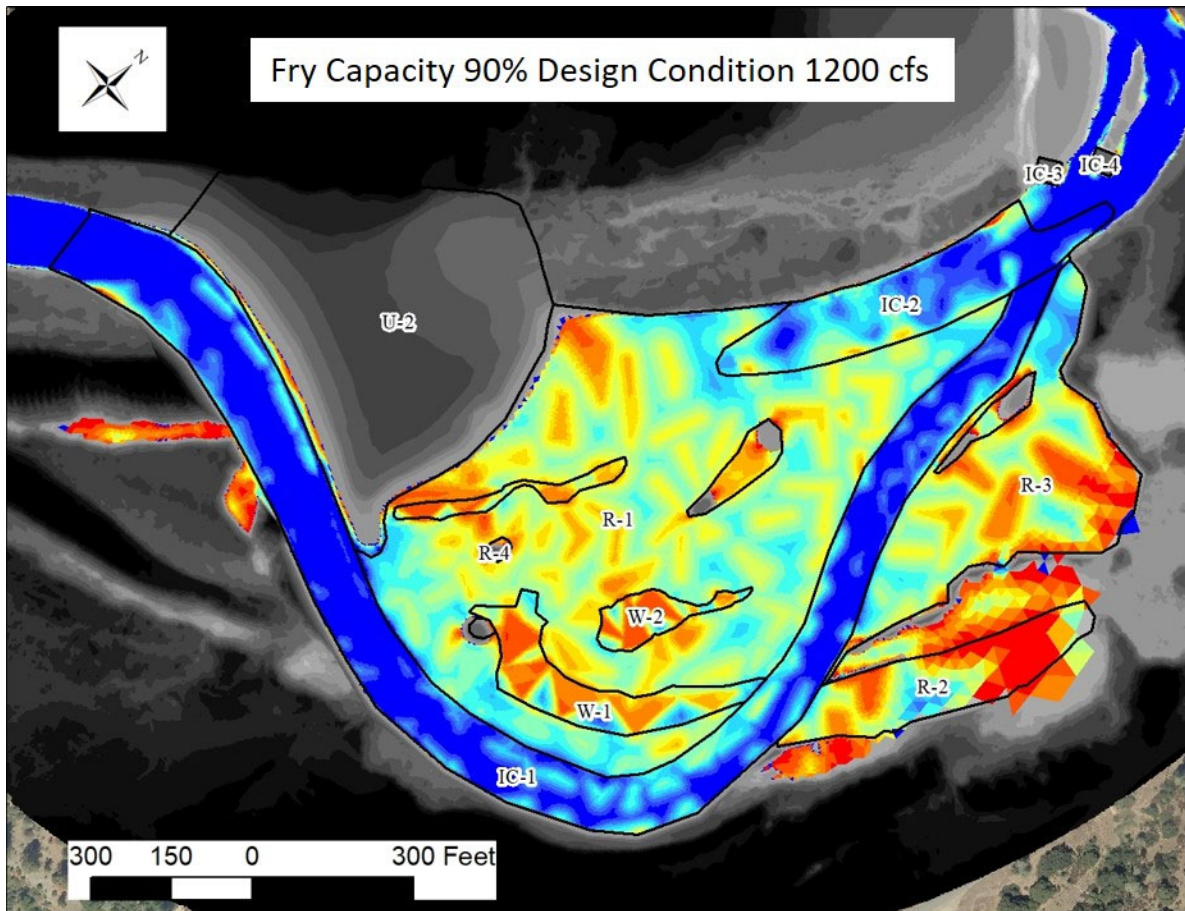
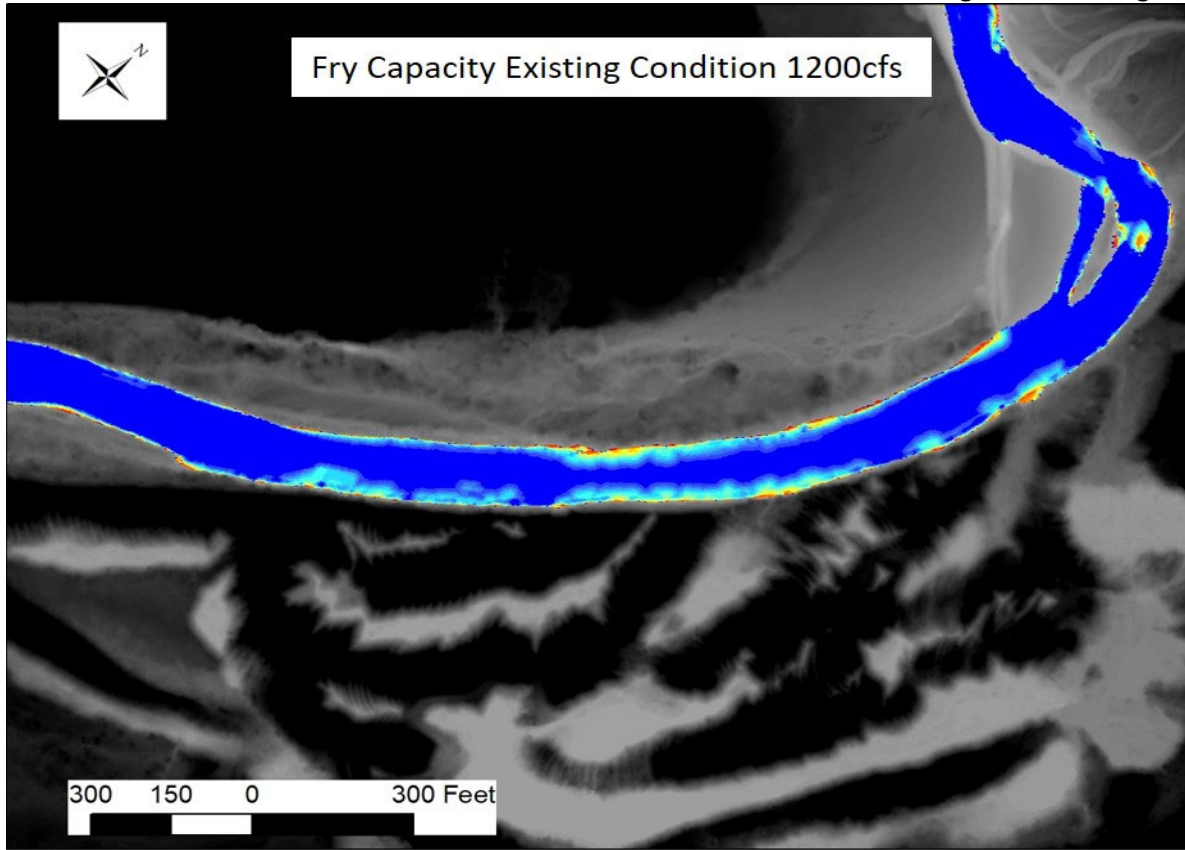
Cover maps used for habitat modeling

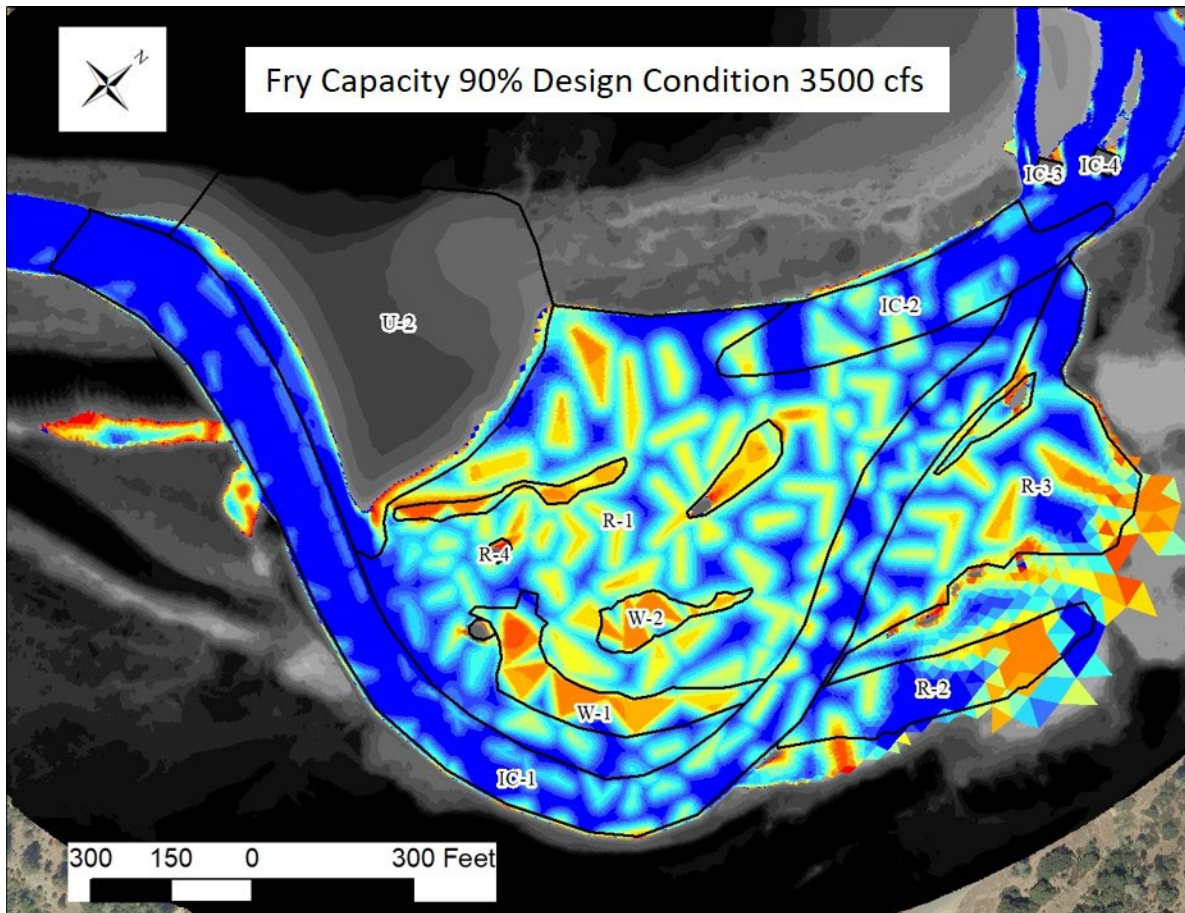
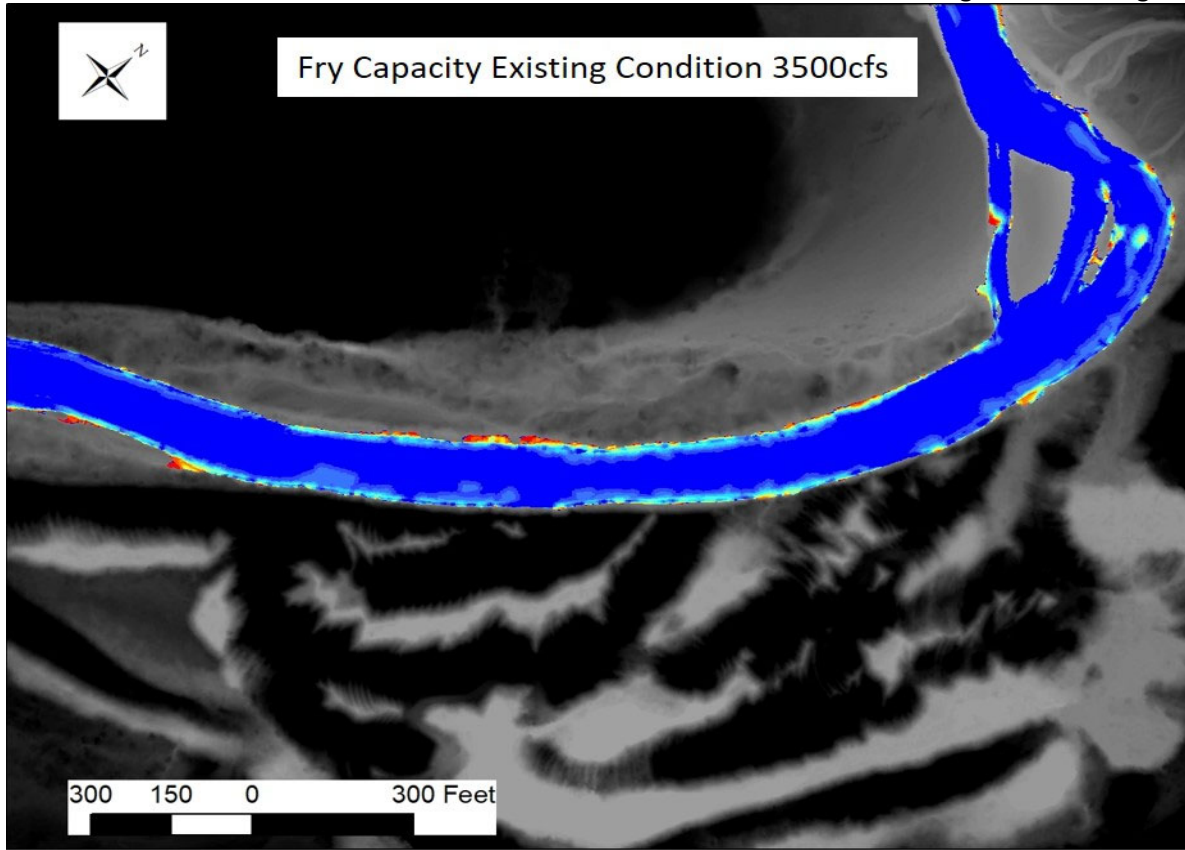


Fish capacity area (density) heat maps

Red represents the best habitat. Blue is the least suitable.







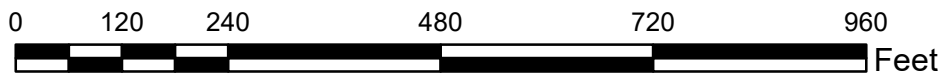
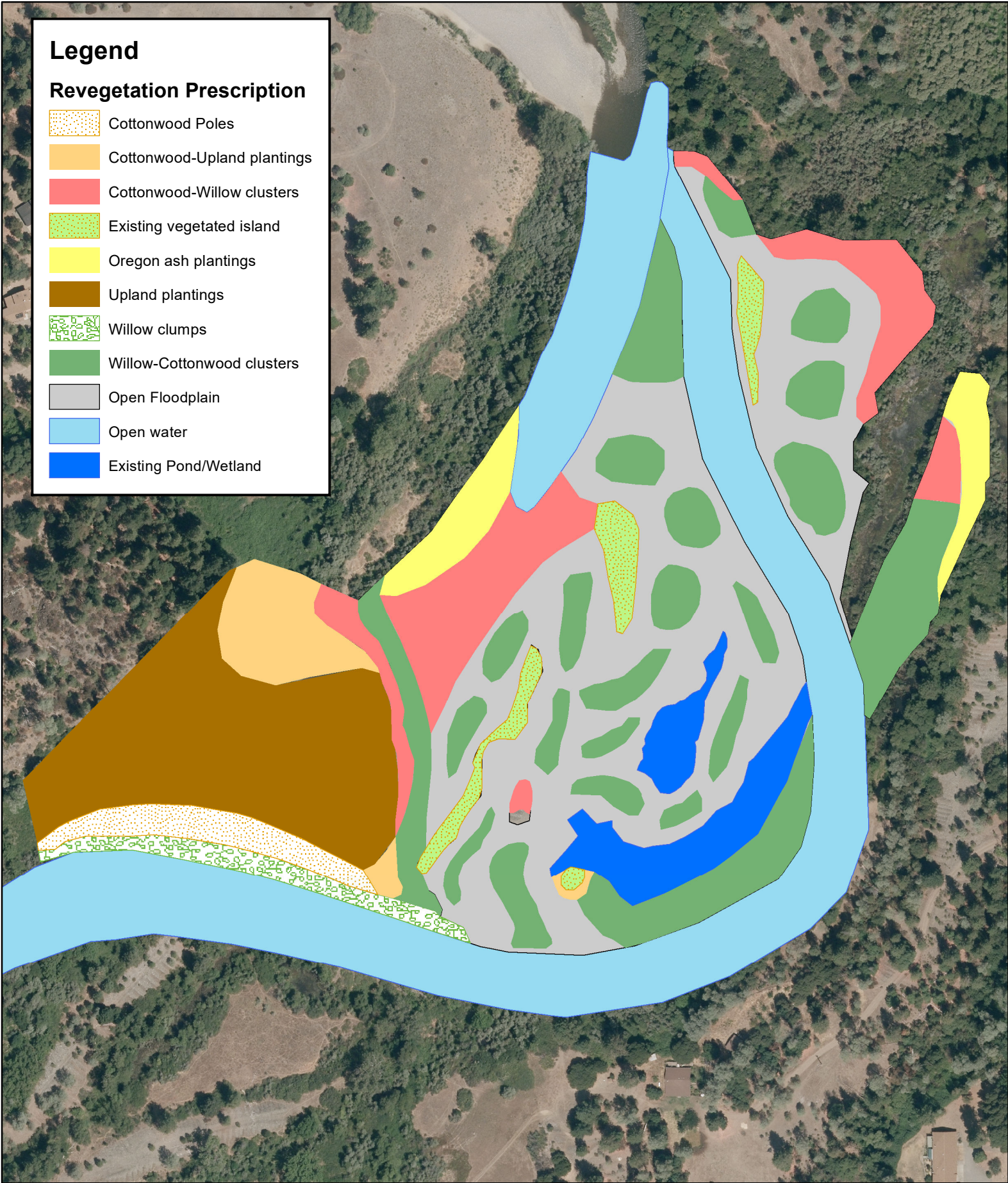
Appendix F: Revegetation Design Details

