60% BASIS OF DESIGN REPORT ◦ DECEMBER 2025

Shackleford Creek - Scott River Confluence – Fish Passage Barrier Remediation Designs

PREPARED FOR

Scott River Watershed Council
514 N State Hwy 3, P.O. Box 355
Etna, CA 96027

PREPARED BY

Stillwater Sciences
850 G Street, Suite K
Arcata, CA 95521

Stillwater Sciences

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Cover photos: Looking upstream of Shackleford Creek at the confluence with the Scott River (December 2024).

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Acronyms and Abbreviations

2-D	two-dimensional
CDFW	California Department of Fish and Wildlife
CY	cubic yard
DEM	digital elevation model
DTM	digital terrain model
FEMA	Federal Emergency Management Agency
HEC-RAS	Hydrologic Engineering Center, River Analysis System
lidar	light detection and ranging
Project	Shackleford Creek at Scott River Confluence Fish Passage Barrier Remediation Design Project
Ma	million years
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
REM	relative elevation model
Stillwater	Stillwater Sciences
USGS	U.S. Geological Survey

1 INTRODUCTION

This report documents a existing conditions and the 60% design for the Shackleford Creek at Scott River Confluence Fish Passage Barrier Remediation Design Project (Project). The Project is located in Siskiyou County as shown on the location map in Figure 1-1. The primary goal of the Project is to improve fish passage at the Shackleford Creek confluence. Currently, the lower reach of Shackleford goes dry during an extended period, halting upstream and downstream salmonid migration during this period. In addition to fish passage improvements, the Project also aims to enhance overall instream and floodplain habitat within the Project vicinity and address bank erosion risk along the right bank of the Scott River at the toe of Scott River Road.

This Project is funded by the California Department of Fish and Wildlife (CDFW) grant number Q2296038. The Scott River Watershed Council (SRWC) is the Project proponent and Stillwater Sciences (Stillwater) is the technical lead. Initial design concepts were presented to a Technical Advisory Committee composed of representatives from state and federal resources agencies, tribes, and local stakeholders.

1.1 Project Location

The Scott River drains 813 square miles from its headwaters at approximately elevations of 7,000 to 8,000 feet to an alluvial valley floor at 2,700 feet and onward to the Klamath River at 1,580 feet. The Project is located at the confluence of Shackleford Creek and the Scott River, approximately 24.6 miles upstream from the Klamath River confluence. The project is located along the Scott River where it transitions from a broad alluvial valley to a canyon reach. Shackleford Creek is a major tributary to the Scott River, with headwaters in the Salmon Mountains draining 41.9 square miles. Average annual precipitation in the Project vicinity is 42 inches, ranging from 20 inches in the valley bottom to 60 inches at higher elevations.

Figure 1-1 Site map.

1.2 Need for the Project

The Scott River supports a core, functionally independent population of Southern Oregon/Northern California Coast coho salmon, one of the most productive natural stocks in the Klamath River basin (NMFS 2014). Although little information is available to estimate coho abundance prior to the mid-20th century, legacy impacts from placer mining and other land uses have contributed significantly to a reduced population size relative to the historical size. CDFW currently estimates the adult coho population size in the Scott River watershed based on cooperative annual spawning ground surveys in the mainstem and tributaries (initiated in 2001) and adult migration past a video counting facility located in the mainstem Scott River at River Kilometer 29 (initiated in 2007). Monitoring of the yearling juvenile emigration has also taken place since 2000. Since video operations began in 2007, the estimated escapement of coho salmon in the Scott River has ranged from a low of 63 to a high of 2,752 and averaged 645 (Knechtle and Giudice 2020). The total number of Chinook salmon that entered the Scott River during the 2019 season was estimated to be 2,090 fish (Knechtle and Giudice 2020).

The National Marine Fisheries Service determined that 6,500 spawners are required to maintain a viable coho salmon population in the Scott River (NMFS 2014). The discrepancy between the current estimated coho population size and the size required to sustain a viable population underscores the need for immediate intervention to help achieve recovery targets by eliminating migration barriers, improving water quality and availability, and restoring critical habitat.

An analysis of factors limiting coho salmon in the Scott River identified a lack of suitable rearing habitat during the summer and winter months as the most probable limitation for smolt production and the factor most limiting the population (SRWC 2006, NMFS 2014). Off-channel habitats are particularly important for survival, growth, high flow refuge, and overall life history diversity of juvenile coho in the Project area. These off-channel habitats include those with slow-moving water, complex cover, and abundant food availability and are typically associated with floodplain wetlands and backwaters, secondary channels, alcoves, beaver ponds, and low-gradient tributaries. As water temperatures increase, individuals redistribute to thermal refugia with suitable low velocities and water temperatures.

Juvenile coho salmon redistribute from their natal habitats during the spring and fall in search of suitable summer or winter rearing locations. Gorman (2016) found that in the Shasta River and Scott River, individual juvenile coho salmon that out-migrated as young-of-the-year, possibly due to poor natal conditions, experienced higher juvenile mortality than those rearing in natal streams. High mortality of juveniles transitioning to a non-natal stream can contribute to lower future adult returns. This mortality could have large effects on returns when, as in 2014 (a drought year), the abundance of young-of-the-year outmigrants is much larger than the number of smolt outmigrants within a cohort. Gorman (2016) interpreted from otolith analysis and passive integrated transponder tag, or PIT tag, detections in the Shasta River that natal rearing contributes more to population persistence than non-natal rearing.

Based on its location at the transition between the Scott River's broad alluvial valley and canyon reach, this Project provides unique opportunities to improve fish utilization of tributary and offstream habitat within a key location in the broader Scott River watershed. Both the NOAA recovery plan (NMFS 2014) and the CDFW Recovery Strategy (CDFG 2004) identify Shackleford Creek and Mill Creek as tributaries with high intrinsic potential (NOAA) and Key Stream (CDFW) for coho salmon in the Scott River. Spawning surveys conducted over the past several decades indicate that coho utilization in Shackleford Creek has been decreasing.

A secondary need for the project is to reduce erosional risk at Scott River Road. Shackleford Creek is currently aligned perpendicular to the roadway at the confluence of the Scott River which has constricted the Scott River by depositing sediment in the alluvial fan. High flow events have been documented to overtop the roadway, and several areas appear to be eroding over time. A project that protects the roadway by deflecting some of the erosional forces away from Scott River Road would reduce immediate erosional risk.

1.3 Goals and Objectives

The primary goal of the Project is to increase flow connectivity during moderate and low-flow conditions between Shackleford Creek and the Scott River. Additional Project objectives are to enhance instream and off-channel habitat and to reduce the risk of continued erosion on the right bank of the Scott River along Scott River Road.

To accomplish these goals and objectives, the following suite of restoration approaches are proposed:

1. Realignment and/or excavation of the lower reaches of Shackleford Creek to improve sediment transport capacity and increase dry season flow connectivity.
2. Enhance connectivity of left bank Scott River floodplain channels.
3. Enhance general floodplain connectivity throughout the Project area.
4. Install two types of large wood structures:
    a. Engineered log jams on the floodplain (Scott River left bank and Shackleford Creek delta) to achieve a variety of habitat and geomorphic benefits.
    b. Deflector structures along the Scott River right bank to improve bank stability and enhance instream habitat.

These preliminary conceptual design approaches were compiled in a conceptual design package and presented to TAC members during an April 17, 2025 meeting. During the meeting, TAC members provided general feedback that the design approach was appropriate, but no specific written feedback from TAC members was received.

Based on the conceptual designs, TAC members general input, a site visit conducted by Stillwater and SRWC staff in early July 2025, and other analyses, engineering designs have been advanced to the 60% design level and are discussed in Section 4 of this report and presented in Appendix A.

Achieving the Project goals and objectives will be a challenge based on conditions outside of the Project extent including high sediment loads within the Shackleford Creek watershed and surface and groundwater extraction within the Project vicinity. As the Project design advances to final design, these external drivers must be considered when weighing final project design modifications.

2 EXISTING CONDITIONS ASSESSMENT

2.1 Existing Topography

2.1.1 Datums

Project mapping and analyses are referenced to the California State Plane Zone 1, North American Datum of 1983 (NAD83 2011) in units of U.S. survey feet and the North American Vertical Datum of 1988 (NAVD88–Geoid 18) in units of U.S. survey feet. All elevations referenced in this report are with respect to NAVD88 unless otherwise noted.

2.1.2 Topographic data and digital terrain model

The topographic data used for this assessment were obtained from a combination of publicly available March 2018 light detection and ranging (lidar) point cloud data from the U.S. Geological Survey (USGS) and more recent October 2024 topobathymetric lidar data covering channel and adjacent floodplain areas collected throughout the Scott River Watershed. These data were mosaicked together and processed to include only ground points (e.g., no vegetation) and to create a digital terrain model (DTM) in AutoCAD Civil3D. A DTM can also be referred to as a digital elevation model or digital elevation model (DEM). The DTM was used in the geomorphic assessment, hydraulic modeling, and engineering design.

2.2 Geomorphology

During the conceptual design phase, the Project team conducted a desktop geomorphic assessment to characterize existing geomorphology and geomorphic processes within the Project area, assess risks associated with potential hazards, support assessment of opportunities and constraints, and inform Project designs. The desktop geomorphic assessment included review of existing information, historical aerial imagery and maps, and analysis of channel longitudinal profile and valley bottom landforms interpreted from a relative elevation model. During the 60% design phase, field-based pebble counts were conducted as described below in Section 2.2.5.

2.2.1 Geology and tectonics

The Scott Valley is a Quaternary tectonic basin located within the Klamath Mountains geomorphic province, which is underlain by a series of geologic terranes composed of accreted oceanic lithosphere, volcanic arcs, and mélange (Irwin 1994). The Project area is located in the Eastern Klamath terrane. The modern alluvial Scott Valley was formed by Basin and Range extensional tectonics and was controlled by activity along two principal faults that form a graben, the northern Greenhorn fault and the western Scott Valley fault (Foglia et al. 2013). Activity along the Greenhorn and Scott Valley faults caused a dip in the alluvial Scott Valley during the Quaternary period, resulting in stream captures, realignment of tributaries, dissection of older alluvial deposits, and tilting of the bedrock across the valley floor from east to west (Foglia et al. 2013).

Bedrock geologic units surrounding the Scott Valley range from late Precambrian to Early Cretaceous age and predominantly consist of the following strata in order of upward succession: Abrams and Salmon schists of early Paleozoic or late Precambrian age (older than 541 million years [Ma]), sedimentary rocks of Silurian-Ordovician age (419–485 Ma), the Copley greenstone of Devonian age (359–419 Ma), and ultramafic and igneous intrusive rocks of late Mesozoic age (Late Jurassic to Early Cretaceous, 100–163 Ma) (Figure 2-1) (Strand 1963, Hotz 1977). The oldest rocks are the Salmon and Abrams schists, recrystallized sedimentary and volcanic rocks of early Paleozoic or late Precambrian age. Unconformably overlying these rocks are more than 5,000 feet of slightly metamorphosed, strongly folded sedimentary rocks (e.g., sandstone, chert, slate, and limestone) of Silurian-Ordovician age correlated with the Duzel, Moffett Creek, and Gazelle formations (Hotz 1977). These relatively resistant rocks largely compose the bedrock in the mountains throughout the southern part of Scott Valley near the Project area. During the Mesozoic, these bedrock units were intruded and deformed, leading to the formation of granitic and ultramafic rocks ranging in composition from peridotite to granodiorite (Mack 1958). The peridotites are typically highly sheared and serpentinized. The granodiorites are also commonly highly weathered and erosive where jointed and sheared, often producing a large supply of sand to the Scott River, especially from the west side tributaries such as Sugar Creek (Sommarstrom et al. 1990).

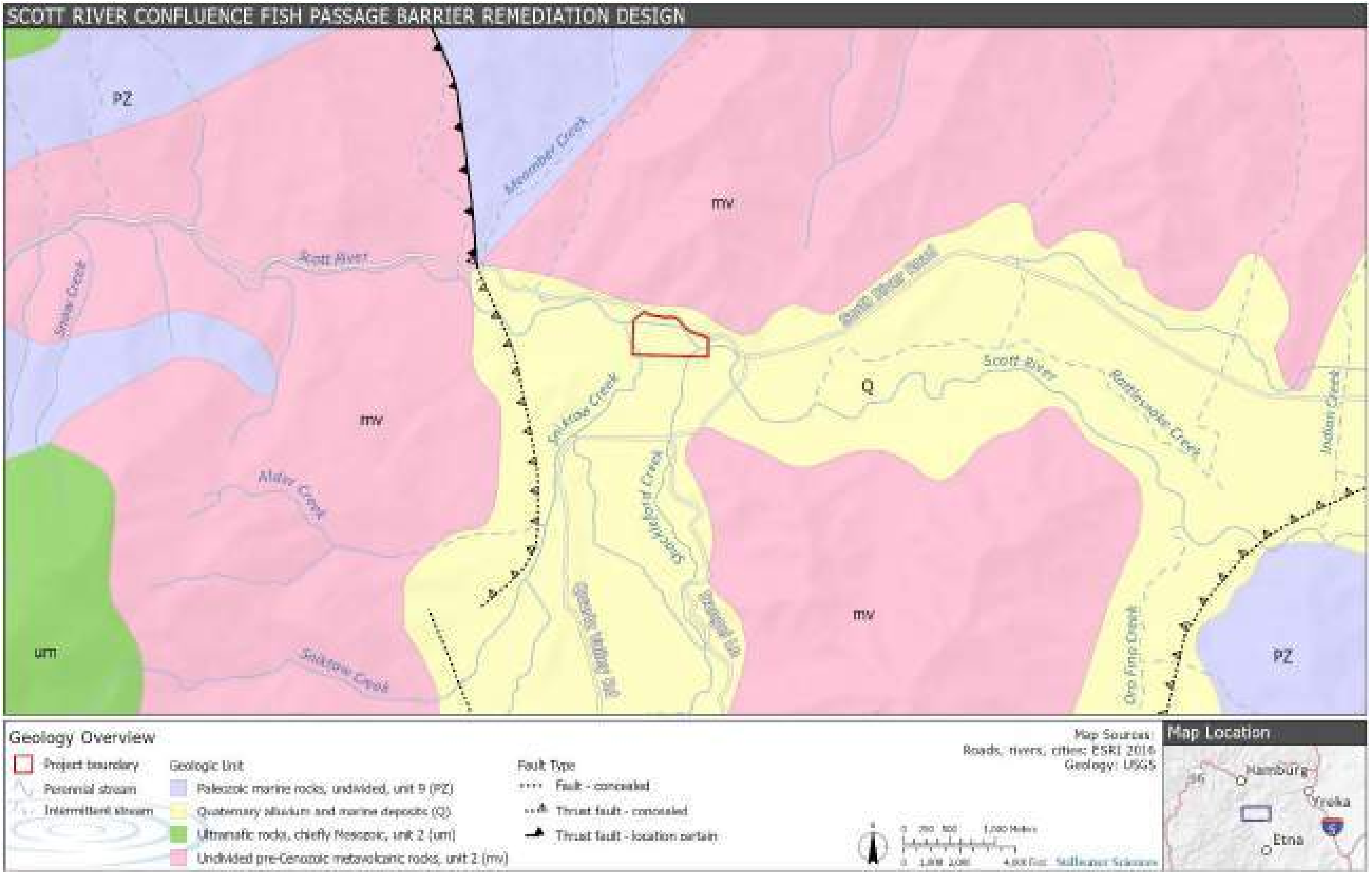

Figure 2-1. Generalized geologic map of the Shackleford Creek and Scott River confluence and project vicinity.

The alluvial fill in the Scott Valley consists of isolated remnants of older alluvium (Late Pleistocene) that includes dissected fan and terrace deposits as well as younger alluvium (Holocene) that includes stream channel, floodplain, and alluvial fan deposits related to the current course of the Scott River and its tributaries. The older alluvial deposits are more prevalent at the south end of Scott Valley near Callahan, where they form terraces along the valley margins. The maximum exposed thickness of older alluvial deposits in this area is probably less than 50 feet (Mack 1958). These older alluvial deposits are poorly sorted and consist of well-rounded granodiorite, serpentine, chert, and quartzite clasts within a matrix of sand and silty clay. The younger alluvium reaches a thickness of as much as 400 feet in the widest part of Scott Valley, with thickness decreasing to the north and south (Foglia et al. 2013).

2.2.2 Watershed impacts

2.2.2.1 Historical beaver activity

Scott Valley, once referred to as Beaver Valley, has a long history of an abundant beaver population living throughout the watershed. It was reported that in 1850 alone, Stephen Meek and his party reportedly trapped 1,800 beavers within the Scott Valley (Harling 2010). When analyzing aerial images of the Shackleford Creek watershed, it appears that there are still beaver meadows with potential active beaver in the headwaters of Shackleford Creek and Mill Creek. Evidence of recent beaver dams spanning the channel of the Scott River were also seen during site visits and on aerials.

2.2.2.2 Historical land impacts

Historically, Quartz Valley and the nearby Scott and Oro Fino valleys were mined for gold via hydraulic mining during the late 1800s and early 1900s (QVIR 2006). This method of mining produces less chemical contamination than other methods of mining but produces significant disruption of natural surface water and groundwater processes and typically leads to high erosion rates and sedimentation (QVIR 2006).

Much of the Scott River Valley and Siskiyou County were logged beginning in the late 1800s (QVIR 2006). Clearcutting and the presence of logging roads in the area contributed and still contribute significant amounts of sediment to the river system (QVIR 2006). Since 1850, ranching and agriculture have been a consistent presence throughout the Quartz Valley (QVIR 2006). Historically, cattle grazing occurred in the upper reaches of Shackleford Creek during the summers, and many of the landowners are still engaged in cattle grazing, which is likely another significant source of sediment into the river system (QVIR 2006).

2.2.2.3 Groundwater extraction

Agriculture is a key economic activity within the Scott River Valley. As can be seen on aerial imagery (Figure 2-2), many center pivots that pump groundwater for irrigation reside within the valley. According to 2023 data from the California Department of Water Resources, groundwater levels were approximately 12 to 30 feet from the ground surface in the Quartz Valley.

During the dry summer, groundwater return flow, or baseflow from the alluvial aquifer system underlying Scott valley accounts for the low streamflow in the Scott River system (Foglia et al. 2013). Since the late 1970s, compared to those in the 1940s to 1960s streamflows during the summer in dry years have been markedly lower (Foglia et al. 2013). Van Kirk and Naman (2008) and Drake et al. (2000) concluded that a statistically significant contribution of this downward trend is due to climate effects represented by reduced snowpack at lower elevations (Foglia et al. 2013). Van Kirk and Naman (2008), using statistical analysis, also concluded that groundwater pumping for irrigation and increased consumptive water use were significant contributors to this trend (Foglia et al. 2013).

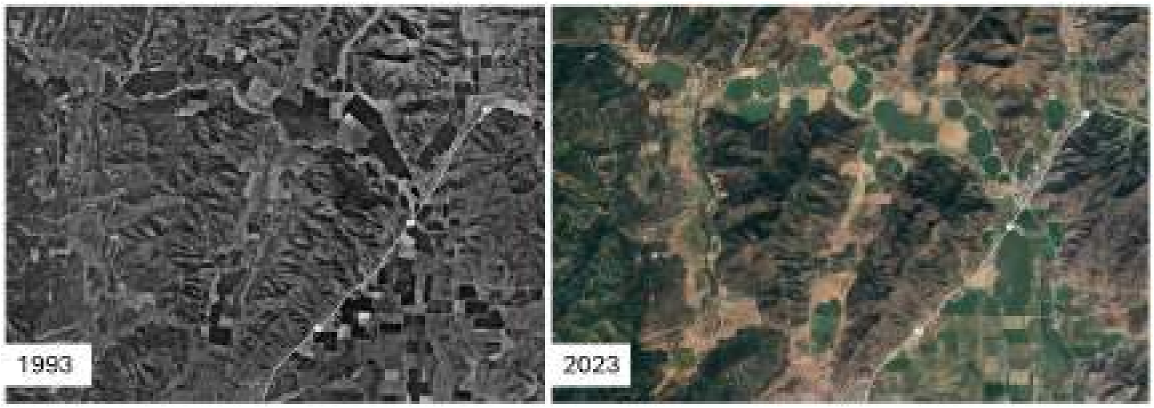

Figure 2-2. Much of the irrigation switched to center pivot systems in the early 2000s.

Additional groundwater monitoring in the Project area is recommended to support future phases of this Project design.

2.2.3 Historical aerial imagery and land survey map interpretation

2.2.3.1 Aerial photograph interpretation

Historical aerial photographs were reviewed to help characterize long-term changes in geomorphology, riparian vegetation, and land use within the Project area. The historical aerial photo time series that was reviewed during the analysis is presented in Appendix B and included the following years: 1944, 1951, 1955, 1965, 1973, 1976, 1980, 1993, 1998, 2003, 2004, 2006, 2009, 2012, 2016, 2017, 2020, 2021, and 2023. The earliest aerial photograph shows that land use impacts from agriculture, logging, and legacy mining were already present throughout Shackleford Creek watershed by 1944.

As land became increasingly developed for agriculture along the valley floor, both Sniktaw and Shackleford Creeks were realigned and channelized to make room for more fields. The Sniktaw Creek confluence was realigned to make room for an agricultural field pre-1944 and then again by 1980 (Figure 2-3). Old channel scars from Shackleford Creek can be seen across the valley floor in the 1951 aerial and potentially show that Sniktaw and Shackleford Creek may have joined before entering the Scott River at times (Figure 2-4). Figures 4 and 5 also show that the Scott River has migrated through the Shackleford Creek delta over time. An exhibit comparing Scott River alignments in 1944, 1955, 1965 and 2010 is provided in Appendix B.

Figure 2-3. Sniktaw Creek was realigned and channelized in the mid-1970s.

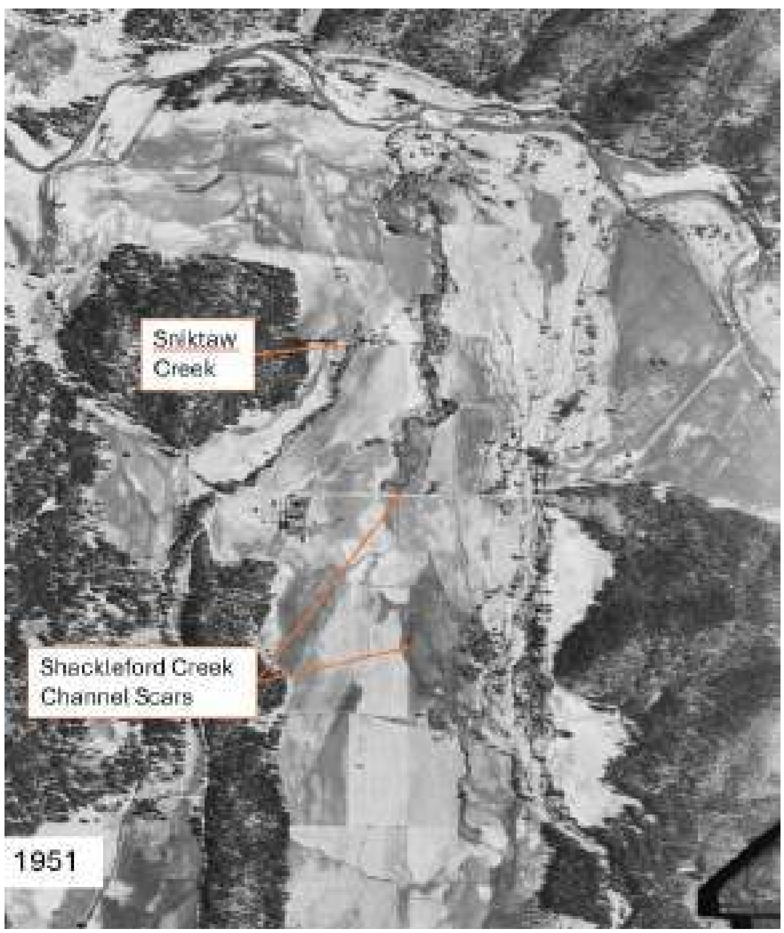

Figure 2-4. Old channel scars show Sniktaw and Shackleford Creeks may have joined prior to entering Scott River prior to channelization.

By 1965, Shackleford Creek was realigned to the east side of the valley to make way for agricultural fields. Berms were constructed along Shackleford Creek as early as 1965, with increasingly robust berms apparent upstream of Quartz Valley Road starting in the mid-1970s and then extended downstream to the confluence area in the mid-1990s (Figure 2-5).

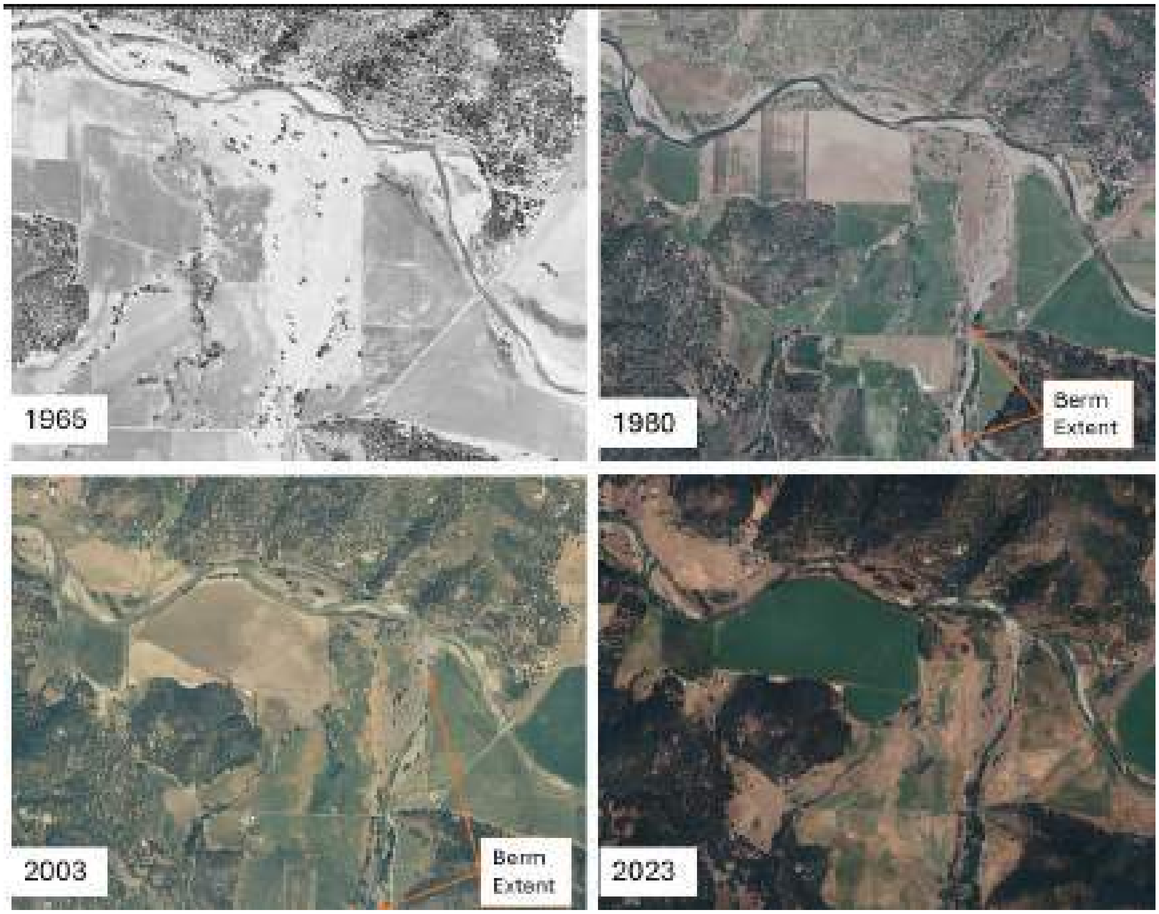

Figure 2-5. Historical aerial photographs from 1965 to 2023 showing land use impacts, including berms disconnecting Shackleford Creek from its floodplain, starting in the mid-1970s and expanding downstream to the confluence area in the mid-1990s.

Only 7 of 21 historical aerials reviewed show Shackleford Creek connected to the Scott River (1944, 6/28/76, 6/17/80, 6/3/2003, 4/27/2006, 7/7/2012, and 7/8/2017). All aerials were taken during the lower flow months between April and August.

2.2.3.2 Historical land survey maps interpretation

Historical land survey maps from 1876 (Figure 2-7), 1883, and 1927 were acquired from the Bureau of Land Management's General Land Offices for the Quartz Valley area (Appendix B). The channel alignment of Shackleford Creek appears to be relatively static since 1876. Additionally, the headwaters of Sniktaw Creek, Shackleford Creek, and other tributaries were indicated as "dry" in the 1876 land survey map. Land use impacts shown on the 1876 map include agriculture, logging mills, ditches, and mining claims.

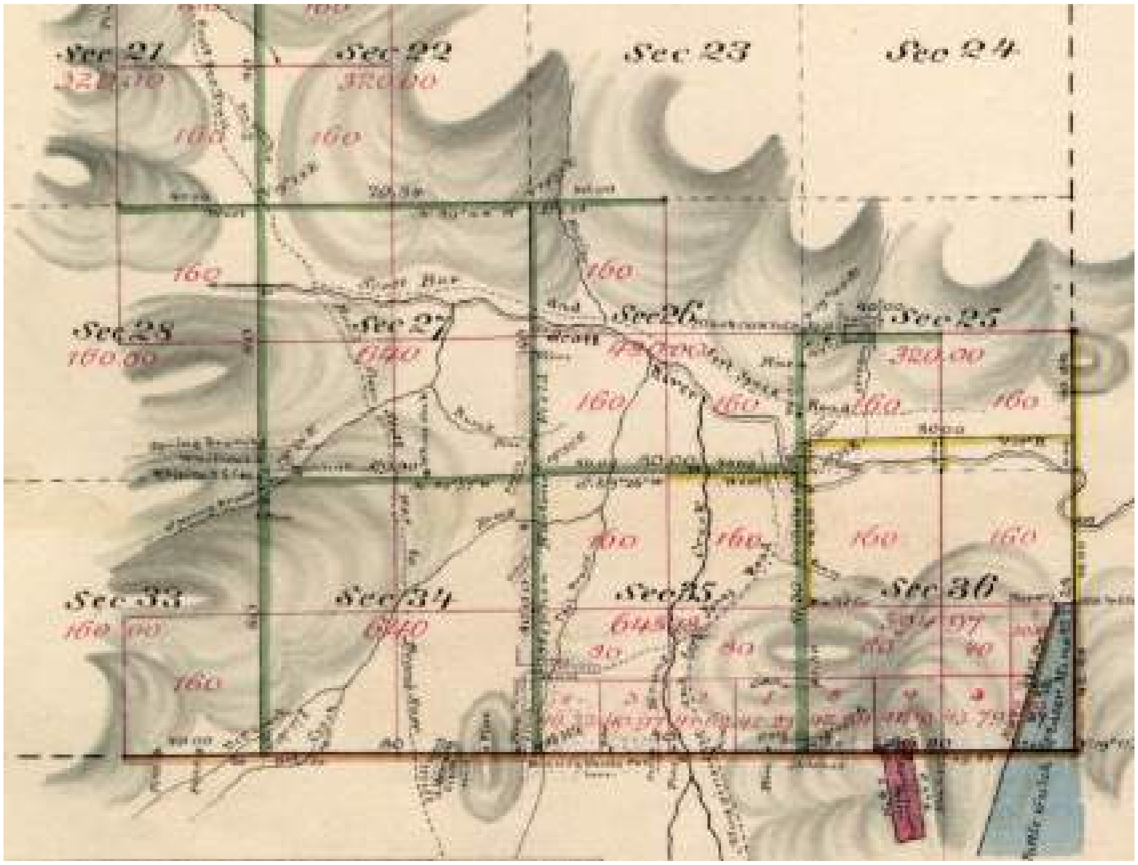

Figure 2-6. Land survey map from 1876 for the Quartz Valley area.

2.2.4 Relative elevation model

A relative elevation model (REM) is a tool that compares elevation data relative to a defined baseline, such as the water surface elevation. Unlike a standard DEM, which represents absolute topographic heights, the REM isolates and visualizes topographic relationships that influence hydraulic, hydrologic, and geomorphic processes. This type of model is particularly effective for analyzing floodplain connectivity, sediment transport pathways, and channel-floodplain interactions. By emphasizing relative rather than absolute elevations, the REM highlights subtle terrain variations that are crucial for understanding geomorphic stability and hydrologic dynamics in fluvial systems. The creation of an REM relies on a DEM as its foundational dataset. The DEM provides bare-earth topography devoid of vegetation and human-made structures, allowing for the calculation of relative elevations critical to geomorphic analysis. The REM enhances this baseline by revealing features such as secondary channels, levees, and depressions that are integral to floodplain and channel assessments.

For the Shackleford Creek study area, the REM was derived from the 2018 USGS lidar DEM, focusing on the confluence with the Scott River. The cross-section method was employed to calculate relative elevations, leveraging profiles perpendicular to the primary flow direction to ensure accurate representation of elevation differences. This method reduces spatial errors and provides a more reliable depiction of geomorphic and hydrologic features compared to traditional interpolation techniques like inverse distance weighting, particularly in areas with complex channel morphology such as confluences (Washington State Department of Ecology 2014).

The REM creation process involved several key steps: classifying lidar points to generate the DEM, aligning the water surface reference plane, and conducting quality control to reduce biases around and between confluence areas. High-resolution lidar data enabled the identification of fine-scale features that influence hydrologic connectivity and sediment dynamics. By aligning cross-sections with the flow direction and applying quality-controlled methodologies, the resulting REM provides a high-fidelity analytical tool for understanding floodplain behavior and interactions between channels and adjacent landscapes.

An REM for the project area is shown in Figure 2-7 with the following key observations:

- Constructed berms along both sides of Shackleford Creek are clearly evident.
- Historical flowpaths of Shackleford Creek across its alluvial fan are clearly visible with some evidence of historical interaction with Sniktaw Creek.
- Several Scott River floodplain channel are evident which in some cases comprised the river's historical alignment.
- The Scott River transitions to more confined channel morphology downstream from the Sniktaw confluence.

In summary, the REM highlights both the anthropogenic constraints (constructed berms) and many low-lying floodplain areas which provide excellent opportunities for improving floodplain connectivity within the Project area.

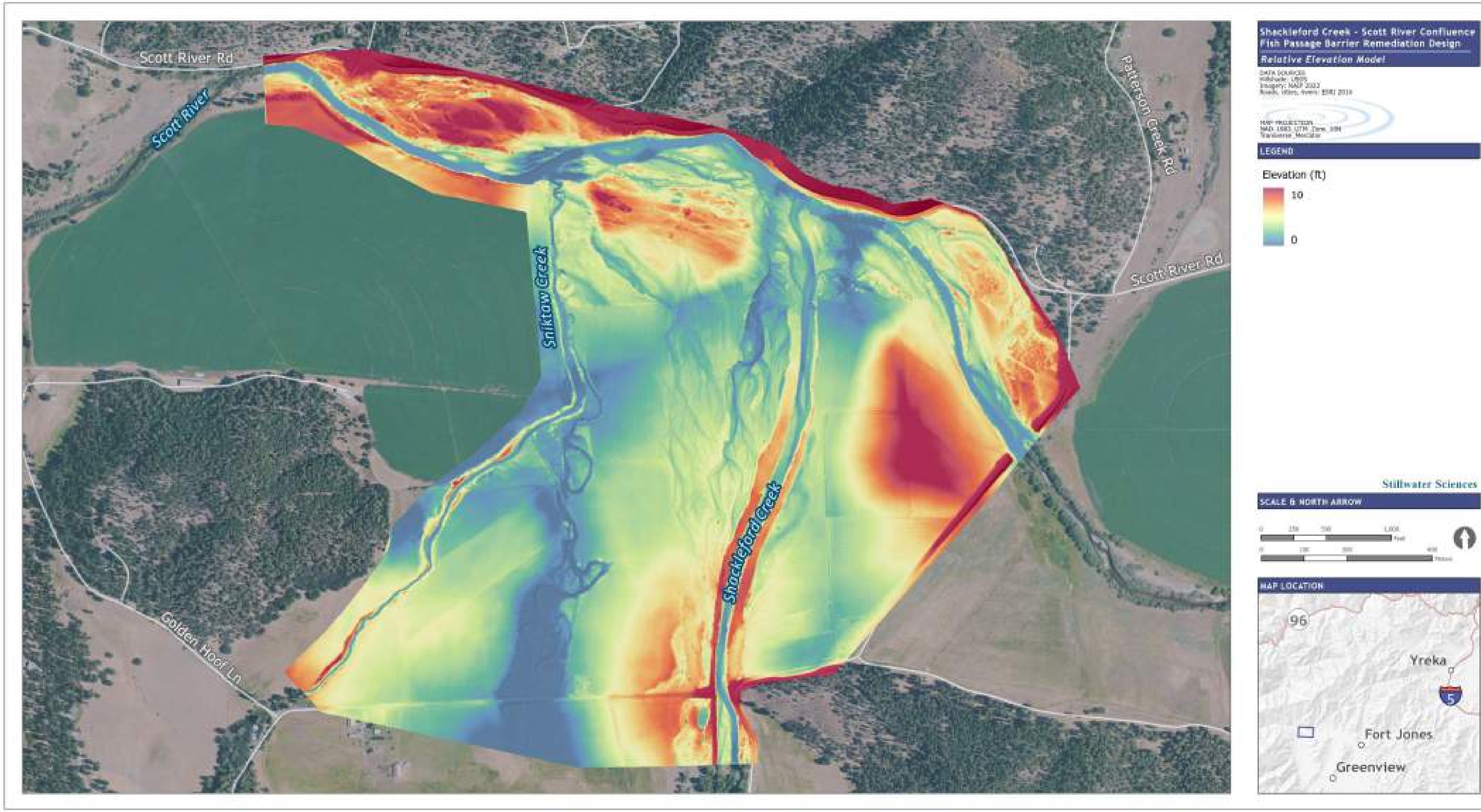

Figure 2-7. Height of valley bottom geomorphic features relative to the reference surface

2.2.5 Sediment Gradations

Pebble count surveys were conducted with a gravelometer at three locations within the project area on July 8th, 2025, to determine sediment gradation data to inform design (Wolman 1954). Two pebble count surveys were conducted on Shackleford Creek while one pebble count survey was conducted on Scott River. The locations of these surveys are shown in Figure 2-8. Results from the pebble counts show Shackleford Creek has a coarser bed in the single thread area and finer bed in the split flow channel at the upstream end of the alluvial fan. Shackleford Creek had a coarser bed than the Scott River with the resulting D_{50} of 51.4 mm and 42.5 mm respectively (Figure 2-9).