(Next Page)

Legend

Revegetation Prescription

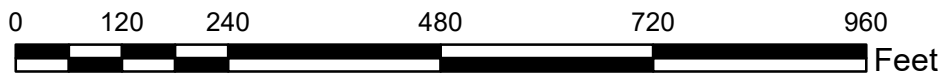
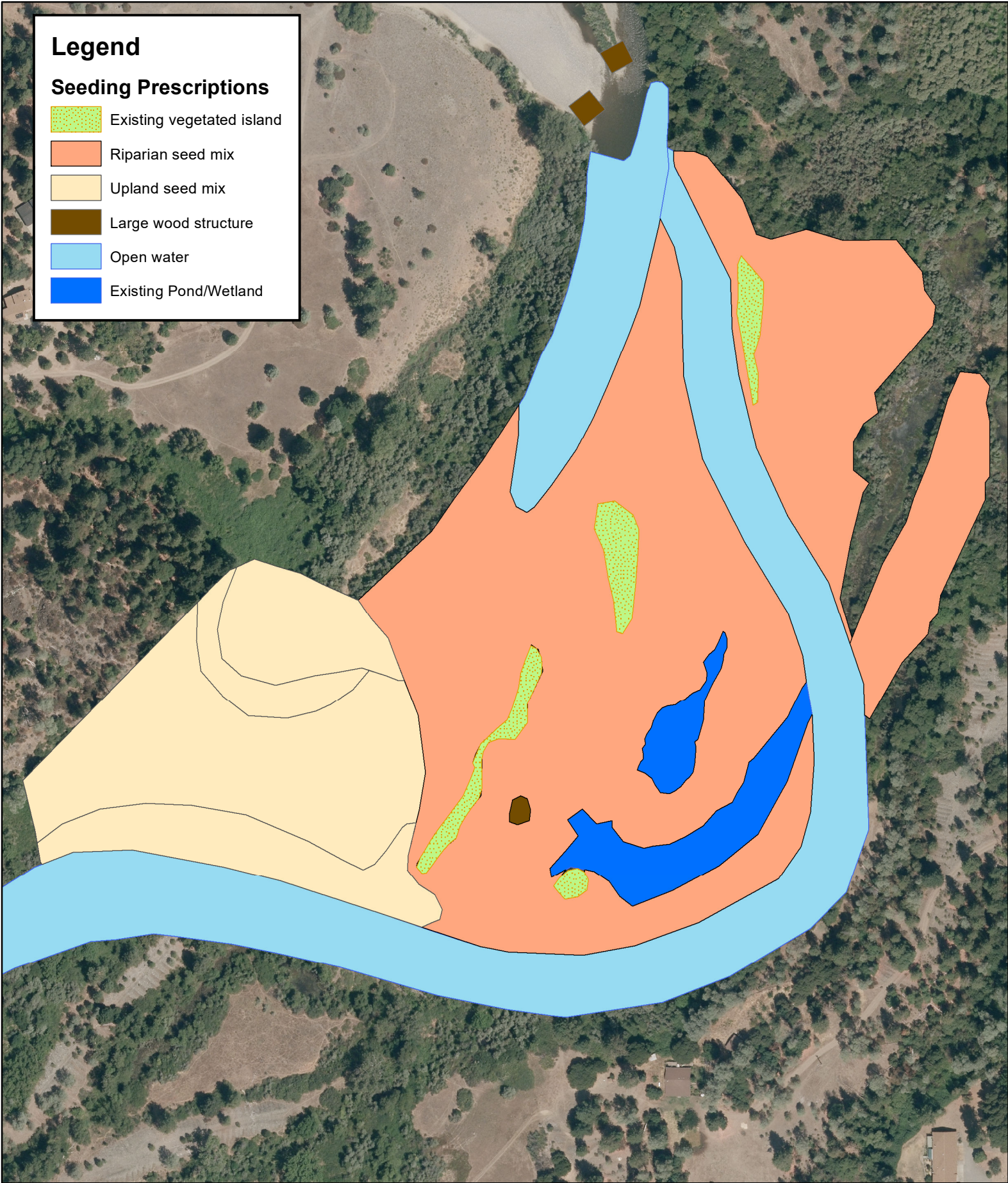
- Cottonwood Poles
- Cottonwood-Upland plantings
- Cottonwood-Willow clusters
- Existing vegetated island
- Oregon ash plantings
- Upland plantings
- Willow clumps
- Willow-Cottonwood clusters
- Open Floodplain
- Open water
- Existing Pond/Wetland



Legend

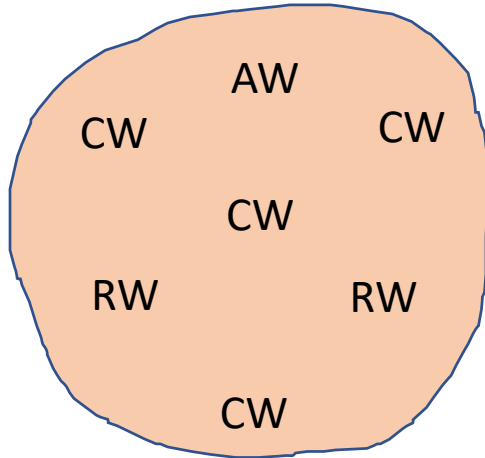
Seeding Prescriptions

- Existing vegetated island
- Riparian seed mix
- Upland seed mix
- Large wood structure
- Open water
- Existing Pond/Wetland



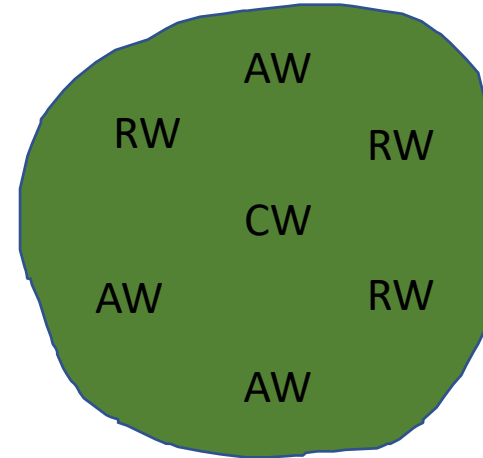
Revegetation Cluster Layouts

Cottonwood-Willow Cluster



CW – Cottonwood, 4 per cluster
RW – Red willow, 2 per cluster
AW – Arroyo willow, 1 per cluster

Willow-Cottonwood Cluster



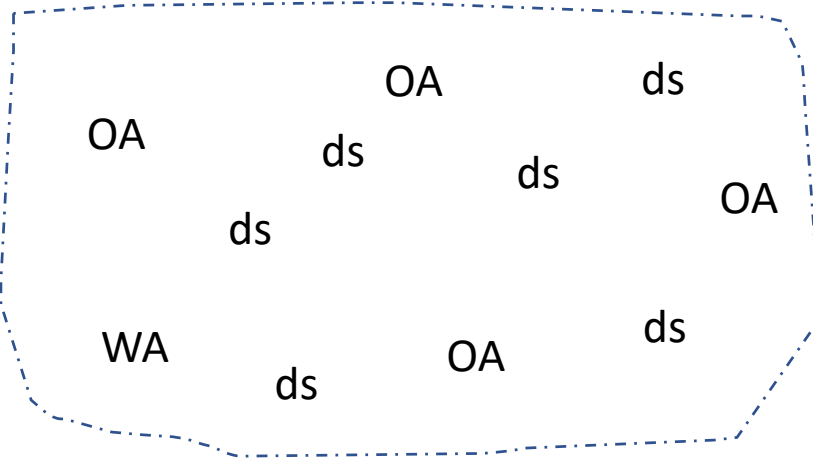
CW – Cottonwood, 1 per cluster
RW – Red willow, 3 per cluster
AW – Arroyo willow, 3 per cluster

Notes:

1. Planting clusters will be approximately 5 ft diameter (width of one excavator bucket)
2. Distance between clusters will be variable with a minimum distance of 10' between centers
3. 300 clusters will be planted per acre
4. All plants in these clusters will be 5-6' long live-stakes harvested on site
5. Willow species are interchangeable and will depend on final availability
6. Red-osier dogwood may also be used in place of willow species and will depend on availability

Revegetation Planting Polygon Layouts

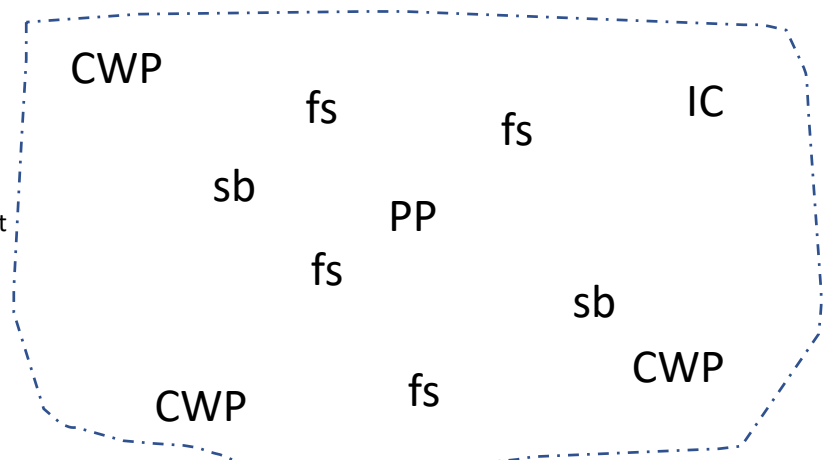
Oregon Ash Planting Polygons



~20 ft

OA – Oregon ash (4 per 200 sq ft)
WA – White alder (1 per 200 sq ft)
ds – Douglas spirea (6 per 200 sq ft)

Cottonwood-Upland Planting Polygons



~10 ft

~20 ft

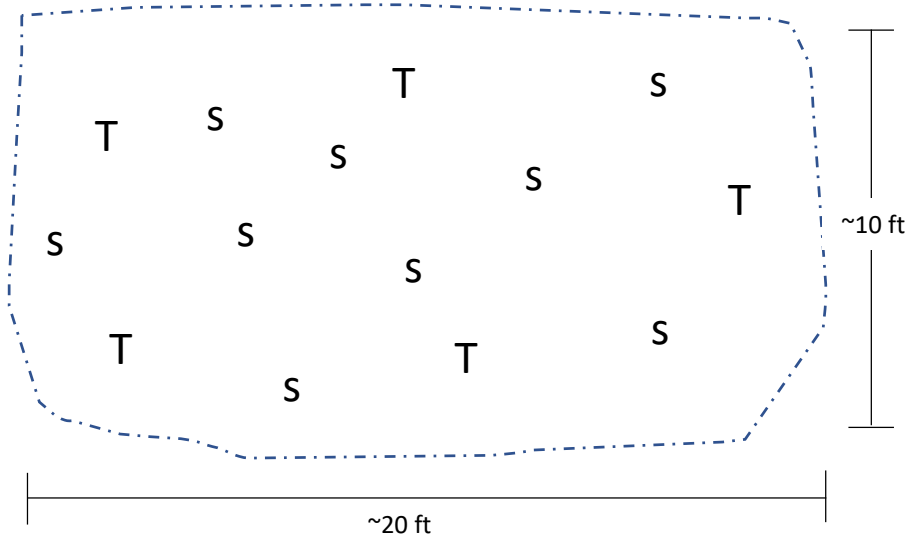
CWP – Cottonwood Pole, (3 per 200 sq ft)
PP – Ponderosa pine, (1 per 200 sq ft)
IC – Incense cedar, (1 per 200 sq ft)
fs – Fragrant sumac (4 per 200 sq ft)
sb – snowberry (2 per 20 sq ft)

Notes:

1. Planting polygons will be planted continuously throughout the site and not in discrete clusters
2. Cottonwood pole cuttings should be a minimum of 10 ft long and installed during upland plug construction
3. All other plants in these plantings are rooted plants (bare root or container stock)
4. A total of 11 woody plants, 5 trees and 6 shrubs per 200 sq ft (~2,400 per acre)
5. All trees should be planted ~8-12 ft apart, shrubs can be planted at variable distances from ~3-8' apart
6. Final spatial configuration will vary
7. Additional native shrubs suited to riparian floodplains will be included in the final planting plan, increasing planting diversity

Revegetation Planting Polygon Layouts

Upland Planting Polygon



T – Tree species (5 per 200 sq ft)
 s – Shrub species (9 per 200 sq ft)

Species list for upland plantings

Species	Common name	Form
<i>Calocedrus decurrens</i>	incense cedar	Tree
<i>Pinus ponderosa</i>	Ponderosa pine	Tree
<i>Pinus sabiniana</i>	ghost pine	Tree
<i>Pseudotsuga menziesii</i>	Douglas-fir	Tree
<i>Quercus chrysolepis</i>	live-canyon oak	Tree
<i>Quercus garryana</i>	Gary oak	Tree
<i>Quercus wislizenii var. frutescens</i>	interior live-oak	Tree
<i>Amelanchier alnifolia</i>	western serviceberry	Shrub
<i>Ceanothus cuneatus</i>	buckbrush	Shrub
<i>Ceanothus integrifolius</i>	deerbrush	Shrub
<i>Cercocarpus betuloides</i>	birchleaf mt. mahogany	Shrub
<i>Rhus aromatica</i>	fragrant sumac	Shrub
<i>Rubus leucodermis</i>	black-cap raspberry	Shrub
<i>Rubus ursinus</i>	trailing blackberry	Shrub
<i>Sambucus nigra</i>	blue elderberry	Shrub

Notes:

1. Planting polygons will be planted continuously throughout the site and not in discrete clusters
2. All plants in these plantings will be rooted plants (bare root or container stock).
3. Oaks may be planted as acorns with 3 acorns per hole.
4. A total of 14 woody plants, 5 trees and 9 shrubs per 200 sq ft (~3,000 plants per acre)
5. All trees should be planted ~8-12 ft apart, shrubs can be planted ~3-5' apart
6. Final spatial configuration will vary

Revegetation Quantities, Woody Plants

Upland plantings

Species	Common name	Quantity	Material
<i>Calocedrus decurrens</i>	incense cedar	848	Bare root
<i>Pinus ponderosa</i>	Ponderosa pine	848	Bare root
<i>Pinus sabiniana</i>	ghost pine	636	Bare root
<i>Pseudotsuga menziesii</i>	Douglas-fir	212	Bare root
<i>Quercus chrysolepis</i>	live-canyon oak	424	Container
<i>Quercus garryana</i>	Gary oak	424	Container
<i>Quercus wislizenii</i> var. <i>frutescens</i>	interior live-oak	848	Container
<i>Amelanchier alnifolia</i>	western serviceberry	636	Bare root
<i>Ceanothus cuneatus</i>	buckbrush	424	Bare root
<i>Ceanothus integerrimus</i>	deerbrush	212	Bare root
<i>Cercocarpus betuloides</i>	birchleaf mt. mahogany	636	Bare root
<i>Rhus aromatica</i>	fragrant sumac	1060	Bare root
<i>Rubus leucodermis</i>	black-cap raspberry	848	Bare root
<i>Rubus ursinus</i>	trailing blackberry	212	Bare root
<i>Sambucus nigra</i>	blue elderberry	212	Bare root

Cottonwood-Upland Plantings

Species	Common Name	Quantity	Material
<i>Calocedrus decurrens</i>	incense cedar	217	Bare root
<i>Pinus ponderosa</i>	Ponderosa pine	217	Bare root
<i>Populus fremontii</i>	Fremont's cottonwood	652	Pole cutting
<i>Rhus aromatica</i>	fragrant sumac	869	Bare root
<i>Symphoricarpos albus</i>	snowberry	435	Bare root

Notes:

1. Quantities, ratios and species listed here are targets and likely to change depending on availability
2. *Quercus* species may be planted as acorns. Acorn plantings will be 3 acorns per hole, tripling the numbers identified above
3. *Populus fremontii* can be exchanged for *Populus balsamifera*
4. All pole cuttings must be a minimum of 10' long

Oregon ash plantings

Species	Common Name	Quantity	Material
<i>Faxinus latifloius</i>	Oregon ash	826	Bare root
<i>Alnus rhombifolia</i>	white alder	206	Bare root
<i>Spiraea douglasii</i>	Douglas spirea	1239	Bare root

Cottonwood-Willow Clusters

Species	Common Name	Quantity	Material
<i>Populus fremontii</i>	Fremont's cottonwood	13795	Live-cutting
<i>Salix laevigata</i>	red willow	6898	Live-cutting
<i>Salix lasiolepis</i>	Arroyo willow	3449	Live-cutting

Willow-Cottonwood Clusters

Species	Common Name	Quantity	Material
<i>Populus fremontii</i>	Fremont's cottonwood	1697	Live-cutting
<i>Salix laevigata</i>	red willow	5090	Live-cutting
<i>Salix lasiolepis</i>	Arroyo willow	5090	Live-cutting

Cottonwood Poles

Species	Common Name	Quantity	Material
<i>Populus fremontii</i>	Fremont's cottonwood	1,306	Pole cutting

Revegetation Quantities, Seed

Riparian Seed Mix

Species	Common Name	Bulk lbs/acre
<i>Achillea millifolium</i>	common yarrow	0.5
<i>Bromus carinatus</i>	California brome	13
<i>Elymus glaucus</i>	blue wildrye	12
<i>Hordeum brachyantherum</i>	meadow barley	4
<i>Festuca microstachys</i>	three weeks fescue	6
<i>Festuca californica</i>	California fescue	6
<i>Lupinus species</i>	lupine species	4
<i>Trifolium willdenovii</i>	tomcat clover	3
	Total lbs/acre:	48.5

Upland Seed Mix

Species	Common Name	Bulk lbs/acre
<i>Achillea millifolium</i>	common yarrow	0.5
<i>Bromus carinatus</i>	California brome	13
<i>Elymus elymoides</i>	squirreltail	6
<i>Elymus glaucus</i>	blue wildrye	12
<i>Eriophyllum lanatum</i>	Oregon sunshine	1
<i>Festuca microstachys</i>	three weeks fescue	6
<i>Festuca californica</i>	California fescue	6
<i>Lupinus species</i>	lupine species	4
	Total lbs/acre:	48.5

Notes:

1. Quantities, ratios and species listed here are targets and likely to change depending on availability
2. Possible lupine species include *L. albifrons*, *L. bicolor*, *L. microcarpus* and *L. latifolius*
3. Additional upland species may be added to the seed mix including *Penstemon deustus*, *Balsamorhiza deltoidei*, and *Stipa lemmonii*

Appendix G: Invasive Species Prevention Plan

CONTENTS

Introduction	1
Invasive Species Prevention.....	2
Sanitation Protocols.....	3
Invasive Exotic Vegetation (IEV).....	3
Invasive Exotic Pathogens (IEP).....	4
Phytopthera species.....	4
Chytid fungus	4
References	4

INTRODUCTION

The project is located along the Trinity River at Oregon Gulch in Junction City. Over 600,000 cubic yards of dredged mine tailings from the early 20th century are piled in mounds 20-30 ft high in a relatively broad floodplain of the Trinity River. Most of the mine tailings (75%) will be removed and disposed of off-site. The remaining tailings will be used for the reconstruction of the floodplain using a restoration technique called “stage 0” (Powers et al. 2019). Stage-zero projects reconstruct floodplains down to a single elevation, restoring the original valley grade across the valley bottom longitudinally and laterally. The reconstructed floodplain will preserve existing native vegetation and include new surface roughness features in an effort to accelerate forest island formation. The revegetation plan will focus on planting surface roughness features and establishing native forests on an engineered upland feature designed to prevent the new channel from re-occupying the old channel.

Existing site conditions are variable. The deep layers of mine tailings are mostly devoid of vegetation. The crests of the piles are unable to support significant vegetation (Figure 1). Vegetation is limited to the lower elevations between mounds. Some invasive species are present in the lower elevations and include Himalayan blackberry (*Rubus armeniacus*), reed canarygrass (*Phalaris arundinacea*), yellow star thistle (*Centaurea solstitialis*) and tree of heaven (*Ailanthus altissima*). Sudden Oak Death (SOD) caused by the pathogen *Phytophthora ramorum* is not known to be in this reach of the Trinity River.



Figure 1. Mine tailings piles at the Oregon Gulch project site. Vegetation does not grow on the crests of the piles and is limited to low elevation areas between piles.

For the purpose of invasive species management, the project is split into three phases; 1) mine tailing removal, 2) floodplain reconstruction and 3) revegetation post construction. The management of invasive species will be refined for each phase based on the implementation activities. The first phase, mine tailings removal, will occur over a period of 2 years. This phase will begin with the removal of all vegetation growing on the tailings, including some invasive species. The bulk of the work in the phase is the physical removal of the mine tailings using heavy equipment such as excavators and dump trucks. The second phase, floodplain reconstruction, will occur in one season. The floodplain will be recontoured to a new elevation that will reconnect the main stem flow of the Trinity river to the floodplain during minor flood events. The remaining tailings will be reformed into an upland feature that will plug the old channel, forcing the river into the newly construction floodplain. Heavy equipment will be required for this phase of the project. The final phase, revegetation post-construction, will focus on planting the upland feature. Planting the floodplain will occur during and after construction and will require the use of small excavators for willow and cottonwood staking.

INVASIVE SPECIES PREVENTION

Invasive species eradication and prevention will be prominent features of this project. We will follow the following objectives to prevent the spread of invasive exotic vegetation IEV and invasive exotic pathogens (IEP) from and into the project site;

- All equipment used for this project will be sanitized to ensure they are free of IEV and IEP.

- Ensure no IEV propagules are transported off site during tailings removal
- Ensure no IEV propagules are transported to the project area from the areas receiving mine tailings
- All project materials (plants, soils, woody debris) imported from off-site must be free of IEV and IEP species.

We will employ a variety of methods to achieve these objectives.

Sanitation Protocols

To prevent invasive species, the following sanitation protocols will be followed;

- All heavy equipment will be thoroughly cleaned before working in the project area.
- A wash station will be established on site to clean any equipment moving into the project area from offsite.
- Destination sites for tailings will be inspected for IEV species prior to hauling any material. If sites are infested with IEV, additional sanitation protocols or IEV removal from the site will be implemented.
- Clothing, boots, and gear will be cleaned prior to entering or leaving the work site. Boot brushes can be used to remove dirt and seeds from boots and pants.
- To reduce the possibility of transmitting chytrid fungus, we will clean and dry all equipment and wet or muddy footwear before and between visiting frog sites.

Invasive Exotic Vegetation (IEV)

Preventing the spread of invasive exotic vegetation is critical to any restoration project. In addition to the sanitation steps outlined above, we will follow the equipment and tool cleaning protocols outlined in “Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers (3rd ed.)” (Cal-IPC 2012).

Phase one of the project will include the removal and/or containment of all IEV species present on or near the site. Prior to the removal of tailings, IEV species present on site within the tailings will be removed and stored in manageable piles on site. The piles will be burned to ensure no IEV propagules (i.e. root systems) survive. Populations of IEV in close proximity to the project, with a focus on staging areas and access roads, will be treated and contained during all phases of the project using mechanical removal methods. Effective containment will require a multi-year treatment schedule to ensure no seed is produced during project implementation, reducing the risk of transporting IEV propagules on heavy equipment during project implementation.

The timeline for IEV prevention and removal management for phase one:

- All equipment for phase one will be cleaned prior to working on site.
- All equipment employed for removal of IEV from tailing piles will be re-cleaned after removal is completed.
- Equipment will not be cleaned during tailings removal operations. IEV prevention will rely on keeping IEV species contained at the project site *and* at the all sites receiving tailings. All receiving sites are close to the project site and are within Trinity County.

Phase two and three of the project will continue IEV removal and containment efforts. All equipment used will be re-sanitized following the above protocols prior to implementation or both phases of operation. Equipment housed on site will not require repeat cleanings during the implementation phases 2 or 3.

Invasive Exotic Pathogens (IEP)

Phytophthora species

Sudden Oak Death (SOD) (*Phytophthora ramorum*) is not known to be present this section of the Trinity River. It is known to be present in the southwest corner of Trinity County. *Phytophthora ramorum* primarily spreads aurally, but human caused introductions are frequent. Any soil or nursery plants procured for this project will be from low risk sources located outside of known infested areas and only nurseries that follow the Best Management Practices designed to prevent the spread of SOD as outlined by the California Oak Mortality Task Force (<http://www.suddenoakdeath.org/diagnosis-and-management/best-management-practices/>). Nurseries will be inspected prior to plant procurement to confirm BMPs are being followed.

Chytrid fungus

Foothill yellow-legged frogs are frequently observed at Oregon Gulch. To prevent introductions of Chytrid fungus (*Batrachochytrium dendrobatidis*), sanitation of all equipment and personal gear as described above will be strictly adhered to for all in a water work.

We will also take the following precautions:

- Only touch frogs when absolutely necessary. Remember to use disposable gloves, sample bags and sterile equipment.
- Never move a frog from one area to another.
- Carry cleaning utensils and a disinfectant for use between sites.

REFERENCES

Cal-IPC. 2012. Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers (3rd ed.). Cal-IPC Publication 2012-03. California Invasive Plant Council, Berkeley, CA. Available at www.cal-ipc.org.

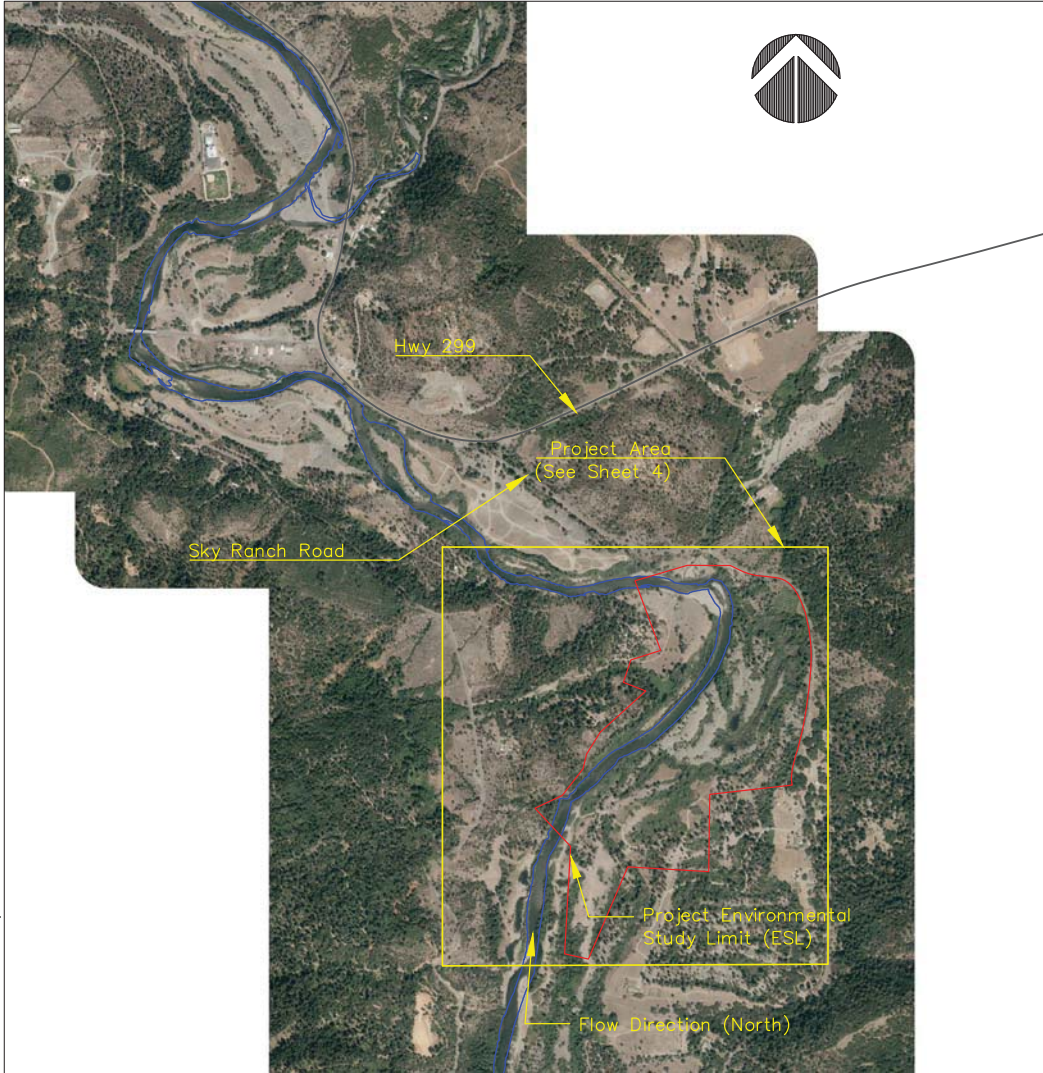
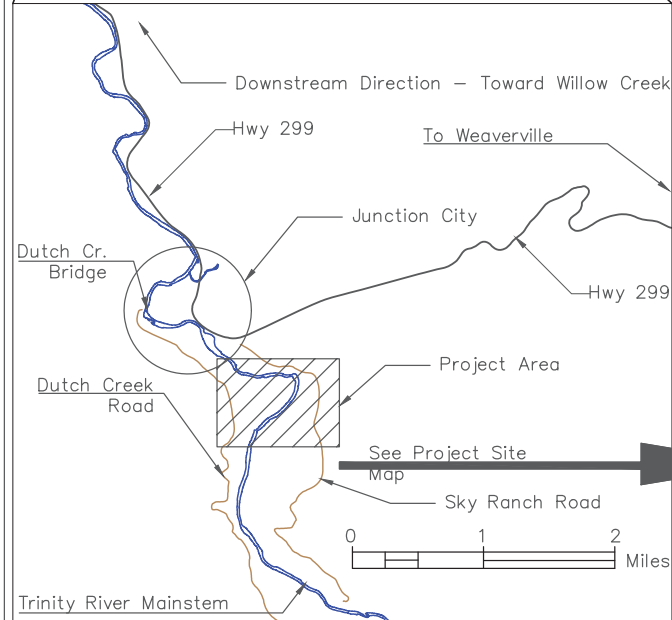
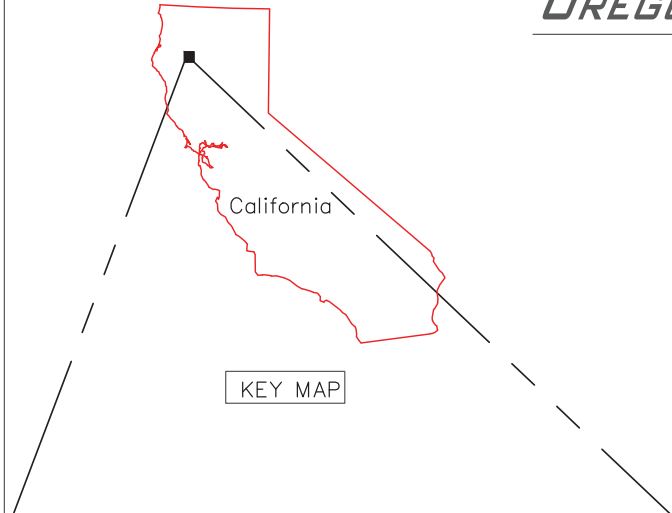
Powers, PD, M. Helstab, S.L. Niezgoda. 2019. A process-based approach to restoring depositional river valleys to Stage 0, an anastomosing channel network. River Research Applications. Vol 3; 3-13.