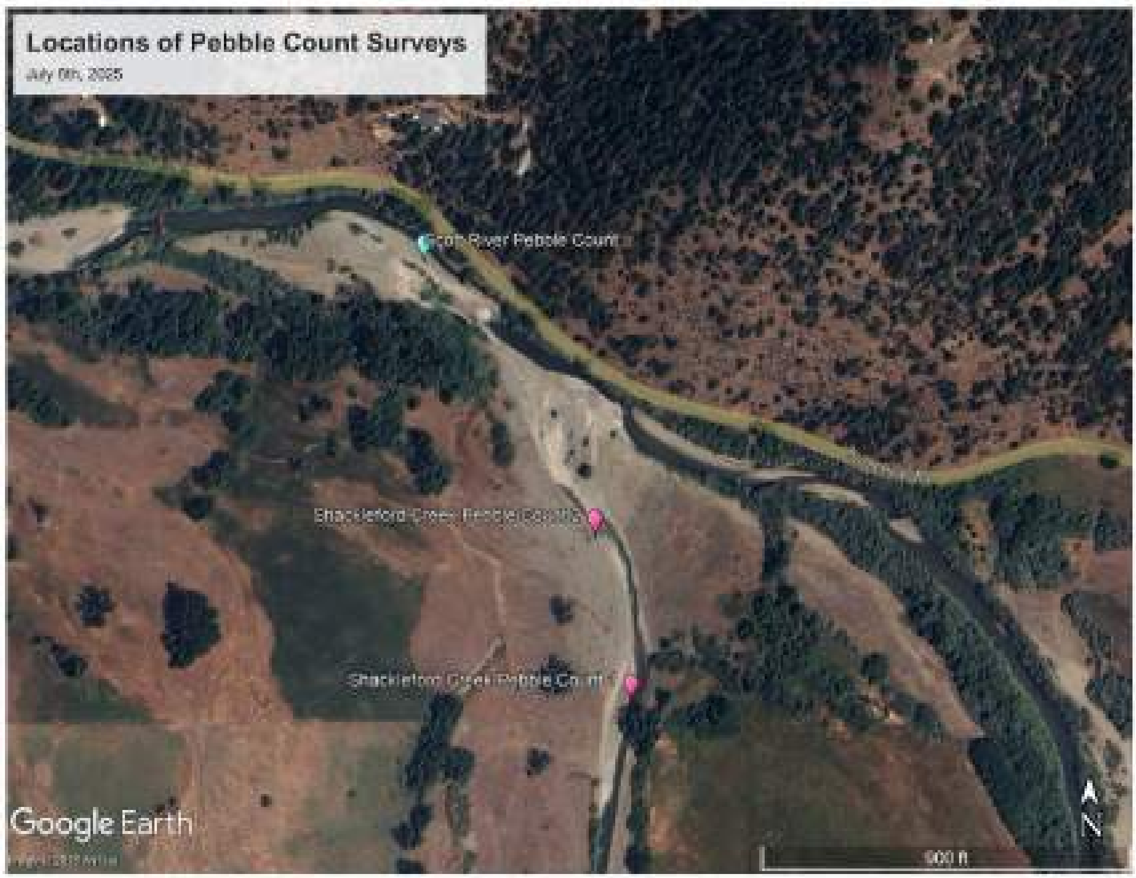

Figure 2-8. Pebble Count Survey Locations

2.2.6 Summary of geomorphic processes and stressors

As previously discussed, historical and current land use practices throughout the Shackleford Creek watershed have increased the sediment supply to Shackleford Creek. Evidence of this high sediment load is prevalent at the Project site, and upstream where braided reaches of Shackleford Creek and Mill Creek indicate a high sediment supply. This increase in sediment deposition within the Project area, in combination with lowering of the groundwater table is exacerbating the drying of Shackleford Creek. In addition, the constructed berms along Shackleford Creek have disconnected the floodplain, disrupting natural hydraulic and sediment transport processes that would have likely spread deposition over a broader area than under current conditions where the berms effectively focus sediment deposition right at the mouth of Shackleford Creek.

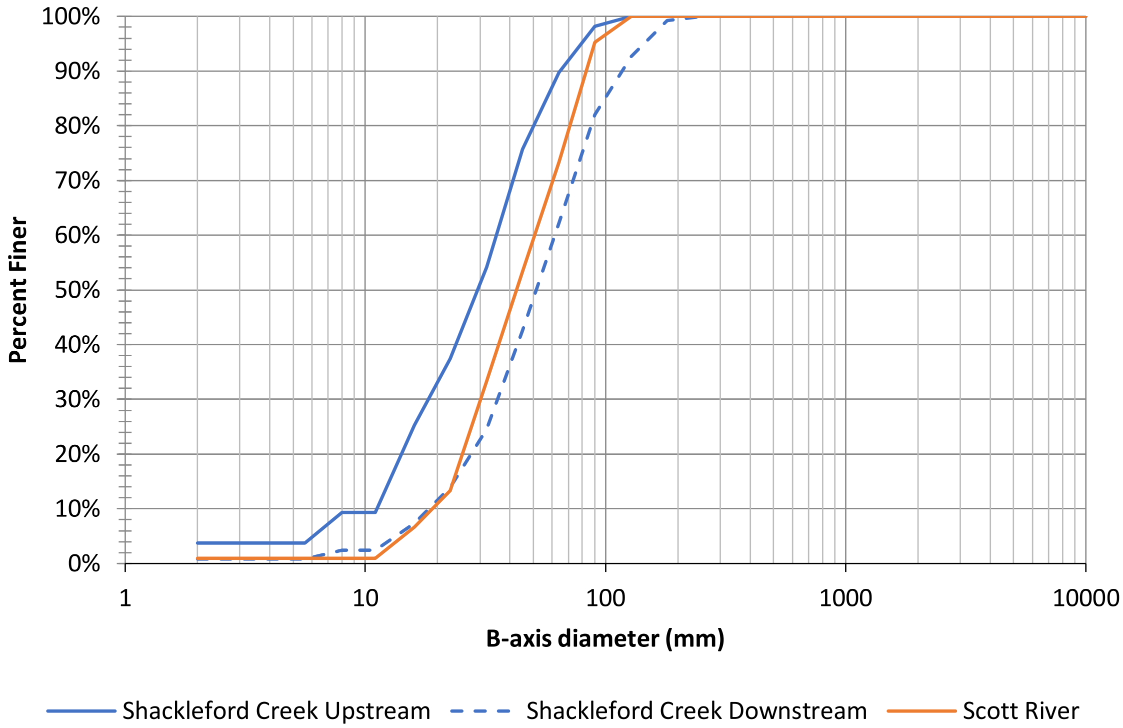

Figure 2-9. Shackleford Creek Pebble Count 1 Grain Size Distribution

2.3 Fisheries and Aquatic Habitat

Both the NOAA recovery plan (NMFS 2014) and the CDFW Recovery Strategy (CDFG 2004) identify Shackleford Creek and Mill Creek as tributaries with high intrinsic potential (NOAA) and Key Stream (CDFW) for coho salmon in the Scott River.

Siskiyou Resource Conservation District (RCD) has performed extensive fisheries and aquatic habitat surveys throughout the Shackleford and Mill Creek in the 2000's in accessible reaches. Spawning ground surveys performed in 2004, 2007 and 2010 (the previously strong brood year of coho salmon) documented the highest density of coho spawning in the Scott River watershed occurring in Shackleford Creek and Mill Creek in 2010 with similar results in 2007 (refer to Appendix C).

Recent spawning surveys have observed significantly reduced amounts of coho spawning in the accessible reaches (E. Yokel, pers. comm., April 2025).

The importance of the Shackleford and Mill Creek coho fishery is a main driving force for the desire to increase the period of connectivity of the confluence.

2.4 Riparian vegetation

The project area shows a distinct gradient in vegetation from the Scott River margin to the upland alluvial fan. Along the Scott River, dense willow thickets dominate the channel edge, interspersed with tall grasses that create a layered riparian fringe (Figure 2-10). Moving inland, the floodplain supports patches of taller woody vegetation, including mixed riparian shrubs and small trees, forming a semi-closed canopy with a dense understory typical of areas with moderate flood connectivity (Figure 2-11). On the elevated alluvial fan, vegetation shifts to open herbaceous zones dominated by non-native annual grasses and scattered low shrubs, reflecting historic disturbance and limited inundation (Figure 2-12). Shackleford Creek has minimal riparian vegetation along its margin. The poorly sorted alluvium supports mostly non-native grasses with little woody cover. Across the site, canopy height is generally low with much of the site under 2 feet, with scattered shrubs and small trees (10–20 ft) and only a few medium-sized trees (20–40 ft) near the river. Large trees (>40 ft) occur primarily along the Scott River channel margin, near Snicktaw Creek, and sporadically elsewhere (Figure 2-13). The distribution of taller trees is likely associated with historical shifts in flow paths of the Scott River, Shackleford Creek, and Snicktaw Creek.

The majority of the tall grasses appear to be reed canary grass, or *Phalaris arundinacea,* which can quickly dominate sites with moist soil. It can exclude all other vegetation and is extremely difficult to eradicate once established. Nativity of this plant is debated; it is native to Europe and possibly parts of Asia, but it may also be native to the northwestern United States. Aggressive behavior that is exhibited in many parts of the central and western United States may be a result of escaped cultivars that were bred for vigor and quick growth (Invasives.org 2025).

Figure 2-10. Photo of Scott River Margin with reed canary grass lining the bank, interspersed with willow thickets, taller trees, and riparian shrubs.

Figure 2-11. This image shows a dense patch of woody vegetation with a thick understory adjacent to the Scott River. Likely plant types include riparian shrubs such as willow along with small trees like alder or cottonwood, mixed with herbaceous ground cover.

Figure 2-12. The upland surface is dominated by open herbaceous cover, primarily non-native annual grasses, with scattered low perennial shrubs adapted to dry, well-drained soils.

Figure 2-13. Canopy height classification for the project area using CTrees global tree-level data (2020; https://ctrees.org/tree-level). The canopy data is classified by height to illustrate distribution of taller vegetation within the Project area.

3 HYDROLOGY AND HYDRAULICS

This section summarizes hydrologic and hydraulic conditions that influence project design. The streamflow patterns, hydraulic model development, and groundwater-surface interaction are explored and related to restoration strategies.

3.1 Surface water hydrologic analysis

There are several gages within the project area vicinity that are useful to derive project hydrology.

- Scott River: The project site is 3.3 miles upstream of the long-term USGS gage (Scott R NR Fort Jones CA, USGS-11519500), which has recorded flow data since 1941.
- Shackleford Creek: Discharge was measured at USGS gage 11519000, located about 5 miles upstream of the confluence, from October 1957 to September 1960. Currently, there is a gage operated by the California Department of Water Resources (DWR) that has collected stage data since June 2004 located 0.7 miles upstream of the project site near Quartz Valley Road.
- Sniktaw Creek This tributary is ungaged; flows were estimated based on watershed area ratios relative to Shackleford Creek.
- Other Data:
    - The California Natural Flows Database was evaluated for the project area (California Environmental Flows Working Group (CEFWG). *California Natural Flows Database: Functional flow metrics v1.2.1*, May 2021. https://rivers.codefornature.org/ (9/3/2025))
    - Discharge data from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) report for Siskiyou County, CA was also reviewed.

3.1.1 Peak flows

An 84-year record of instantaneous peak flows from USGS gage 11519500 was used to estimate flood frequency. Two standard methods were applied for comparison:

- Weibull Method: Ranks annual peak flows and estimates flood frequency directly from observed data. The Q100 event was extrapolated based on trends in frequency compared to discharge.
- Bulletin 17C: A statistical approach, commonly used for predicting rare events (e.g., 100-year floods), especially with shorter datasets. This method was applied in the HEC SSP statistical software on the same peak flows dataset.

The resulting predictions for Q1.1 through Q100 are compared in Table 3-1. The results were similar for Q1.1 through Q10, but the Weibull Method resulted in higher predictions for the Q25-Q100. The flood of record (54,600 cfs) on December 22, 1964 is shown on Figure 3-1. This event is greater than the Q100 for the bulletin 17C methodology, but similar to the Q100 Weibull prediction. Given the long period of record, and closer representation of Q100 to an observed peak flow event in the 83-year record, the Weibull method was selected to represent peak flows used in hydraulic modeling.

Table **3-1.** Flood frequency analysis of the Scott River at USGS gage no. 11519500 and FEMA flood frequency estimates.

Return Interval	Weibull	Bulletin 17C	% Difference
Q1.1	1687	1795	-6%
Q1.5	3820	3954	-3%
Q2	5650	5779	-2%
Q5	13338	12300	8%
Q10	16214	18363	-12%
Q25	35671	28276	23%
Q50	41567	37460	10%
Q100	57085	48324	17%

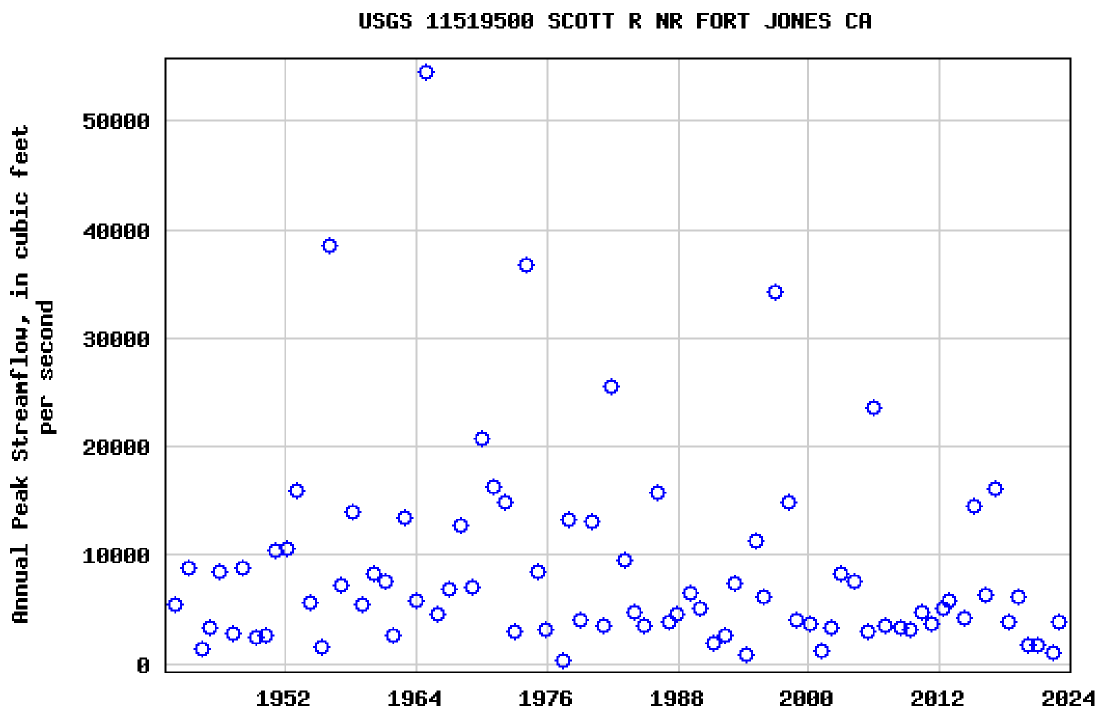

Figure 3-1. Annual Peak Streamflow from 1941 to 2024 for the Scott River USGS Gage 11519500.

3.1.1.1 Adjusting Peak Flows to Represent Project Area

Between the upstream project boundary and USGS Gage 11519500, Shackleford Creek and Sniktaw Creek serve as the primary tributary inflows. To evaluate how flow events differ between the USGS gage and the upstream extent of the project on the Scott River (above the Shackleford confluence), data from the California Environmental Flows Database (CEFWG, 2021) were analyzed. The relationship between streamflow at the two locations was expressed as a ratio (Scott River Upstream / Scott River at USGS Gage), which was then applied to the Scott River peak flow dataset.

Although smaller watersheds may contribute additional flow during major runoff events, it was assumed for this analysis that the difference in discharge between the upstream boundary and the USGS gage is primarily attributable to the Shackleford and Sniktaw watersheds. The remaining flow was apportioned between Shackleford Creek and Sniktaw Creek based on their respective drainage areas. Notably, the division of flow between these tributaries has varied over time, influenced by flood events and water diversions. Current conditions indicate that a substantially larger area drains through Shackleford Creek.

3.1.1.2 Storm Event Peaks between Scott River and Shackleford Creek

Streamflow data from the Scott River USGS gage and stage data from the Shackleford Creek California DWR gage were compared to assess flow patterns. The general trends of flows in the Scott River and Shackleford Creek appear to be relatively consistent (Figure 12). Overall, periods of higher flows from storm events can be seen on both gages consistently indicating the majority of storm events occur over both Scott River and Shackleford watersheds simultaneously, but as expected, the runoff in the smaller Shackleford Creek watershed is slightly more responsive to precipitation. Examining individual events, peak storm flows at the Scott River gage generally lagged a few hours behind peak stage on Shackleford Creek. The greatest lag time observed in the 2025 water year was 12 hours.

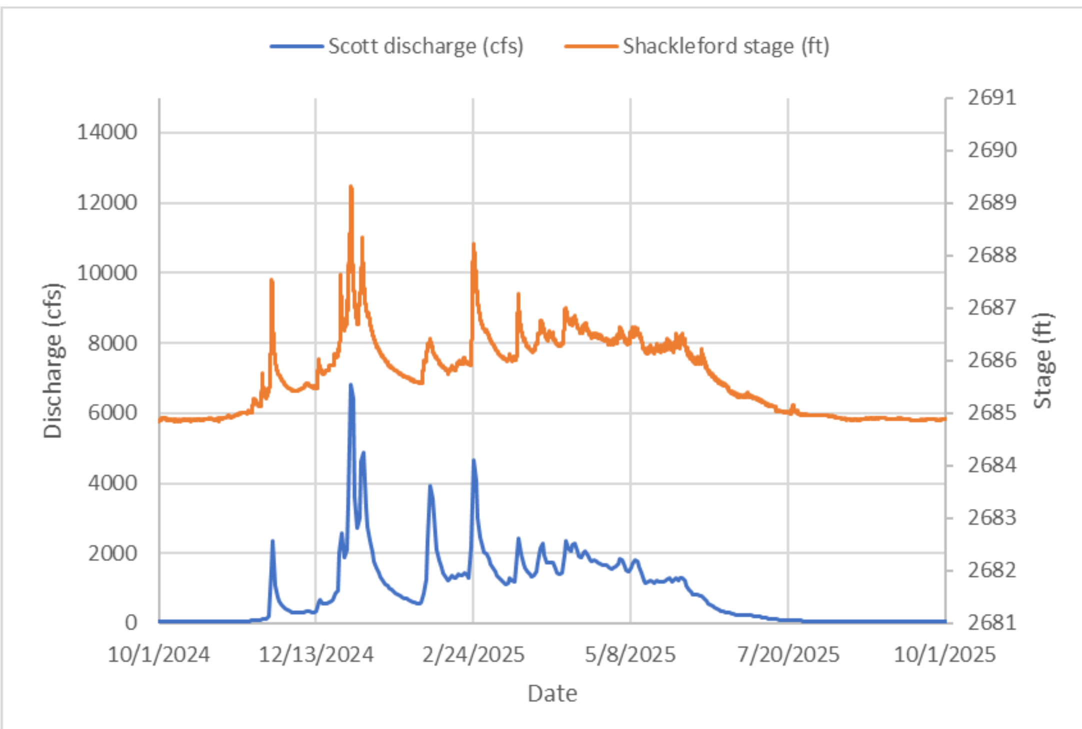

Figure 3-2. Daily average flow for Scott River USGS Gage 11519500 and stage data for Shackleford Creek DWR gage for the period 10/1/2024 to 10/1/2025.

3.1.2 Exceedance flows

Exceedance flows were calculated using daily flow records from USGS Gage 11519500 for the period of 1942–2025. These flows were adjusted to the Project area using the same assumptions applied to peak flow estimates. Additionally, data from the California Natural Flows Database (Grantham et al., 2022) were incorporated, providing statewide model-based estimates of flows necessary to support key physical and ecological processes. Table 2 presents the exceedance flows and four functional flows in ascending order.

These lower flows are biologically significant, particularly for fish habitat and passage. Specifically, the 10% and 20% exceedance flows are considered high fish passage flows for adult and juvenile salmonids, respectively (Flosi et al. 2010; NOAA 2001).

Table 3-2. Exceedance and functional flow estimates.

Data Source	Event	Scott River @ USGS 11519500 (cfs)	Scott River US of Project (cfs)	Shackleford (cfs)	Sniktaw (cfs)
USGS Gage During Low Flow	Sept 9th 2025	46	46	-	-
California Natural Flows	Dry Season Baseflow	73	63	8	2
California Natural Flows	Wet Season Baseflow	240	212	23	5
Daily Flow Exceedance 1942- 2024	50% Exc	275	234	34	7
California Natural Flows	Fall Pulse	352	296	47	9
Daily Flow Exceedance 1942- 2024	30% Exc	673	572	84	17
Daily Flow Exceedance 1942- 2025	20% Exc	1,010	859	126	25
California Natural Flows	Spring Recession	1,390	1,220	142	28
Daily Flow Exceedance 1942- 2024	10% Exc	1,500	1,275	188	37
Daily Flow Exceedance 1942- 2025	5% Exc	2,020	1,717	253	50

3.1.3 Monthly average daily discharge

Additional analysis was performed to evaluate historical trends in monthly average daily discharge for the project area, using data from USGS gage 11519500 on the Scott River for August and September when streamflow is typically lowest. The analysis was performed to evaluate how water use in the upstream areas of the watershed or climate might be affecting flows (Figures 3-3 and 3-4). The trendlines show a gradual decrease in average flow, reducing average streamflow by approximately 60 cfs from the 1940s to the present day. This reduction in flow has major implications for salmonid connectivity into Shackleford Creek. While discharge data was not available for Shackleford Creek, similar trends are likely occurring.

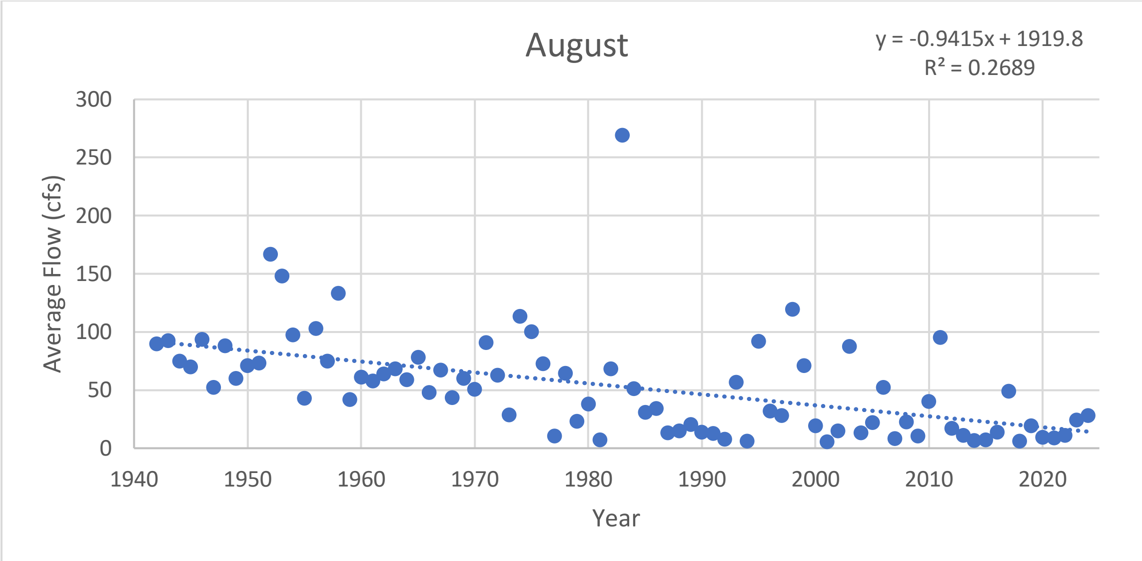

Figure 3-3. Monthly average discharge for the month of August from 1941 to 2024 for the Scott River USGS gage 11519500.

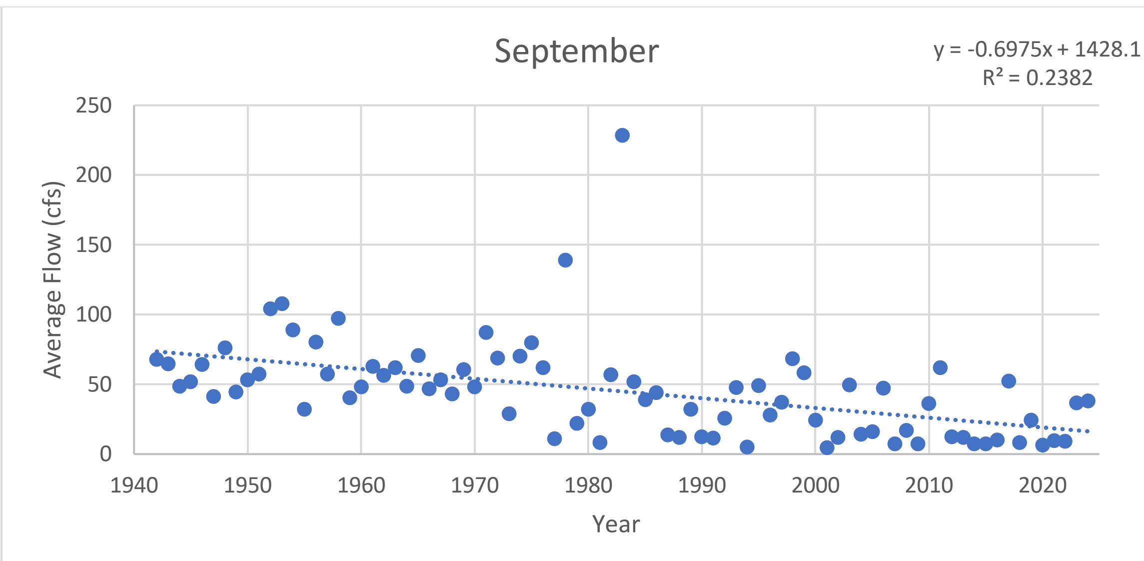

Figure 3-4. Monthly average discharges for the month of September from 1941 to 2024 for the Scott River USGS gage 11519500

3.2 Existing Conditions Hydraulic Modeling

To better understand channel flow dynamics, hydraulic modeling was performed using the U.S. Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System (HEC-RAS), version 6.6.0 (2024). HEC-RAS simulates the physical properties of streams and rivers by conducting two-dimensional (2-D) hydrodynamic routing with unsteady flow. The model uses a user-defined computational mesh to represent terrain data. For this project, the mesh was developed in HEC-RAS 2025 and then exported to HEC-RAS 6.6 for computational runs.

3.2.1 Setup

A terrain mesh for the project reach was created by importing the DEM derived from the topographic surface described in Section 2.1 into HEC-RAS. This mesh characterizes both main channel and off-channel (overbank) geometries. 10-foot resolution mesh cells defined the main channel areas as well as some complex floodplain areas within the project limits. Outside of those specified refinement regions, the mesh defaulted to 15-foot cells. Breaklines were used to refine mesh alignment. Upstream and downstream model extents were then assigned boundary conditions. Three upstream boundaries (Shackleford Creek, Sniktaw Creek, and Scott River) were assigned the project design flows that included a range of exceedance and peak flows. The downstream boundary was set to a normal depth flow condition with a friction slope of 0.672%, based on the terrain. Ground surface roughness characteristics were defined in HEC-RAS using spatially discrete areas, representing Manning’s n zones across the model domain. These areas were refined in the calibration process described in the subsequent sections. Manning’s values were assigned based on standard references (Chow 1959), field observations, professional judgement and aerial imagery (see Table 3-3 and Figure 3-5).

Table 3-3. Existing conditions Manning’s roughness values.

Land cover	Manning’s roughness coefficient
Unvegetated channel	0.030
Grassland	0.035
Cultivated	0.030
Dense riparian	0.100
Moderate riparian	0.060
Dense forest	0.100
Moderate forest	0.060
Paved road	0.015
Wash	0.045
Developed open space	0.050

Figure 3-5. Existing condition land cover classification overview within the Project boundary (red line).

3.2.2 Hydraulic Model Calibration and Validation

3.2.2.1 Low Flow Calibration

On September 3, 2025, SRWC staff collected eight water surface elevation (WSE) observations. At that time, the Fort Jones gage (USGS 11519500) recorded a flow of 46 cfs, with no surface water contribution from Shackleford Creek. Given the absence of tributary inflows during late fall, the hydraulic model was run with an input of 46 cfs in the Scott River, assuming minimal gains or losses between the project site and the USGS gage.

Initial model runs for the low flow event showed a slight underprediction near the Shackleford–Scott confluence (~0.1 ft) and a larger underprediction for the three downstream WSE observations (ranging from ~0.5 to 0.8 ft). To improve model accuracy, roughness polygons were adjusted to extend the riparian zone along the water's edge, and the model was re-run. Following this calibration, the five WSE observations near the Shackleford–Scott confluence closely matched the model results (Figure 3-6). The three downstream observations remained underpredicted by 0.4 to 0.7 ft, likely due to changes in channel bed topography between the 2024 LiDAR survey and the time of observation. Minor deposition downstream of the confluence could explain these discrepancies. At higher flows, such minor topographic changes are expected to have a reduced impact on WSE predictions.

3.2.2.2 High Flow Validation

No water surface elevation (WSE) measurements were collected during major flood events. However, two significant high-flow events occurred on December 27 and 29, 2024, with recorded discharges of 2,300 cfs and 7,000 cfs, respectively, at the USGS Fort Jones gage (11519500). The 2,300 cfs event corresponds to a 3rd percentile exceedance flow, while the 7,000 cfs event slightly exceeds the 2-year flood event threshold (~5,600 cfs). These substantial flows provided an opportunity to compare observed inundation extents.

The SWS team visually compared drone footage and photographs from these events to the hydraulic model outputs. Overall, the model accurately represented the spatial extent of flooding. As shown in Figure 3-7, the model results closely matched the observed flood patterns from the December 29 event, although some ponded water visible in the photos was not captured by the model. This discrepancy is expected, as 2D hydraulic models typically do not simulate ponding resulting from rainfall or seepage. Importantly, the photo validation did not reveal any areas requiring correction within the hydraulic model.

Figure 3-6. Low flow model calibration for September 3rd, 2025

Figure 3-7. High flow model validation for December 29th, 2024 storm event.

3.2.3 Hydraulic Simulations

Key design flows were simulated by running an unsteady stepped flow hydrograph. Modeled flow values included select annual exceedance flows as well as peak flow values described in Section 3.1. Table 4 reports the modeled flow values split between the three upstream boundary conditions: Scott River, Shackleford Creek, and Sniktaw Creek. The relationship between each boundary condition was kept steady through the hydrograph (i.e., the inflows have coincident peaks).

The hydraulic model was run with 1-second computational timestep and a 1-hour hydrograph interval to balance temporal resolution with computational efficiency. The simulation ran for a total of 72 hours which allowed the model to reach steady conditions after each ramp up in flow. Full-motion outputs were generated for water surface elevation, velocity, and depth across the 2D mesh domain. Model stability was maintained throughout the run, with no critical errors or instabilities observed.

Table 3-4. Summary of HEC-RAS model input discharges.

Flow Description	Scott River (cfs)	Shackleford Creek (cfs)	Sniktaw Creek (cfs)
Dry season baseflow	63	8	2
50% annual exceedance	234	34	7
20% annual exceedance	859	126	25
10% annual exceedance	1,275	188	37
1.1-year peak flow	1,434	211	42
1.5-year peak flow	3,247	478	95
2-year peak flow	4,523	940	187
5-year peak flow	11,467	1,560	311
10-year peak flow	14,638	1,314	262
25-year peak flow	30,320	4,461	889
50-year peak flow	35,332	5,199	1,036
100-year peak flow	48,522	7,140	1,423

3.2.4 Results

Figure 3-8 displays existing condition inundation extents for key exceedance and peak flows. Figures 3-9 through 3-12 display flow velocities for the 1.5-, 5-, 10- and 25-year peak flows respectively. These results help illustrate floodplain connectivity, activation of varying flow paths, and general hydraulic dynamics across the Project area.

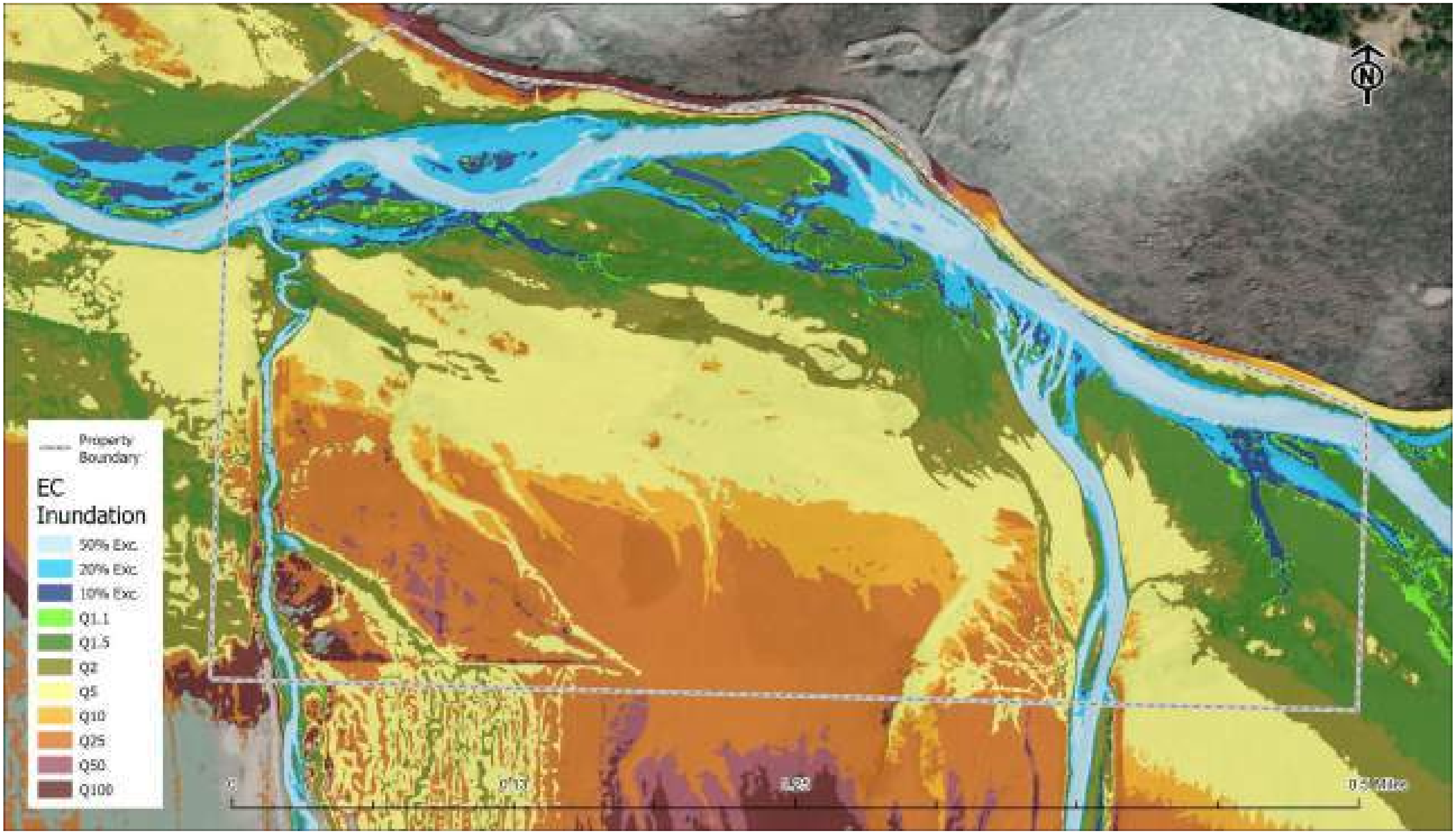

Figure 3-8. Floodplain inundation for exiting conditions ranging from 50% daily exceedance flow to the 100-year flood event.

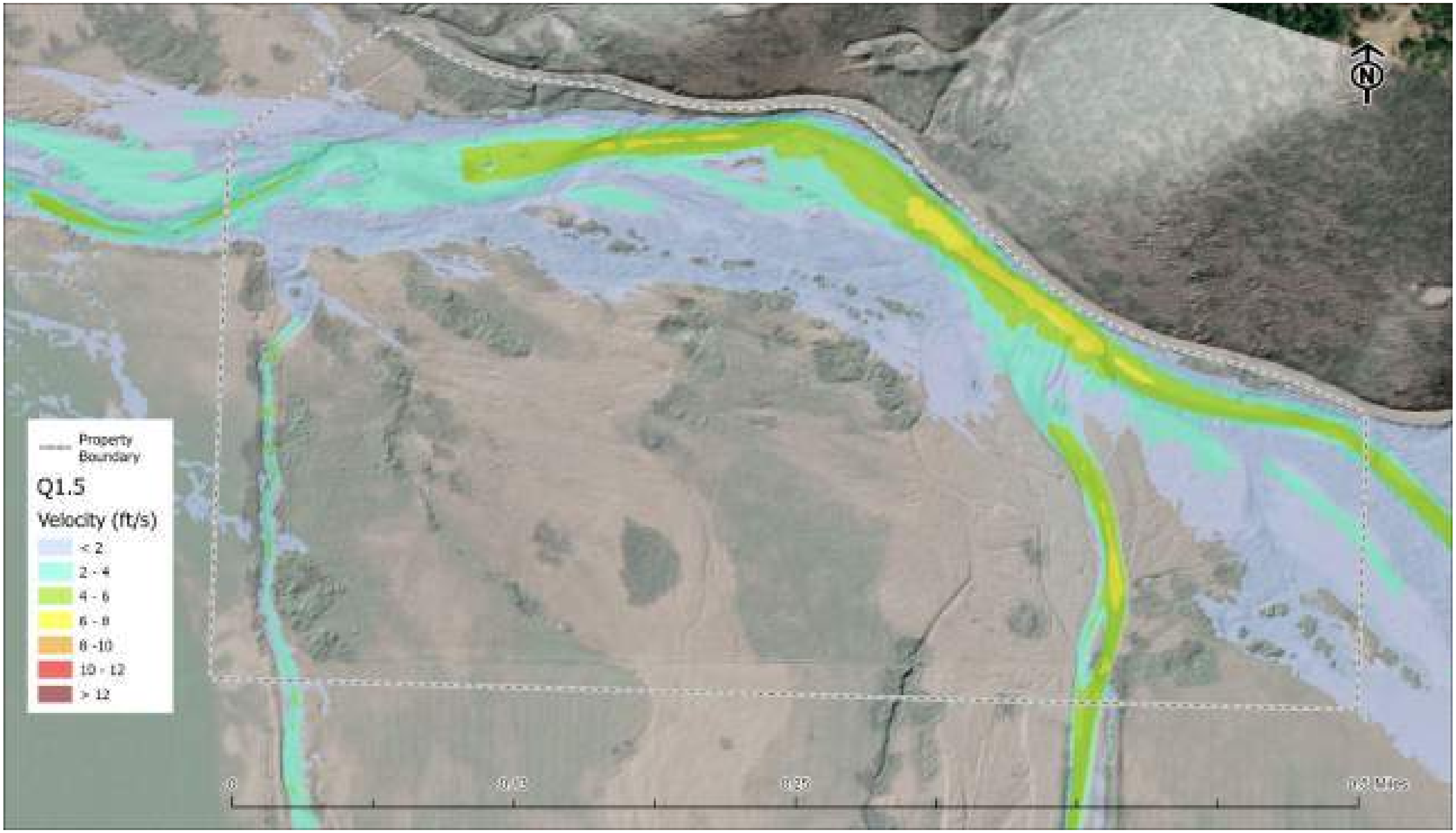

Figure 3-9. Flow velocity and inundation for exiting conditions at the Q1.5 flow event within the Project area.