Appendix H: Large Wood Design Details

Appendix I: Construction Drawings

(Next Page)

OREGON GULCH - 90% DESIGN DRAWINGS



Oregon Gulch Channel Rehabilitation Project - 90% Design Drawings
June 2020



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM
Oregon Gulch 90% Design Drawings - Yurok Tribe
Cover Sheet - Location Map



Yurok Tribe

Drawing Type:

COVER

Drawn By

DJ Bandrowski

Checked By

Gaeuman & Martin

Design Date:

June 2020

Sheet number

1 of 22

Index of Sheets

No.	Sheet Name
1	Cover Sheet - Location Map
2	Sheet Index - Notes - Quantities
3	Notes and Legend
4	Planview - Existing Ground - Terrain Surface
5	Planview - Existing Ground - Aerial Photo with Contours
6	Planview - Design Grade - Terrain Surface
7	Planview - Design Grade - Aerial Photo with Contours
8	Planview - Design Alignment and Cross-Sections Locations
9	Planview - Design and Construction Boundaries
10	Design Profile - IC-1 Sheet 1
11	Design Profile - IC-1 Sheet 2
12	Design X-Sections - Sheet 1
13	Design X-Sections - Sheet 2
14	Design X-Sections - Sheet 3
15	Large Wood Design - Planview - IC-3 and IC-4 - Sheet 1
16	Large Wood Design - Planview - IC-3 and IC-4 - Sheet 2
17	Large Wood Design - X-Section - IC-3
18	Large Wood Design - X-Section - IC-4
19	Large Wood Design - Sequence - IC-3
20	Large Wood Design - Sequence - IC-4
21	Large Wood Design - Wood Habitat Details - Sheet 1
22	Large Wood Design - Wood Habitat Details - Sheet 2

Material Quantity List

Feature ID	CUT (CY)	FILL PR - (CY)	FILL CGC - (CY)	FILL CSB - (CY)	FILL FINES - (CY)	12-18" Driven Posts No Rootwad (25ft.)	8-12" Oblique Pin Logs No Rootwad (15ft.)	< 6" DBH Racking Wood (20ft.)	Whole Trees (80ft. Max)	>18" DBH Rootwad (30ft)	12-18" DBH Rootwad (30ft.)
R-1	233,070	2,070	4,140						50	40	30
R-2	32,640								5		15
R-3	68,880								10	5	25
R-4				150					2	4	4
U-1		143,000									
U-2		21,010	5,200	12,350	2,390				15	30	10
IC-1	181,890								15	30	30
IC-2		1,260	3,790						10	15	10
IC-3				225		4	8	20	4	12	
IC-4				275		4	8	20	2	11	
W-1									25	15	20
W-2									10	5	5
Total =	516,480	24,340	13,130	13,000	2,390	8	16	40	148	167	149



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe

Sheet Index and Quantities



Yurok Tribe

Drawing Type:

INDEX

Drawn By

DJ Bandrowski

Checked By

Gaeuman & Martin

Design Date:

June 2020

Sheet number

GENERAL NOTES

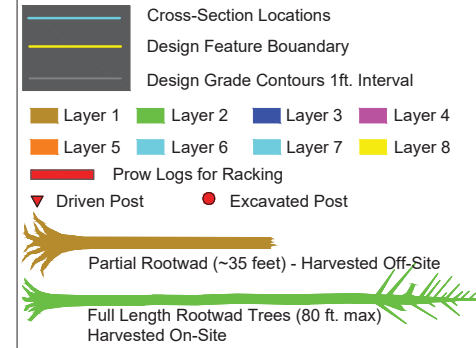
- These plans are a graphical representation of the work to be performed for the Trinity River Restoration Program, Oregon Gulch Channel Rehabilitation
- References to the right or left bank on these plans are based on a reference point looking downstream.
- All dimensions are shown in feet unless otherwise specified.
- The aerial topographic survey for these plans was prepared by:
Woolpert, Inc. (Orthophotography)
Woolpert, Inc. (Terrestrial and Bathymetric Topography)
CA Department of Water Resources. (Site Control)
Date of Existing Ground DTM Development - 2012
- Aerial photographs: July 2019.
- Existing contours within the active channel, tree, and brush areas may not meet 1 ft accuracy and should be considered approximate.
- Survey control points were established by the Department of Water Resources. All subsequent surveys reference these survey control points.
- Horizontal Datum for survey control points is NAD 83, California State Plane Coordinates, Zone 1, Survey Feet.
- Vertical Datum for survey control points is NAVD 88, Survey Feet.
- Grade of finished access roads should not exceed 15%.
- Contractor must reestablish access roads disturbed by construction activities by connecting any new roads to existing roads unless otherwise directed by on-site government representative.
- New access roads constructed by the contractor must be returned to original grade unless a government representative authorizes a new access road to remain in place post-construction.
- Design grade contour interval is 1-foot unless otherwise noted.
- Slopes shown on drawings are in the Horizontal:Vertical format.
- Upper case text in plans denotes features to be constructed.
- Prior to construction, the contractor shall clear and grub vegetation within construction areas only, unless flagged as 'save tree', 'clump planting', or 'large wood' by government.
- The government will flag biologically sensitive areas for protection from disturbance prior to construction.
- The contractor shall develop and maintain all construction access ramps, turnouts, turnarounds, etc., as necessary to haul and place fill as designated.
- Should it appear that the work to be done, is not sufficiently detailed or explained on these plans and attached specifications, the contractor shall contact the government representative who will intern contact the consultant team responsible for the plan preparation, prior to conducting work on that portion of the project.

LARGE WOOD - DESIGN SPECIFIC NOTES

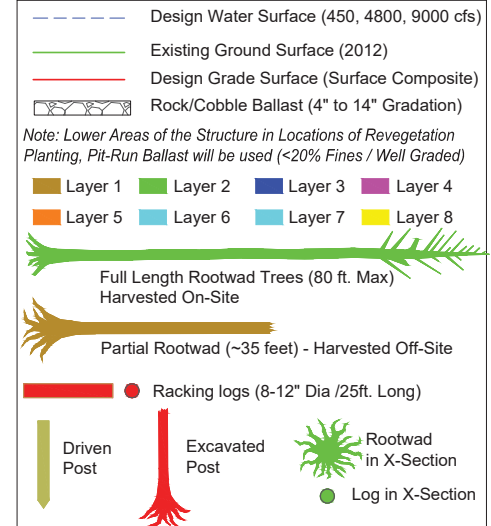
- These design drawings are a graphical representation of analysis performed and documented in the accompanying design report, and associated appendix documents.
 - Douglas fir wood shall be used for all Large Wood Structures including horizontal and vertical elements. The only exception is for Pin Logs, Ponderosa Pine may also be used.
- Rock cobble ballast and foundation materials for Large Wood Structures shall be a gradation between 4-14 inches. For all Large Wood Structures a minimum of 1.5 feet is required above last log layer
- Pit-Run Ballast (well graded matrix of soils/gravels with less than 20% fines) shall be used in lieu of cobble ballast in lower elevation areas of the Large Wood Structures to facilitate revegetation planting of willow clumps or cotton wood/willow cuttings. Exact locations within the Large Wood Structure shall be determined in the field by on-site design representative.
 - Pin Logs are not shown on planview or cross-section drawings. See sheet 34 for pin log typical details. Pin logs will be either dug into place or driven into place at oblique angles to provide additional stability of the wood elements both structural and habitat types. Exact pin locations and material size will be determined in the field by on-site design representative.
 - Revegetation planting materials shall be harvested on-site and placed strategically into the Large Wood Structures. Typical details can be found on Sheet 34. Exact material specifications, sequencing steps, care of material during staging, etc. shall be determined by on-site revegetation specialist.
 - Slash Material per structure and habitat feature is listed on Sheet 2. Exact quantities per layer and specific details regarding arrangement within each feature will be determined on-site by design representative.

Survey Control				
Pt. No.	Northing	Easting	Elevation	Code
1	2150336.1900	6267511.1700	1480.94	02JD
2	2146938.6600	6272860.2830	1485.812	OG1
3	2147259.3460	6272778.9250	1484.46	OG2
4	2144993.2540	6271903.2600	1485.46	SC-D
5	2145290.3480	6272003.1440	1479.96	SC-E
6	2143891.4840	6271192.8930	1480.35	SC-F
7	2144463.2840	6271200.8820	1482.67	SC-G

Legend - Planview



Legend Cross-Sections



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Sheridan & Deep Gulch Large Wood Drawings
General Notes, Legend, and Survey Control Points



Yurok Tribe

Drawing Type:

NOTES

Drawn By

DJ Bandrowski

Checked By

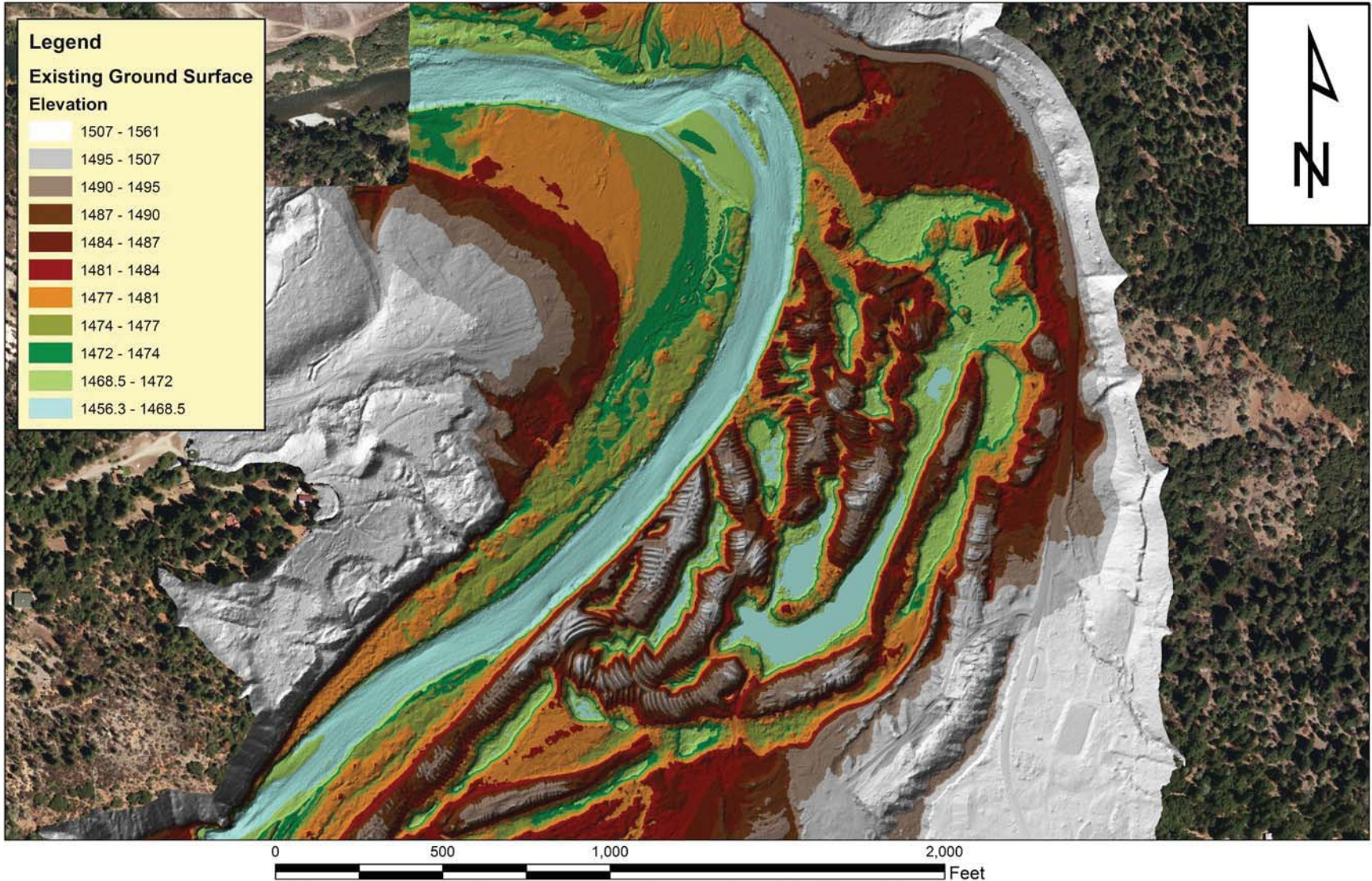
Gaeuman & Martin

Design Date:

June 2020

Sheet number

3 of 22



TRINITY RIVER RESTORATION PROGRAM
 Oregon Gulch 90% Design Drawings - Yurok Tribe
 Planview - Existing Ground - Terrain Surface



Drawing Type:

PLAN

Drawn By

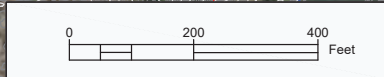
DJ Bandrowski
 Checked By

Gaeuman & Martin
 Design Date:

June 2020
 Sheet number



Environmental Study Limits (ESL)



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe Planview - Existing Ground - Aerial Image w- Contours



Yurok Tribe

Drawing Type:

PLAN

Drawn By

DJ Bandrowski

Checked By

Gaeuman & Martin

Design Date:

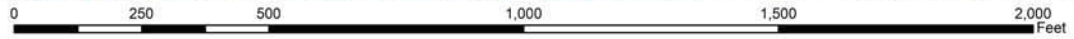
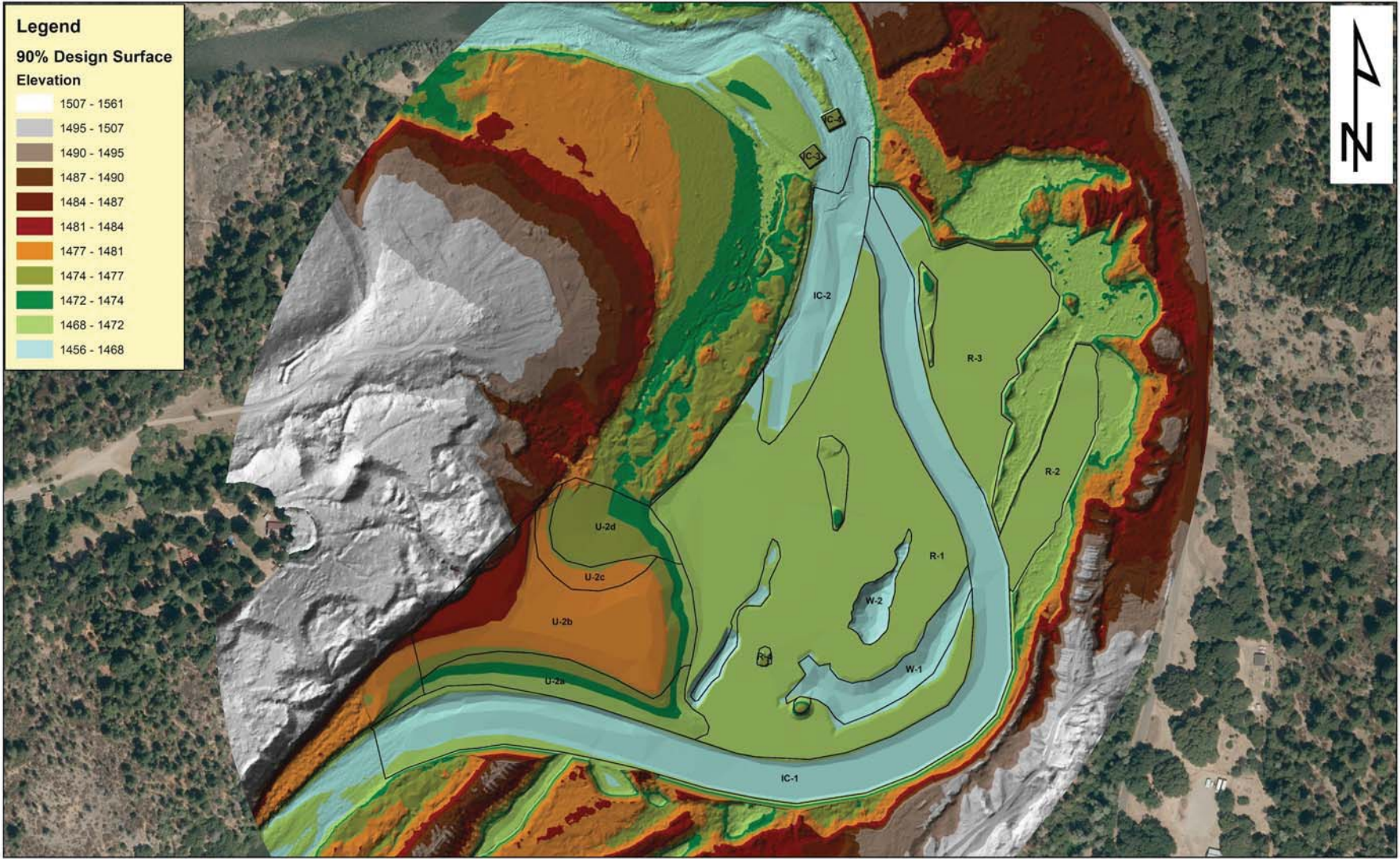
June 2020

Sheet number

Legend

90% Design Surface Elevation

1507 - 1561
1495 - 1507
1490 - 1495
1487 - 1490
1484 - 1487
1481 - 1484
1477 - 1481
1474 - 1477
1472 - 1474
1468 - 1472
1456 - 1468



TRINITY RIVER RESTORATION PROGRAM
 Oregon Gulch 90% Design Drawings - Yurok Tribe
 Planview - Design Grade - Terrain Surface



Drawing Type:

PLAN

Drawn By

DJ Bandrowski

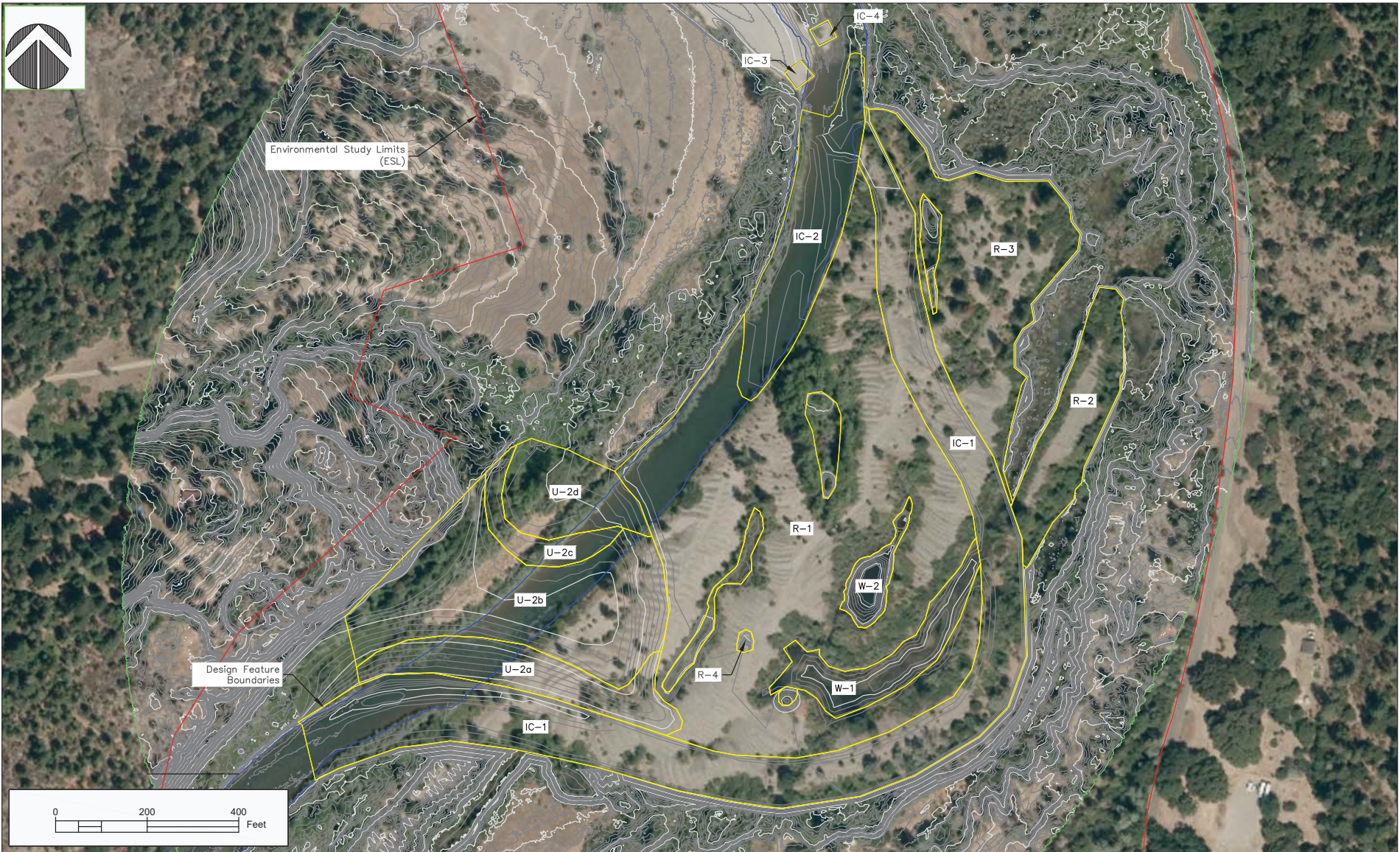
Checked By

Gaeuman & Martin
 Design Date:

June 10th, 2020

Sheet number

6 of 22



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe
Planview - Design Grade - Aerial Image & w- Contours



Yurok Tribe

Drawing Type:

PLAN

Drawn By

DJ Bandrowski

Checked By

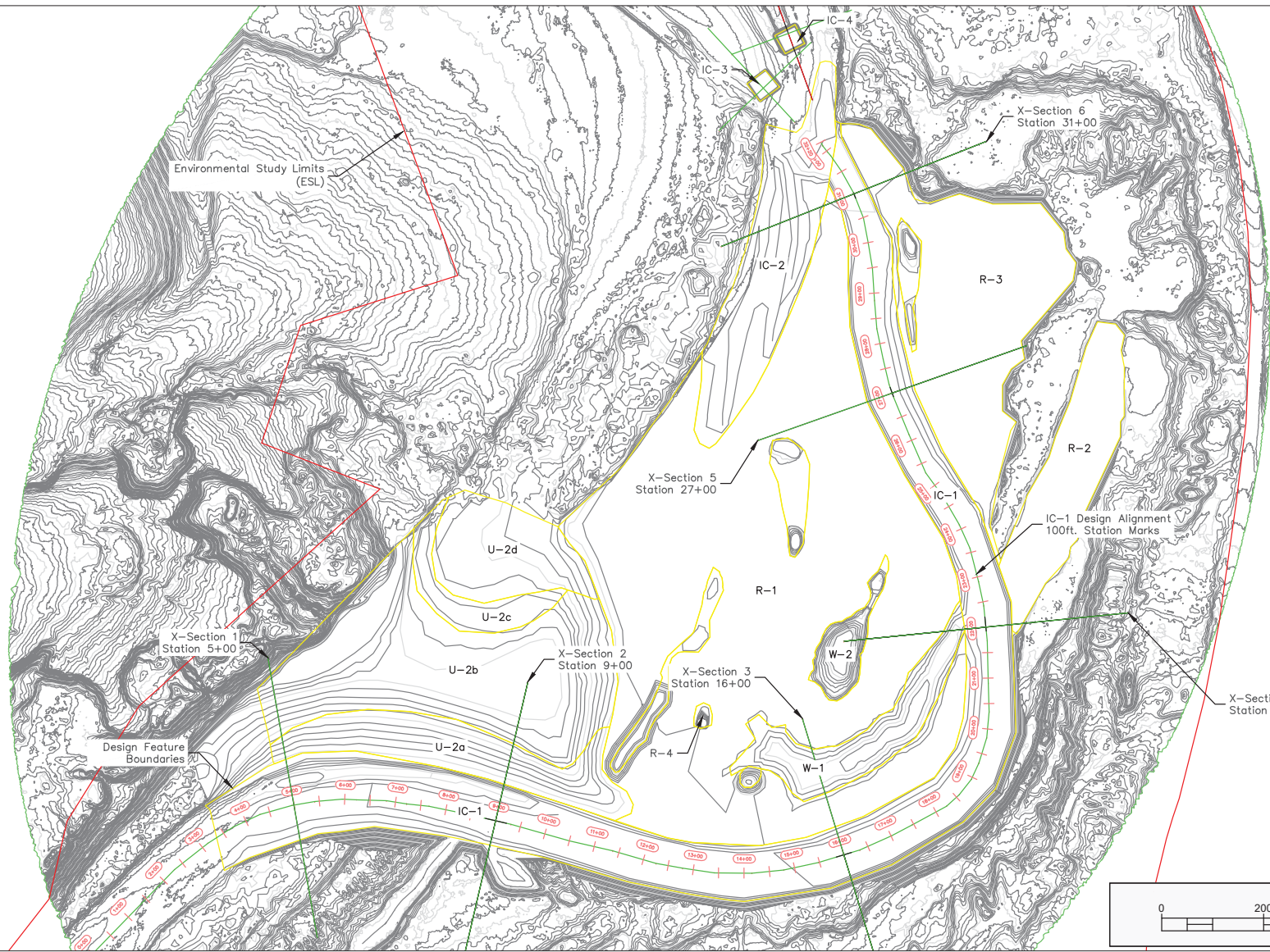
Gaeuman & Martin

Design Date:

June 2020

Sheet number

7 of 22



TRINITY RIVER RESTORATION PROGRAM
Oregon Gulch 90% Design Drawings - Yurok Tribe
Planview - IC-1 Design Profile and X-Section Locations



Drawing Type:

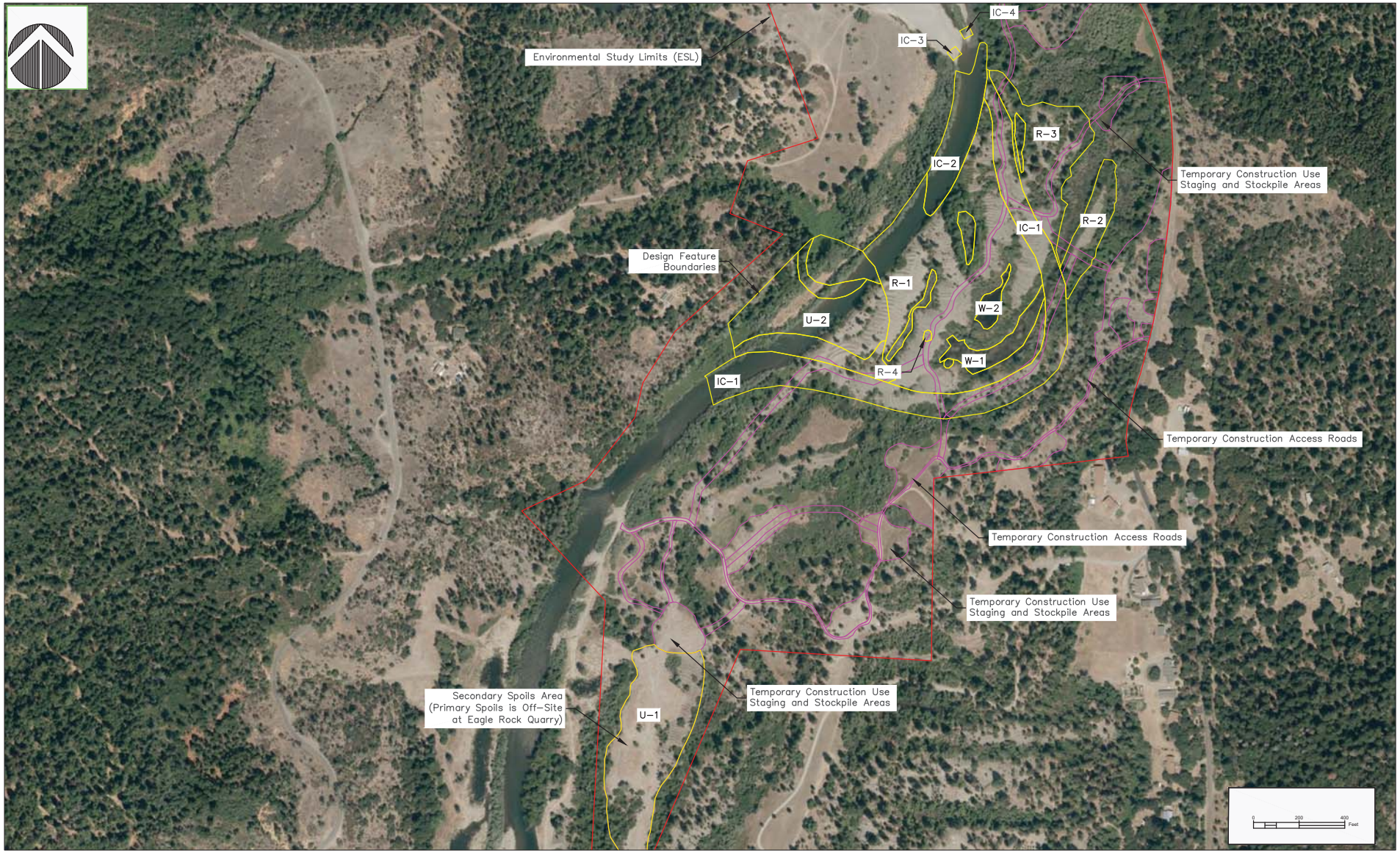
PLAN

Drawn By

DJ Bandrowski
 Checked By

Gaeuman & Martin
 Design Date:

June 2020
 Sheet number



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe Planview - Design and Construction Feature Boundaries



Yurok Tribe

Drawing Type:

PLAN

Drawn By

DJ Bandrowski

Checked By

Gaeuman & Martin
Design Date:

June 2020
Sheet number



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe Profile View - IC-1 Design Channel Alignment - Sheet 1



Yurok Tribe

Drawing Type:

PROFILE

Drawn By

DJ Bandrowski

Checked By

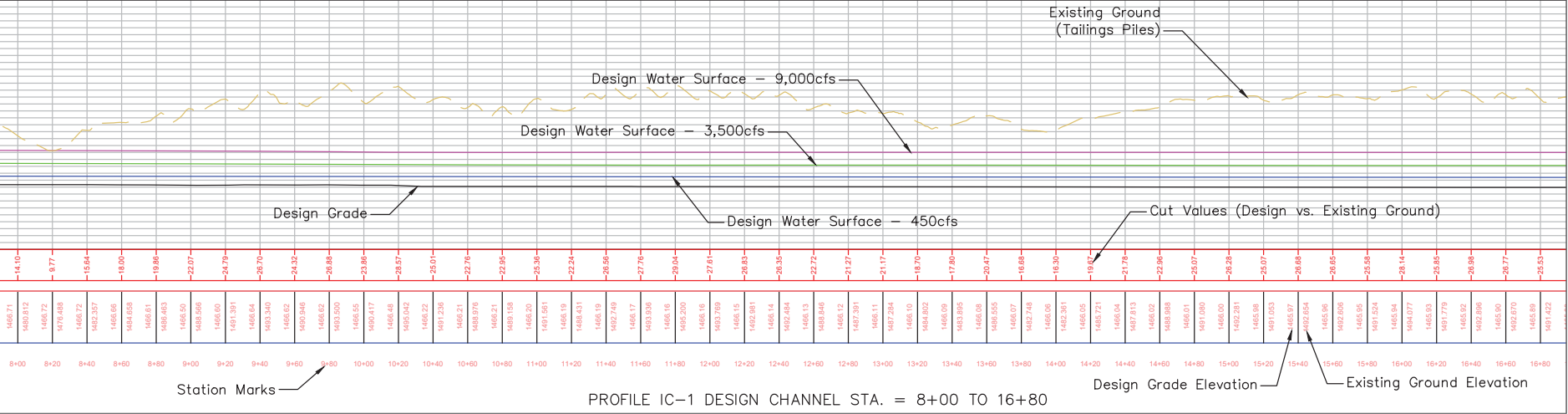
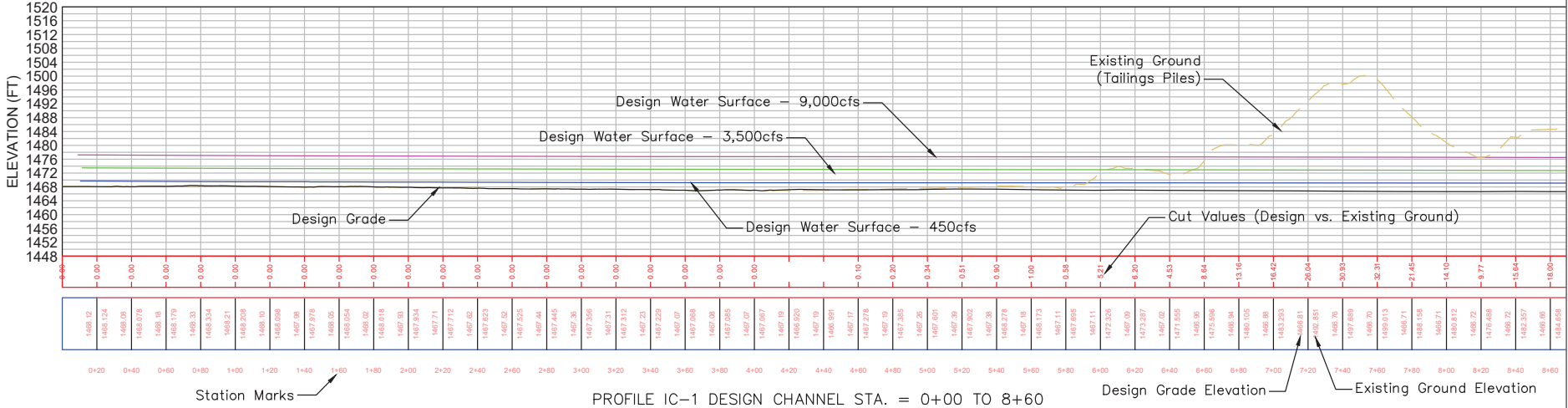
Gaeuman/Martin