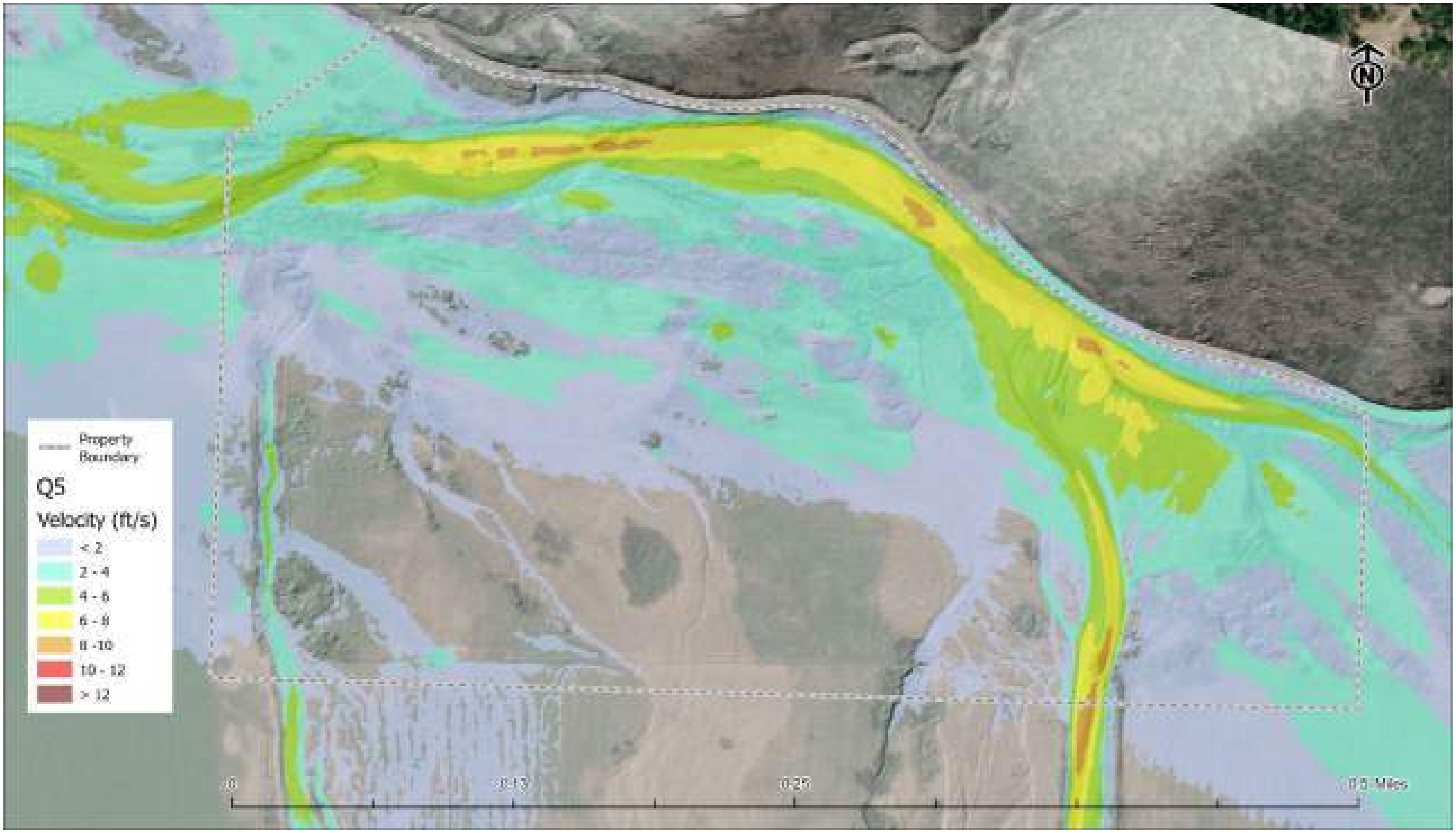

Figure 3-10. Flow velocity and inundation for exiting conditions at the Q5 flow event within the Project area.

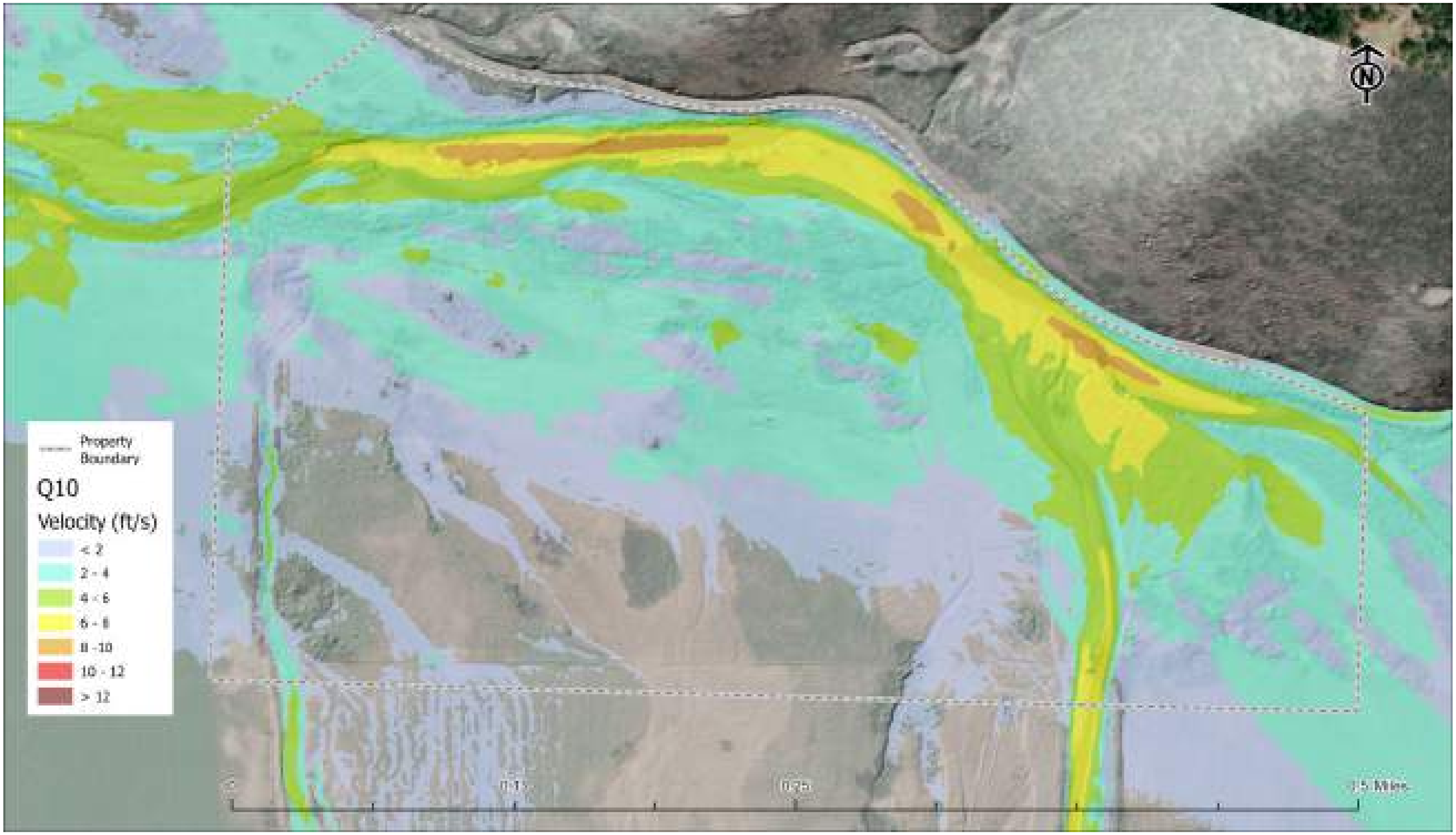

Figure 3-11. Flow velocity and inundation for exiting conditions at the Q10 flow event within the Project area.

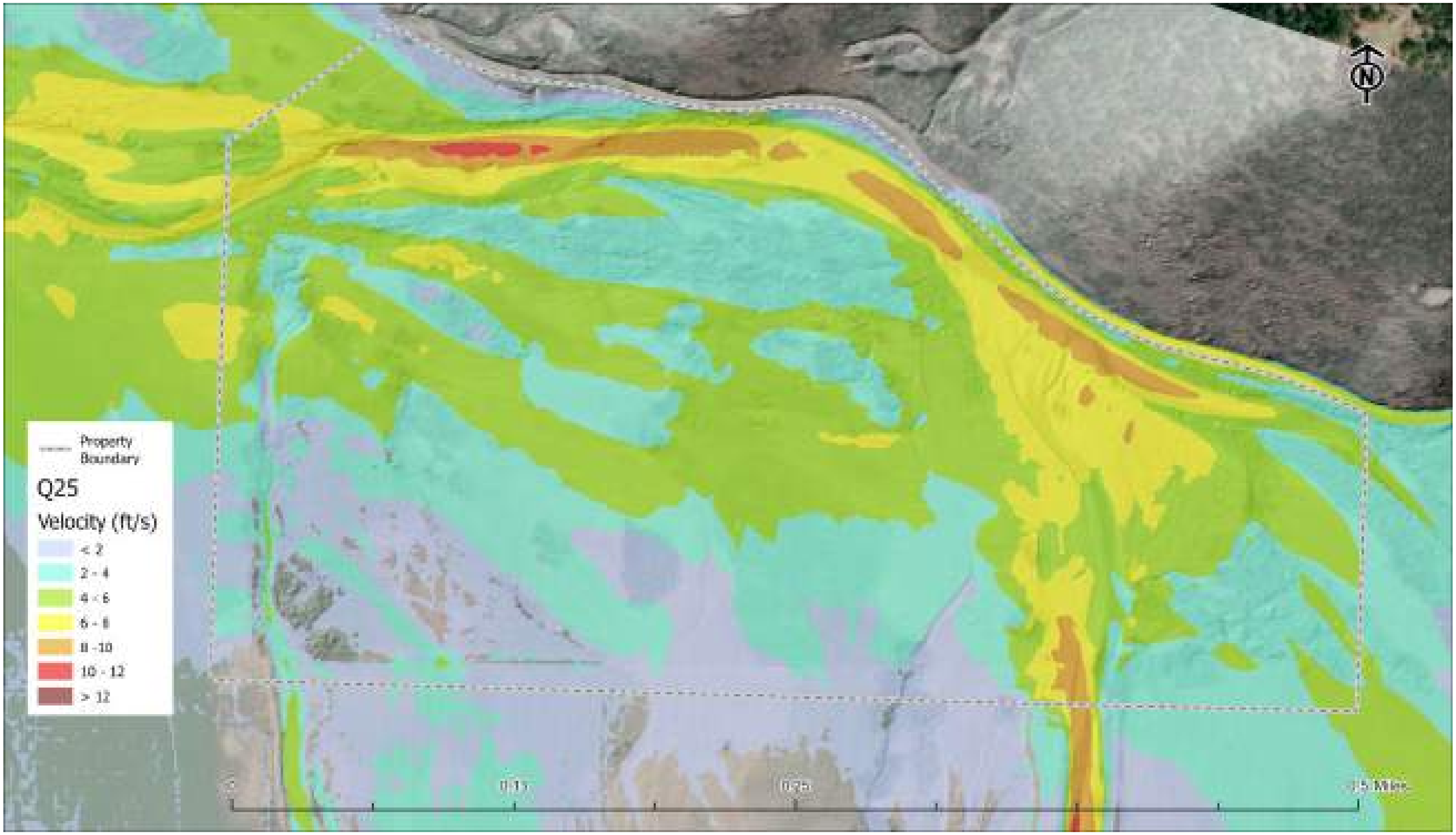

Figure 3-12. Flow velocity and inundation for exiting conditions at the Q25 flow event within the Project area.

Overall, these hydraulic model outputs show the complex flow dynamics at the Shackleford Creek confluence with the Scott River. In terms of sediment transport dynamics, one recurring theme in all the figures is a lower velocity zone due to a backwatering effect where Shackleford Creek confluences with the Scott River. This low velocity zone moves upstream on Shackleford Creek as flows increase. This hydraulic dynamic is common to most confluence areas and produces a geomorphic response with sediment deposition occurring in this lower velocity zone and subsequent channel migration forming the alluvial fan feature.

3.3 Sediment Transport Analysis

3.3.1 Background

Understanding the sediment transport processes of erosion and sedimentation within the project reach is essential to developing a self-sustaining and resilient restoration solution. The Project design needs to fit into the reach-scale geomorphic context, to provide upstream and downstream continuity for sediment transport through the confluence to increase the temporal period of surface flow connectivity. At the Shackleford Creek alluvial fan near the confluence, surface water often becomes disconnected. This fan is dominated by coarse substrates. Finer sediments (silts and clays) help retain moisture in soils and support vegetation establishment. Design elements that create places for fine sediment to settle on the fan can improve surface-water connectivity over time. Because this confluence is dynamic, it is important to understand the sediment transport processes that shape it.

Sediment is transported in coarse-bed rivers (comprised of primarily gravel and cobble-sized particles) in a few distinct ways (Figure 3-13). Larger particles such as gravels, cobbles, and some sand move as bedload and tend to roll, slide, or saltate when mobile. Smaller particles such as fine sand, silt, and clay move as suspended load and tend to move in suspension within the water column. Sediment transport equations/analyses traditionally focus only on the bedload portion. The bedload is typically the primary geomorphic controlling sediment in coarse-bed rivers, and so the suspended load is typically not considered for such applications.

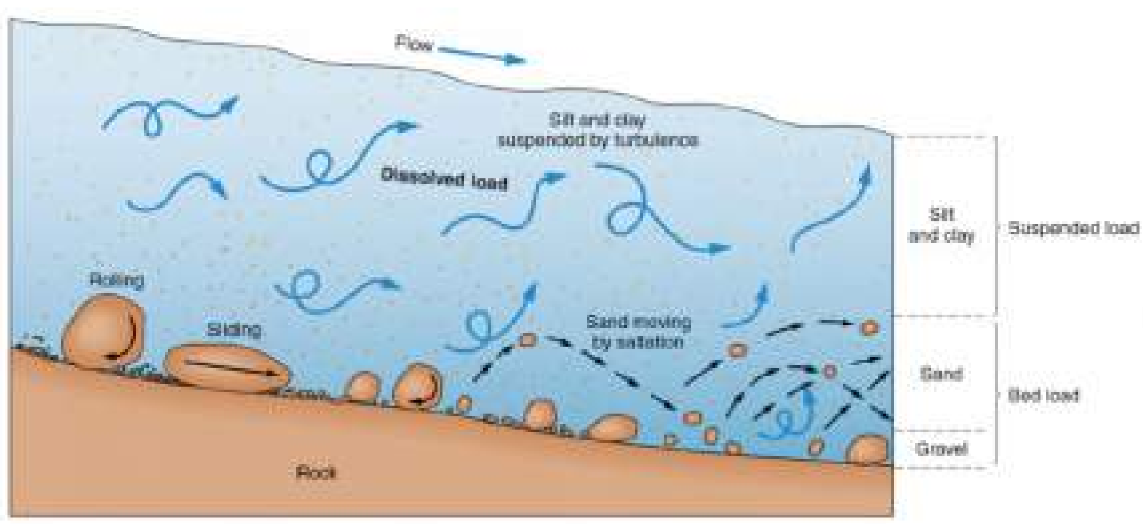

Figure 3-13. Conceptual diagram of how sediment is transported in coarse-bed rivers.

The simplest approach for estimating sediment transport is to consider the mobility of a single particle, commonly called incipient motion. The incipient motion analysis is based on the

Shields equation, which estimates the amount of shear stress (slippage force along the bed of the river) necessary to cause the first (i.e., incipient) mobilization of a particle. The relatively simple concept of determining the threshold force necessary to mobilize a particle has been expanded through the years with lab and field studies to estimate the mobilization of particles across an entire riverbed. A particular particle's size, shape, orientation to flow, and size relative to other particles around it all influence whether the particle will move. Sediment transport studies have tried to capture the complex factors that influence transport by developing equations based on field and lab investigations.

One important concept developed for coarse-bed streams is "equal mobility." The equal mobility concept asserts that the entire matrix of sediments in a river bed, ranging from small to large particles, will tend to mobilize at a similar threshold shear stress, because small particles hide behind large particles and large particles protrude into flow above small particles, counterbalancing the effects of the individual grains' size differences (Figure 3-14).

Figure 3-14. Photo of riverbed showing cobbles, with small grains "hiding" beneath larger grains, impeding their mobility. Note also the Caddisfly casings utilizing the interstitial spaces between the larger gravel clasts.

3.3.2 Incipient Motion Analysis

An incipient motion analysis comparing existing conditions (EC) and proposed conditions (PC) was performed to understand the effects of the design on sediment transport capacity in the project reach. To calculate the critical shear stress for incipient motion, the following equation from Andrews and Nankervis (1995) was used to calculate critical shear stress for different grain sizes, which adjusts the shear stress required to move a certain particle by comparing the sediment size to the median grain size (D_{50}). The data used to develop the equation were derived from a variety of rivers across the western US:

$$\tau_c^* = 0.0354\left(\frac{d_i}{d_{50}}\right)^{-0.975}$$

$\tau_c^* = critical\ shear\ stress$
$d_i = grain\ size\ of\ particle$
$d_{50} = mean\ grain\ size$

The average values of these results were used to compare to shear stresses calculated in the EC and PC models to estimate the potential for sediment movement in the project reach. Water-surface elevations and shear stresses along the thalwegs of Scott River and Shackleford Creek of the EC model are shown in Appendix D along with the calculated critical shear stresses. Additional discussion related to EC and PC model comparison is included in Section 4.4.

3.4 Groundwater-surface water Interaction

The confluence area between Shackleford Creek and the Scott River is a dynamic environment characterized by ephemeral surface connectivity and variable temperature inputs. To better understand how the groundwater table and water temperature respond to flows in both the Scott River and Shackleford Creek, fourteen temperature and WSE monitoring stations were installed by SRWC with locations shown in Figure 3-15. This network supports evaluation of current system function and will enable monitoring of changes following project implementation.

3.4.1 Monitoring Well Network

Vented pressure transducers were deployed in Shackleford Creek and Scott River monitoring wells (SHSRMW) in 2025 at the locations shown in Figure 3-15. Each site utilized an Onset Pressure Transducer housed in a vented steel casing. Figure 3-16 provides a photo of the typical monitoring well installation. Monitoring Sites 1–7 and 16 were installed in early August 2025, with the remaining wells added on September 3, 2025. The distribution of groundwater wells was designed to capture changes in groundwater levels and temperatures in response to changing flow conditions in the Scott River and Shackleford Creek.

3.4.2 Water Temperature

The full monitoring network became operational on September 3, 2025, which coincided with a period when Shackleford Creek had no surface flow. As a result, this analysis reflects dry fall conditions. Future data collection will provide a broader temporal perspective on temperature dynamics. Figure 3-17 presents observed temperatures at each monitoring location on September 3, 2025. While temperatures varied across the site, no clear relationship was observed between temperature and proximity to either river at this time.

The highest temperatures were recorded at Site 7 (19.6°C) and Site 16 (18.6°C). The lowest temperature was at Site 1 (11.5°C), upstream of the confluence, followed by Site 11 and Site 12. Elevated groundwater temperatures in the Shackleford Creek alluvial fan may result from surface exposure before water infiltrates into the subsurface. Cooler sites are likely influenced by groundwater not recently exposed to surface warming, often located near vegetation that provides shade and farther downstream from the likely primary surface water inputs. Continued monitoring will help further understand these trends in groundwater and surface water interactions.

Water temperature is critical for salmonid habitat suitability. Temperatures above 19°C are considered unsuitable for juvenile coho, 17°C to 19°C is marginal, and 10°C to 17°C is optimal (Table 3-5). On September 3, Sites 1, 3, 4, 5, 11, and 12 fell within the optimal range. These sites are generally close to the Scott River and have some vegetative cover. Only Site 7 exceeded the unsuitable threshold, while the remaining sites were marginal. This analysis indicates that Shackleford Creek is not a source of cool water during fall, and the exposed alluvial fan may contribute to elevated groundwater temperatures. Design considerations may include increasing shade along the water's edge or evaluating how shifting Shackleford alignments will impact temperature dynamics.

Table 3-5. Water quality thresholds for temperature and DO relating to habitat suitability for juvenile coho salmon rearing and migration.

Characterization	Temperature (degrees Celsius)	Dissolved Oxygen (mg/L)
Good	10–17	≥7
Marginal	17–19	4–7
Poor/Unsuitable	19–22	≤4

Sources: Bjorn and Reiser 1991, Hines and Ambrose 1998, USEPA 2003, Welsh et al. 2001

3.4.3 Groundwater-Surface Water Model

The monitoring network provides a comprehensive view of how groundwater elevations change in response to inputs from the Scott River and Shackleford Creek. Although the instruments have only been in place since August and September, a declining water table trend is already evident at the uppermost monitoring location (Site 16), near the property boundary on Shackleford Creek. Figure 3-18 shows a drop of over two feet in subsurface groundwater elevation, indicating increasing disconnection between the groundwater table and the dry channel in the Shackleford alluvial fan.

A snapshot of surface and groundwater conditions was developed to represent late summer/early fall conditions when Shackleford Creek's surface water was disconnected from groundwater (September 3). WSE observations from the monitoring wells were combined with direct Scott River WSE measurements and hydraulic model results. Additional interpolation points developed from observed data relationships, improved spatial coverage. The combined dataset included 13 groundwater monitoring observations, 8 direct WSE measurements along the Scott River, 8 hydraulic model results, and 17 interpolation points. These data were used to generate a surface representing the groundwater–surface water elevation using inverse distance weighting.

Figure 3-19 shows contours illustrating anticipated groundwater flow direction. The contours are generally perpendicular to the Shackleford Creek and Scott River indicating downstream groundwater flow parallel to surface water flow paths. Shackleford Creek locally mounds groundwater in the alluvial fan, even when the channel is dry at the surface. Figure 3-19 also displays estimated depth to groundwater (DTG), calculated by subtracting the groundwater–surface water surface from the existing ground surface DEM. DTG values around the alluvial fan are approximately 4 to 8 feet, but are much shallower, about 0 to 2 feet, in the vegetated zone west of the fan. Enhancing Scott River connectivity to this area may increase the duration that Shackleford creek surface water is present and provide additional cold water benefits as described previously.

Figure 3-15. Location of water surface elevation stations – Shackleford Creek – Scott River Confluence.

Figure 3-16. Example of Onset vented pressure transducer monitoring location SHSCMW2 on river left bar of Scott River downstream of Shackleford Creek Confluence.

Figure 3-17. Monitoring network temperature distribution in degrees Celsius (°C) on September 3rd, 2025.

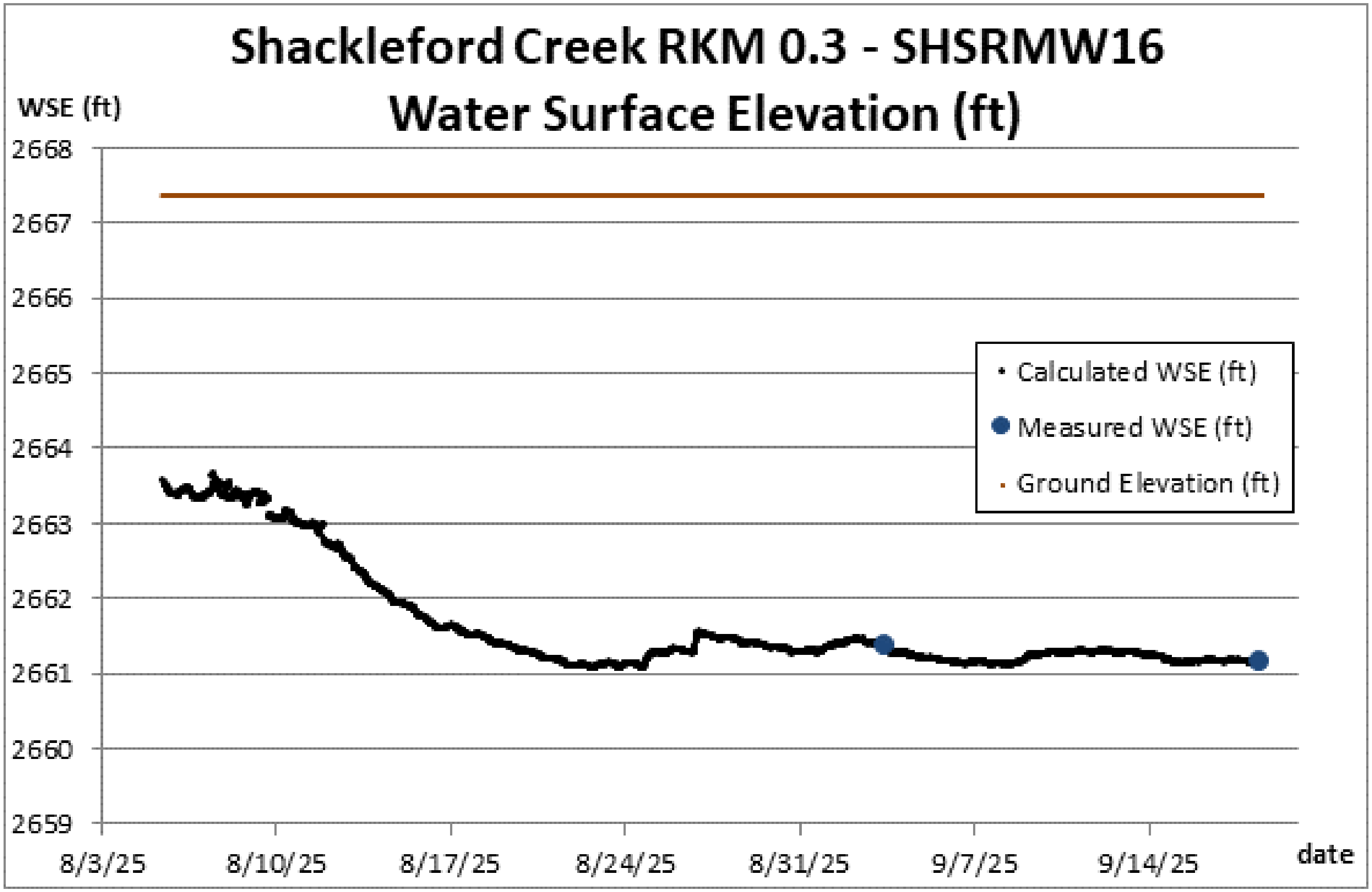

Figure 3-18. SHSRMW16 groundwater elevation change from August to September of 2025.

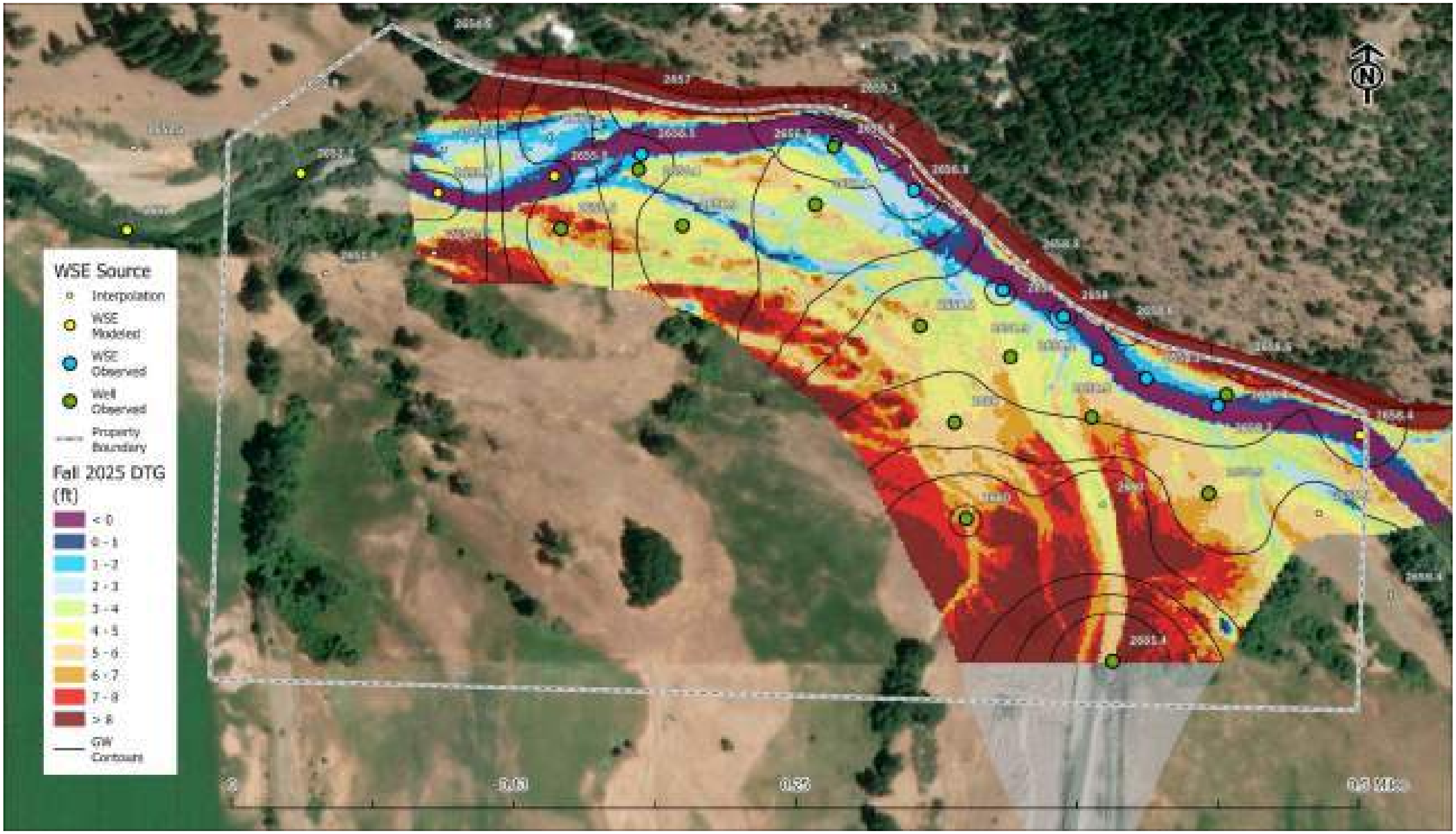

Figure 3-19. Depth to groundwater on September 3, 2025.

4 Design

4.1 60% Design Process

Conceptual (30%) design alternatives were presented to the TAC in April 2025 with several potential realignments of the Shackleford Creek thalweg proposed. The 30% design was prepared with office-based information only and did not include proposed conditions hydraulic modeling.

Stillwater Sciences and SRWC visited the Project site in July 2025 to observe field conditions and assess the feasibility of the 30% design alternatives. Additionally, hydraulic modeling was conducted to support 60% design development (Section 4.3) and provided strong justification for realigning lower Shackleford Creek to meet the Scott River downstream from the current point of confluence. This realignment is necessary to accommodate the desired bank protection along Scott River Road while not substantially increasing WSEs during high flow events.

Further supporting the Shackleford Creek realignment proposed herein, 1944 imagery illustrates that the confluence has shifted upstream and toward the Scott River Road over the last 80 years. The proposed design realigns the confluence closer to its 1944 location while providing more flow capacity on the left bank of the Scott River through the confluence area.

A plan view and cross section of the 60% designs are shown in Figures 4-1 and 4-2 respectively, and the full designs are included in Appendix A.

4.1.1 Opportunities

The 60% design was developed to achieve the Project goals of improving base flow surface water connectivity in lower Shackleford Creek to the greatest degree feasible, generally enhancing instream and floodplain habitat, and reducing erosion risk along the Scott River Road.

- **Enhance Shackleford-Scott Confluence Connectivity** – The confluence zone is frequently dry during late summer and fall, presenting a major fish passage barrier. The groundwater analysis illustrates that the groundwater table is 5-7 feet below the stream surface during these drier periods. The following actions may increase the duration over which there is a surface water connection:
    - Realign lower Shackleford Creek to connect to the Scott River downstream on river left where the groundwater table is closer to the ground surface. This is likely to increase the duration of surface flow in the lower reaches of Shackleford Creek.
    - Increase floodplain roughness throughout the Shackleford Creek alluvial fan deposit to encourage flow heterogeneity that will result in channel scour and fine sediment deposition within the floodplains. Over longer timespans, this finer sediment on the floodplain may help retain groundwater during drier periods and promote establishment of riparian vegetation across a broader portion of the alluvial fan.

- **Improve Salmonid and Riparian Habitat Throughout the Project area** – The project reach is lacking large wood features, shaded habitat and general complexity.
    - Install large wood features that provide diverse salmonid habitat in addition to bank protection.

- Increase areas of high-flow refuge that support deposition of finer substrates and riparian vegetation establishment.
- Increase frequency of inundation in zones with existing vegetation.
- Create side channel habitat, including beaver mimicry structures, to increase habitat diversity for more life stages of salmonids.

- **Reduce Erosion along Scott River Road -** Several locations on the right bank of the Scott River are eroding and threatening the road.
  - Design bank protection features that direct high velocity flow away from the right bank during storm events.
  - Reconnect and excavate left bank floodplain to expand channel capacity.
  - Realign Shackleford Creek so sediment deposition from Shackelford forms an alluvial fan farther downstream on the Scott River where there is more room for the road.

4.1.2 Constraints

Multiple constraints impact the Project area. While Project designs may improve some of these issues, there are several constraints that are not possible to address working solely within the Project footprint:

- **Groundwater** in Shackleford Creek at the Upstream extent of the Project is approximately 6 ft below the thalweg invert elevation during an extended period of the dry season (Figure 3-18). It is unlikely that the work proposed in these 60% designs within the current footprint will improve the surface water connectivity within the upper portion of the Project reach. This disconnection is driven by upstream water withdrawals (both groundwater and surface water) the upstream berms that are disrupting natural sediment transport process, and the natural depositional trends of alluvial fan morphology, as further elaborated below.
- **Flooding of the Scott River Road** currently occurs during ~5-year storm events making road protection limited to reducing toe erosion only. This flood risk also highly constrains the design approach requiring any bank protection and/or channel roughness features to be offset by floodplain excavation to ensure that WSEs are not increased as a result of the project.
- **Alluvial fan geomorphology** is highly dynamic and typically results in ongoing sediment deposition. During flood events, large volumes of sediment are likely to deposit and may cause Shackleford Creek to avulse out of the proposed channel and/or migrate away from proposed treatments and again impede on Scott River Road.
- **Upstream berms** along Shackleford Creek channelize and contain flows up to the 100-year flood event. As a result, coarse sediment deposition is increased downstream from the berm terminus which increases deposition within the alluvial fan. This deposition increases erosion potential along Scott River Road and decreases surface water connectivity during the dry season. Furthermore, the berms do not allow for a realignment of Shackleford Creek farther to the west which would provide the greatest opportunity of protecting the road.
- **Reed canary grass** is thriving in the wetter near-channel and floodplain portions of the Project area and the proposed design features are likely to create more suitable habitat for this species. Implications of this should be considered in the final design, construction, and monitoring/maintenance phases of the project.

- **Climate Change** is expected to increase flow variability and timing which could further exacerbate the surface water disconnection between Shackleford Creek and Scott River and also lead to higher risk of extreme sediment deposition leading to channel avulsion.

4.1.3 Summary of Opportunities and Constraints

Considering the discussion above, leaving Shackleford Creek in its current alignment resulting in a constriction of the Scott River where the Scott River Road is most susceptible to erosion is not feasible. Additional left bank channel capacity is needed to convey storm flows offsetting the proposed right bank stabilization measures features. The current alignment is characterized by coarse substrate and a lack of established riparian vegetation, which impedes fish movement and habitat quality. In contrast, the proposed design spreads flow across the upper alluvial fan and includes roughness features that promote flow heterogeneity and the establishment of riparian vegetation, all of which are necessary to enhance habitat at the confluence. Although the large wood structures and brush trenches would be resilient to flood events, the channel grading – especially the proposed realignment of Shackleford – would be highly susceptible to sediment deposition and channel avulsion.

4.2 Design Features

Key Features:

- **Scott River Realignment with Split Flow Channels**
    - **Realignment:** The main channel thalweg is realigned to allow for fill and large wood placement along the road embankment, improving bank stability and habitat complexity.
    - **Split Flow Channels:** New side channels graded to activate during low flows, providing juvenile salmonid habitat and increased conveyance. These channels help create diverse habitat, reduce erosive forces along the road, and enhance floodplain connectivity.
    - **Large Wood Structures:** Installed at key locations (e.g., bar apex, floodplain, and along the road embankment) to deflect flows, protect infrastructure, and increase habitat diversity. These structures are detailed in various configurations (large, medium, small) and are anchored using piles, boulders and threaded rebar.
    - **Right Bank Fill:** Fill is placed along the Scott River right bank to reduce erosion risk to Scott River Road by providing room for bank protection treatments in front of the road.
    - **Simulated Beaver Structures:** Low-crest permeable features constructed from willow stakes, large wood, and brush. Features are located in split flow channels along the Scott River.

- **Shackleford Creek Modifications**
    - **Realignment of alluvial fan**: The creek is realigned farther downstream to help move the alluvial fan which is creating bank erosion along the road and decreasing surface water connectivity between the Scott River and Shackleford Creek. Groundwater is also closer to the surface where the new confluence of Scott River and Shackleford Creek is proposed which can help with increasing hydrologic connectivity.
    - **Overflow Channels:** New overflow channels are graded to provide high flow connectivity to help increase sediment deposition away from Scott River Road.

- **Floodplain Large Wood Structures:** Placed throughout floodplain to encourage sediment deposition, riparian vegetation recruitment, and add habitat complexity.
- **Brush Trenches:** Trenches filled with live willow stakes, cottonwood branches, and coarse woody material are constructed to intercept groundwater, promote riparian growth, and increase floodplain roughness. These features help trap sediment, slow overland flow, and provide habitat complexity. Woody material from grading areas will be reused in habitat structures and brush trenches.

The design features are illustrated in greater detail in the 60% designs in Appendix A.

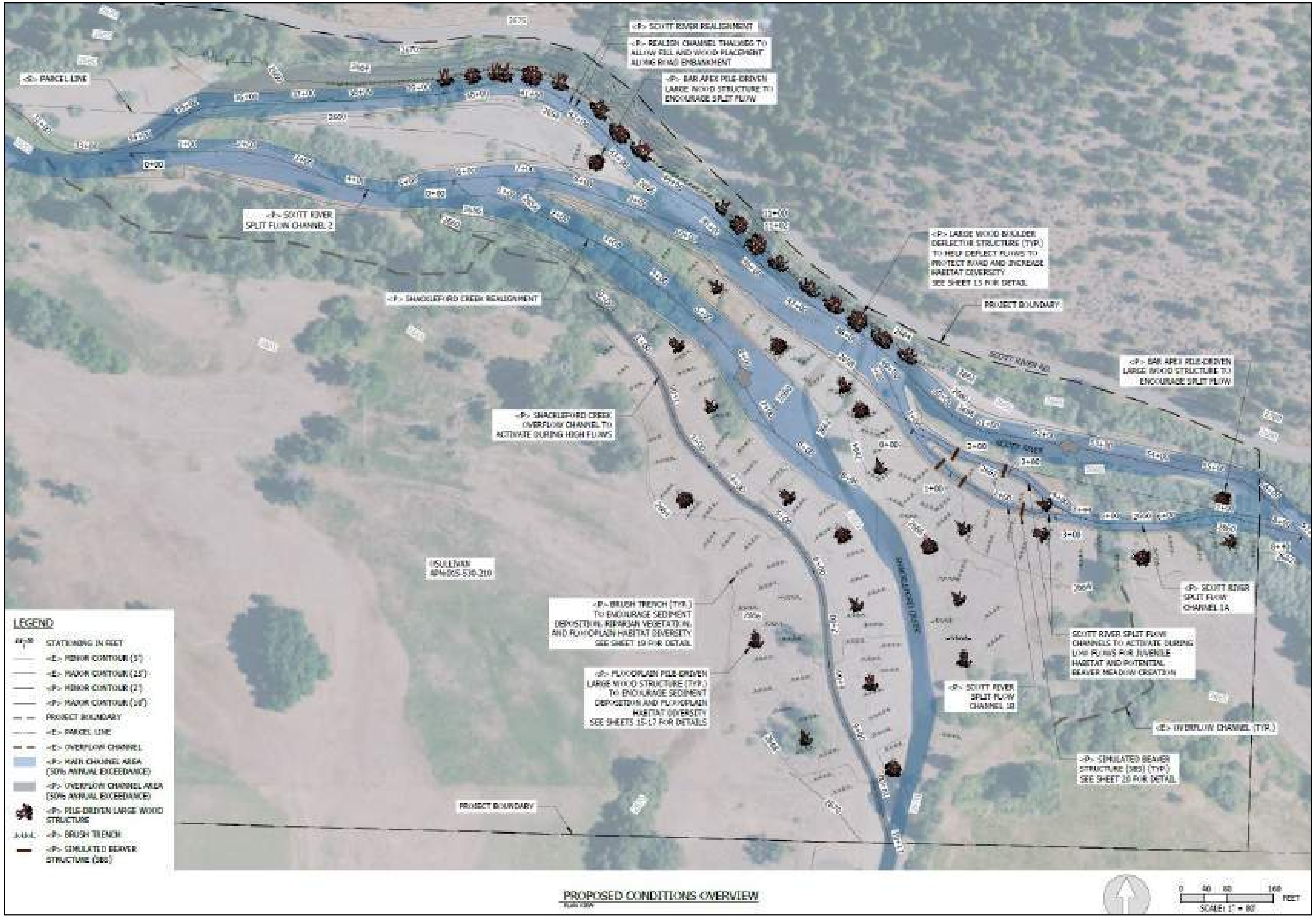

Figure 4-1. Proposed conditions plan view from 60% design plans

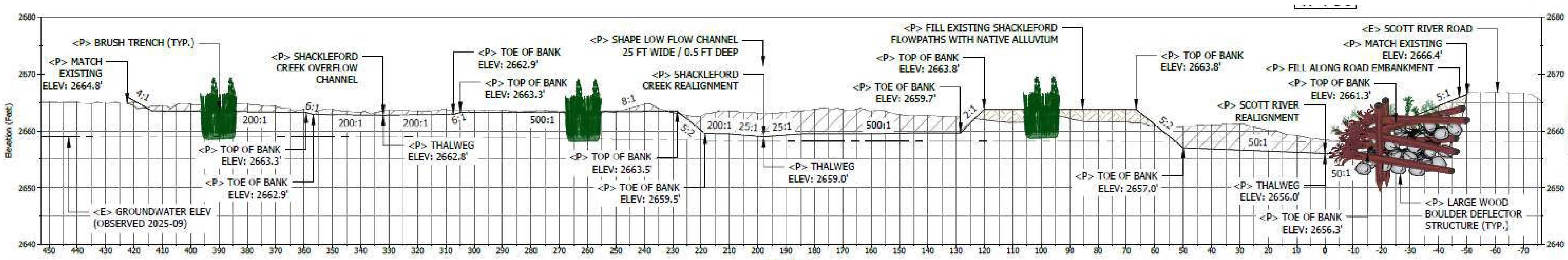

Figure 4-2. Example cross section view of proposed conditions from 60% design plans.

4.3 Design Features Hydraulic Impact

The proposed design surface which includes channel and floodplain grading was exported from CAD for use in the proposed conditions hydraulic model. The existing conditions model mesh, breaklines, and roughness features were updated to reflect proposed project conditions. All other model inputs including boundary conditions and the flow hydrograph remained the same.

The pile-driven large wood structures installed along the road embankment were represented as roughness features with very high (n = 0.150) Manning's n values. Several techniques exist to model large wood structures in hydraulic models including increasing roughness, adding a blocked obstruction with porosity, and raising the terrain to represent an impervious blockage. Increasing roughness is the most common technique used in practice because it is quick to add to the model, does not dramatically increase model instability, most research to support the analysis has used increased roughness, and alternative techniques that use impervious blockages have been shown to overestimate the effect of large wood structures (Addy and Wilkinson, 2019).

Disturbed areas to be revegetated were modeled with a roughness value n = 0.060, matching the existing condition value of "moderate riparian" areas. This reflects the expected roughness of the area once vegetation is established. The updated roughness classification areas are shown in Figure 4-3 and reported in Table 4-1.

Table 4-1. Proposed conditions Manning's roughness values.

Land cover	Manning's roughness coefficient
Unvegetated channel	0.030
Grassland	0.035
Cultivated	0.030
Dense riparian	0.100
Moderate riparian	0.060
Dense forest	0.100
Moderate forest	0.060
Paved road	0.015
Wash	0.045
Developed open space	0.050
Large wood	0.150

Model simulations were run under proposed conditions to understand how the proposed design influences site hydraulics. A comparison of inundation extents at a range of key flows are shown in Figure 4-4, and changes in velocity at the 1.1-, 2-, 5-, and 25-year peak flows are illustrated in Figure 4-5, Figure 4-6, Figure 4-7, and Figure 4-8, respectively. Notably, the proposed design reduces flow velocities adjacent to Scott River Road, relieving erosional pressure along the road.

Figure 4-3. Proposed condition land cover classification overview within the Project boundary (red line).

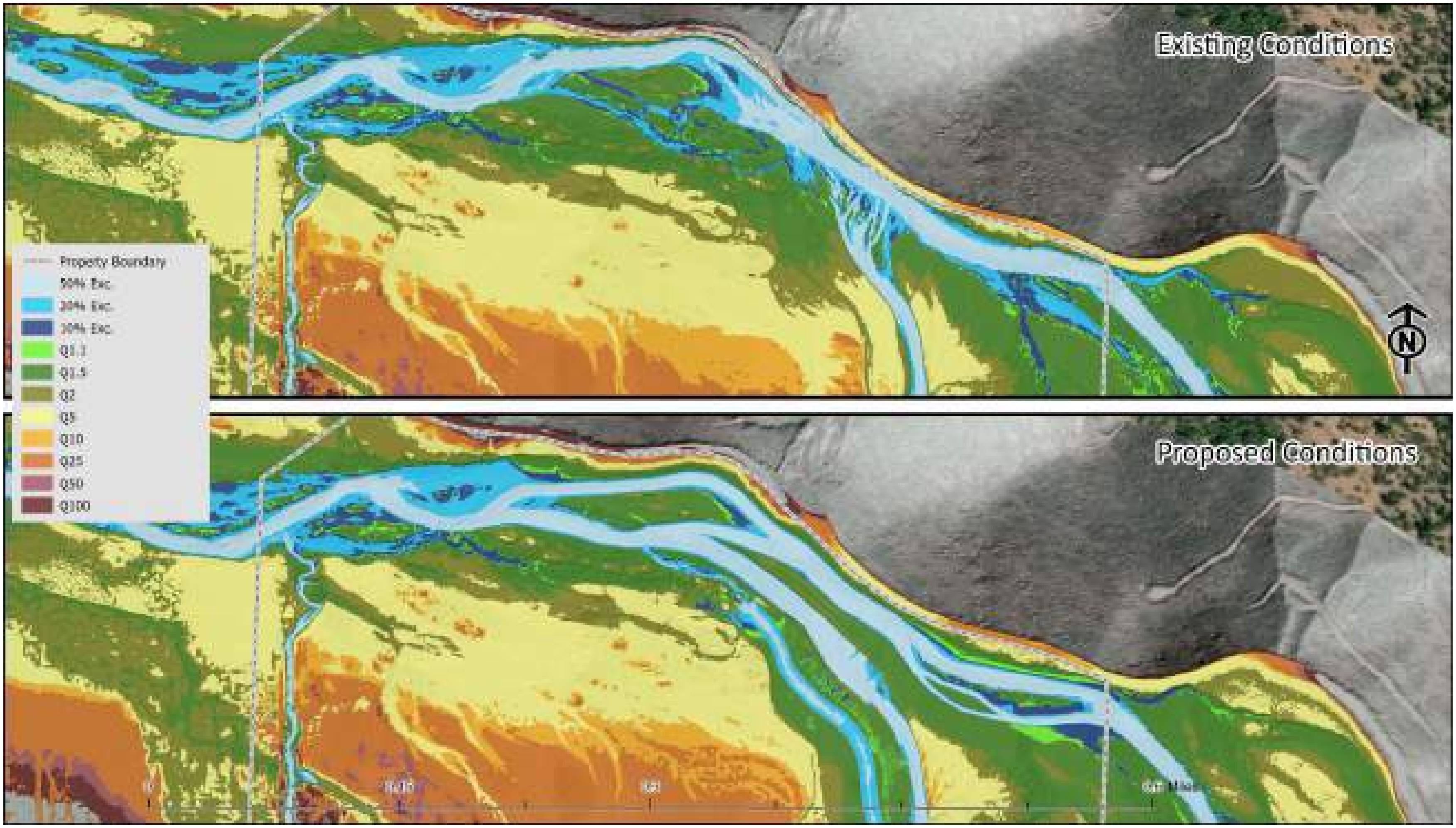

Figure 4-4. Inundation extents for flows ranging from 50% exceedance up to a 100-year flood event for existing (top) and proposed conditions (bottom).

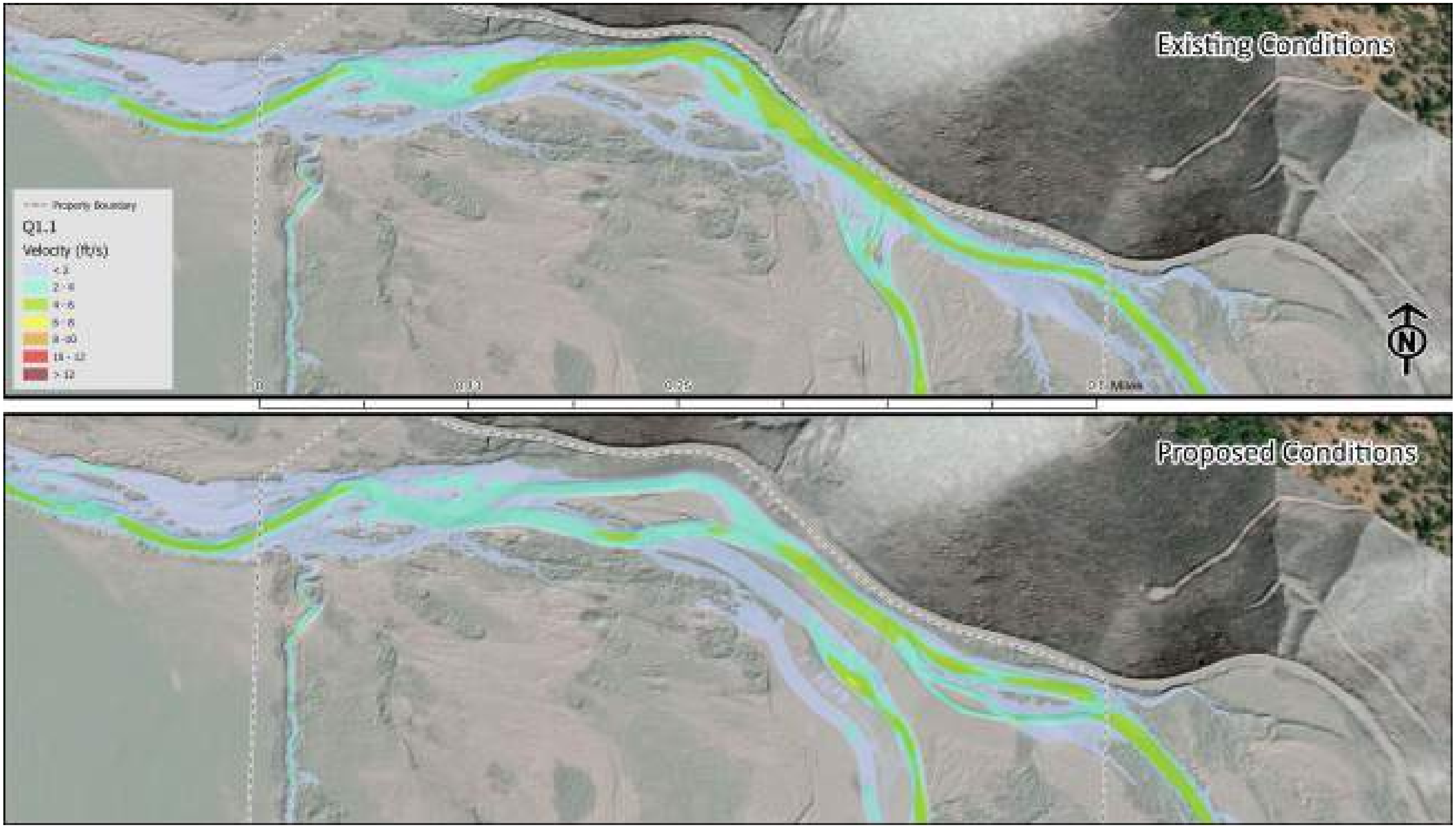

Figure 4-5. Velocity distribution for existing conditions (top) to proposed conditions (bottom) for the 1.1-year flood event.

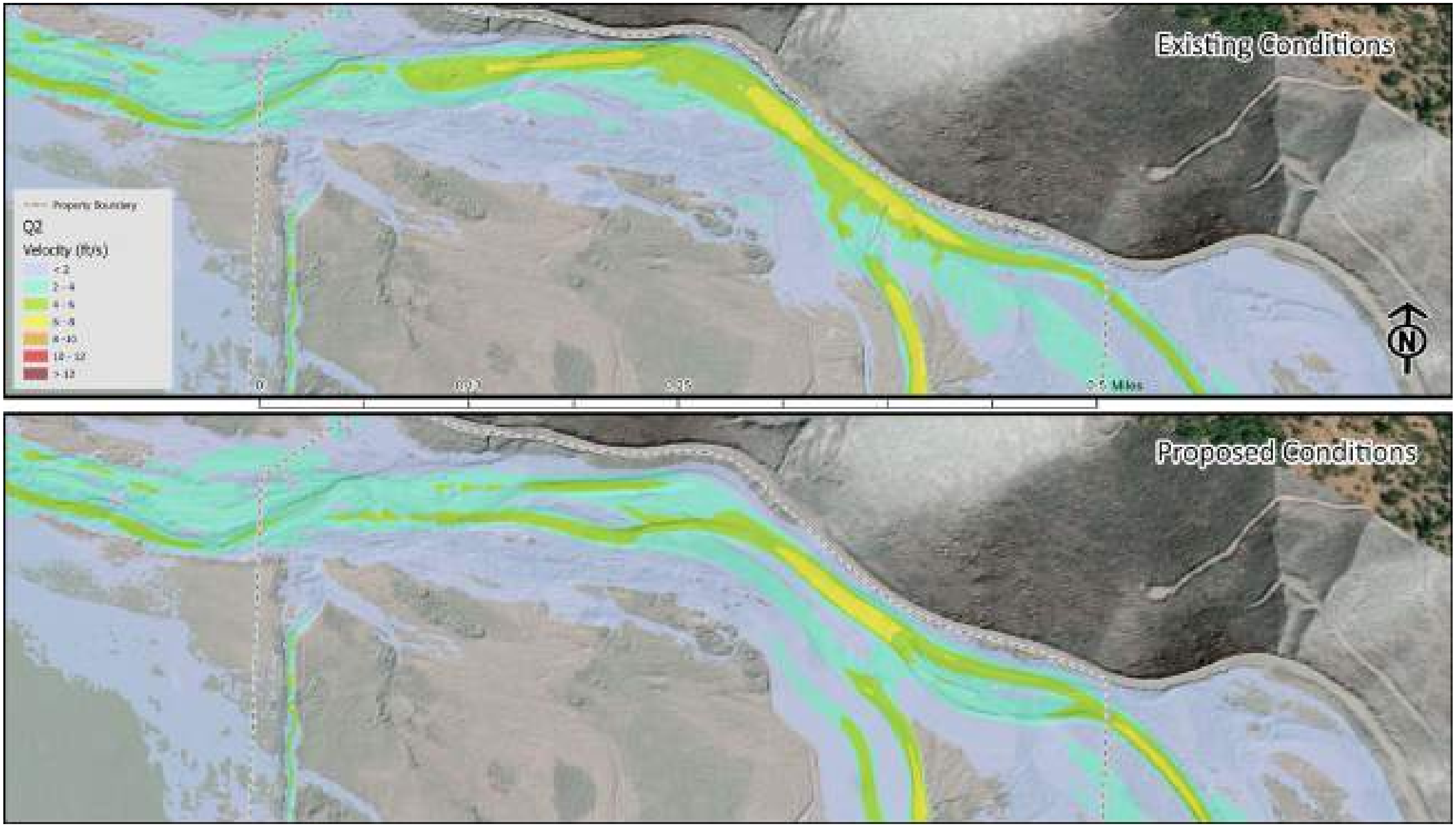

Figure 4-6. Velocity distribution for existing conditions (top) to proposed conditions (bottom) for the 2-year flood event.

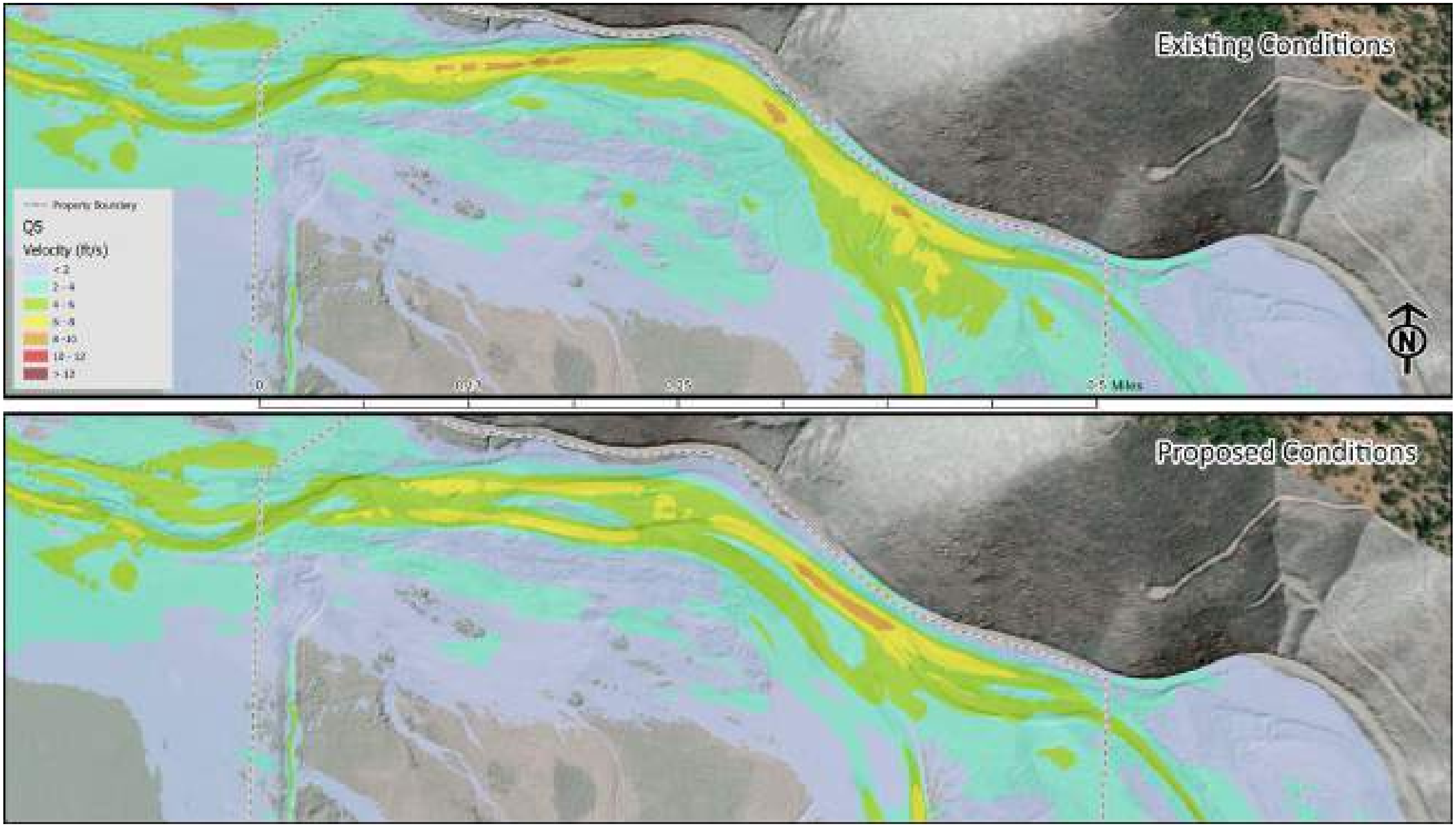

Figure 4-7. Velocity distribution for existing conditions (top) to proposed conditions (bottom) for the 5-year flood event.

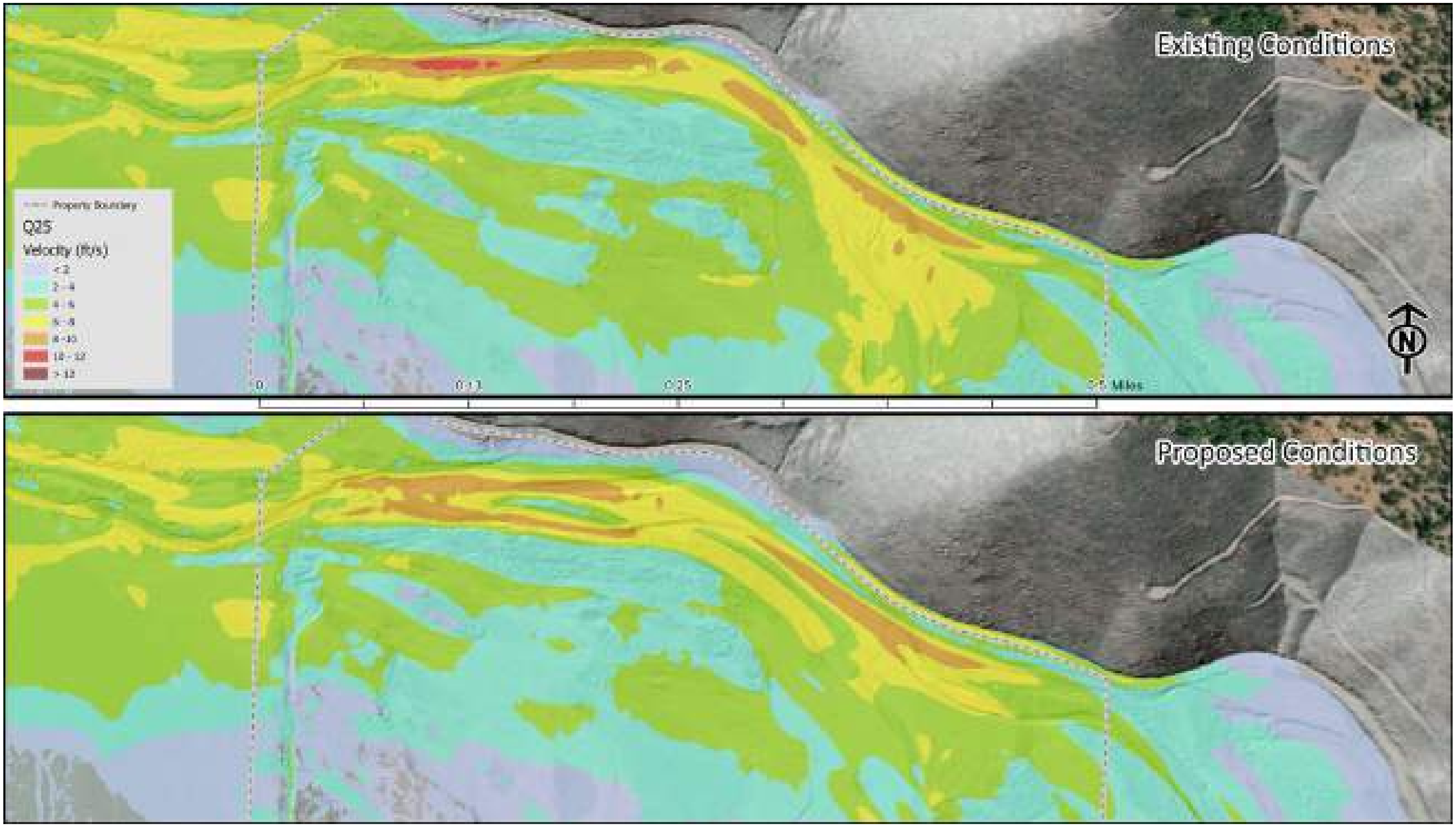

Figure 4-8. Velocity distribution for existing conditions (top) to proposed conditions (bottom) for the 25-year flood event.

4.4 Design Features Sediment Transport Impact

Comparing modeled shear stresses to the estimated range of critical shear stresses (i.e., the thresholds for motion) can help predict the potential amount of sediment movement expected in the reach. Exceeding the lowest shear stress threshold ($\tau_c^* = 0.021$) would indicate mobilization of smaller grain sizes is likely, while exceeding the highest threshold ($\tau_c^* = 0.06$) would be more likely to mobilize the entire riverbed. EC and PC model results for the 1.5-yr and 5-yr recurrence interval discharges are shown in Appendix D, along with the calculated critical shear stresses.

Under current conditions, Shackleford Creek is transporting coarse bedload material from upstream of the project site where the river is channelized and armored as indicated by $Q_{1.5}$ and Q_5 shear stress values that frequently exceed the estimated thresholds. The shear values remain high until closer to the confluence with the Scott River. Under proposed conditions shear values are reduced throughout the alluvial fan so increased sediment deposition is expected at the upstream end of the alluvial fan. The lower shear values may also support deposition of finer materials adjacent to the channels. Over time, fine sediment deposition along with riparian vegetation establishment may improve surface water connectivity over the alluvial fan. While sediment deposition is physically elevating Shackleford Creek which can lead to decreased surface water connectivity, the proposed design may promote some of the deposition upstream of the current constriction point where the Shackleford Creek alluvial fan is growing towards Scott River Road. This is especially true for the Q5 flow event when Shackleford is further backwatered by the Scott River.

The Scott River appears to currently not be mobilizing coarse bedload during the Q1.5 and Q5 flow events through the alluvial fan due to the flatter slope through this area. The alluvial fan is creating the locally flatter slope which is further exacerbating sediment deposition. The proposed conditions are reducing shear velocities here due to increased floodplain connection. However, there is a nick point in the Scott River just downstream of the current alluvial fan and it is possible that the nick point could migrate upstream and steepen the slope of the river if the alluvial fan is pushed downstream as proposed by this design.

4.5 Large Wood Stability

Engineered large wood structures will provide multiple benefits in association with the other project components described above. Two specific types of wood structures are anticipated:

- Bank deflector structures are proposed to deflect Scott River flow away from the vulnerable road embankment along Scott River Road. Additionally, these structures would be designed to increase sediment transport capacity of the Scott River, specifically within the immediate vicinity of the proposed Shackleford Creek confluence. These structures will also provide aquatic habitat benefits including scour and gravel sorting, pool cover, and pockets of slow water habitat during a range of flows.
- Floodplain structures are proposed within the Shackleford delta and confluence area to achieve a variety of objectives. These structures will be strategically placed alongside the proposed Shackleford realignment and floodplain grading with the intent of enhancing scour of the low-flow channel while also promoting floodplain connectivity. As the Shackleford Creek delta conditions naturally change over time, these structures are expected to provide long-term roughness that will promote sediment deposition and heterogeneous delta evolution.

4.6 Earthwork

The proposed cut and fill specified in the current design are described in Table 4-1. Earthwork is imbalanced with the nearly 30,000 CY of excess cut that requires off-haul. The imbalance in material is an attempt to avoid reducing conveyance and elevating flood flows along Scott River Road. Modifications to the design to reduce off-haul could involve increased on-site placement along the right bank of the Scott River downstream from the current Shackleford Creek confluence or reducing grading of the Shackleford creek overflow channel and floodplain. These changes will be evaluated in future design phases.

Table 4-2. Cut and fill balance for earthwork movement.

Feature	Cut (CY)	Fill (CY)	Net (CY)
Shackleford Creek Realignment	8633	1314	-7318
Shackleford Creek Overflow Channel and Floodplain	11920	140	-11780
Scott River Split Flow Channels 1A and 1B	8732	463	-8269
Scott River Split Flow Channel 2	10862	127	-10735
Scott River grading upstream from Sta 49+50	377	2147	1770
Scott River grading between Sta 44+50 and 49+50	3488	2974	-514
Scott River grading downstream from Sta 44+50	4681	12219	7538
Total Volume of Earthwork	48691	19384	-29307

4.7 Construction Access/Staging and Dewatering

Construction access will occur from Scott River Road with staging and stockpiles located on upland benches within the project boundary and outside the active channel. A temporary bridge across the Scott River will be required. Limits of work and ingress/egress will be field-fit by the Engineer to avoid trees and sensitive areas. Fueling and equipment maintenance will occur in uplands. Salvaged woody material from grading will be stockpiled for beneficial reuse, and erosion controls will be installed around stockpiles. Detailed dewatering and stream-diversion methods will be developed during the next design phase.

4.8 Opinion of Probable Construction Cost

An Opinion of Probable Construction Cost (OPCC) was developed for the 60% design. OPCC estimates are subject to change in the final design phase and will be updated as more refined unit costs estimates are available. The OPCC includes 15% contingency and is shown on Table 4-2.

Table 4-3. Opinion of Probable Construction Cost

No.	Item	Unit cost	Quantity	Units	Total cost
1	Mobilization	$190,000	1	Lump Sum	$190,000
2	Clearing, Grubbing & Access	$110,000	1	Lump Sum	$110,000
3	Dewatering	$120,000	1	Lump Sum	$120,000
4	Rough Earthwork (cut/fill balanced onsite)	$15	68075	Cubic Yard	$1,021,125
5	Offhaul	$20	29307	Cubic Yard	$586,140
6	Instream Large Wood Structures (placed and anchored)	$2,500	500	Piece of wood	$1,250,000
7	Boulders (placed and anchored)	$200	1500	Ton	$300,000
8	Brush Trench (Scott River right bank toe)	$150	800	Linear Feet	$120,000
9	Brush Trench (Shackleford floodplain)	$1,500	40	Each	$60,000
10	Simulated Beaver Structures & Brush Trenches	$4,000	5	Each	$20,000
11	Erosion Control and Revegetation	$100,000	1	Lump Sum	$100,000
12	Construction staking and engineering support during construction	$80,000	1	Lump Sum	$80,000
	SubTotal				$3,957,265
	Contingency		15%		$593,590
	Total				$4,550,855

5 PROJECT RISKS AND NEXT STEPS

5.1 Project Risk Discussion

Several areas of potential Project risk were evaluated during the Project design process. These risks are described below followed by the risk management actions proposed for the design, construction, and monitoring phases of the Project.

Risk 1: **Geomorphic dynamism and high upstream sediment yield**
The Project area is geomorphically dynamic, especially in the context of high sediment yield from upstream sources that cannot be addressed within the scope of this Project. Large storm events may alter channel alignment or morphology in ways that reduce effectiveness of proposed grading and structures.

Management: The restoration design approach uses strategic grading to allow space for sediment to deposit in areas that are less likely to cause an adverse effect to surrounding infrastructure. The addition of large wood structures within the Project reach are expected to make channel morphology and habitat within the Project area more resilient to potential future geomorphic changes. Additional detailed hydraulic and geomorphic analyses will be conducted to support the design during future project phases.

Risk 2: Elevated velocities and shear stress along Scott River Road Damage Structures
Flow velocities and shear stresses along the Scott River Road embankment are high, increasing the potential for erosion during large storm events and damage to structures. Large wood structures typically have a design life of approximately 20 years due to declining strength related to wood decay.

Management: To ensure that wood structures are not disarticulated and transported downstream, stability of the structures for a 20-year design life will need stability analyses in a future design phase. Additionally, the Project engineer and/or geologist should conduct detailed construction oversight and post-project monitoring to ensure that the structures are constructed and are performing as designed. Post-project monitoring should be conducted during the first two winters following significant storm events as well as in following years during flow events that exceed the flow velocities that the new features have previously been exposed to. This monitoring should identify changes in site conditions that may affect functionality and durability (i.e., newly mobilized large wood, new significant scour, or repositioning of an existing structure). Monitoring should also occur over a longer time span so that structures can be adaptively managed as conditions evolve.

Risk 3: Watershed-scale Stressors
Watershed-scale stressors including surface and groundwater extraction and high sediment delivery due to upstream land use changes may be more than localized treatments can overcome. Climate change may cause additional stress on groundwater and cause elevated in-stream temperatures.

Management: Stakeholder engagement to communicate the limitations of localized treatments against large-scale stressors may help identify the potential for upstream projects that can improve the success of the proposed work at the confluence. More groundwater data and a field assessment in the next design phase can better inform the proposed design alternatives.

Risk 4: Project Cost
The design includes excess cut material which could lead to large hauling costs. The road protection structures are also costly and require heavily engineered solutions.

Management: Subsequent designs should consider how to minimize cut to the extent possible. Some features might need to be eliminated in a subsequent design phase to limit costs.

5.2 Next Steps

Next steps focus on advancing design while considering new data and practical constraints. Feedback on this design will be used to align features with implementation funding. The following list of tasks should be conducted to support project progress through final design phases:

- Continue to collect and analyze groundwater and surface water data.
- Further refinement of incipient motion analysis and Shackleford Creek channel grading to optimize sediment transport during a range of flow events.

- Better understand target implementation funding value target and refine design accordingly.
- Optimize grading to reduce off-haul volumes.
- Work with Siskiyou County Department of Public Works to refine road protection treatments.

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Appendices

Appendix A

60% Design Drawings

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

SISKIYOU COUNTY, CA

GENERAL NOTES, TERMS, & CONDITIONS:

1. **DESIGN INTENT.** THESE DRAWINGS REPRESENT THE GENERAL DESIGN INTENT TO BE IMPLEMENTED AND CONTRACTOR IS RESPONSIBLE FOR ALL ITEMS SHOWN ON THESE PLANS. CONTRACTOR SHALL BE RESPONSIBLE FOR CONTACTING THE PROJECT MANAGER FOR ANY CLARIFICATIONS OR FURTHER DETAILS NECESSARY TO ACCOMMODATE ACTUAL SITE CONDITIONS. ANY DEVIATION FROM THESE PLANS WITHOUT THE RCD'S REPRESENTATIVE APPROVAL ARE AT THE CONTRACTOR'S OWN RISK AND EXPENSE. NOTIFY PROJECT MANAGER IMMEDIATELY OF ANY UNEXPECTED AND CHANGED CONDITIONS, SAFETY HAZARDS, AND ENVIRONMENTAL PROBLEMS ENCOUNTERED.