Design Date:

June 2020

Sheet number

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Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe
Profile View - IC-1 Design Channel Alignment - Sheet 2



Yurok Tribe

Drawing Type:

PROFILE

Drawn By

DJ Bandrowski

Checked By

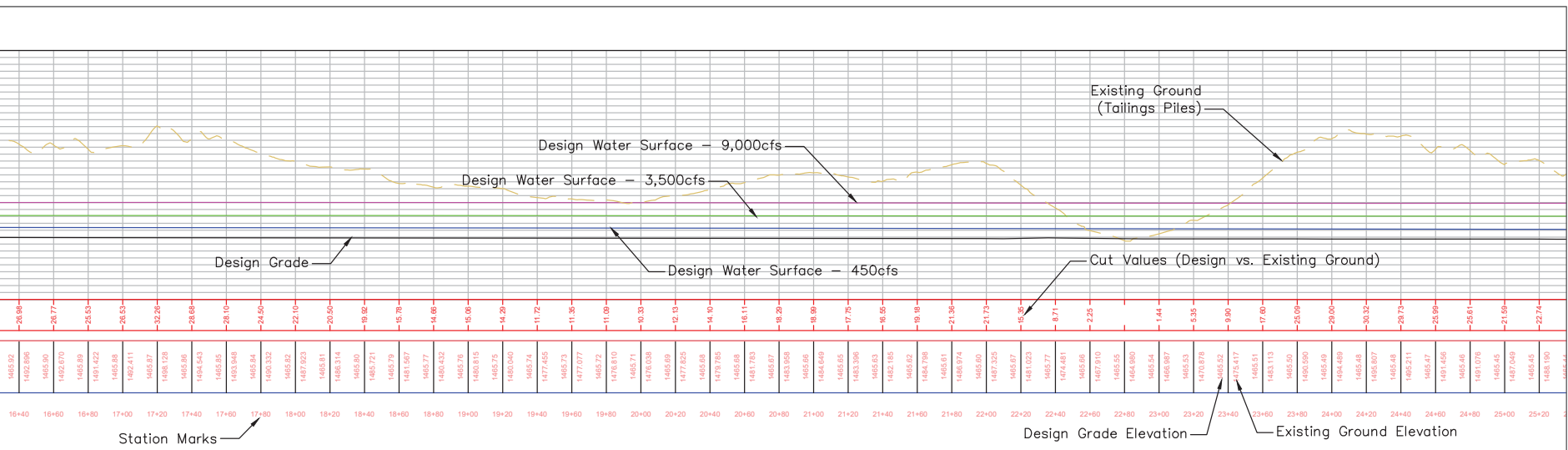
Gaeuman/Martin

Design Date:

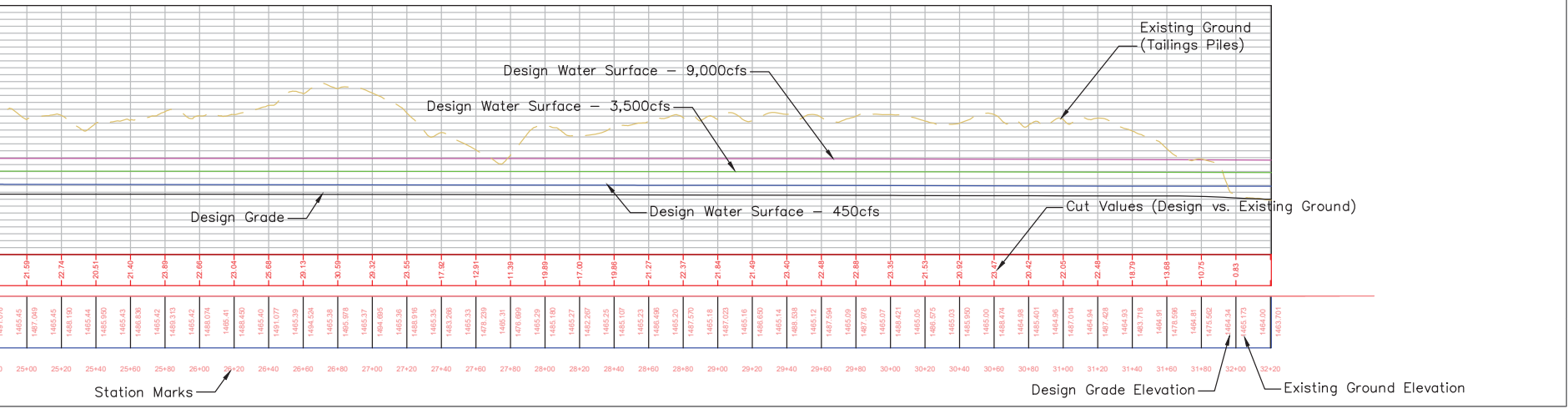
June 2020

Sheet number

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PROFILE IC-1 DESIGN CHANNEL STA. = 16+40 TO 25+20



PROFILE IC-1 DESIGN CHANNEL STA. = 25+00 TO 32+20



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe
Cross-Section View - Channel Design X-SEC - Sheet 1



Yurok Tribe

Drawing Type:

X-SEC

Drawn By

DJ Bandrowski

Checked By

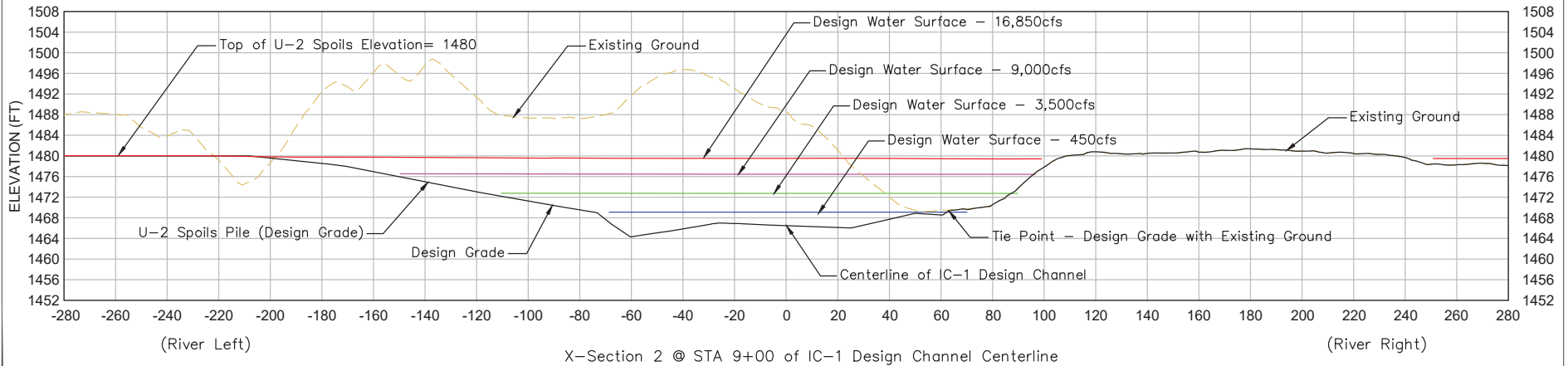
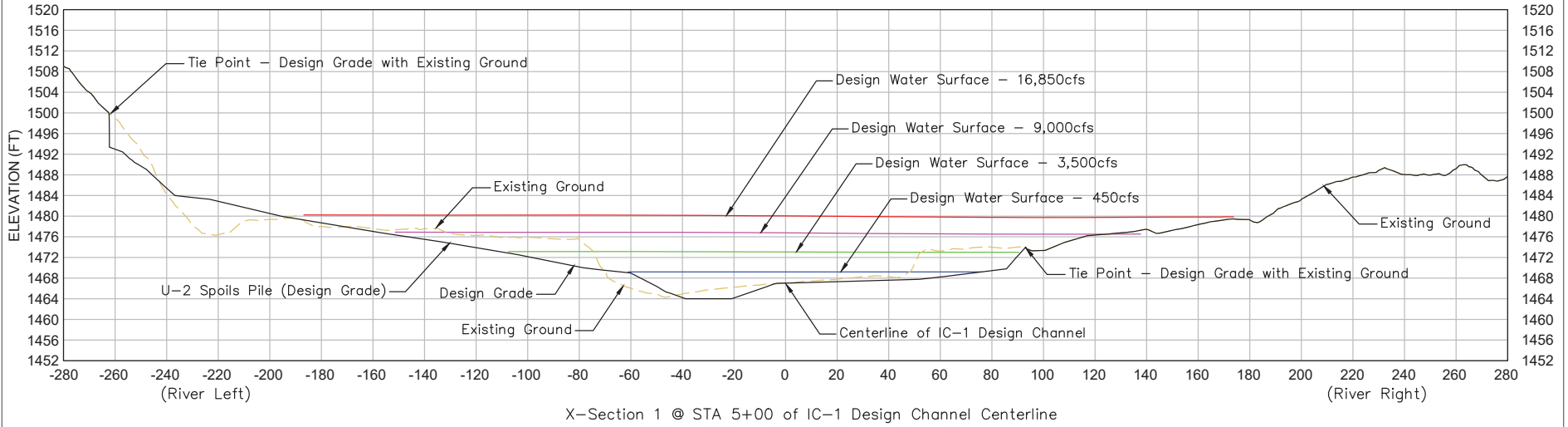
Gaeuman/Martin

Design Date:

June 2020

Sheet number

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Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe
Cross-Section View - Channel Design X-SEC - Sheet 2



Yurok Tribe

Drawing Type:

X-SEC

Drawn By

DJ Bandrowski

Checked By

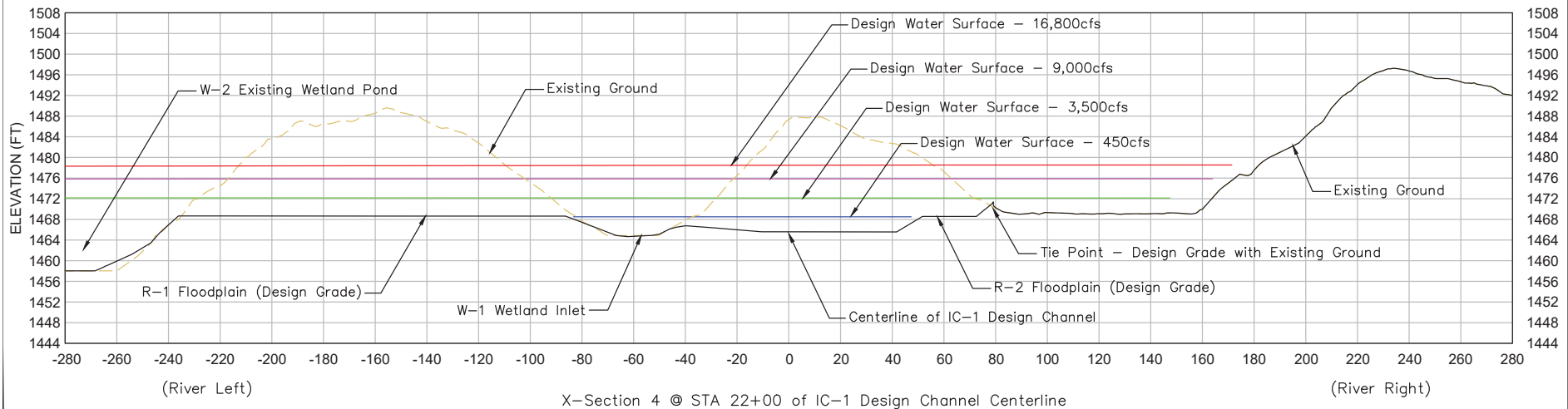
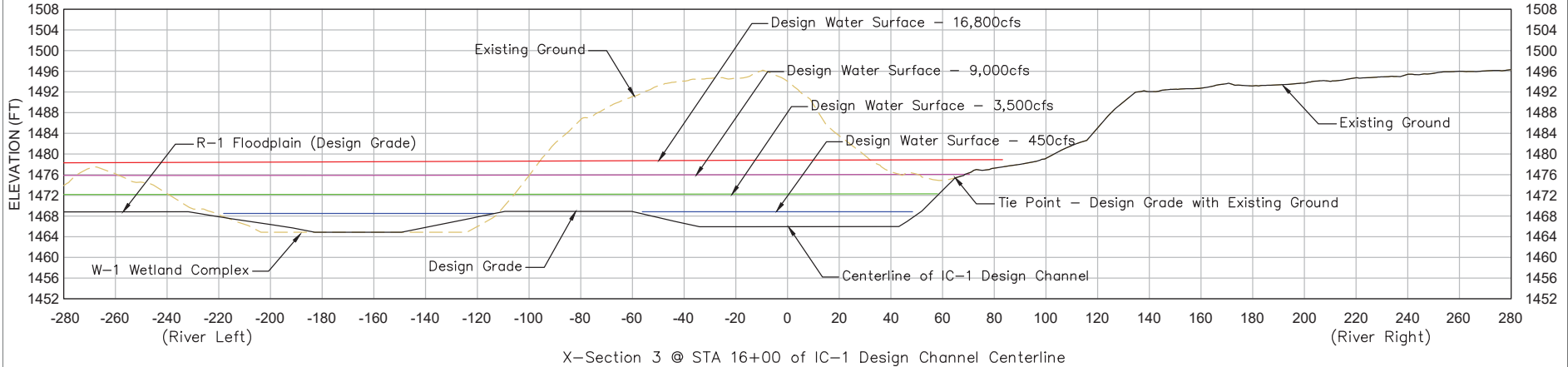
Gaeuman/Martin

Design Date:

June 2020

Sheet number

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Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM
Oregon Gulch 90% Design Drawings - Yurok Tribe
Cross-Section View - Channel Design X-SEC - Sheet 3



Yurok Tribe

Drawing Type:

X-SEC

Drawn By

DJ Bandrowski

Checked By

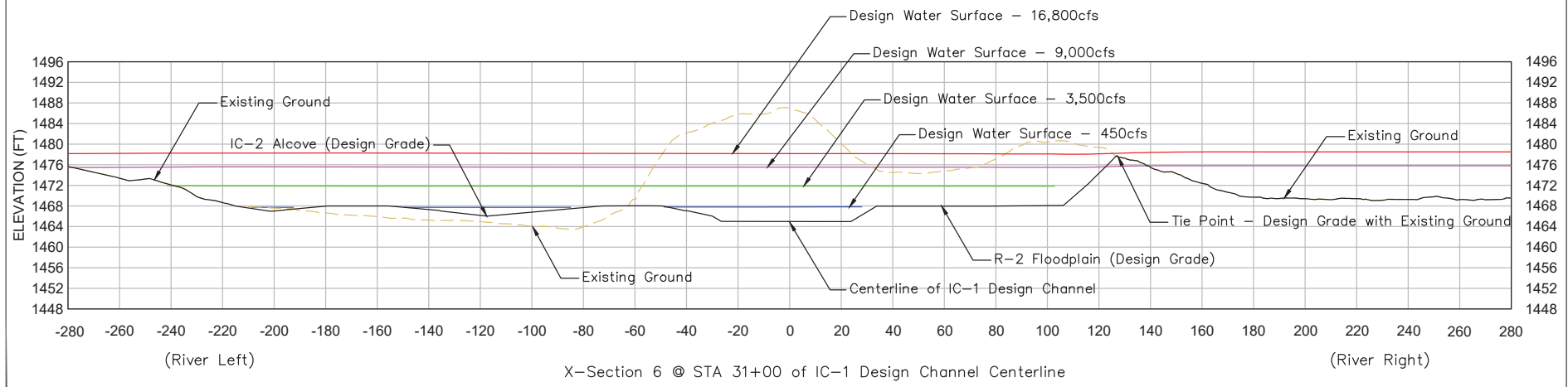
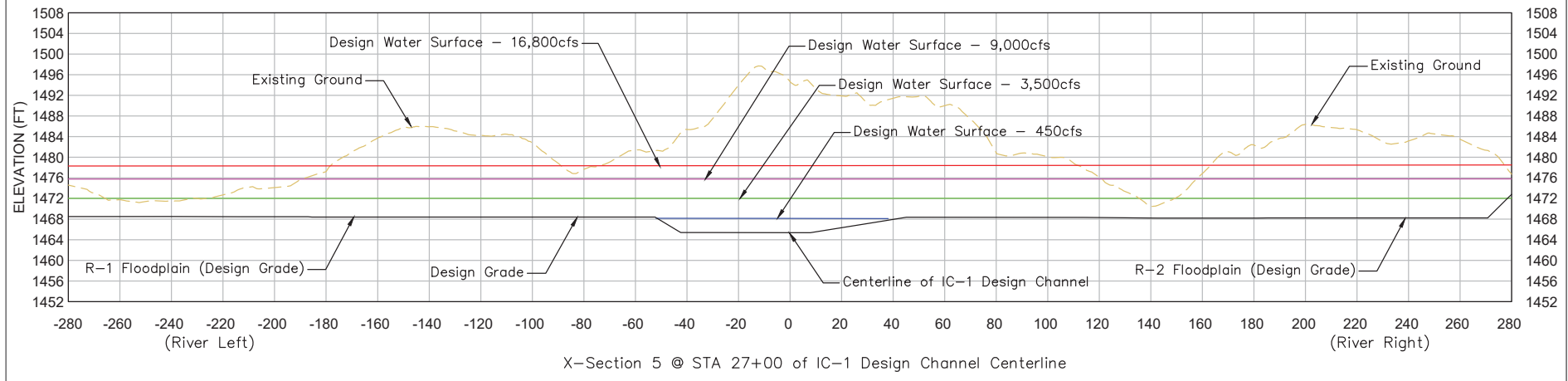
Gaeuman/Martin

Design Date:

June 2020

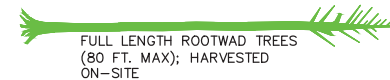
Sheet number

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- DESIGN GRADE
- EXISTING GRADE
- ▨ FILL AREA
- LAYER 1
- LAYER 2
- LAYER 3
- LAYER 4
- LAYER 5
- LAYER 6



TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe
Planview - IC-3 and IC-4 - Wood Structures



Drawing Type:

PLAN

Drawn By

DJ Bandrowski

Checked By

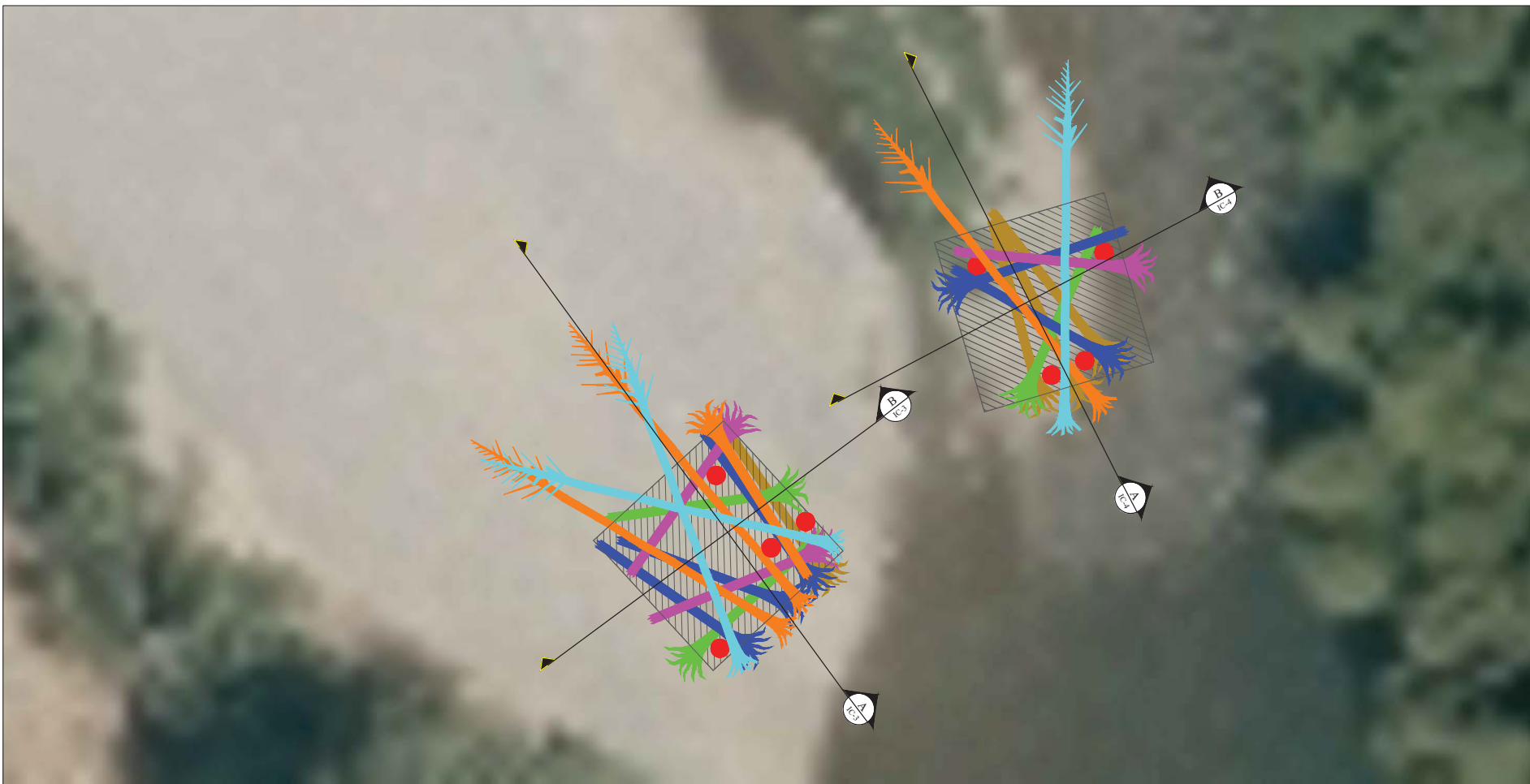
Gaeuman/Martin

Design Date:

June 2020










Sheet number


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SCALE OF FEET



-  DESIGN GRADE
-  FILL AREA
-  EXISTING GRADE
-  LAYER 1
-  LAYER 2
-  LAYER 3
-  LAYER 4
-  LAYER 5
-  LAYER 6

 FULL LENGTH ROOTWAD TREES
(80 FT. MAX); HARVESTED
ON-SITE

 PARTIAL LENGTH ROOTWAD TREE
(35FT. MIN.) HARVESTED OFF-SITE

 VERTICAL POST/PILE



TRINITY RIVER RESTORATION PROGRAM
Oregon Gulch 90% Design Drawings - Yurok Tribe
Planview - IC-3 and IC-4 - Wood Structures



Drawing Type:

PLAN

Drawn By

DJ Bandrowski

Checked By

Gaeuman/Martin

Design Date:

June 2020

Sheet number

16 of 22



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM
Oregon Gulch 90% Design Drawings - Yurok Tribe
Cross-Section - IC-3 - Wood Structure



Yurok Tribe

Drawing Type:

X-SEC

Drawn By

DJ Bandrowski

Checked By

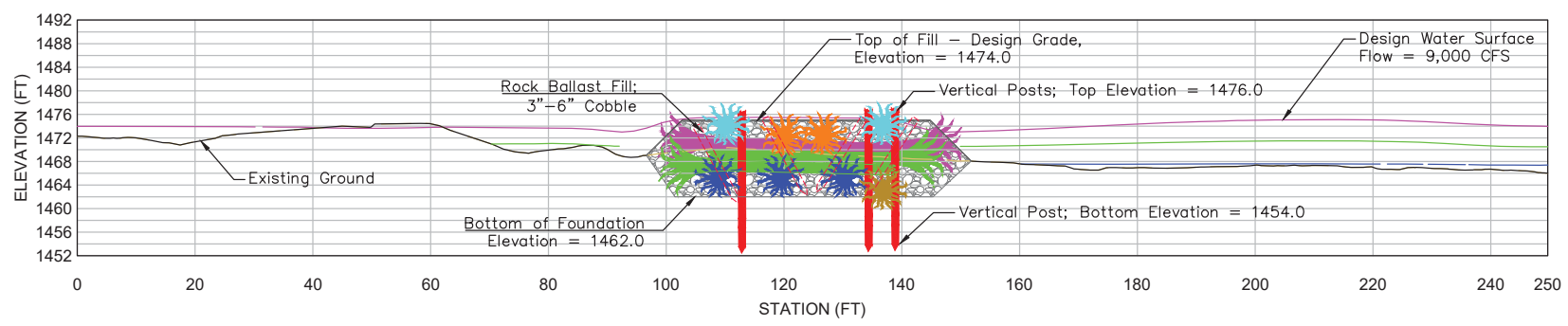
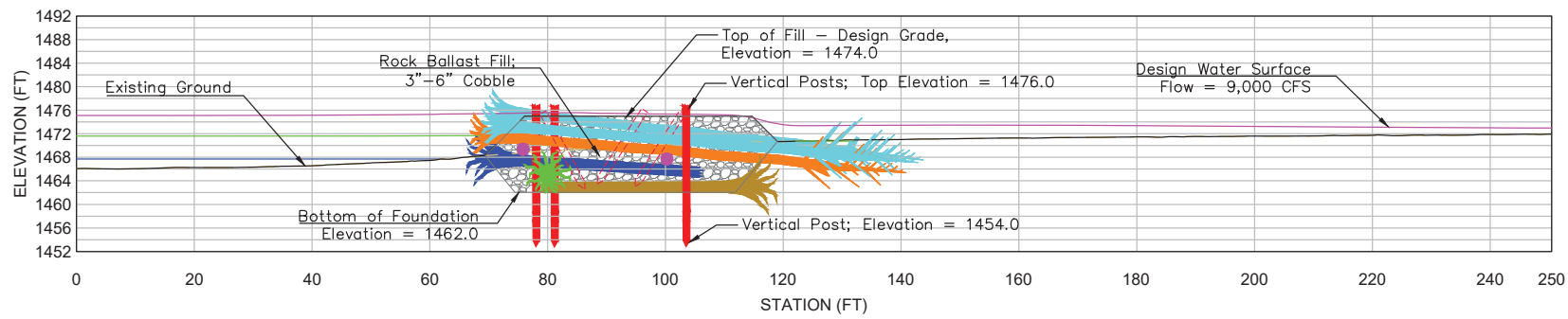
Gaeuman/Martin

Design Date:

June 2020

Sheet number

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DESIGN GRADE	SRH-2D WSE 9,000 CFS	LAYER 1	LAYER 2	LAYER 3	ROOTWAD CROSS-SECTION VIEW ORIENTATION
EXISTING GRADE	SRH-2D WSE 3,500 CFS	LAYER 4	LAYER 5	LAYER 6	
FILL AREA	SRH-2D WSE 450 CFS	FULL LENGTH ROOTWAD TREES (80 FT. MAX); HARVESTED ON-SITE			NON-ROOTWAD POST
		PARTIAL LENGTH ROOTWAD TREE (35FT. MIN.) HARVESTED OFF-SITE			
					LOG CROSS-SECTIONAL VIEW ORIENTATION
					PIN LOG CROSS-SECTIONAL VIEW ORIENTATION



Drawing Type:

X-SEC

Drawn By

DJ Bandrowski

Checked By

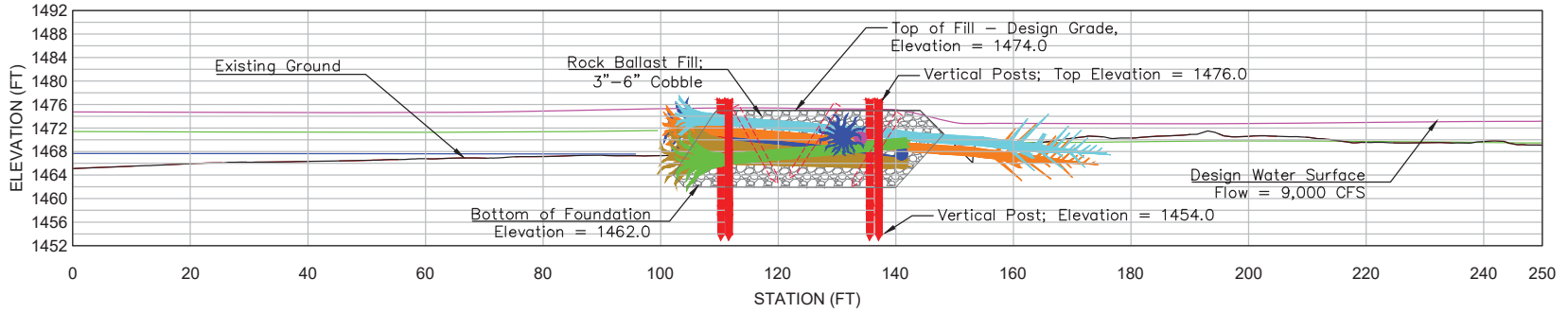
Gaeuman/Martin

Design Date:

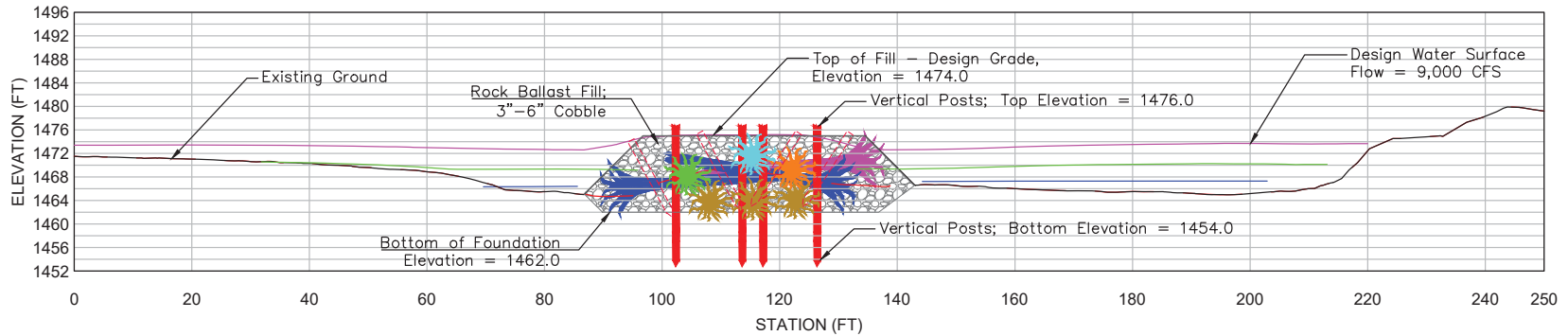
June 2020

Sheet number

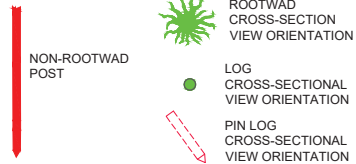
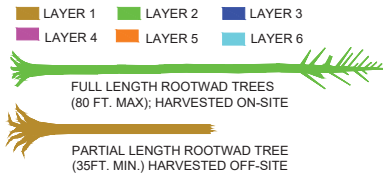
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CROSS-SECTION A-A (Upstream to Downstream)



CROSS-SECTION B-B (River Left to River Right)





Drawing Type:

PLAN

Drawn By

DJ Bandrowski

Checked By

Gaeuman/Martin

Design Date:

June 2020

Sheet number

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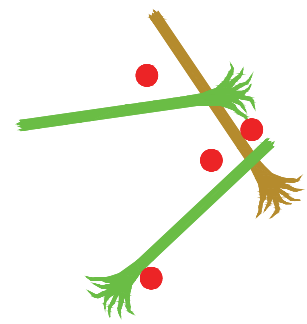
VERTICAL POSTS



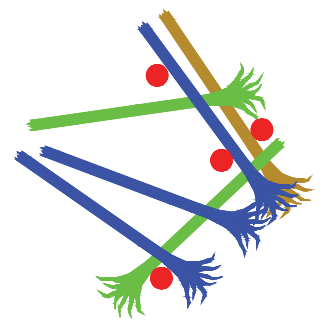
LAYER 1



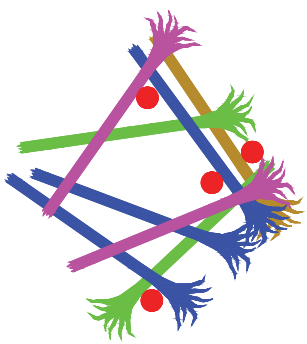
LAYER 2



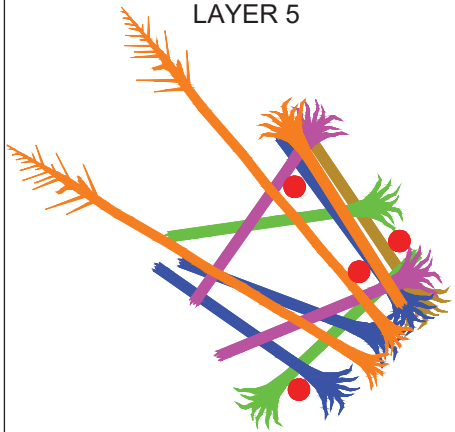
LAYER 3



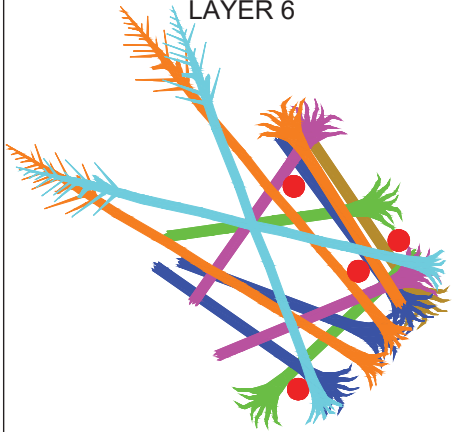
LAYER 4



LAYER 5



LAYER 6



SCALE OF FEET



DESIGN GRADE

EXISTING GRADE

FILL AREA

LAYER 1 LAYER 4

LAYER 2 LAYER 5

LAYER 3 LAYER 6

FULL LENGTH ROOTWAD TREES
 (80 FT. MAX); HARVESTED
 ON-SITE

PARTIAL LENGTH ROOTWAD TREE
 (35FT. MIN.) HARVESTED OFF-SITE

VERTICAL POST/PILE



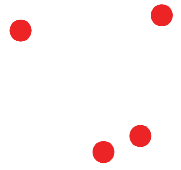
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SEQ