2. **JOB SITE CONDITIONS AND CONTRACTOR RESPONSIBILITY.** CONTRACTOR SHALL ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR SITE CONDITIONS DURING THE COURSE OF THE CONSTRUCTION OF THIS PROJECT, INCLUDING THE SAFETY OF ALL PERSONS AND PROPERTY, AND ALL ENVIRONMENTAL PROTECTION ELEMENTS, WHETHER SHOWN ON THESE DRAWINGS OR NOT. CONTRACTOR SHALL FOLLOW ALL APPLICABLE CONSTRUCTION AND SAFETY REGULATIONS. THESE REQUIREMENTS SHALL APPLY CONTINUOUSLY AND WILL NOT BE LIMITED TO NORMAL WORKING HOURS. THE CONTRACTOR SHALL DEFEND, INDEMNIFY, AND HOLD THE RCD OR THE ENGINEER (STILLWATER SCIENCES) HARMLESS FROM ANY AND ALL LIABILITY, REAL OR ALLEGED, IN CONNECTION WITH THE PERFORMANCE OF WORK ON THIS PROJECT, EXCEPT FROM LIABILITY ARISING FROM THE SOLE NEGLIGENCE OF THE MRC OR ENGINEER.

3. **DAMAGE.** CONTRACTOR SHALL EXERCISE CARE TO AVOID DAMAGE TO EXISTING PUBLIC AND PRIVATE PROPERTY, INCLUDING NATIVE TREES AND SHRUBS, AND OTHER PROPERTY IMPROVEMENTS. IF CONTRACTOR CAUSES DAMAGES TO SUCH ITEMS, HE SHALL BE RESPONSIBLE FOR REPAIR OR REPLACEMENT IN LIKE NUMBER, KIND, CONDITION, AND SIZE. ANY SUCH COST MAY BE DEDUCTED BY OWNER FROM MONIES DUE CONTRACTOR UNDER THIS CONTRACT.

4. **LIMITS OF WORK, ACCESS, STAGING AND MOBILIZATION AREAS.** THE APPROXIMATE LIMITS OF WORK ARE SHOWN ON THE DRAWINGS. EXACT LIMITS OF WORK, POINTS OF INGRESS-EGRESS, CREEK CHANNEL ACCESS, MOBILIZATION, STAGING, AND WORK AREAS WILL BE FLAGGED IN THE FIELD BY THE ENGINEER. EQUIPMENT MAINTENANCE AND FUELING MUST OCCUR OUTSIDE OF THE CHANNEL AREA AS DESCRIBED IN THE ENVIRONMENTAL PERMITS FOR THE PROJECT.

5. **WORK IN STREAM CHANNELS AND STREAM DIVERSIONS.** ALL WORK INVOLVING USE OF HEAVY EQUIPMENT MUST BE COMPLETED FROM TOP OF BANK UNLESS A SPECIFIC POINT OF CREEK CHANNEL ACCESS HAS BEEN APPROVED AND IS SHOWN ON THE PLANS, AND THEN ONLY IN NON-LIVE WATER AS DEFINED BY CDFW. THE CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING THE DEWATERING PLAN DEPICTED IN THIS PLAN SET.

   5.1. CONTRACTOR IS RESPONSIBLE FOR REMOVAL AND DISPOSING OF ALL WATER CONTROL STRUCTURES AND EQUIPMENT.

   5.2. THE CONTRACTOR SHALL FURNISH, INSTALL, AND OPERATE ALL OTHER NECESSARY MACHINERY, APPLIANCES, AND EQUIPMENT TO DIVERT FLOWING WATER AROUND WORK AREAS, AND TO KEEP EXCAVATIONS AND TRENCHES REASONABLY FREE FROM WATER DURING CONSTRUCTION. CONTRACTOR SHALL DISPOSE OF THE WATER SO AS NOT TO CAUSE INJURY TO PUBLIC OR PRIVATE PROPERTY, OR TO CAUSE A NUISANCE OR A MENACE TO THE PUBLIC, OR TO DEGRADE WATER QUALITY. HE SHALL AT ALL TIMES HAVE ON HAND SUFFICIENT PUMPING EQUIPMENT AND MACHINERY IN GOOD WORKING CONDITION FOR ALL ORDINARY EMERGENCIES AND SHALL HAVE AVAILABLE AT ALL TIMES COMPETENT MECHANICS FOR THE OPERATION OF ALL PUMPING EQUIPMENT. IF THE CONTRACTOR CHOOSES TO USE A PUMPING SYSTEM FOR ANY PORTION OF THE WATER CONTROL WORK, HE SHALL HAVE ADEQUATE BACK-UP EQUIPMENT TO INSURE THE CONTINUOUS OPERATION OF THE EQUIPMENT.

   5.3. THE CONTRACTOR SHALL AT ALL TIMES PROVIDE FOR THE ADEQUATE RETURN FLOW OF DIVERSIONS BELOW THE PROJECT SITE. THE CONTRACTOR MAY TEMPORARILY DIVERT WATER DURING CONSTRUCTION, AS OUTLINED IN THE APPROVED STREAM DIVERSION AND WATER CONTROL PLAN. THIS MAY INCLUDE FOR INSTANCE, VISQUEEN AND STRAW BALE OR SAND BAG DIVERSION DIKES AND PIPING SYSTEMS. RETURN FLOW SHALL BE FILTERED THROUGH FILTER CLOTH, STRAW BALES AND/OR THROUGH A SERIES OF STILLING BASINS WHEN REQUIRED.

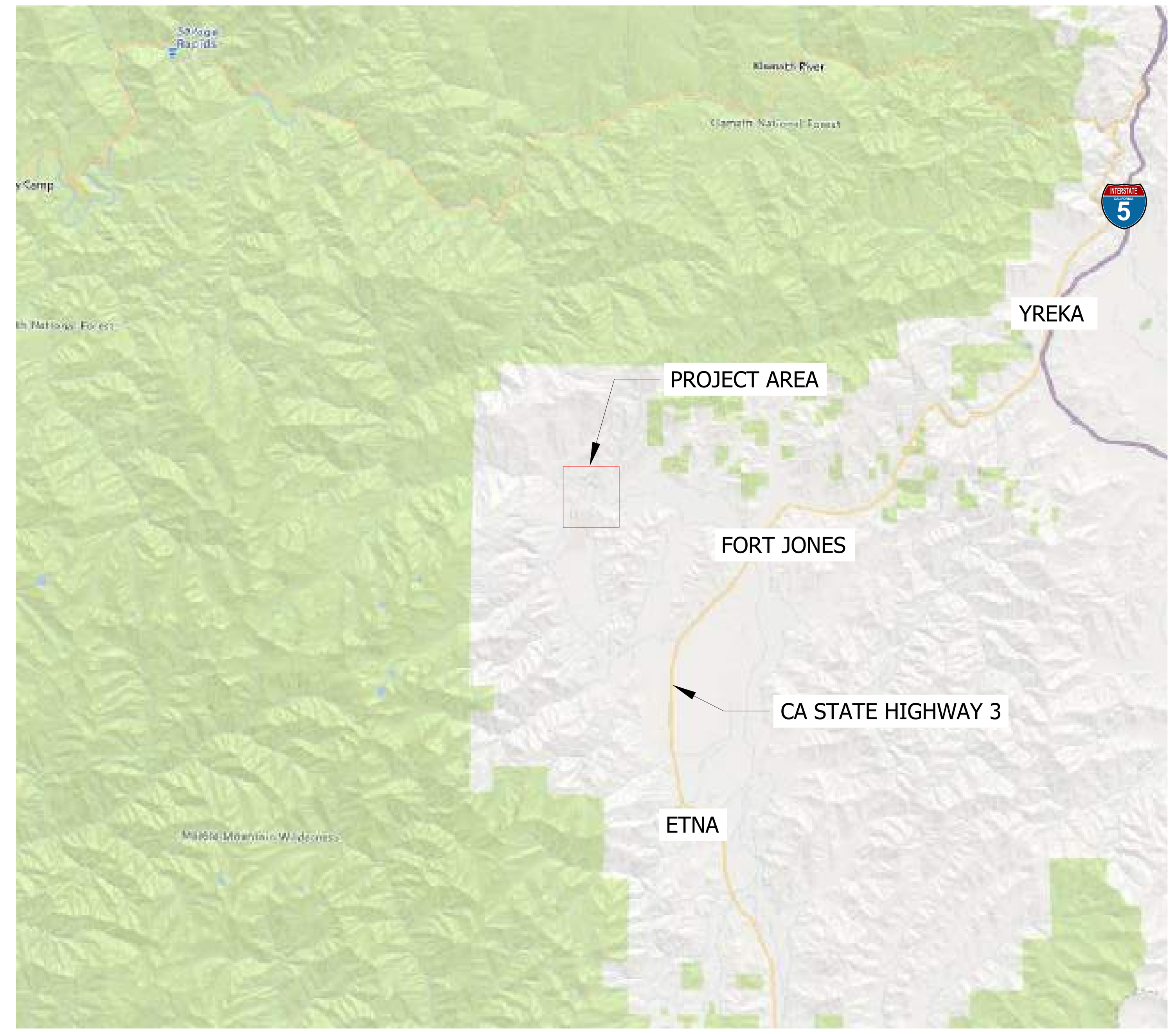
   5.4. TURBID DEWATERING FLOWS SHALL BE PUMPED INTO A HOLDING FACILITY OR SPRAYED OVER A LARGE AREA OUTSIDE THE STREAM CHANNEL TO ALLOW FOR NATURAL FILTRATION OF SEDIMENTS. AT NO TIME SHALL TURBID WATER FROM THE HOLDING FACILITY BE ALLOWED BACK INTO THE STREAM CHANNEL UNTIL WATER IS CLEAR OF SILT.

   5.5. ALL HEAVY EQUIPMENT MUST HAVE A SUPPLY OF SORBENT PADS AVAILABLE TO CLEAN-UP GREASE, OIL, OR FUEL THAT DRIPS OR SPILLS INTO THE STREAM CHANNEL. SORBENT BOOMS MUST BE PLACED DOWNSTREAM FROM LOCATIONS WHERE MACHINERY IS EXPECTED TO CROSS THE STREAM CHANNEL. USED PADS AND BOOMS ARE TO BE DISPOSED OF PROPERLY AT CONTRACTOR'S EXPENSE.

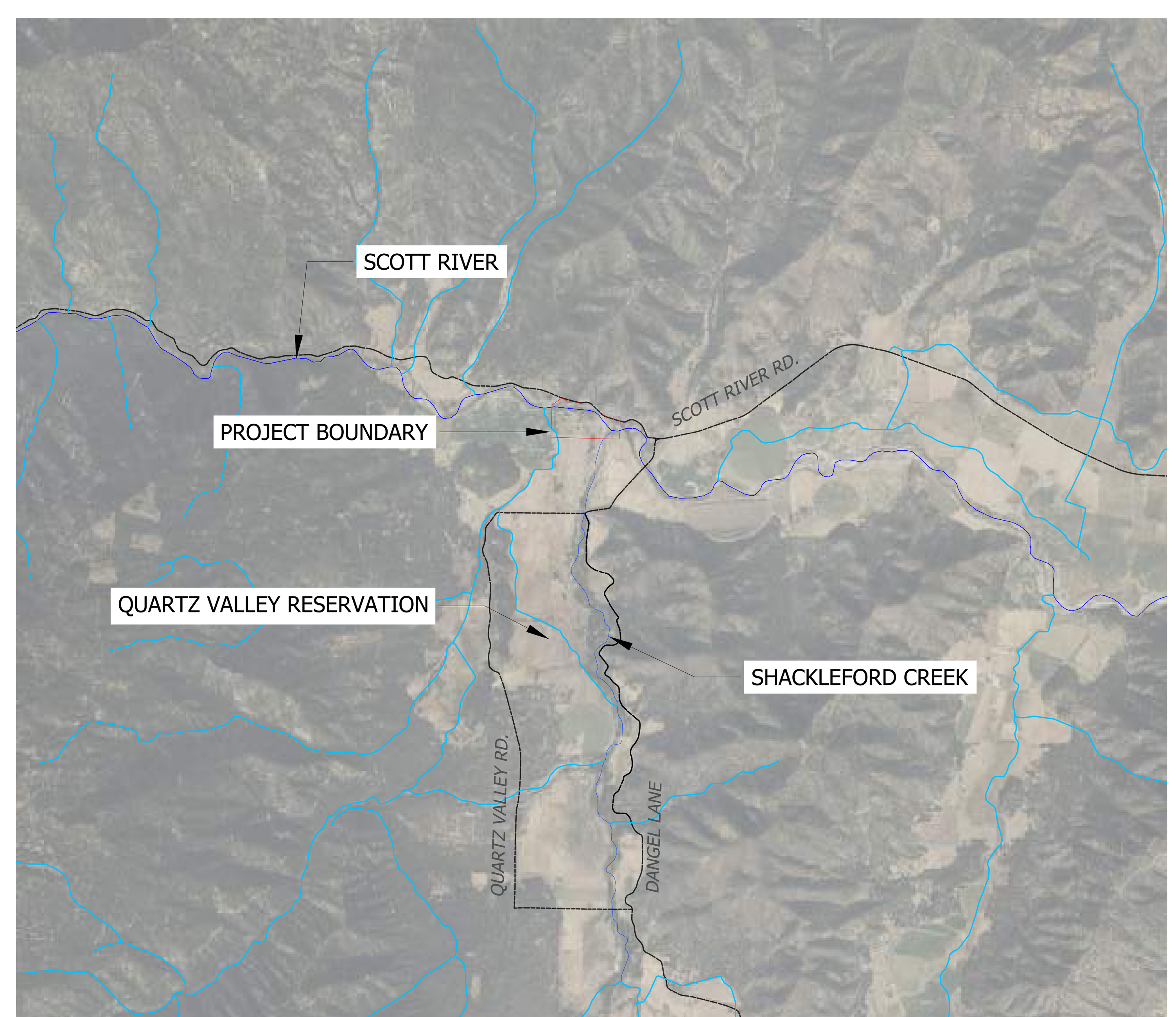
6. **EARTHWORK QUANTITIES.** CONTRACTOR IS RESPONSIBLE FOR ALL EARTHWORK, INCLUDING GRADING, PROVISION AND PLACEMENT OF ROCK MEETING SIZE LIMITS, AS SHOWN ON DRAWINGS, AND DISPOSAL OF ALL EXCESS SOIL AND RUBBLE. EARTHWORK QUANTITIES, INCLUDING GRADING, PLACED ROCK RIP-RAP AND OFF-HAUL QUANTITY ESTIMATES PROVIDED BY THE ENGINEER ARE ESTIMATES ONLY. RCD AND ENGINEER DO NOT, EXPRESSLY OR OTHERWISE BY IMPLICATION, EXTEND ANY WARRANTY TO EARTHWORK CALCULATIONS

7. **THE** FOLLOWING PERMITS ARE REQUIRED FOR THIS PROJECT, THE CONTRACTOR SHALL BE GIVEN COPIES OF ALL THE PERMITS, SHALL BECOME FAMILIAR WITH THE PERMIT REQUIREMENTS, AND SHALL BE RESPONSIBLE FOR ADHERENCE TO AND CONFORMANCE WITH ALL PERMIT CONDITIONS.
   SEC. 404 PERMIT ISSUED BY US ARMY CORPS OF ENGINEERS
   1601/1603 STREAMBED ALTERATION AGREEMENT ISSUED BY CA DEPT. FISH & WILDLIFE
   WATER QUALITY CERTIFICATION, BY NORTH COAST REGIONAL WATER QUALITY CONTROL BOARD
   US FISH AND WILDLIFE SERVICE CONSULTATION AND IMPLEMENTATION RECOMMENDATIONS
   NATIONAL MARINE FISHERIES SERVICE CONSULTATION AND IMPLEMENTATION RECOMMENDATIONS.
8. AREAS TO BE GRADED SHALL BE CLEARED OF ALL VEGETATION INCLUDING ROOTS AND OTHER UNSUITABLE MATERIAL FOR A STRUCTURAL FILL, THEN SCARIFIED TO A DEPTH OF 6 INCHES PRIOR TO PLACING OF ANY FILL.
9. AREAS WITH EXISTING SLOPES WHICH ARE TO RECEIVE FILL MATERIAL SHALL BE KEYED AND BENCHED.
10. FILL MATERIAL SHALL BE SPREAD IN LIFTS NOT EXCEEDING 6 INCHES IN COMPACTED THICKNESS, MOISTENED OR DRIED AS NECESSARY TO NEAR OPTIMUM MOISTURE CONTENT AND COMPACTED BY AN APPROVED METHOD. FILL MATERIAL SHALL BE COMPACTED TO A MINIMUM OF 90% MAXIMUM DENSITY AS DETERMINED BY 1957 ASTM D - 1557 - 91 MODIFIED PROCTOR (AASHO) TEST OR SIMILAR APPROVED METHODS.
11. CUT SLOPES SHALL NOT EXCEED A GRADE OF 1.5 HORIZONTAL TO 1 VERTICAL. FILL AND COMBINATION FILL AND CUT SLOPES SHALL NOT EXCEED 2 HORIZONTAL TO 1 VERTICAL. SLOPES OVER THREE FEET IN VERTICAL HEIGHT SHALL BE PLANTED WITH APPROVED PERENNIAL OR TREATED WITH EQUALLY APPROVED EROSION CONTROL MEASURES PRIOR TO FINAL INSPECTION.
12. BEST MANAGEMENT PRACTICES FOR CONSTRUCTION ACTIVITIES: ERODED SEDIMENTS AND OTHER POLLUTANTS MUST BE RETAINED ONSITE AND MAY NOT BE TRANSPORTED FROM THE SITE VIA SHEET FLOW, SWALES, AREA DRAINS, NATURAL DRAINAGE COURSES, OR WIND. STOCKPILES OF EARTH AND OTHER CONSTRUCTION RELATED MATERIALS MUST BE PROTECTED FROM BEING TRANSPORTED FROM THE SITE BY THE FORCES OF WIND OR WATER. FUELS, OILS, SOLVENTS, AND OTHER TOXIC MATERIALS MUST BE STORED IN ACCORDANCE WITH THEIR LISTING AND ARE NOT TO CONTAMINATE THE SOIL AND SURFACE WATERS. ALL APPROVED STORAGE CONTAINERS ARE TO BE PROTECTED FROM THE WEATHER. SPILLS MAY NOT BE WASHED INTO THE DRAINAGE SYSTEM. EXCESS OR WASTE CONCRETE MAY NOT BE WASHED INTO PUBLIC WAY OR ANY OTHER DRAINAGE SYSTEM. PROVISIONS MUST BE MADE TO RETAIN CONCRETE WASTES ON SITE UNTIL THEY CAN BE DISPOSED AS A SOLID WASTE. TRASH AND CONSTRUCTION RELATED SOLID WASTE MUST BE DEPOSITED INTO A COVERED WASTE RECEPTACLE TO PREVENT CONTAMINATION OF RAINWATER AND DISPERSAL BY WIND. SEDIMENTS AND OTHER MATERIAL MAY NOT BE TRACKED FROM TO THE SITE BY VEHICLE TRAFFIC.

VICINITY MAP



PROJECT LOCATION MAP



Sheet List Table	
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3	PROPOSED CONDITIONS OVERVIEW
4	SCOTT RIVER REALIGNMENT PLAN & PROFILE 33+00 TO 45+00
5	SCOTT RIVER REALIGNMENT PLAN & PROFILE 45+00 TO 57+00
6	SCOTT RIVER SPLIT FLOW 2 PLAN & PROFILE
7	SCOTT RIVER SPLIT FLOW 1A AND 1B PLAN & PROFILE
8	SHACKLEFORD CREEK REALIGNMENT PLAN & PROFILE
9	SHACKLEFORD CREEK OVERFLOW CHANNEL PLAN & PROFILE
10	SECTION OVERVIEW
11	SECTION VIEWS 37+33 TO 47+50
12	SECTION VIEWS 51+58 TO 54+50
13	LARGE WOOD BOULDER DEFLECTOR STRUCTURE DETAIL
14	PILE-DRIVEN LARGE WOOD STRUCTURE DETAIL
15	FLOODPLAIN LARGE WOOD STRUCTURE LARGE DETAIL
16	FLOODPLAIN LARGE WOOD STRUCTURE MEDIUM DETAIL
17	FLOODPLAIN LARGE WOOD STRUCTURE SMALL DETAIL
18	LARGE WOOD STRUCTURE ANCHORING DETAIL
19	BRUSH TRENCH DETAIL
20	SIMULATED BEAVER STRUCTURE DETAIL

EARTHWORK ESTIMATES:

CUT: 48,662 CY

FILL: 19,386 CY ON-SITE

EXPORT: 29,276 CUBIC YARDS

ABBREVIATIONS AND SYMBOLS:

<E> EXISTING

<P> PROPOSED

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

SISKIYOU COUNTY, CA

Stillwater Sciences
215 W OAK ST SUITE 900
FORT COLLINS, CO 80521 P: (720) 656-2330

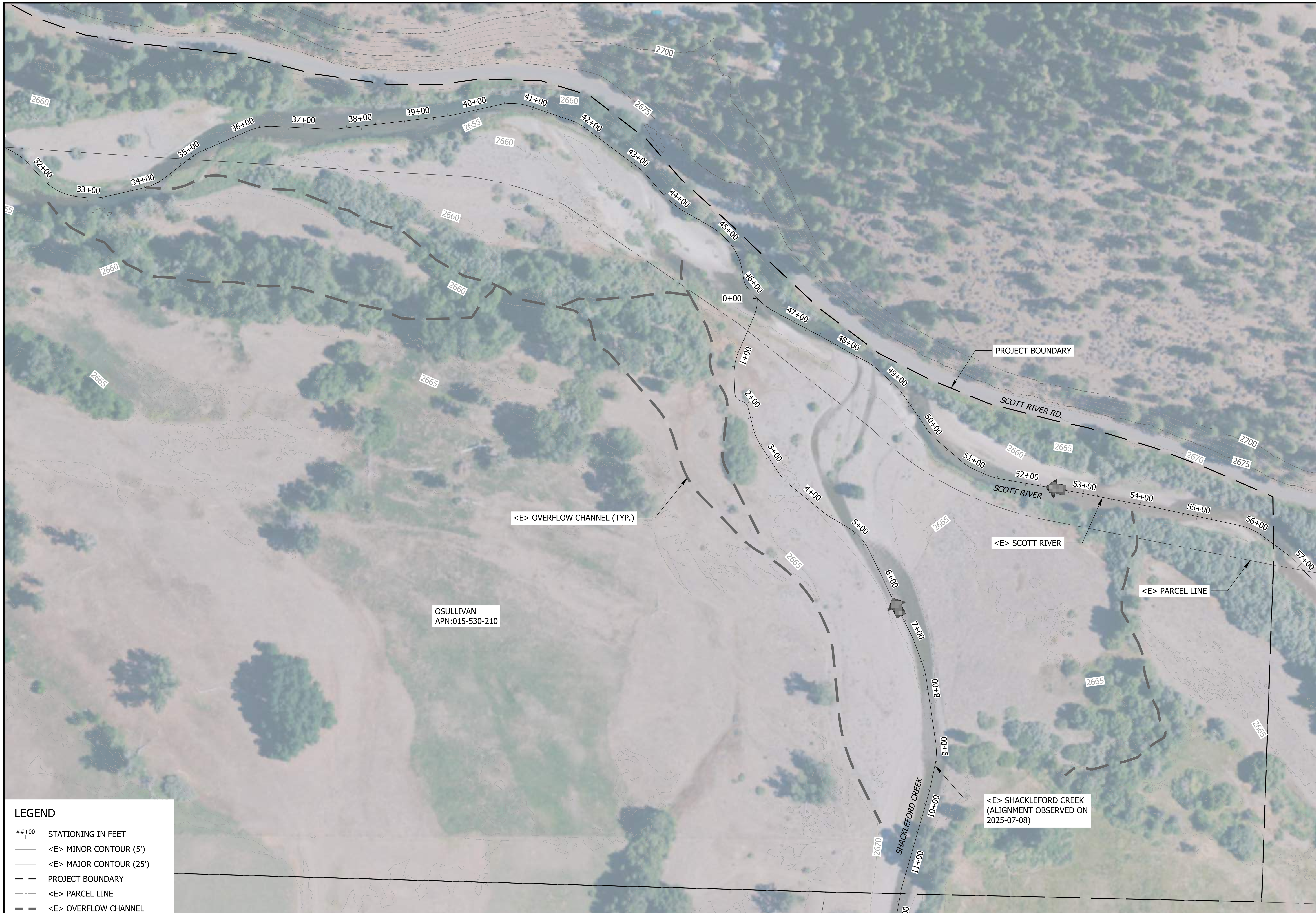
REVISIONS		
NO.	DESCRIPTION	DATE

60% DESIGN

PROJECT NUMBER: 949.01
SCALE: AS NOTED
DATE: 11/19/25

DESIGN: JM
DRAWN: RB/BJ/KS
CHECKED: JM
APPROVED: --

TITLE SHEET



EXISTING CONDITIONS OVERVIEW

PLAN VIEW

0 40 80 160 FEET

SCALE: 1" = 80'

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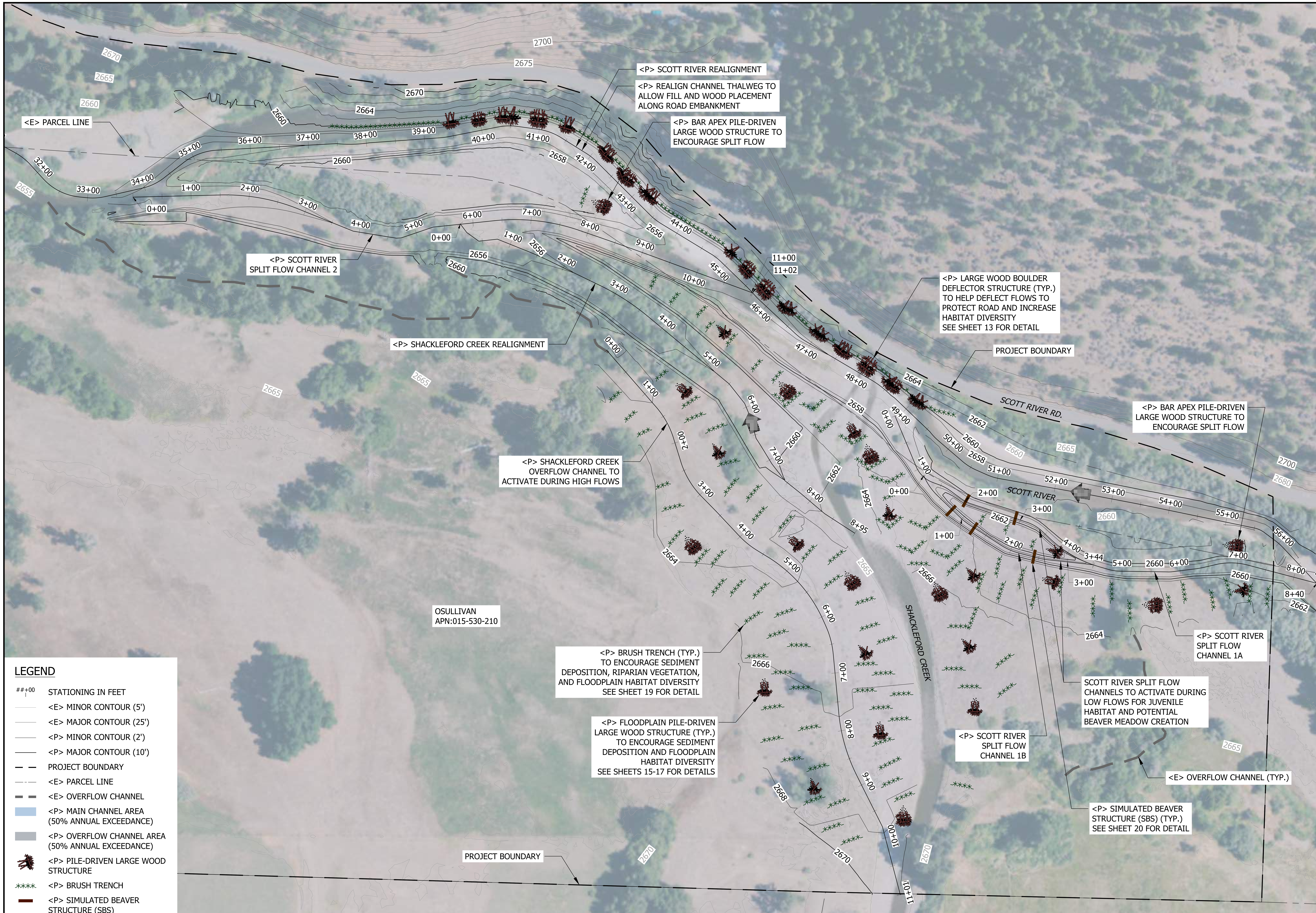
APPROVED: --

EXISTING CONDITIONS OVERVIEW



PROPOSED CONDITIONS OVERVIEW
PLAN VIEW

0 40 80 160 FEET
SCALE: 1" = 80'

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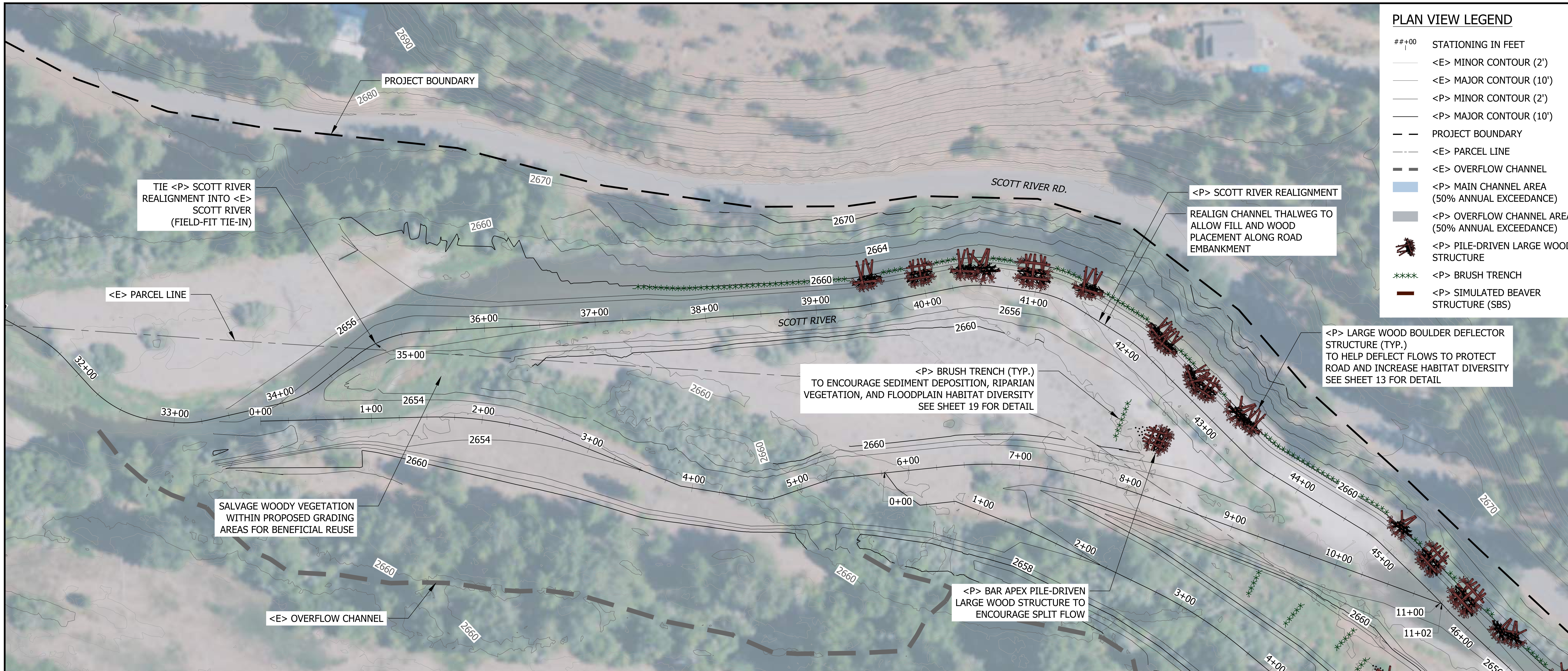
APPROVED: --

PROPOSED CONDITIONS OVERVIEW

PLAN VIEW LEGEND

- ##+00 STATIONING IN FEET
- <E> MINOR CONTOUR (2')
- <E> MAJOR CONTOUR (10')
- <P> MINOR CONTOUR (2')
- <P> MAJOR CONTOUR (10')
- PROJECT BOUNDARY
- <E> PARCEL LINE
- <E> OVERFLOW CHANNEL
- <P> MAIN CHANNEL AREA (50% ANNUAL EXCEEDANCE)
- <P> OVERFLOW CHANNEL AREA (50% ANNUAL EXCEEDANCE)
- <P> PILE-DRIVEN LARGE WOOD STRUCTURE
- <P> BRUSH TRENCH
- <P> SIMULATED BEAVER STRUCTURE (SBS)

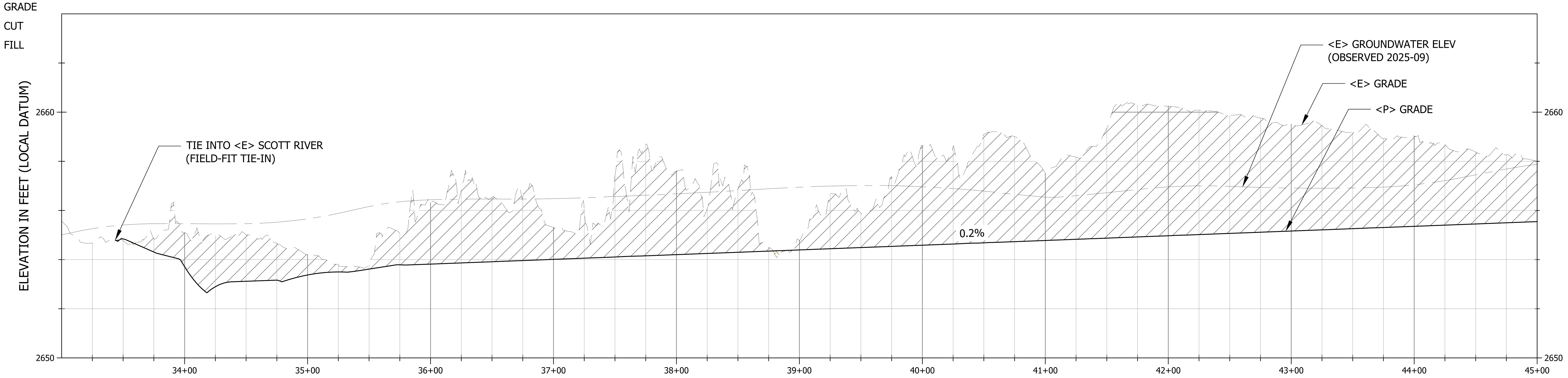


SCOTT RIVER PROPOSED STA 33+00 TO 45+00

PLAN VIEW

PROFILE VIEW LEGEND

- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL



SCOTT RIVER PROPOSED STA 33+00 TO 45+00

PROFILE VIEW, 5X VERTICAL EXAGGERATION

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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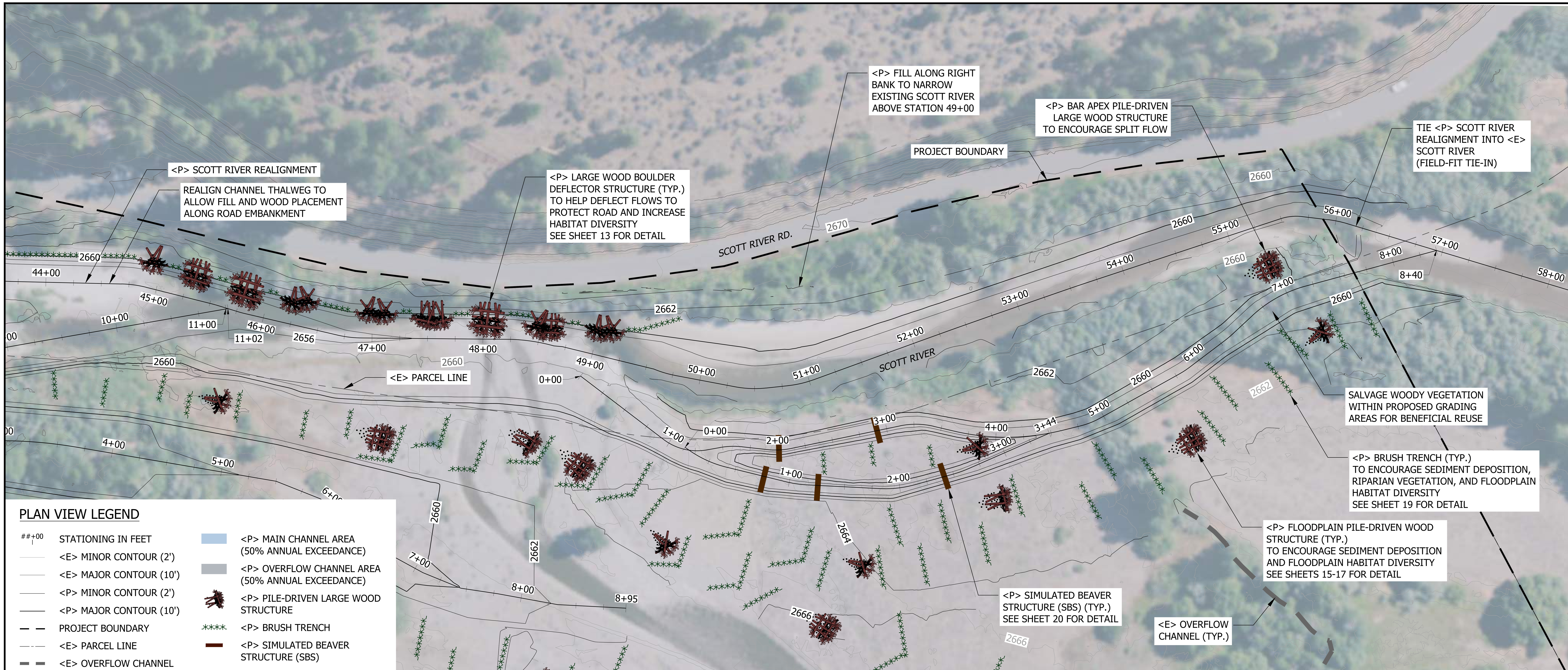
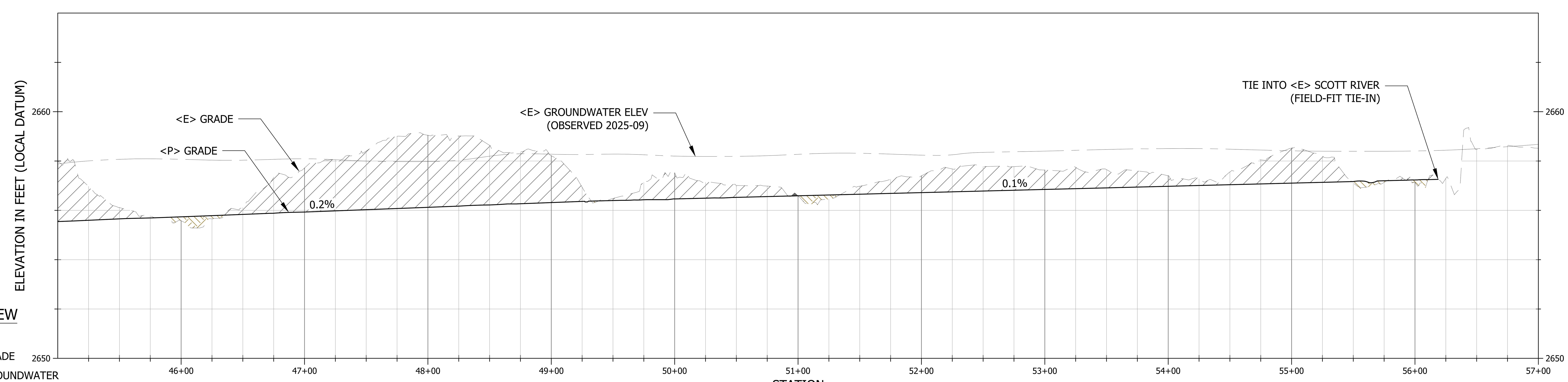
SCOTT RIVER REALIGNMENT PLAN & PROFILE 33+00 TO 45+00