Drawn By
 DJ Bandrowski
 Checked By

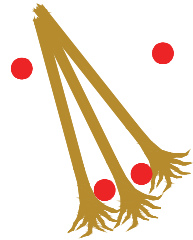
Gaeuman/Martin
 Design Date:

June 2020
 Sheet number

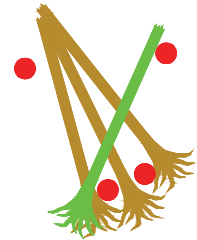
VERTICAL POSTS



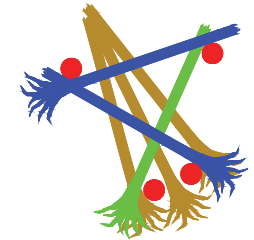
LAYER 1



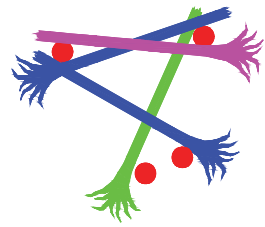
LAYER 2



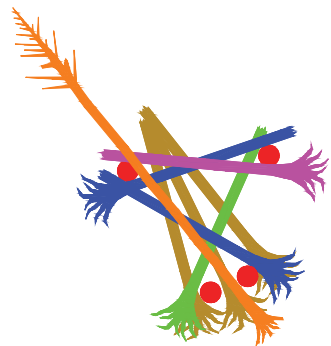
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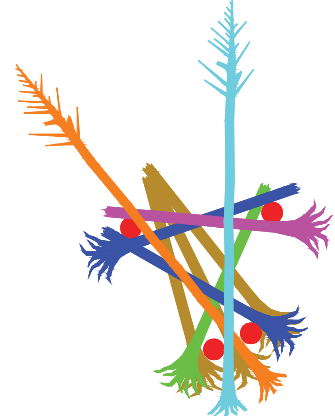
LAYER 4



LAYER 5



LAYER 6



SCALE OF FEET



— DESIGN GRADE

— EXISTING GRADE



FILL AREA

■ LAYER 1 ■ LAYER 4

■ LAYER 2 ■ LAYER 5

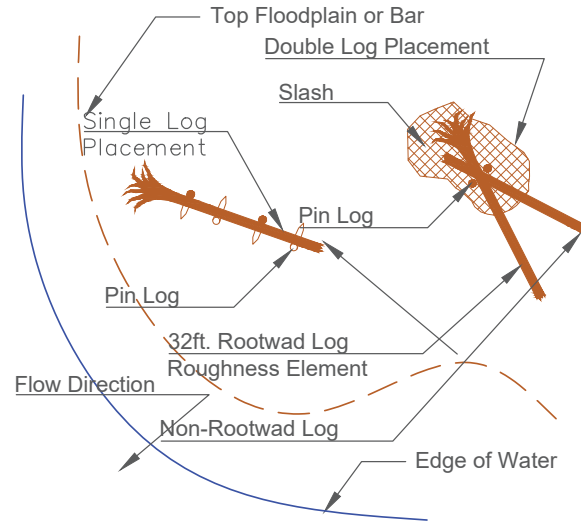
■ LAYER 3 ■ LAYER 6

FULL LENGTH ROOTWAD TREES (80 FT. MAX); HARVESTED ON-SITE

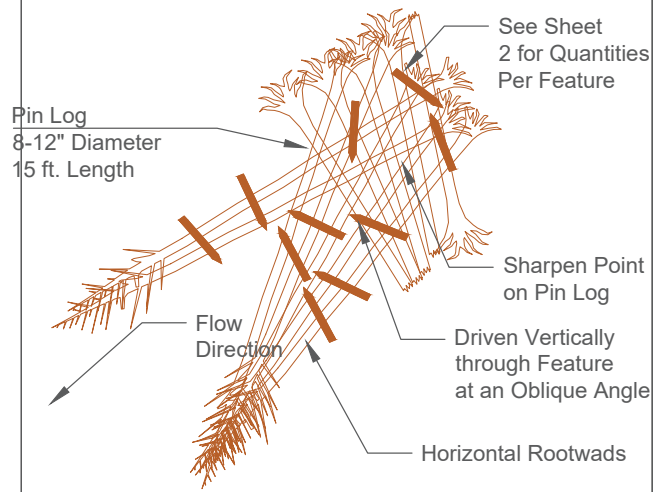
PARTIAL LENGTH ROOTWAD TREE (35FT. MIN.) HARVESTED OFF-SITE

● VERTICAL POST/PILE

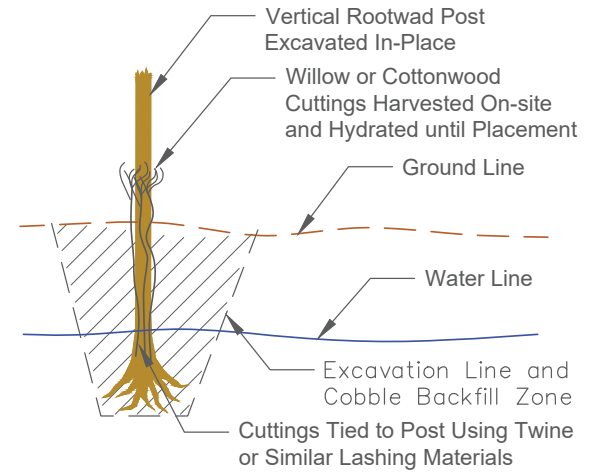
Floodplain/Bar - Typical Habitat Planview



Pin Logs - Typical Detail Planview

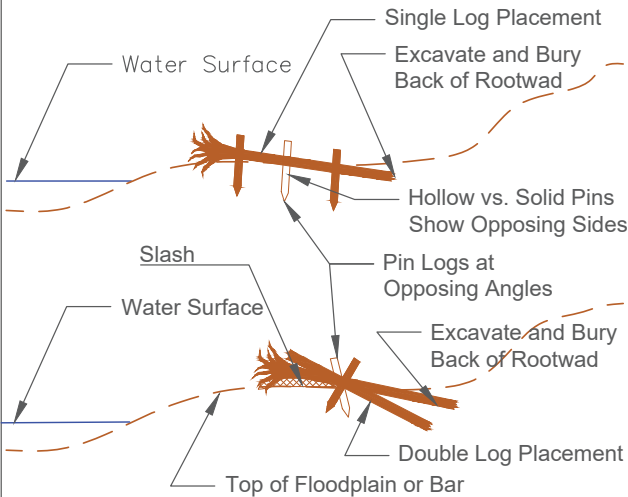


Reveg Pole Cutting - Typical X-Section

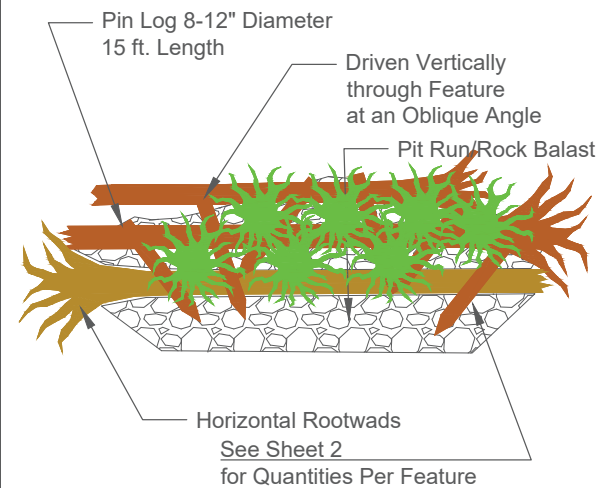


Note: Exact Location and Quantity Determined in the Field

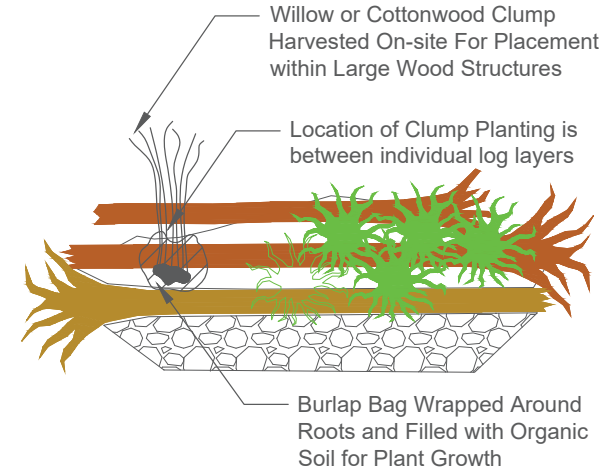
Floodplain/Bar - Typical Habitat X_Section



Pin Logs - Typical Detail X-Section



Reveg Clump Planting - Typical X-Section



Note: Exact Location and Quantity Determined in the Field



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM
 Oregon Gulch 90% Design Drawings - Yurok Tribe
 Large Wood Habitat Placement - Detail Sheet 1



Yurok Tribe

Drawing Type:

DETAIL

Drawn By

DJ Bandrowski

Checked By

Gaeuman & Martin

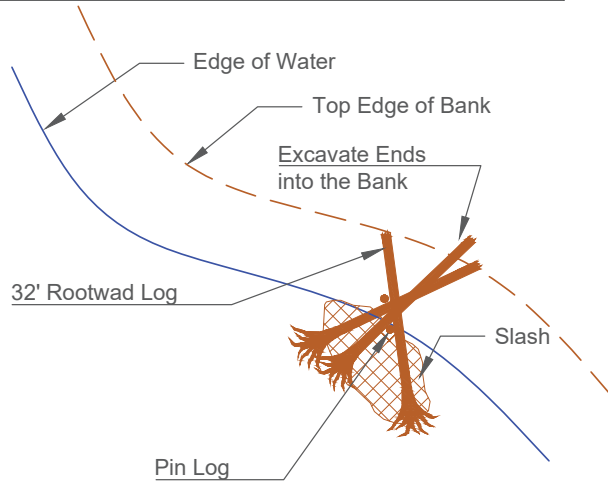
Design Date:

June 2020

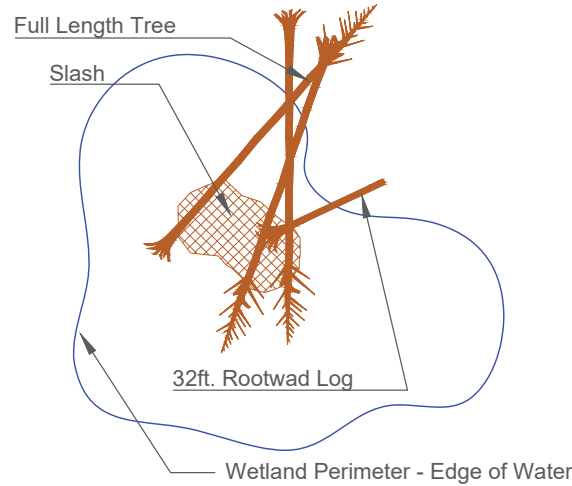
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21 of 22

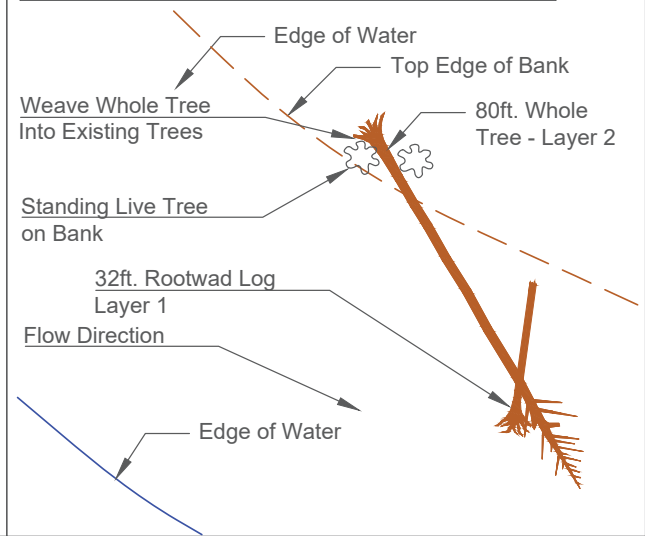
Side Channel - Typical Habitat Planview



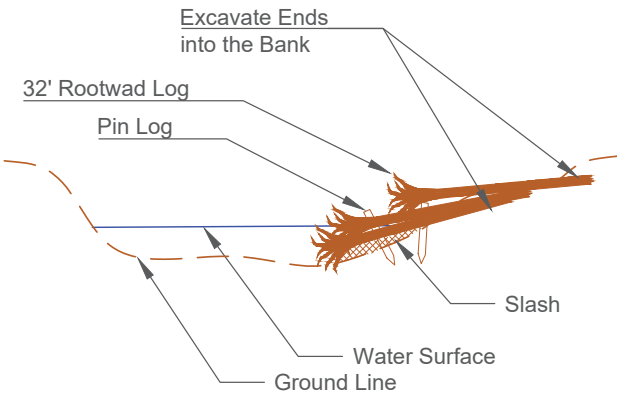
Wetland Pond - Typical Habitat Planview



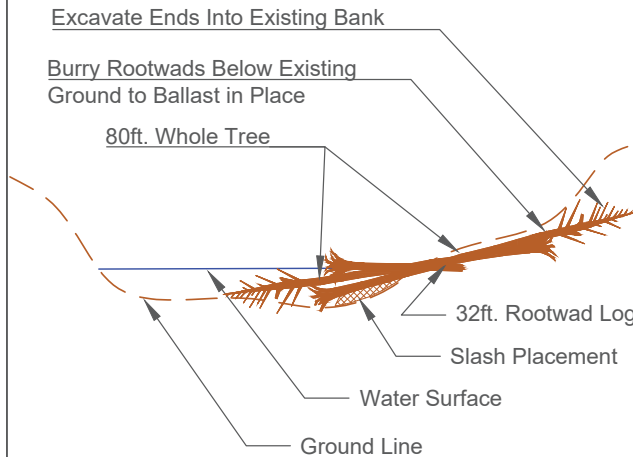
Mainstem - Typical Habitat Planview



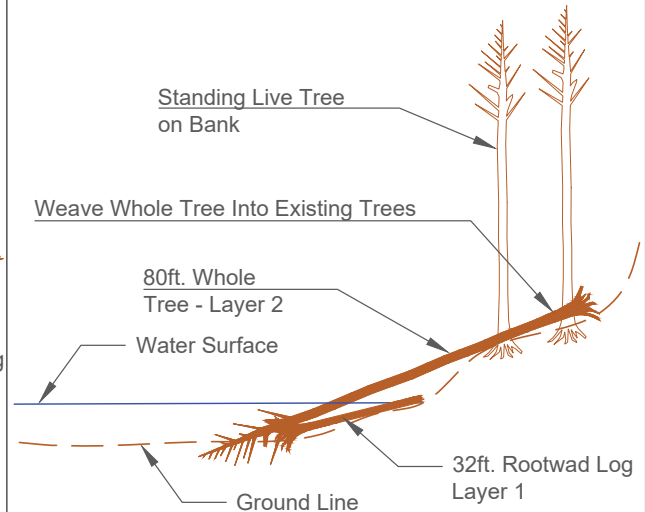
Side Channel - Typical Habitat X_Section



Wetland Pond - Typical Habitat Planview



Mainstem/Pond - Typical Habitat Section



Yurok Tribe

TRINITY RIVER RESTORATION PROGRAM

Oregon Gulch 90% Design Drawings - Yurok Tribe
Large Wood Habitat Placement - Detail Sheet 2



Yurok Tribe

Drawing Type:

DETAIL

Drawn By

DJ Bandrowski

Checked By

Gaeuman & Martin
Design Date:

June 2020

Sheet number

22 of 22