SCOTT RIVER PROPOSED STA 45+00 TO 57+00

PLAN VIEW



SCOTT RIVER PROPOSED STA 45+00 TO 57+00

PROFILE VIEW, 5X VERTICAL EXAGGERATION

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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DRAWN: RB/BJ/KS
CHECKED: JM
APPROVED: --

SCOTT RIVER REALIGNMENT PLAN & PROFILE 45+00 TO 57+00

SHEET 5 OF 20

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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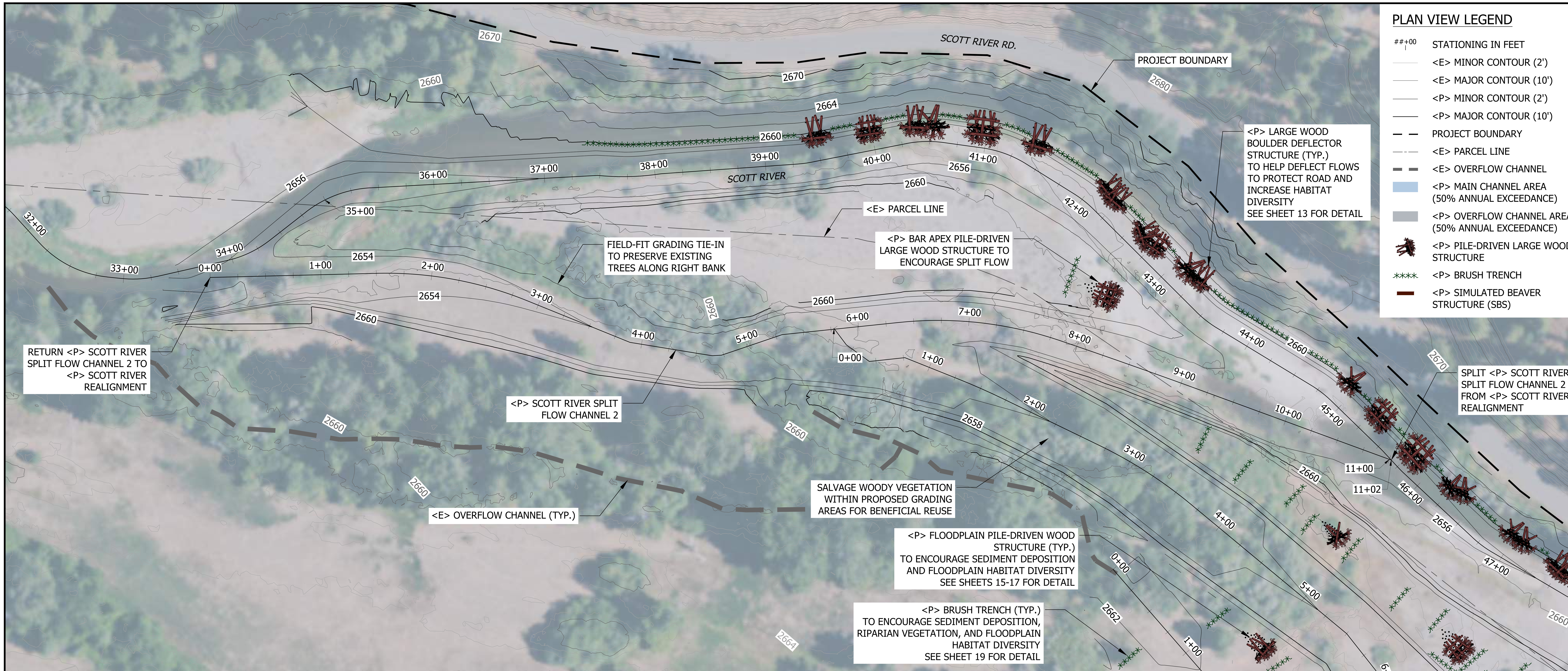
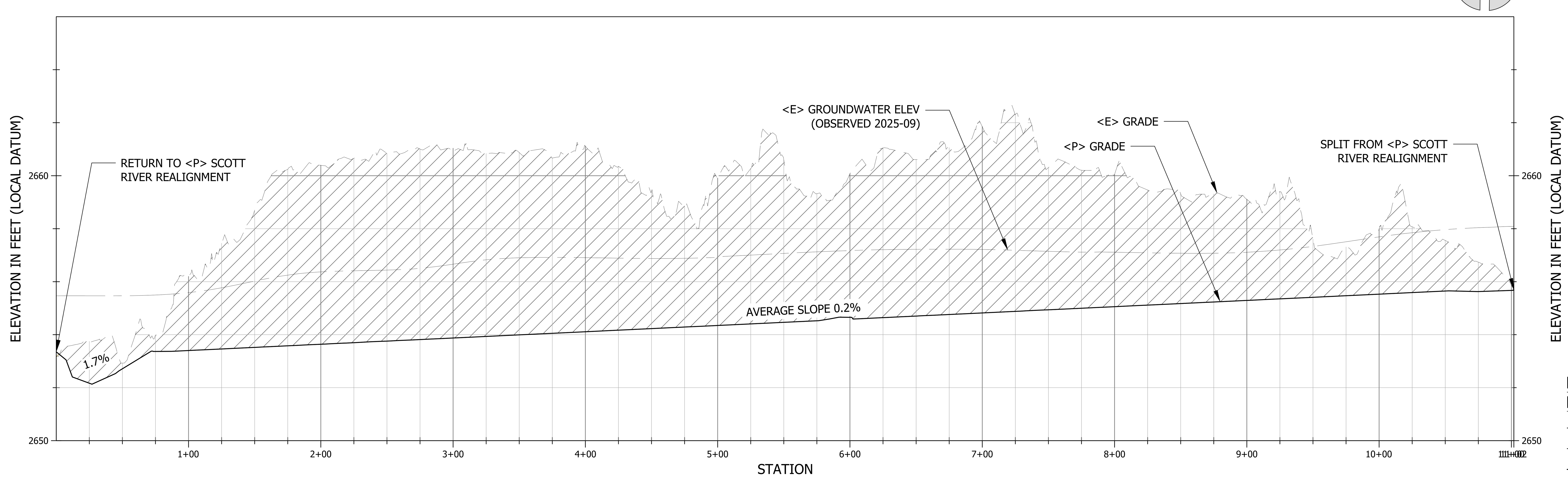


PLAN VIEW LEGEND

- ##+00 STATIONING IN FEET
- <E> MINOR CONTOUR (2')
- <E> MAJOR CONTOUR (10')
- <P> MINOR CONTOUR (2')
- <P> MAJOR CONTOUR (10')
- PROJECT BOUNDARY
- <E> PARCEL LINE
- <E> OVERFLOW CHANNEL
- <P> MAIN CHANNEL AREA (50% ANNUAL EXCEEDANCE)
- <P> OVERFLOW CHANNEL AREA (50% ANNUAL EXCEEDANCE)
- <P> PILE-DRIVEN LARGE WOOD STRUCTURE
- <P> BRUSH TRENCH
- <P> SIMULATED BEAVER STRUCTURE (SBS)

SCOTT RIVER SPLIT FLOW CHANNEL 2
PLAN VIEW

0 25 50 100 FEET
SCALE: 1" = 50'



SCOTT RIVER SPLIT FLOW CHANNEL 2
PROFILE VIEW, 5X VERTICAL EXAGGERATION

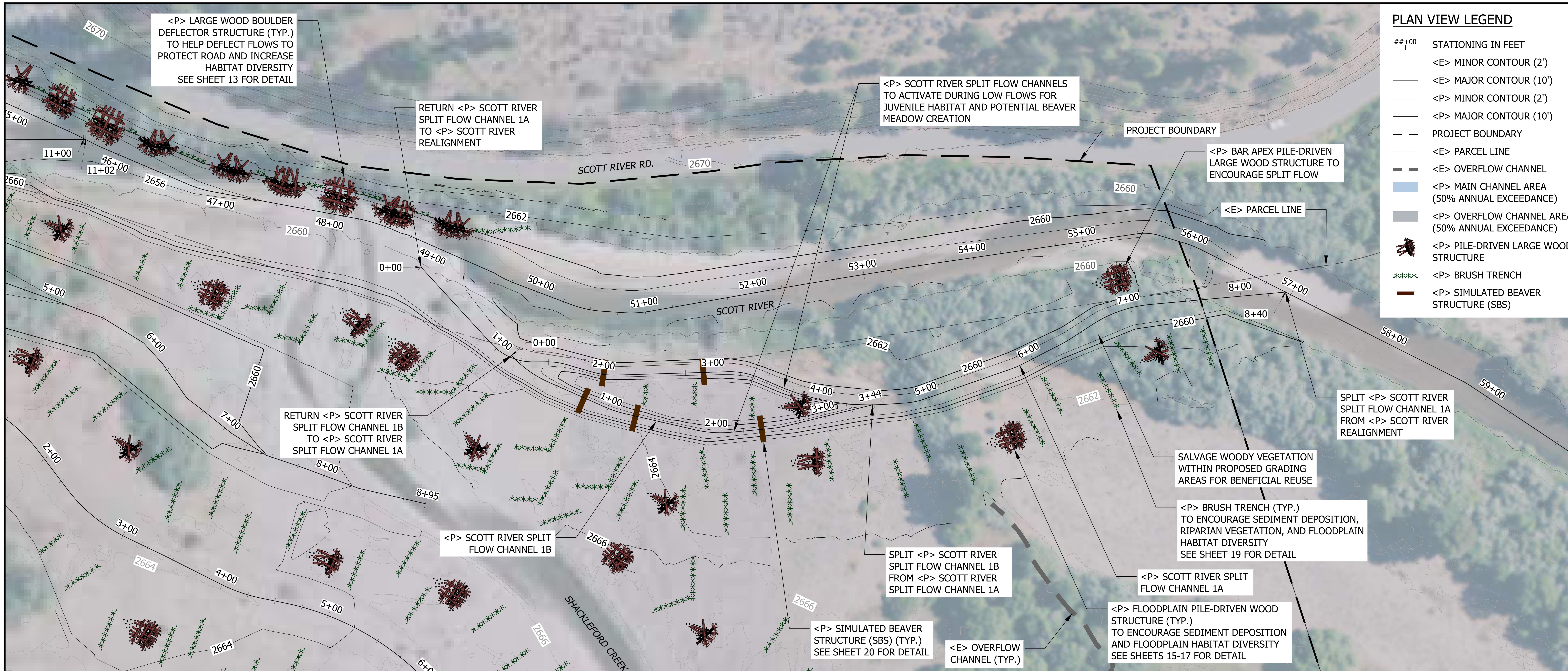
PROFILE VIEW LEGEND

- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL

PROJECT NUMBER: 949.01
SCALE: AS NOTED
DATE: 11/19/25

DESIGN: JM
DRAWN: RB/BJ/KS
CHECKED: JM
APPROVED: --

SCOTT RIVER SPLIT FLOW 2 PLAN & PROFILE

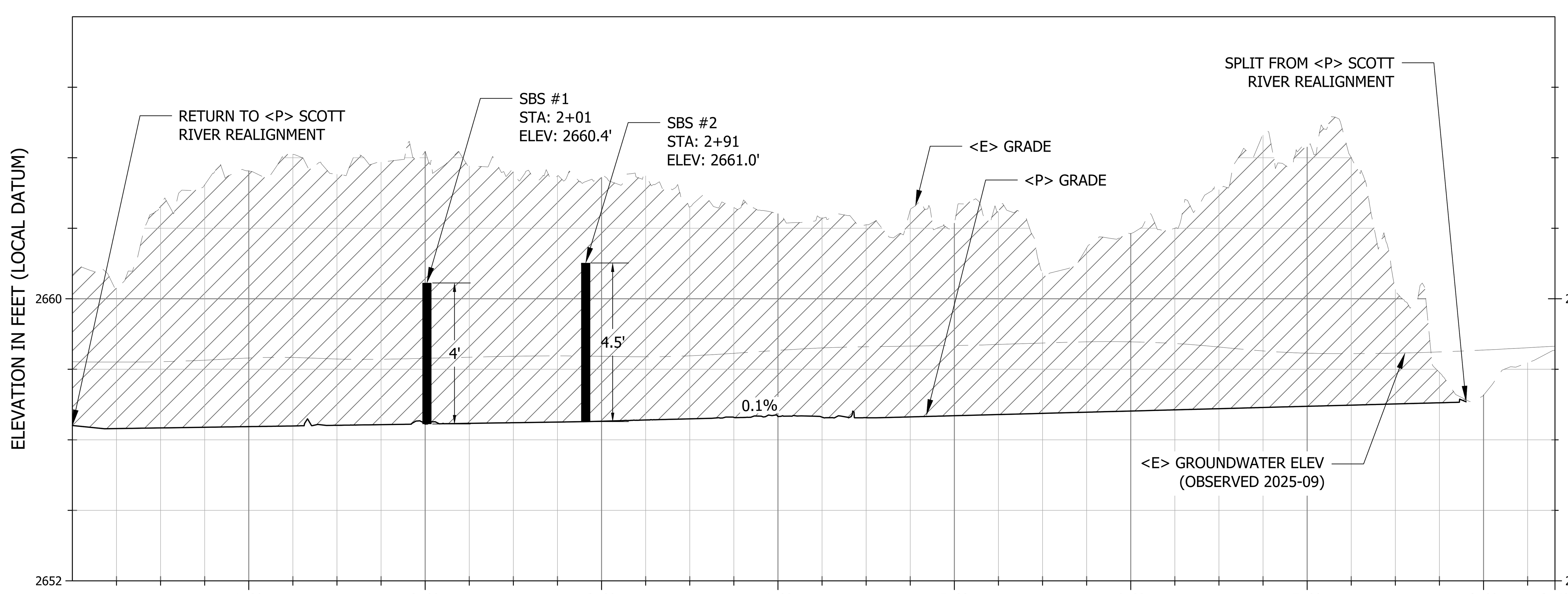


PLAN VIEW LEGEND

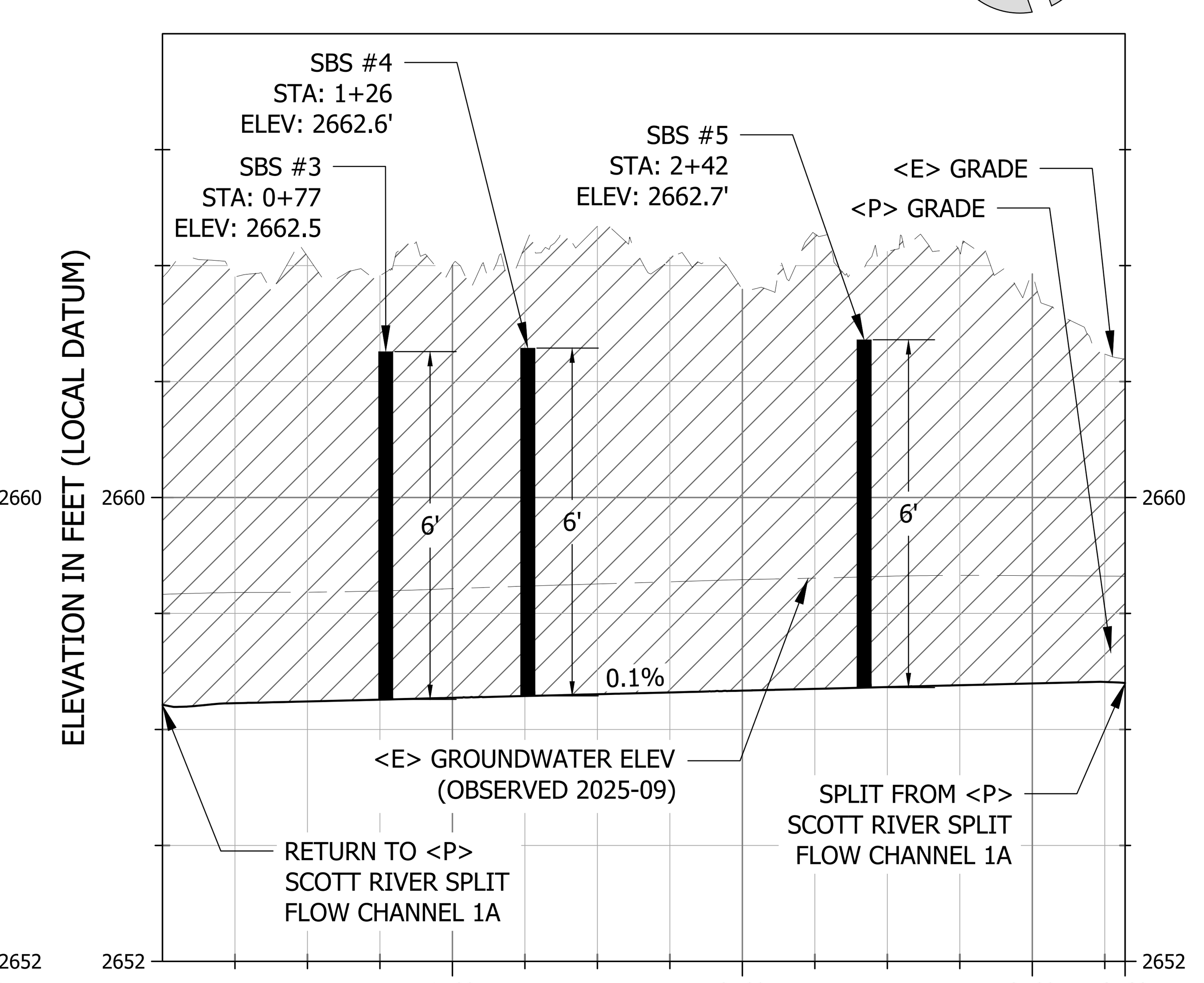
- ##+00 STATIONING IN FEET
- <E> MINOR CONTOUR (2')
- <E> MAJOR CONTOUR (10')
- <P> MINOR CONTOUR (2')
- <P> MAJOR CONTOUR (10')
- PROJECT BOUNDARY
- <E> PARCEL LINE
- <E> OVERFLOW CHANNEL
- <P> MAIN CHANNEL AREA (50% ANNUAL EXCEEDANCE)
- <P> OVERFLOW CHANNEL AREA (50% ANNUAL EXCEEDANCE)
- <P> PILE-DRIVEN LARGE WOOD STRUCTURE
- <P> BRUSH TRENCH
- <P> SIMULATED BEAVER STRUCTURE (SBS)

SCOTT RIVER SPLIT FLOW CHANNELS 1A AND 1B
PLAN VIEW

0 25 50 100 FEET
SCALE: 1" = 50'



SCOTT RIVER SPLIT FLOW CHANNEL 1A
PROFILE VIEW, 5X VERTICAL EXAGGERATION



SCOTT RIVER SPLIT FLOW CHANNEL 1B
PROFILE VIEW, 5X VERTICAL EXAGGERATION

PROFILE VIEW LEGEND

- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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Stillwater Sciences
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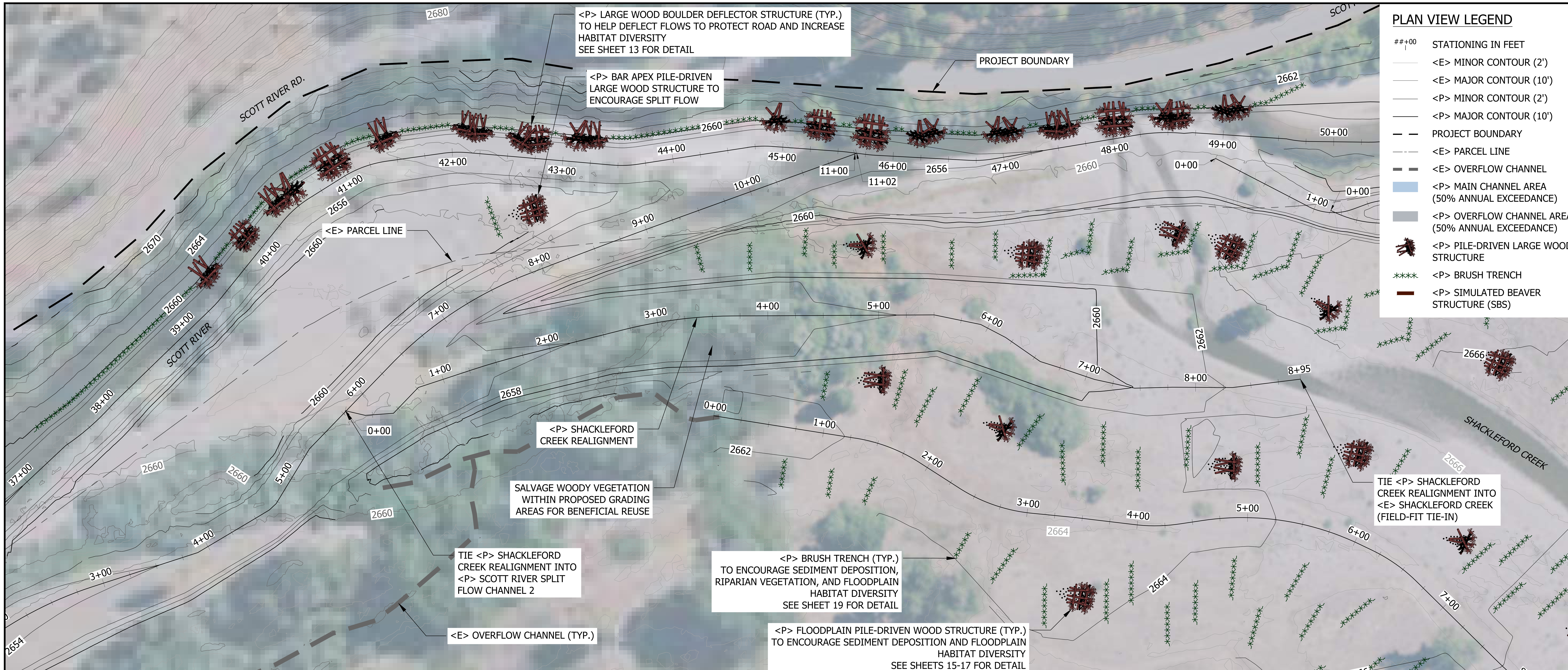
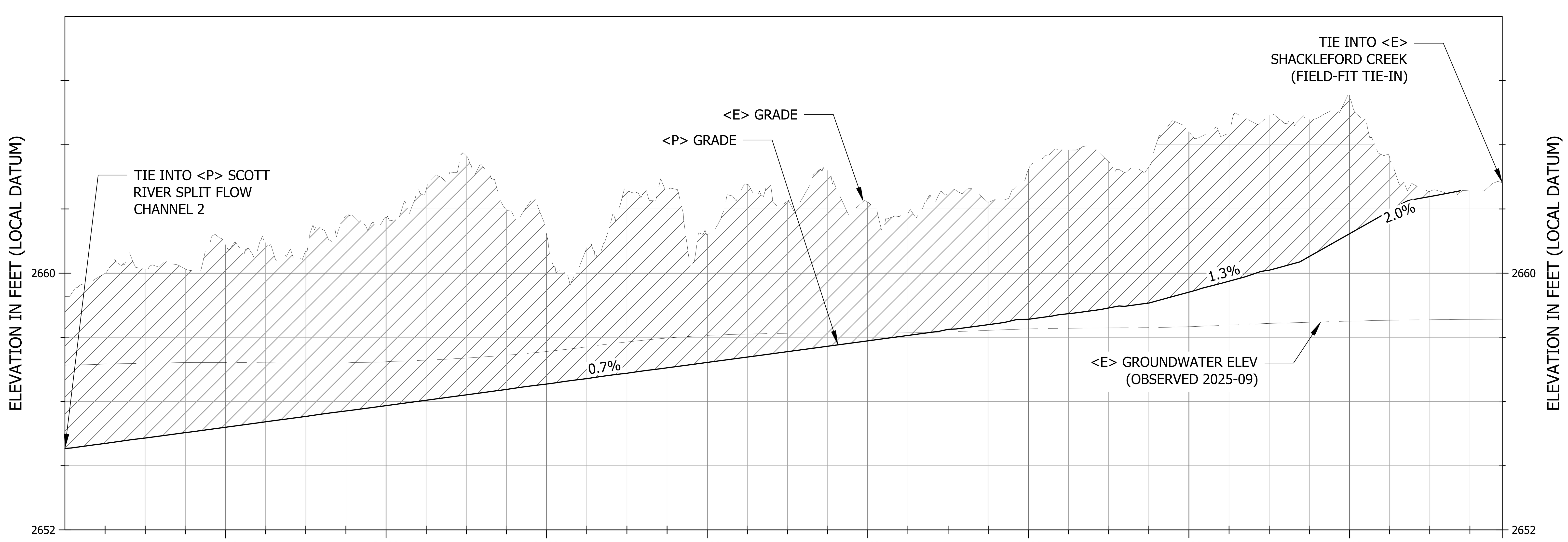
DESIGN: JM
DRAWN: RB/BJ/KS
CHECKED: JM
APPROVED: --

SCOTT RIVER SPLIT FLOW 1A AND 1B PLAN & PROFILE

SHEET 7 OF 20



SHACKLEFORD CREEK REALIGNMENT
PLAN VIEW



SHACKLEFORD CREEK REALIGNMENT
PROFILE VIEW, 5X VERTICAL EXAGGERATION

PROFILE VIEW LEGEND
- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL

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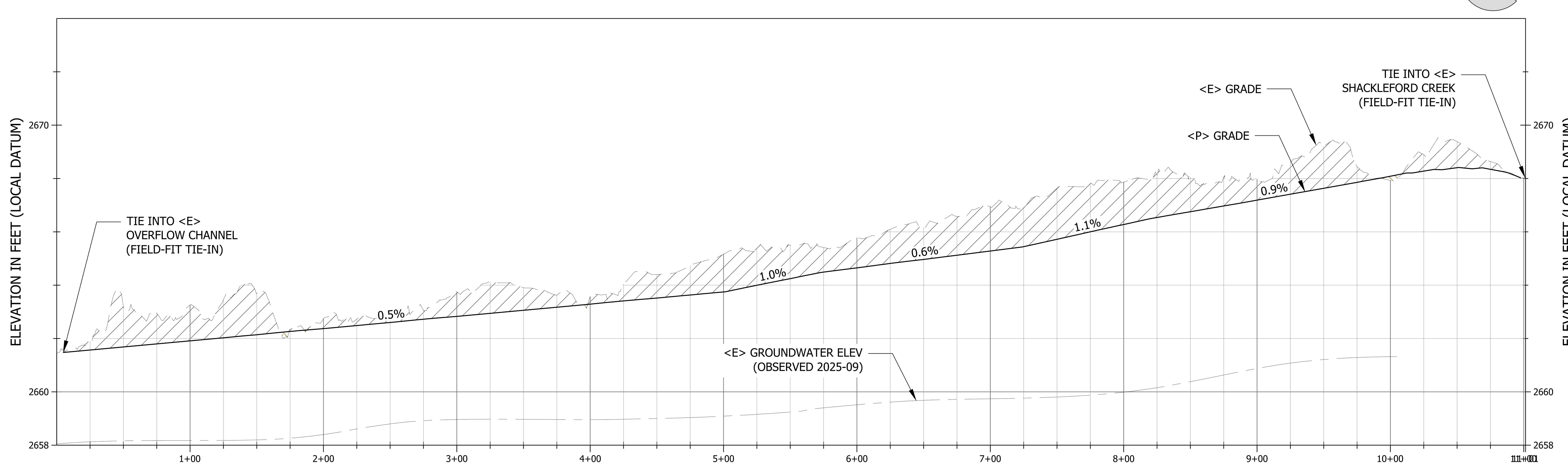
CHECKED: JM
APPROVED: --

SHACKLEFORD CREEK REALIGNMENT PLAN & PROFILE

SHACKLEFORD CREEK OVERFLOW CHANNEL
PLAN VIEW



PROFILE VIEW LEGEND
- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL

SHACKLEFORD CREEK OVERFLOW CHANNEL
PROFILE VIEW, 5X VERTICAL EXAGGERATION

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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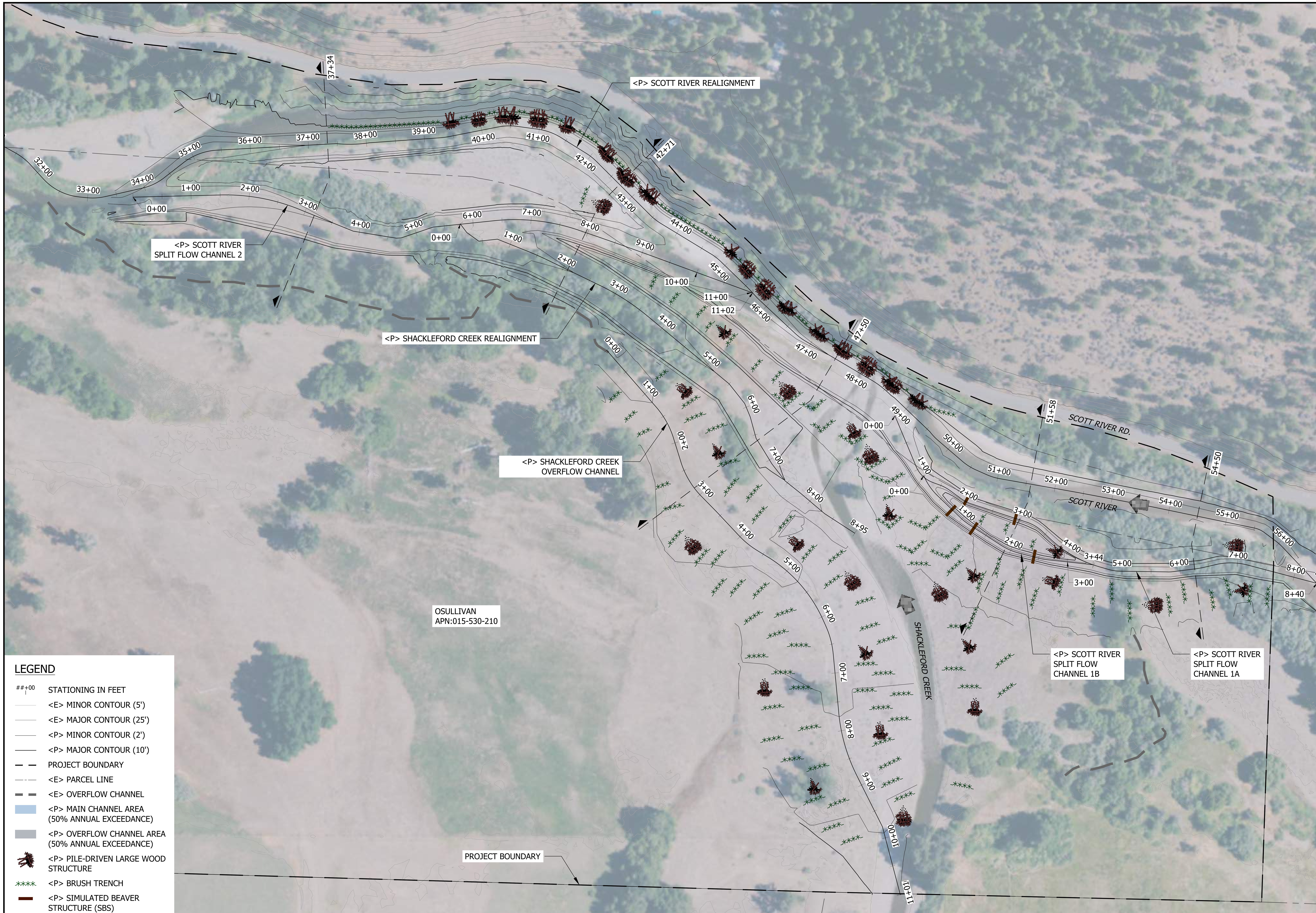
APPROVED: --

SHACKLEFORD CREEK OVERFLOW CHANNEL PLAN & PROFILE



SECTIONS OVERVIEW
PLAN VIEW

0 40 80 160 FEET
SCALE: 1" = 80'

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

SISKIYOU COUNTY, CA

Stillwater Sciences
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REVISIONS

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DESIGN: JM
DRAWN: RB/BJ/KS
CHECKED: JM
APPROVED: --

SECTION OVERVIEW

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

SISKIYOU COUNTY, CA

Stillwater Sciences
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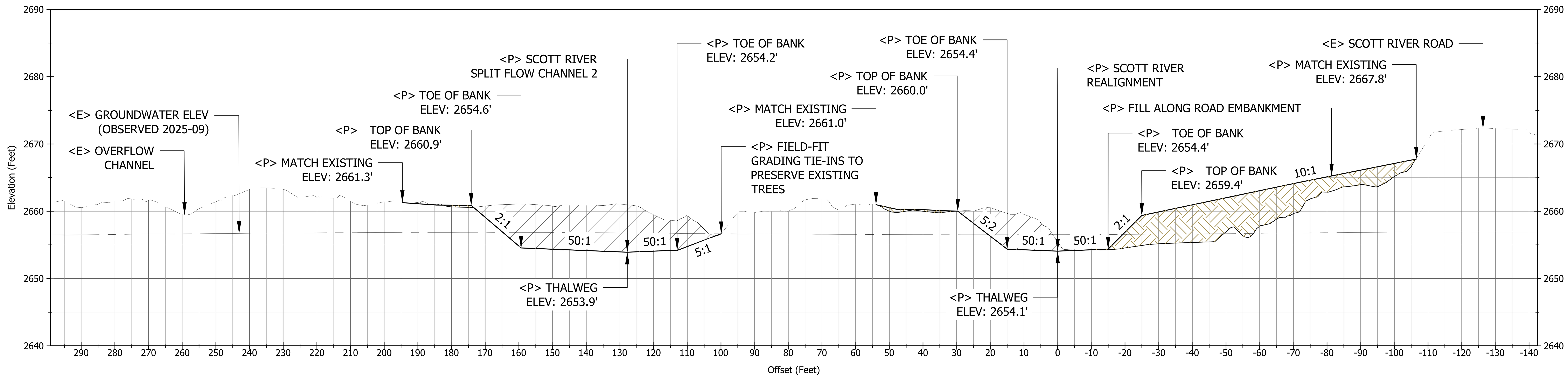
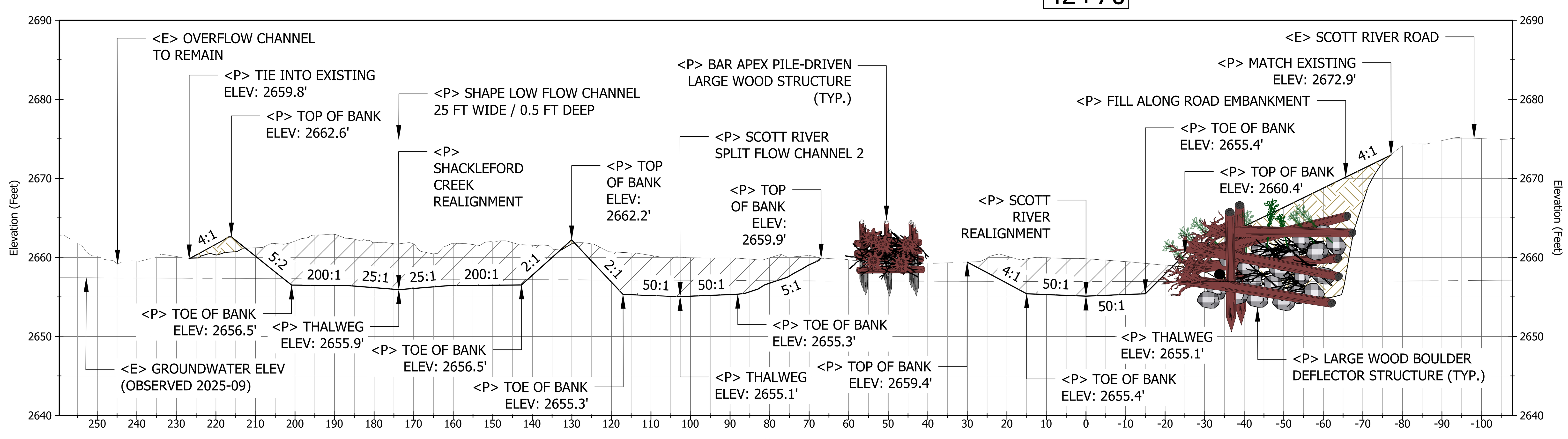
LEGEND

- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL

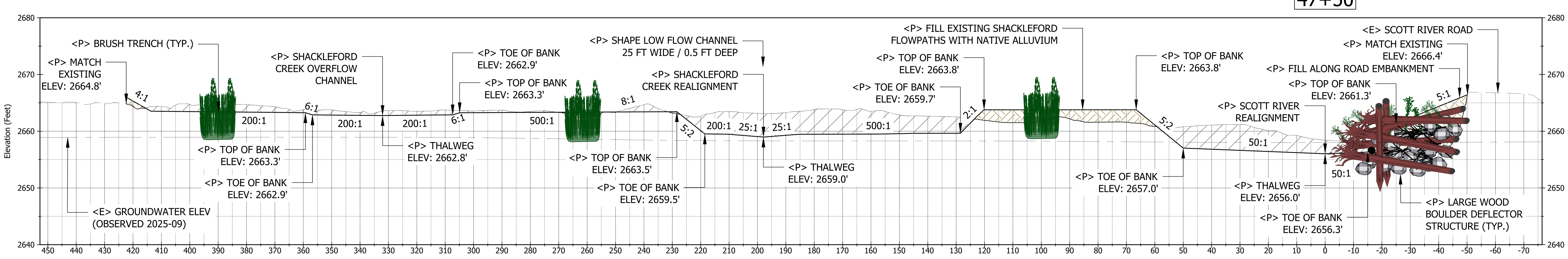
37+33



42+70



47+50



2X VERTICAL EXAGGERATION

0 10 20 40 FEET
SCALE: 1" = 20'

REVISIONS

NO.	DESCRIPTION	DATE

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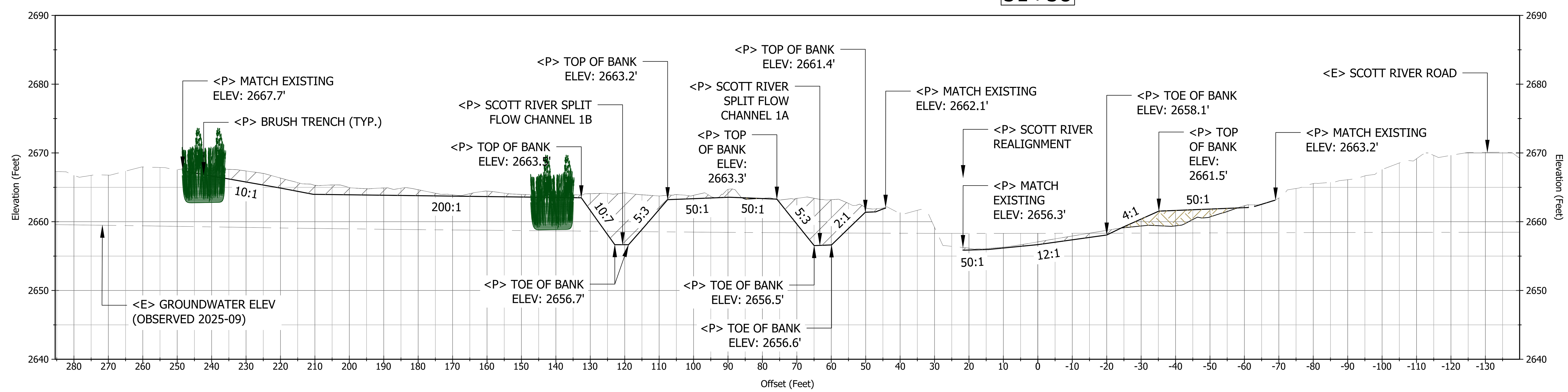
CHECKED: JM
APPROVED: --

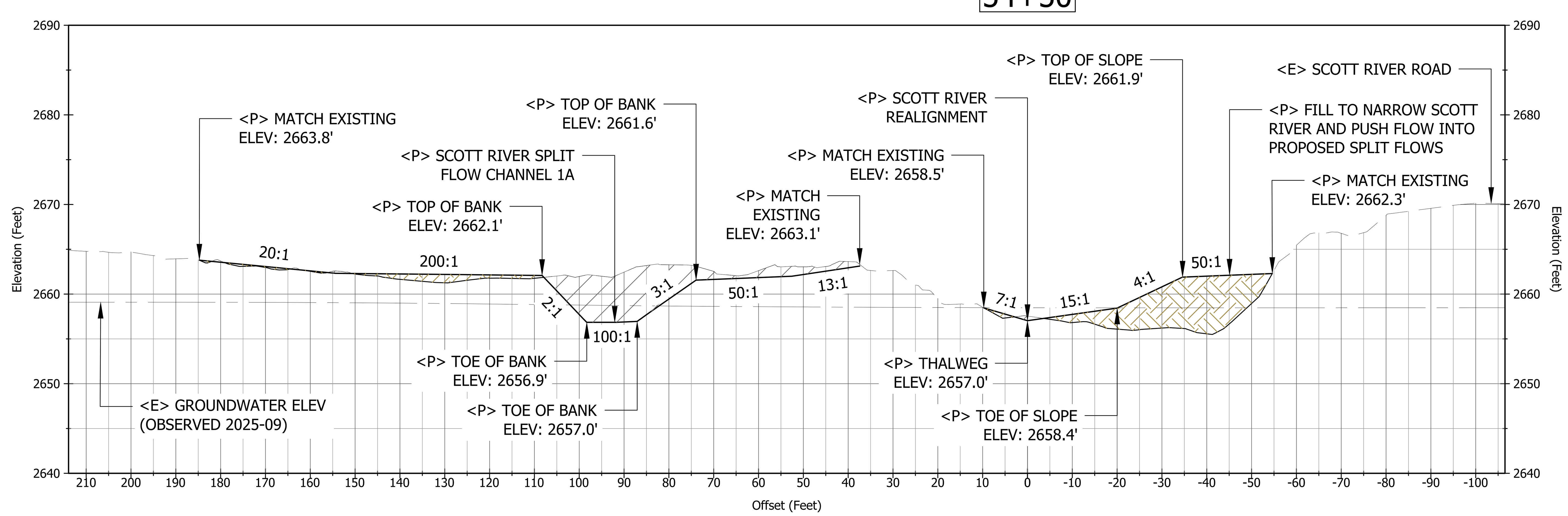
SECTION VIEWS 37+33 TO 47+50

SHEET 11 OF 20

51+58



54+50



LEGEND
- <E> GRADE
- <E> GROUNDWATER
- <P> GRADE
- <P> CUT
- <P> FILL

2X VERTICAL EXAGGERATION

0 10 20 40 FEET
SCALE: 1" = 20'

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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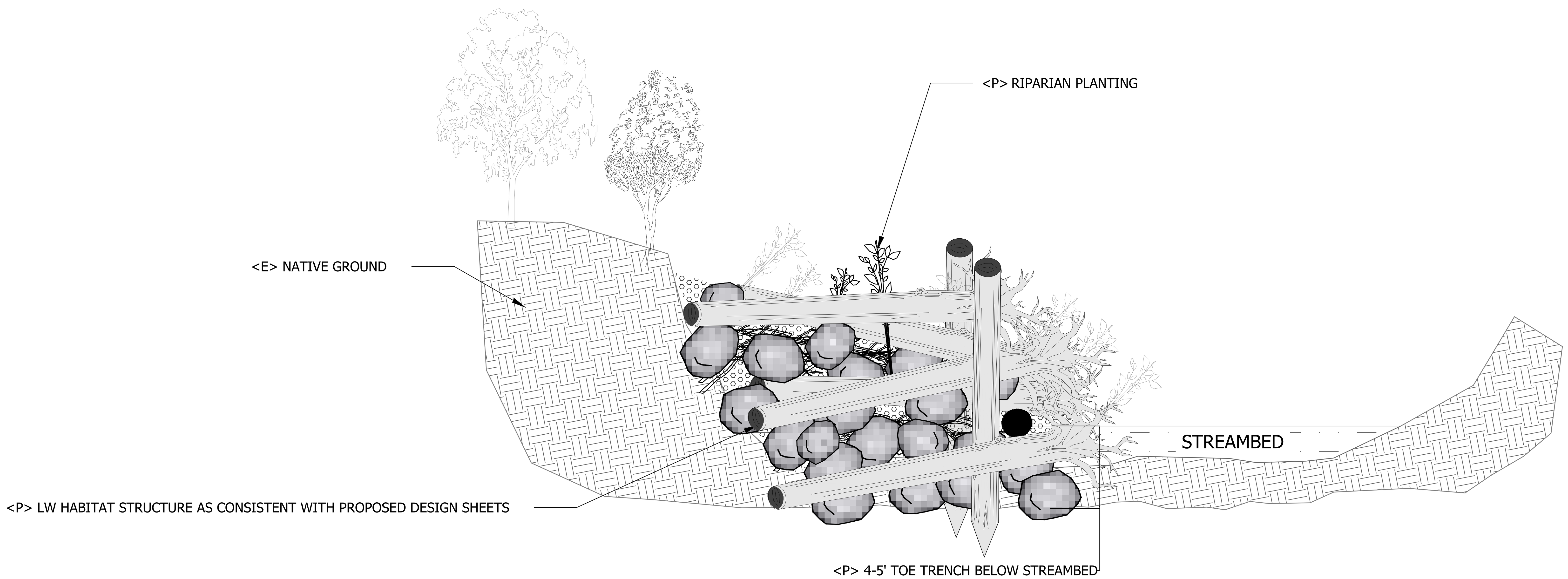
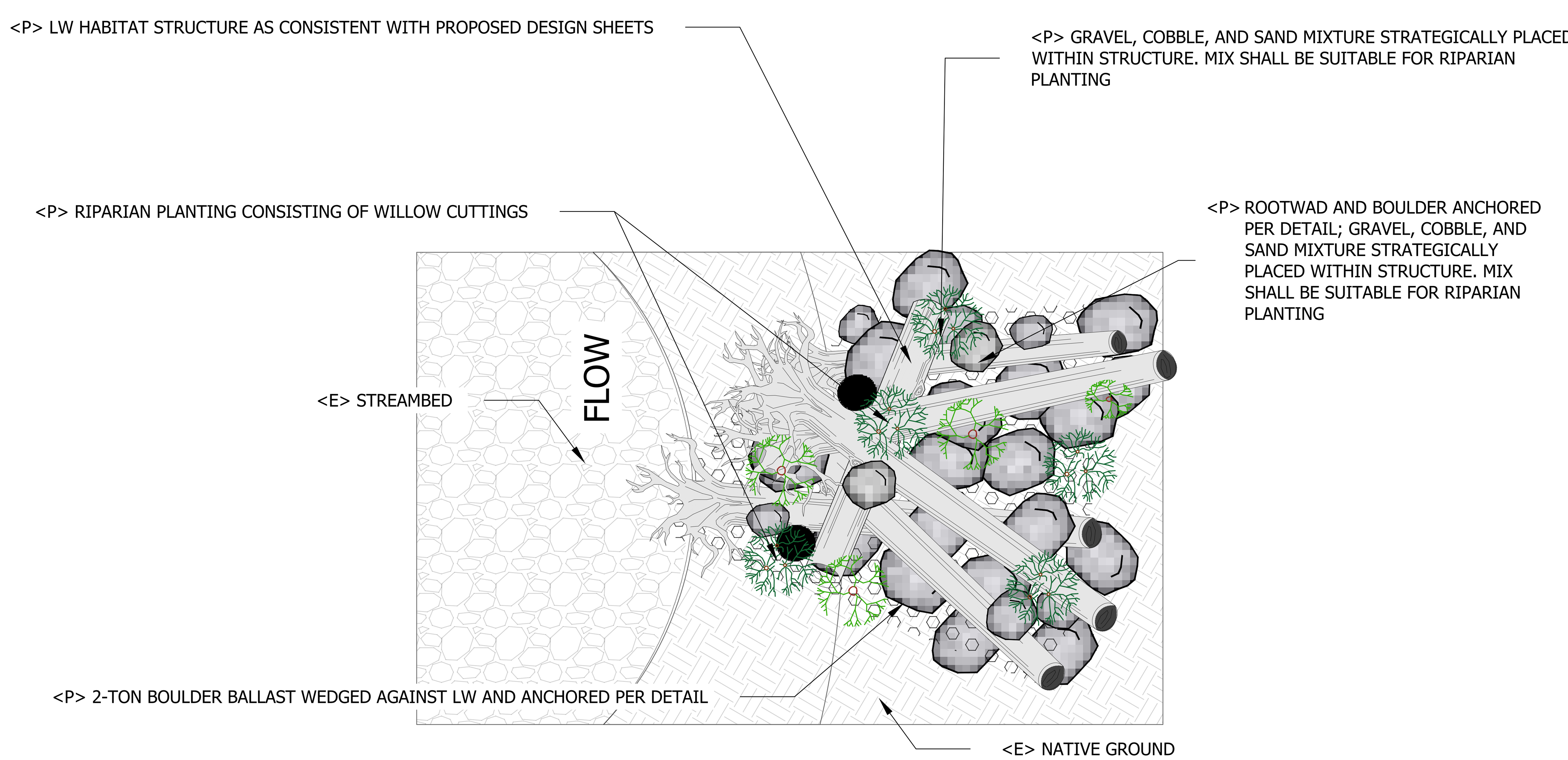
SECTION VIEWS 51+58 TO 54+50

SHEET 12 OF 20



A **LARGE WOOD BOULDER DEFLECTOR DETAIL**
SECTION VIEW Scale: 1" = 10'



B **LARGE WOOD BOULDER DEFLECTOR DETAIL**
PLAN VIEW Scale: 1" = 10'

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

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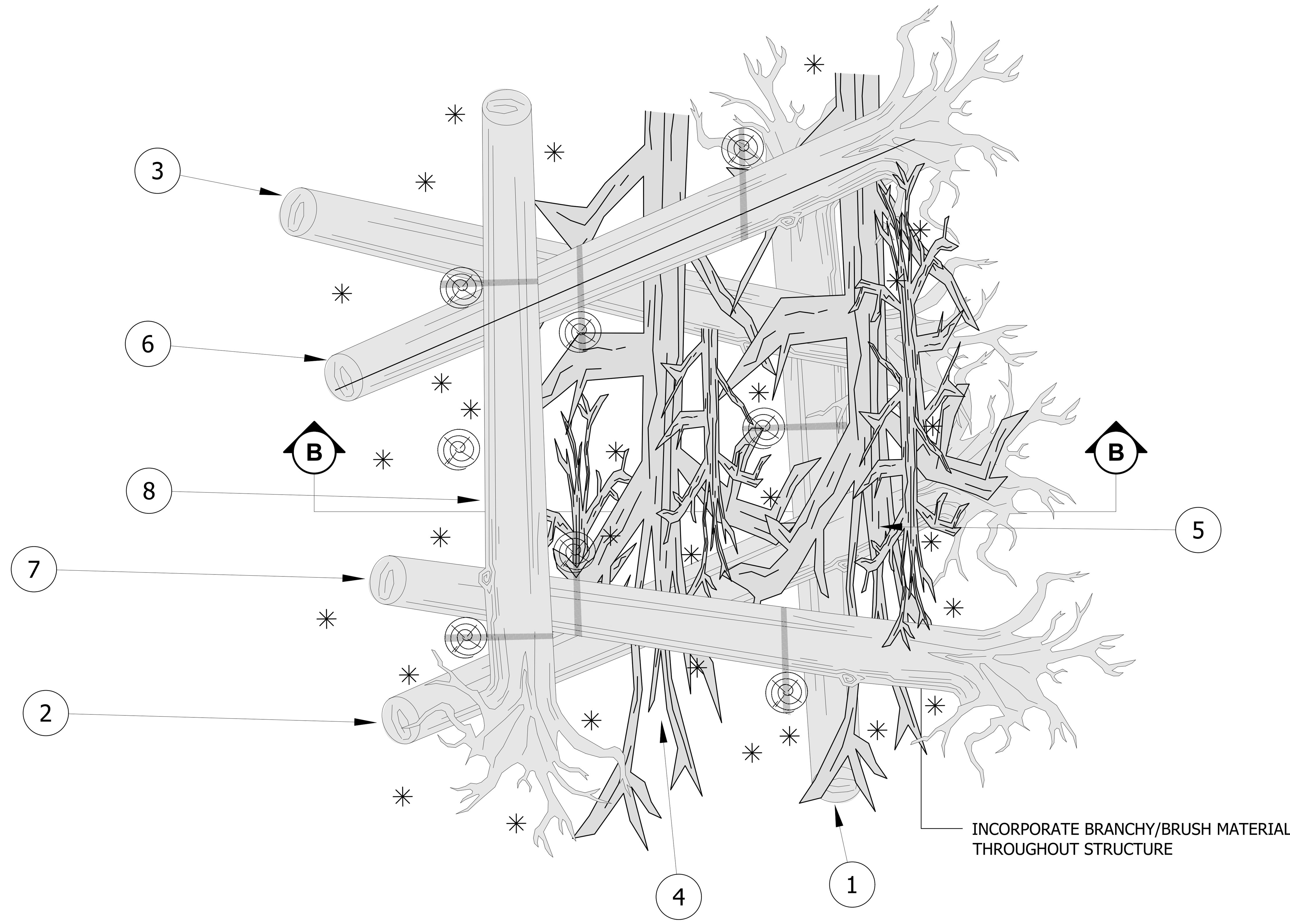
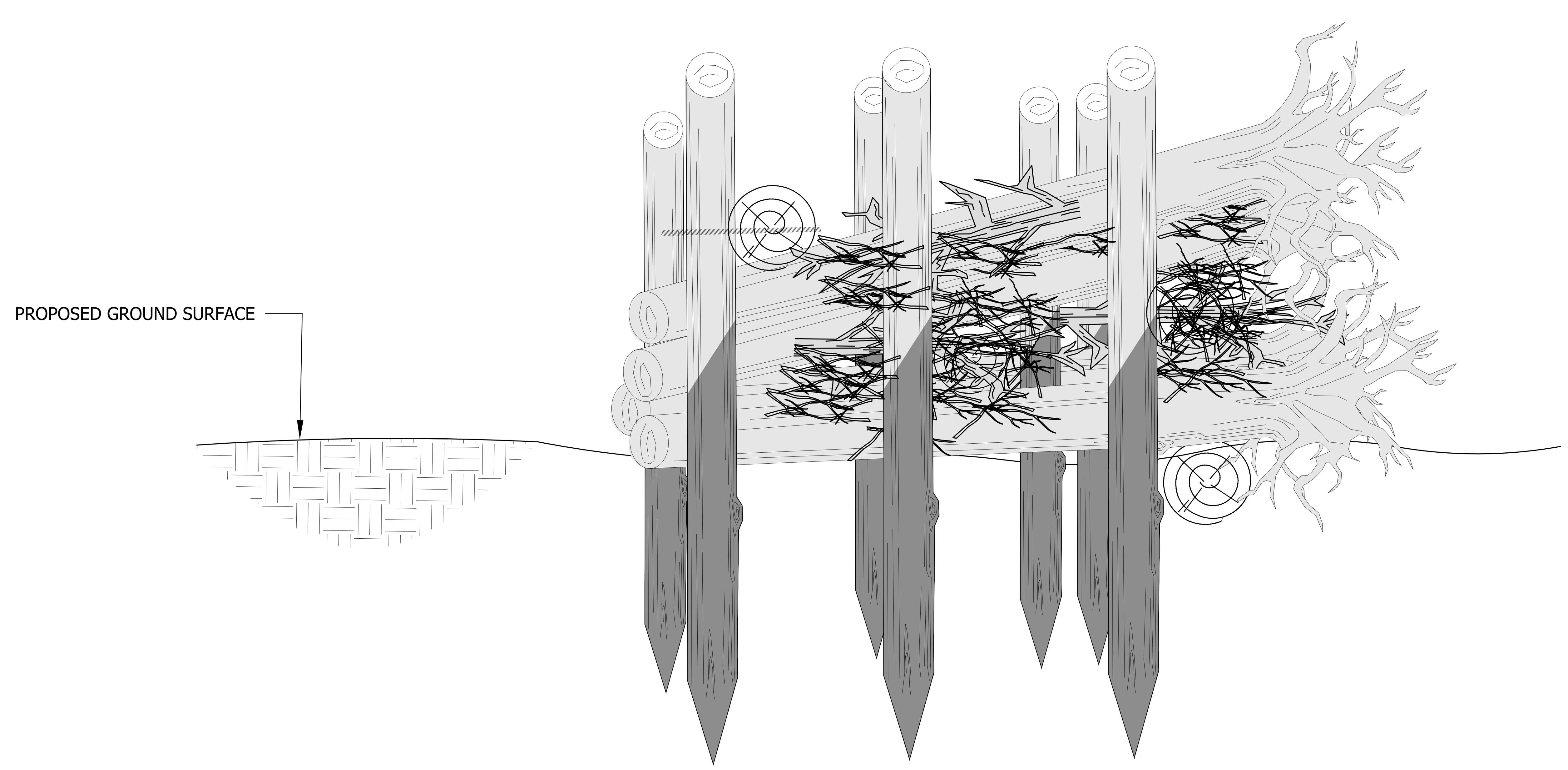
APPROVED: --

LARGE WOOD BOULDER DEFLECTOR STRUCTURE DETAIL



A PILE-DRIVEN LARGE WOOD STRUCTURE
PLAN VIEW Scale: 1" = 6'



B PILE-DRIVEN LARGE WOOD STRUCTURE
SECTION VIEW Scale: 1" = 6'

CONSTRUCTION SEQUENCING NOTES:

1. BURY FOOTER LOG (1) INTO UPSTREAM END OF ISLAND SO TOP OF LOG IS FLUSH WITH GROUND SURFACE.
2. DRIVE 3 PILES ON THE DOWNSTREAM SIDE OF FOOTER (1).
3. PLACE LOGS (2) AND (3) ON GROUND AS SHOWN. ROOTWADS MAY BE DUG INTO GROUND SO LOG SITS FLAT.
4. PLACE LOGS (6) AND (7) ON TOP OF LOGS (2-5). ADD BRANCHY MATERIAL AND WILLOW STAKES IN TO MIDDLE OF STRUCTURE.
5. DRIVE 2 PILES ON THE DOWNSTREAM SIDE OF LOG (6) AND PULL LOG (6) BACK AGAINST PILES.
6. PLACE LOGS (8) AND (9) ON TOP OF (6) AND (7) AS SHOWN.
7. DRIVE 5 PILES ALONG THE DOWNSTREAM END OF STRUCTURE AS SHOWN.
8. PLACE LOG (10) ACROSS LOGS (8) AND (9) AND PULL BACK AGAINST PILES.
9. ADJUST LOGS AS NECESSARY TO ENSURE LOGS THAT WILL BE PINNED TO SPECIFIC PILES WITH BOLTS ARE TOUCHING.

ALL DIMENSIONS ARE APPROXIMATE/ FOR REFERENCE ONLY AND MAY BE ADJUSTED IN THE FIELD AS DIRECTED BY DESIGNER

SHACKLEFORD CREEK - FISH PASSAGE BARRIER REMEDIATION

SISKIYOU COUNTY, CA

Stillwater Sciences
215 W OAK ST SUITE 900
FORT COLLINS, CO 80521 P: (720) 656-2330

REVISIONS

NO.	DESCRIPTION	DATE

60% DESIGN

PROJECT NUMBER: 949.01
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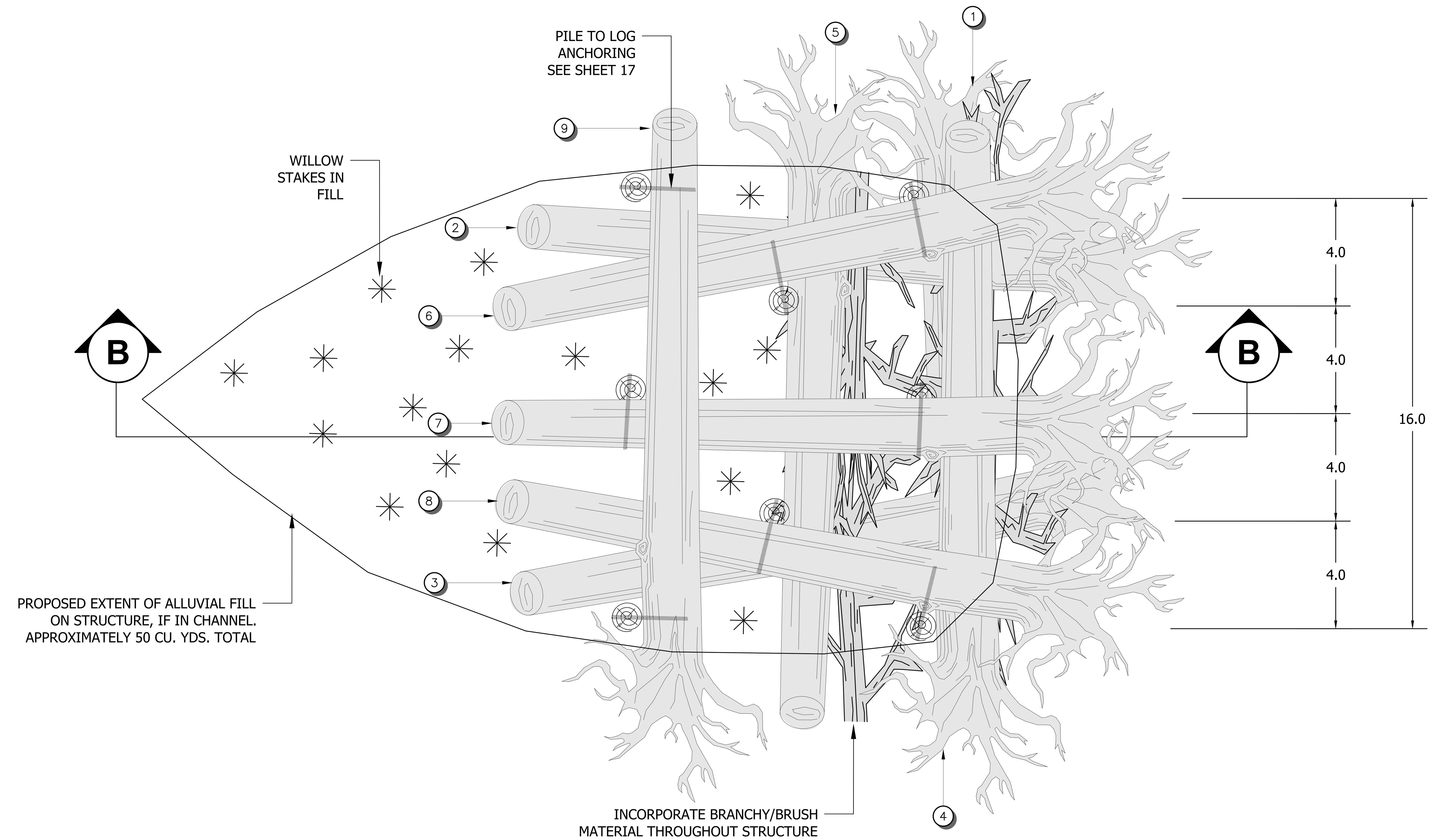
DATE: 11/19/25

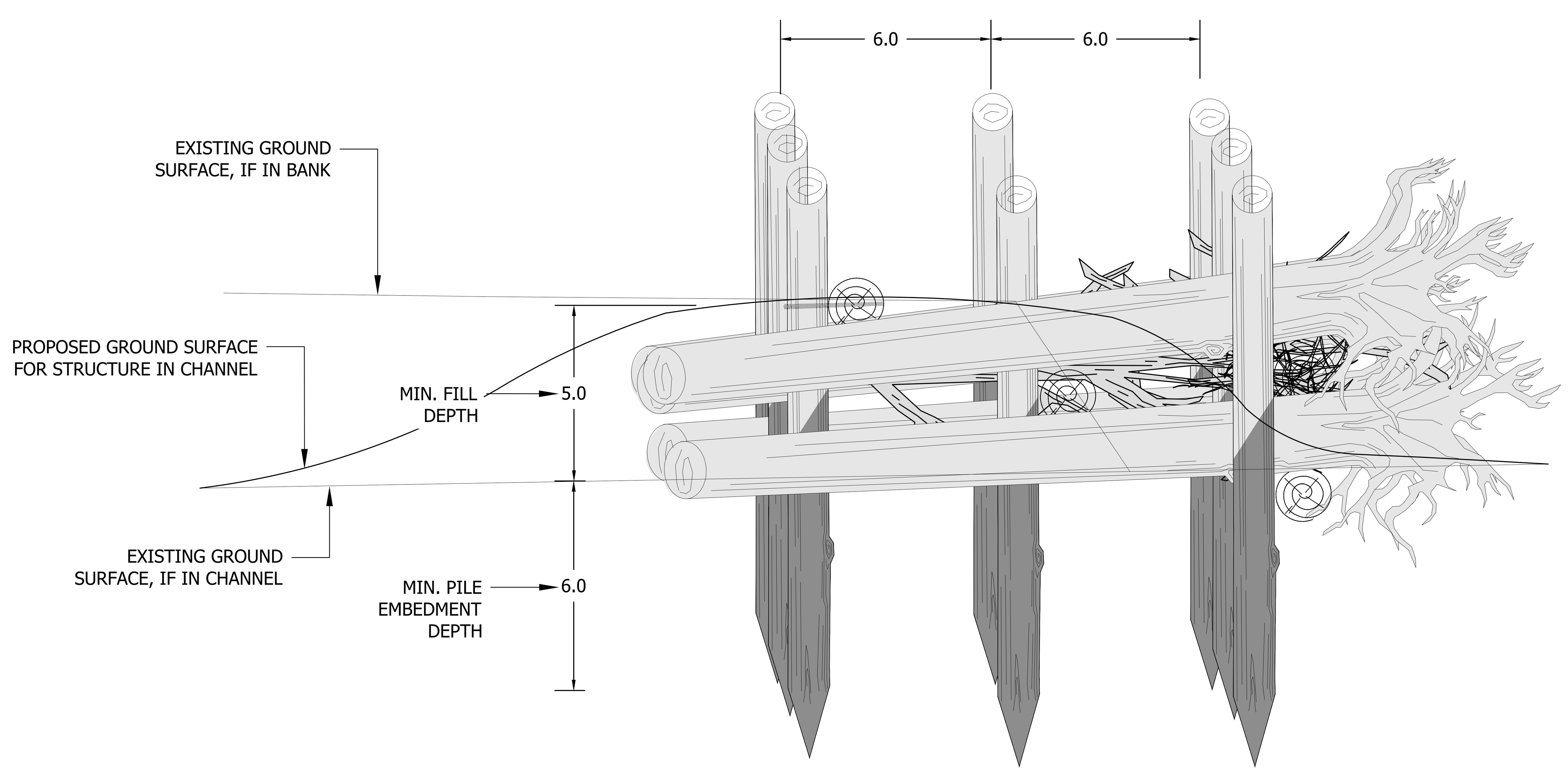
DESIGN: JM
DRAWN: RB/BJ/KS
CHECKED: JM
APPROVED: --

PILE-DRIVEN LARGE WOOD STRUCTURE DETAIL

SHEET 14 OF 20



A **FLOODPLAIN PILE-DRIVEN LARGE WOOD STRUCTURE (LARGE CONFIGURATION)**
PLAN VIEW
Scale = 1" = 3'



B **FLOODPLAIN PILE-DRIVEN LARGE WOOD STRUCTURE (LARGE CONFIGURATION)**
SECTION VIEW
Scale = 1" = 3'

CONSTRUCTION SEQUENCING NOTES:

1. DRIVE 8 PILES INTO APPROXIMATE CONFIGURATION SHOWN.
2. BURY FOOTER LOG (1) IN FRONT OF PILES ON UPSTREAM END OF STRUCTURE SO TOP OF LOG IS FLUSH WITH GROUND SURFACE.
3. PLACE LOGS (2) AND (3) WITH ROOTWADS FACING UPSTREAM SITTING ON FOOTER LOG (1) AS SHOWN. ROOTWADS MAY BE DUG INTO GROUND SO LOG SITS FLAT.
4. PLACE FOOTER LOG (4) ON TOP OF LOGS (2-3) IN FRONT OF PILES AS SHOWN THEN FILL GAPS WITH BRANCHY MATERIAL.
5. PLACE FOOTER LOG (5) ON TOP OF LOGS (2-3) IN FRONT OF PILES AS SHOWN THEN BACKFILL WITH NATIVE ALLUVIUM BETWEEN PILES TO THE TOP OF LOG (5).
6. PLACE LOGS (6-8) WITH ROOTWADS FACING UPSTREAM ON TOP OF LOGS (4-5) AND BOLT LOGS TO PILES AS SHOWN.
7. PLACE LOG (9) ON TOP OF LOGS (6-8) IN FRONT OF PILES AND BOLT TO PILES AS SHOWN.
8. BACKFILL WITH NATIVE ALLUVIUM TO AT LEAST 1 FOOT ABOVE LOGS (6-8) TAPERING FILL IN DOWNSTREAM DIRECTION IF IN THE CHANNEL OR MATCHING EXISTING GRADE IF IN BANK AS SHOWN.
9. INSTALL WILLOW STAKES WHILE BACKFILLING ON DOWNSTREAM SIDE OF STRUCTURE AS DIRECTED BY DESIGNER.
10. CHECK LOGS/PILES TO ENSURE BOLTS ARE STILL SECURE.

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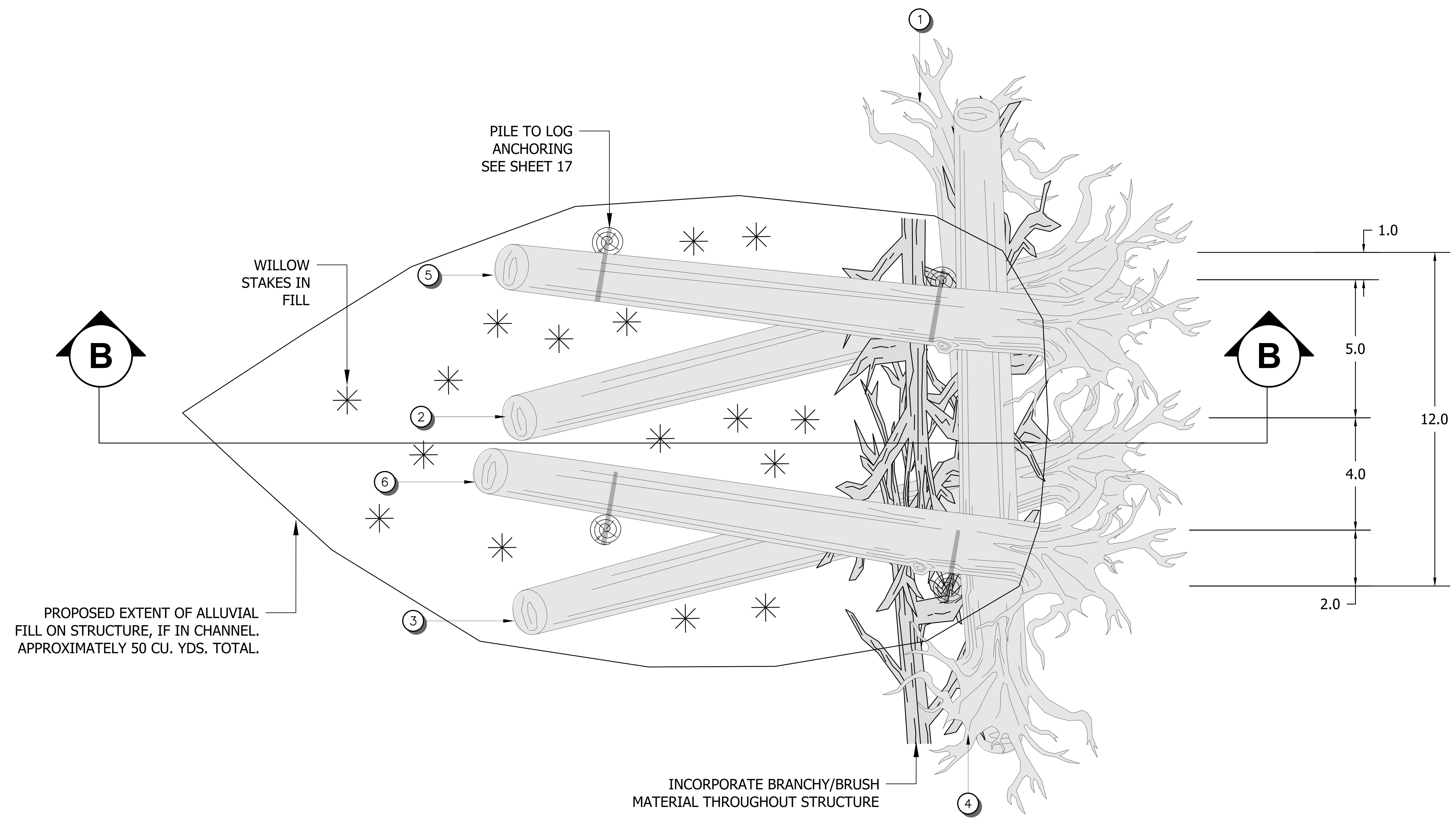
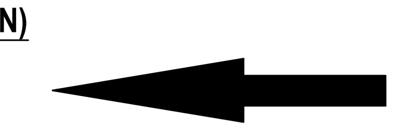
FLOODPLAIN LARGE WOOD STRUCTURE LARGE DETAIL



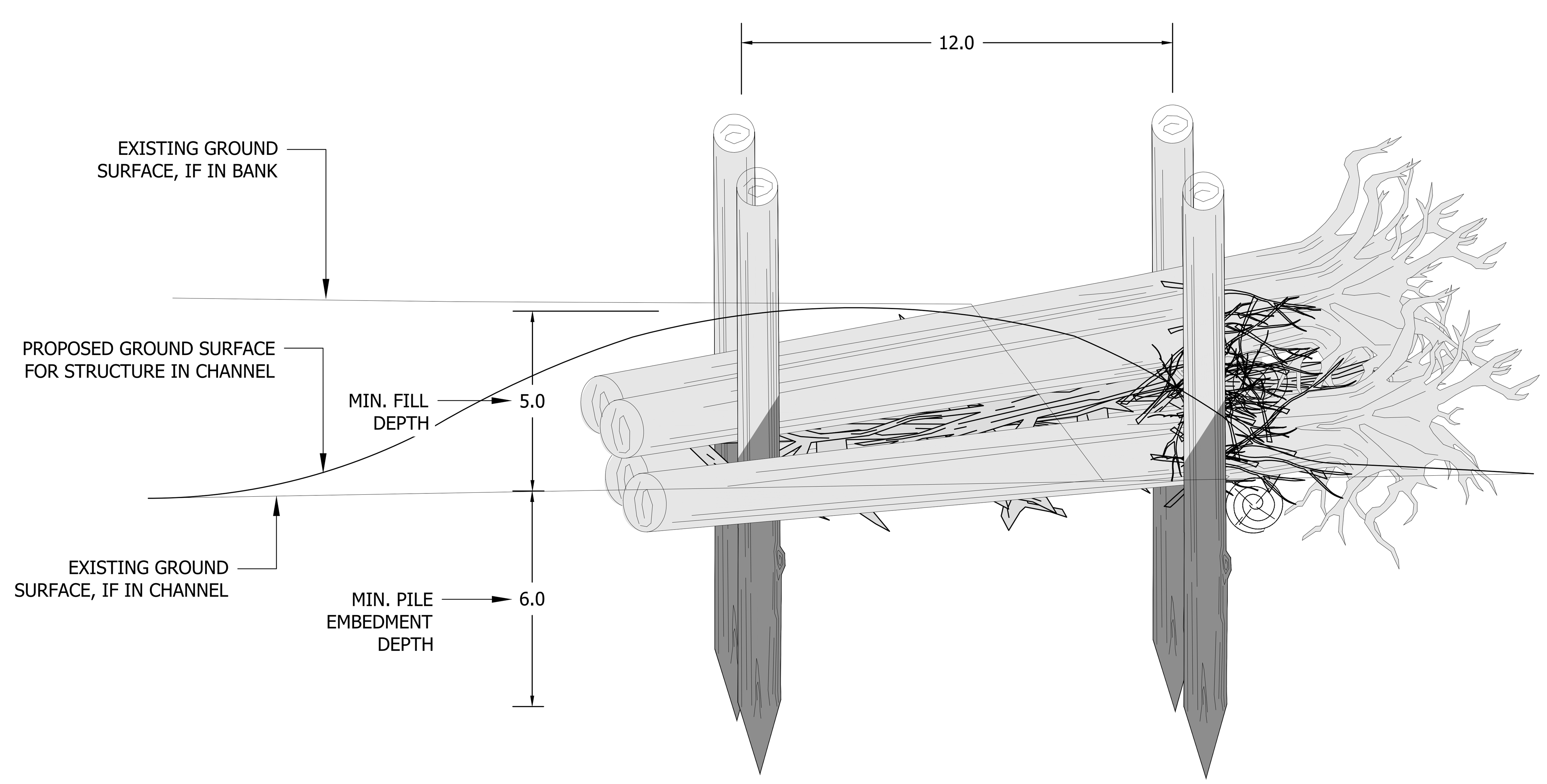
A **FLOODPLAIN PILE-DRIVEN LARGE WOOD STRUCTURE (MEDIUM CONFIGURATION)**
PLAN VIEW Scale = 1" = 3'



CONSTRUCTION SEQUENCING NOTES:

1. DRIVE 4 PILES INTO APPROXIMATE CONFIGURATION SHOWN.
2. BURY FOOTER LOG (1) IN FRONT OF PILES ON UPSTREAM END OF STRUCTURE SO TOP OF LOG IS FLUSH WITH GROUND SURFACE.
3. PLACE LOGS (2) AND (3) WITH ROOTWADS FACING UPSTREAM SITTING ON FOOTER LOG (1) AS SHOWN. ROOTWADS MAY BE DUG INTO GROUND SO LOG SITS FLAT.
4. PLACE FOOTER LOG (4) ON TOP OF LOGS (2-3) IN FRONT OF PILES AS SHOWN THEN FILL GAPS WITH BRANCHY MATERIAL.
5. PLACE LOGS (5) AND (6) WITH ROOTWADS FACING UPSTREAM ON TOP OF FOOTER LOG (4) AND BOLT LOGS TO PILES AS SHOWN.
6. BACKFILL WITH NATIVE ALLUVIUM TO AT LEAST 1 FOOT ABOVE LOGS (5) AND (6) TAPERING FILL IN DOWNSTREAM DIRECTION IF IN THE CHANNEL OR MATCHING EXISTING GRADE IF IN BANK AS SHOWN.
7. INSTALL WILLOW STAKES WHILE BACKFILLING ON DOWNSTREAM SIDE OF STRUCTURE AS DIRECTED BY DESIGNER.
8. CHECK LOGS/PILES TO ENSURE BOLTS ARE STILL SECURE.

ALL DIMENSIONS ARE APPROXIMATE/ FOR REFERENCE ONLY AND MAY BE ADJUSTED IN THE FIELD AS DIRECTED BY DESIGNER



B **FLOODPLAIN PILE-DRIVEN LARGE WOOD STRUCTURE (MEDIUM CONFIGURATION)**
SECTION VIEW Scale = 1" = 3'

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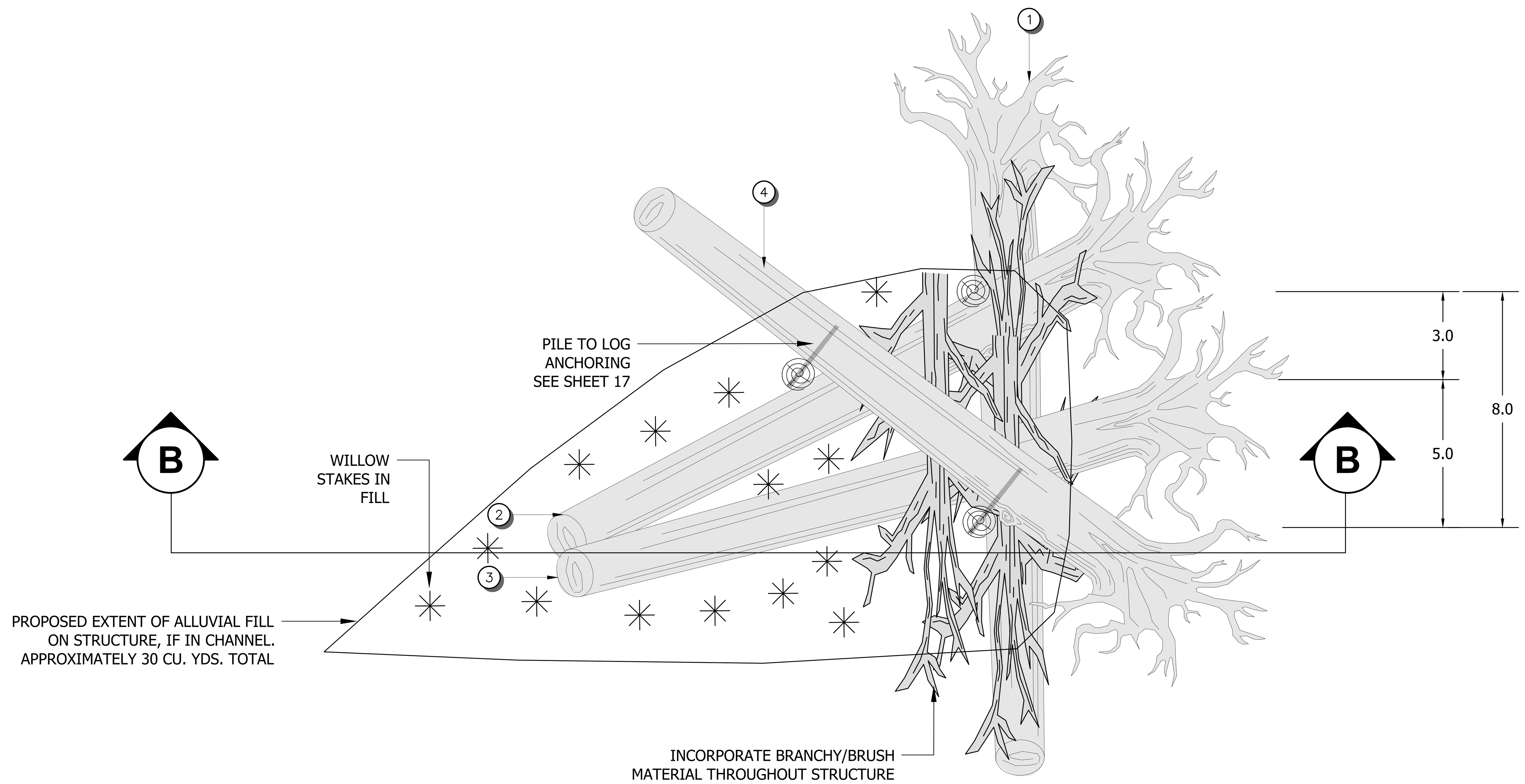
FLOODPLAIN LARGE WOOD STRUCTURE MEDIUM DETAIL



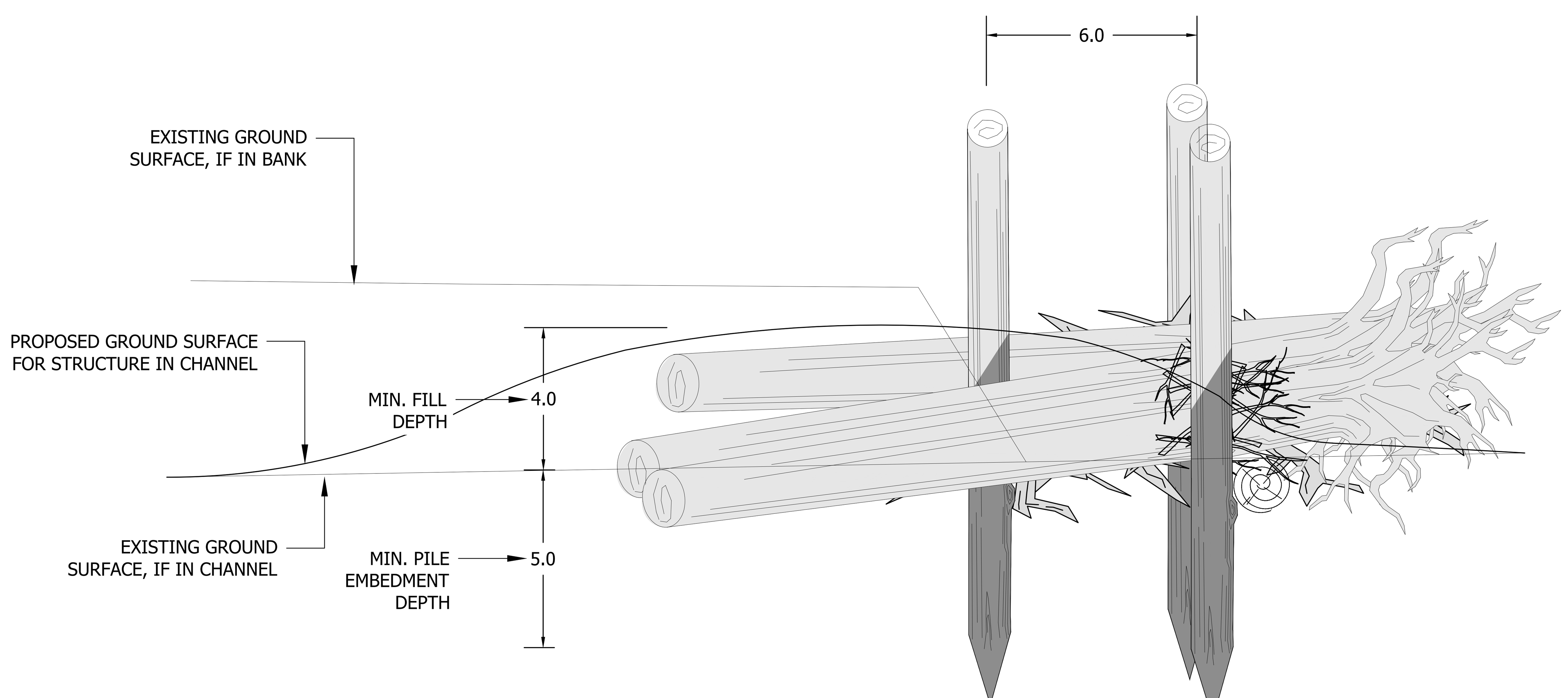
A **FLOODPLAIN PILE-DRIVEN LARGE WOOD STRUCTURE (SMALL CONFIGURATION)**
PLAN VIEW Scale = 1" = 3'

FLOW DIRECTION

CONSTRUCTION SEQUENCING NOTES:

1. DRIVE 3 PILES INTO APPROXIMATE CONFIGURATION SHOWN.
2. BURY FOOTER LOG (1) IN FRONT OF PILES ON UPSTREAM END OF STRUCTURE SO TOP OF LOG IS FLUSH WITH GROUND SURFACE.
3. PLACE LOGS (2) AND (3) WITH ROOTWADS FACING UPSTREAM SITTING ON FOOTER LOG (1) AS SHOWN. ROOTWADS MAY BE DUG INTO GROUND SO LOG SITS FLAT.
4. PLACE LOG (4) ON TOP OF LOGS (2-3) IN FRONT OF PILES THEN BOLT TO PILES AS SHOWN
5. BACKFILL WITH NATIVE ALLUVIUM TO AT LEAST 2.5 FEET ABOVE LOGS (2) AND (3) TAPERING FILL IN DOWNSTREAM DIRECTION IF IN THE CHANNEL OR MATCHING EXISTING GRADE IF IN BANK AS SHOWN.
6. INSTALL WILLOW STAKES WHILE BACKFILLING ON DOWNSTREAM SIDE OF STRUCTURE AS DIRECTED BY DESIGNER.
7. CHECK LOGS/PILES TO ENSURE BOLTS ARE STILL SECURE.

ALL DIMENSIONS ARE APPROXIMATE/ FOR REFERENCE ONLY AND MAY BE ADJUSTED IN THE FIELD AS DIRECTED BY DESIGNER



B **FLOODPLAIN PILE-DRIVEN LARGE WOOD STRUCTURE (SMALL CONFIGURATION)**
SECTION VIEW Scale = 1" = 3'

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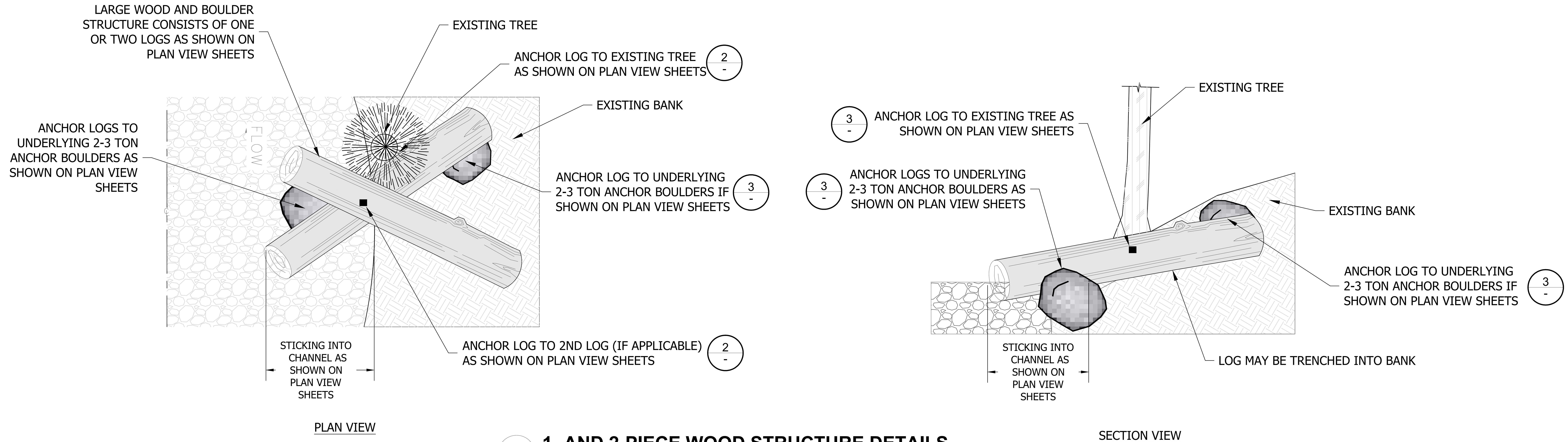
FLOODPLAIN LARGE WOOD STRUCTURE SMALL DETAIL

SHEET 17 OF 20

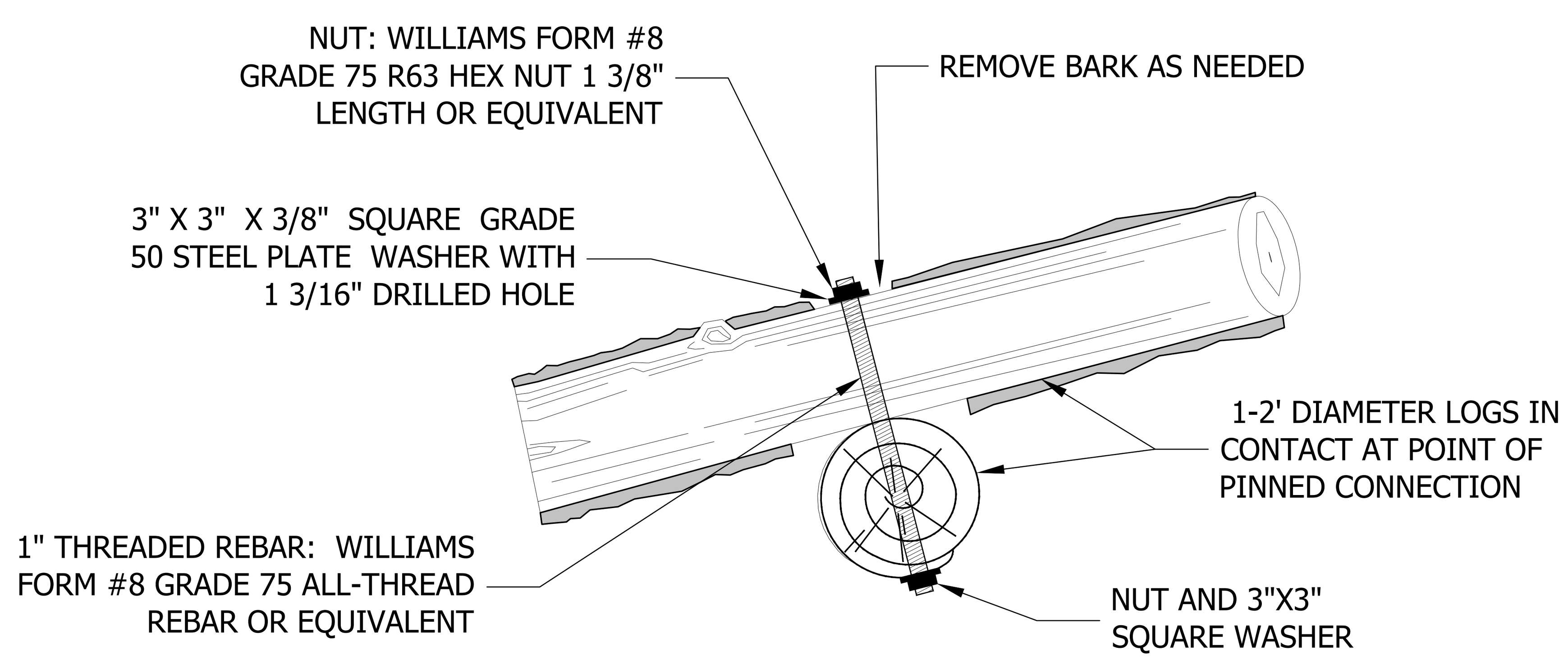


1 **1- AND 2-PIECE WOOD STRUCTURE DETAILS**

NTS

NOTES:

1. LOG STRUCTURES SHALL BE INSTALLED AS SHOWN ON PLAN VIEW SHEETS
2. WHERE BANKS ARE STEEP, LOG STRUCTURES MAY BE TRENCHED INTO THE BANK TO ALLOW FOR A LOWER ANGLE AND PROVIDE MORE WOOD VOLUME IN THE ACTIVE CHANNEL
3. LOG STRUCTURE CONSTRUCTION DETAILS MAY BE MODIFIED IN THE FIELD AS APPROVED BY THE PROJECT MANAGER AND ENGINEER



NOTES:

1. BARK REMOVAL NOT REQUIRED ON LIVE TREES TO REDUCE IMPACTS TO TREE HEALTH
2. 1 1/8" DRILL HOLES THROUGH WOOD COMPONENTS

2 **LOG-LOG OR LOG-TREE ANCHORING**

NTS

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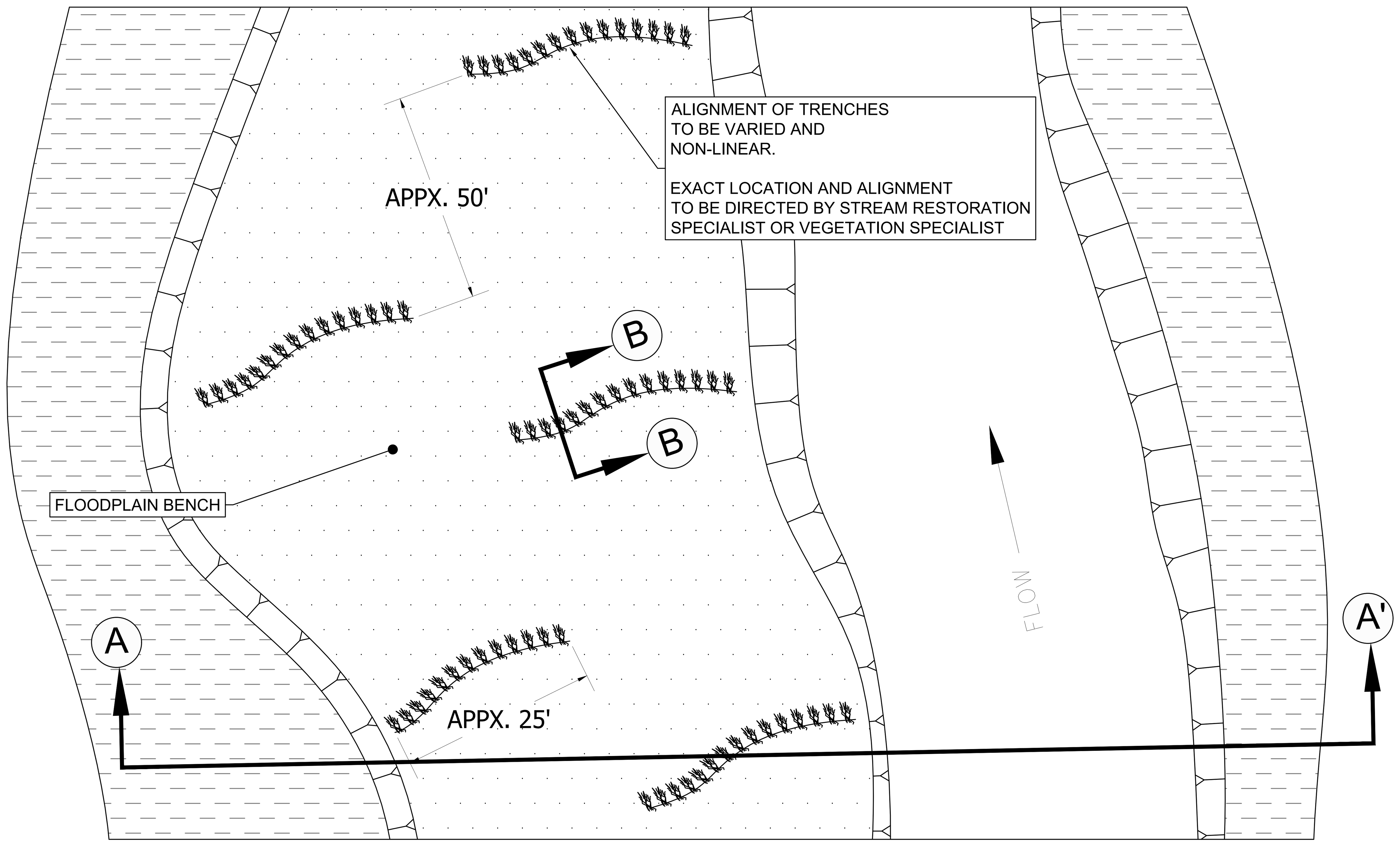
LARGE WOOD STRUCTURE ANCHORING DETAIL

NOTES:
1. BRUSH TRENCHES TO BE FILLED WITH ABUNDANT LIVE WILLOW STAKES AND COTTONWOOD BRANCHES INTERMIXED WITH DEAD CWM TO FORM A THICKET OF STEMS EXTENDING FROM AT OR NEAR BOTTOM OF TRENCH TO APPROXIMATELY 1.5 TO 4 FT ABOVE FLOODPLAIN SURFACE.
2. STEM DENSITY AND ARRANGEMENT TO BE SUFFICIENT TO OBSTRUCT DIRECT PASSAGE OF MATERIALS LARGER THAN APPROXIMATELY 12 INCHES IN LENGTH THROUGH THE TRENCH.
3. CRACK WILLOW MUST NOT BE USED IN BRUSH TRENCHES.
4. WILLOW, COTTONWOOD, AND CWM STEM DENSITY DISTRIBUTIONS REPRESENT INSTALLATION TARGETS. VARIATION FROM SPECIFIED MATERIAL DENSITIES IS ACCEPTABLE WHEN DUE TO THE CHARACTER OF NATURAL MATERIALS USED.
5. WILLOW STAKES MAY BE CLUMPED FOR DENSE PLANTING AS DETERMINED ON INSTALLATION.
6. HIGHER INSTALLED DENSITY OF ANY WOODY MATERIAL IS ACCEPTABLE.
7. MAXIMIZE PLACEMENT OF LIVE COTTONWOOD BRANCHES FROM SITE CLEARING OPERATIONS.
8. WILLOW STAKES TO BE SOAKED IN WATER FOR 7 TO 14 DAYS BEFORE INSTALLATION.
9. WILLOW STAKES TO BE PLANTED IN CLUMPED AND SCATTERED CONFIGURATIONS.
10. WHOLE WILLOWS TO BE EXTRACTED WITH AS LARGE AN INTACT ROOT WAD AS POSSIBLE.
11. WILLOWS TO BE HANDLED AS LITTLE AS POSSIBLE AND TRANSPLANTED AS QUICKLY AS POSSIBLE.
12. WILLOWS TO BE STOCKPILED IN A SHADED LOCATION OR PROVIDED SHADE TO THE DEGREE POSSIBLE.
13. WILLOWS STOCKPILED LONGER THAN A DAY WILL BE WATERED.
14. HAND WATERING IS ACCEPTABLE.



BRUSH TRENCH- PLAN

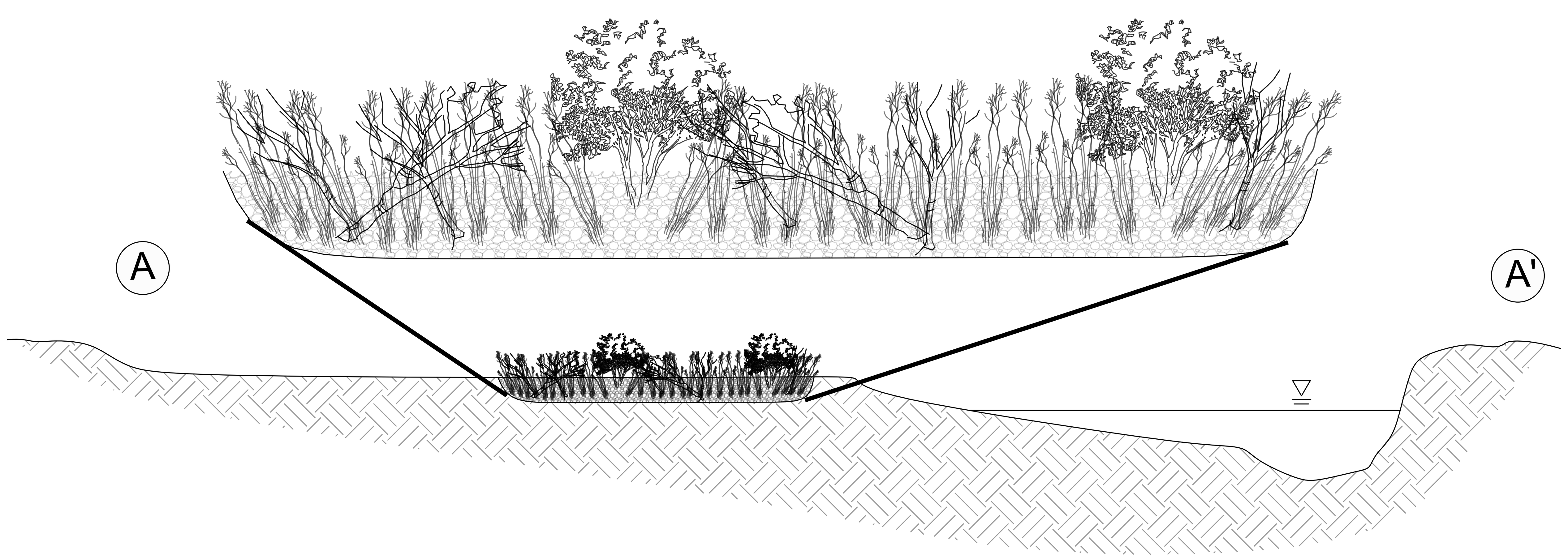
TRENCH:

- TRENCH LOCATIONS TO BE FIELD FIT WITH DESIGNER MINIMUM 15 FT BETWEEN TRENCHES FOR MACHINE ACCESS
- TRENCH LENGTH TO BE FIELD FIT AND MAY VARY: AVERAGE 36 LINEAR FEET (LF) PER TRENCH
- DIG TRENCHES TO INTERCEPT GROUNDWATER
- SHALLOW TRENCH AT 4 TO 5 FT DEEP TOTAL 1204 LF OF SHALLOW TRENCH
- DEEP TRENCH AT 5 TO 7 FT DEEP TOTAL 500 LF OF DEEP TRENCH
- DEEP TRENCH LOCATION TO BE INDENTIFIED IN FIELD
- IF DEEP TRENCH LOCATIONS TO BE IDENTIFIED IN FIELD
- IF 7 FT EXCAVATION DOES NOT INTERCEPT GROUNDWATER, TRENCH TO BE FIELD RELOCATED OR ONLY DEAD MATERIAL MAY BE USED, AS APPROVED BY DESIGNER
- TRENCH BOTTOM WIDTH OF APPROXIMATELY 2 FT; SIDESLOPES AT ANGLE OF REPOSE

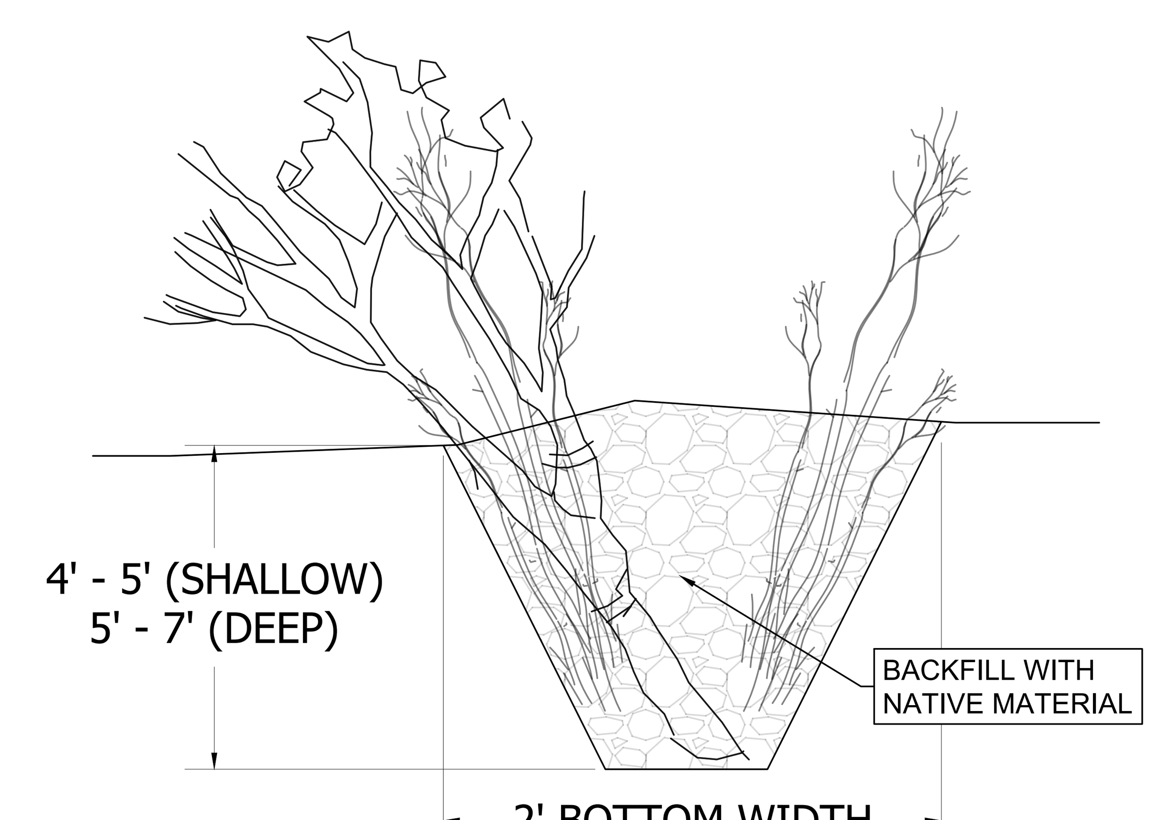
MATERIALS:
- LIVE WILLOW STAKES 4 TO 6 FT LONG
- LIVE COTTONWOOD BRANCHES: 2 TO 5 INCH BASAL DIAMETER, 4 TO 10 FT IN LENGTH WITH ABUNDANT SIDE BRANCHES
- DEAD COARSE WOODY MATERIAL (CWM): 4 TO 8 INCH DIAMETER, 6 TO 12 FT IN LENGTH WITH ABUNDANT SIDE BRANCHES
- ALL MATERIALS TO BE SALVAGED ON SITE OR FROM CITY-APPROVED SITE(S) ON CITY PROPERTY.
- TRANSPLANT AND BRUSH TRENCH MATERIAL HARVEST SOURCE AREA IDENTIFIED ON SHEET V1. ADDITIONAL SUITABLE LOCATION(S) MAY BE APPROVED BY CITY.

QUANTITIES:
- WILLOW STAKES: 3 LIVE WILLOW STAKES PER LF OF TRENCH
- LIVE COTTONWOOD BRANCHES: 5 LIVE BRANCHES EVERY 10 LF OF TRENCH FOR INTERLOCKING
- DEAD CWM: 3 TO 6 BRANCHES STICKING ABOVE GROUND PER LF OF TRENCH
- IF EXTRA WILLOW TRANSPLANTS ARE AVAILABLE AFTER INCORPORATION INTO BANK REGRADE AREAS AND LARGE WOOD STRUCTURES, INCORPORATE THESE INTO BRUSH TRENCHES IN FIELD FIT LOCATIONS

EXAMPLE PHOTO: BRUSH TRENCH STRUCTURES CREATE COMPLEX FLOODPLAIN



BRUSH TRENCH - SECTION A-A'



BRUSH TRENCH- SECTION B-B

1 **BRUSH TRENCH DETAIL**
NTS

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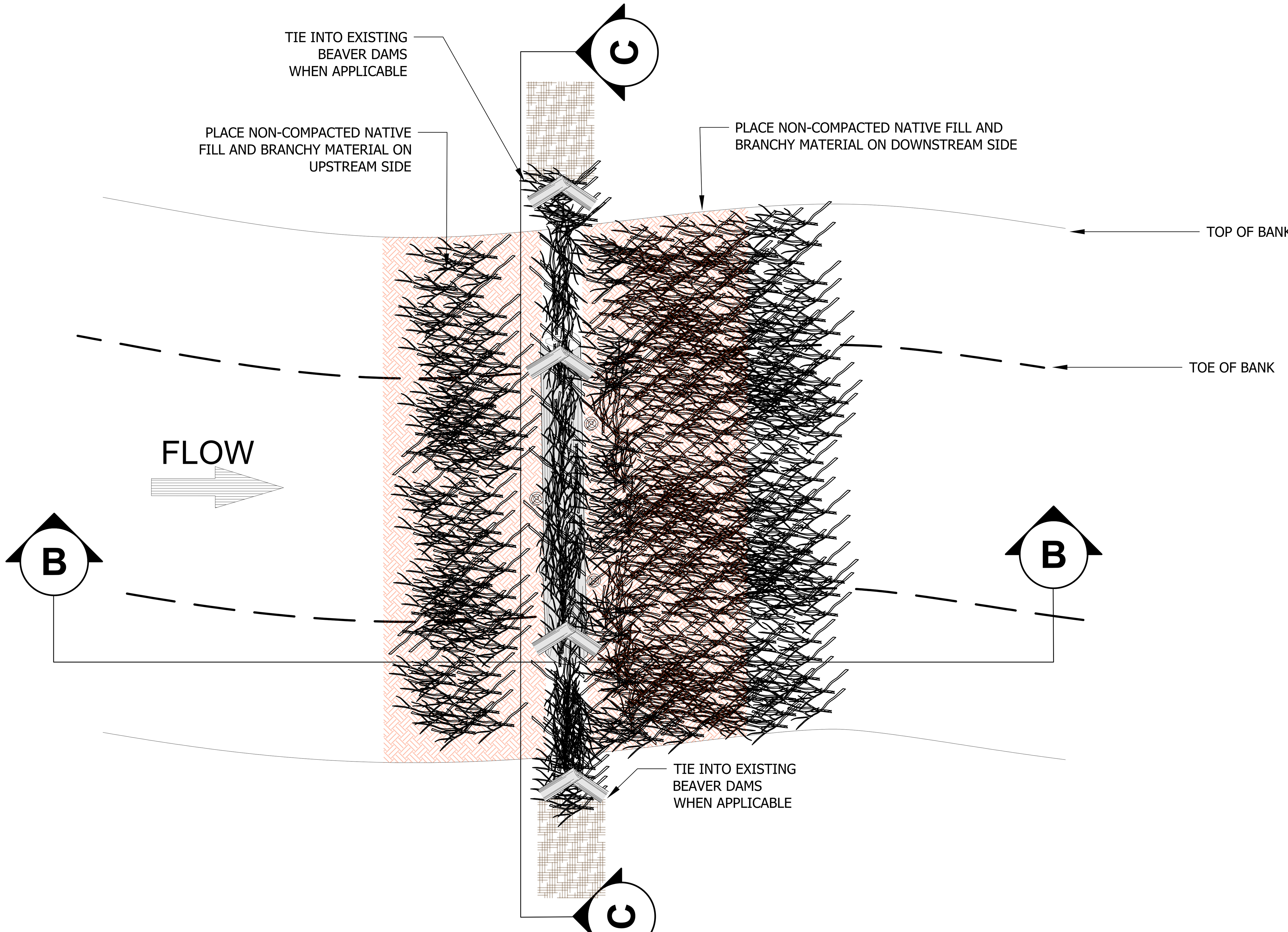
BRUSH TRENCH DETAIL

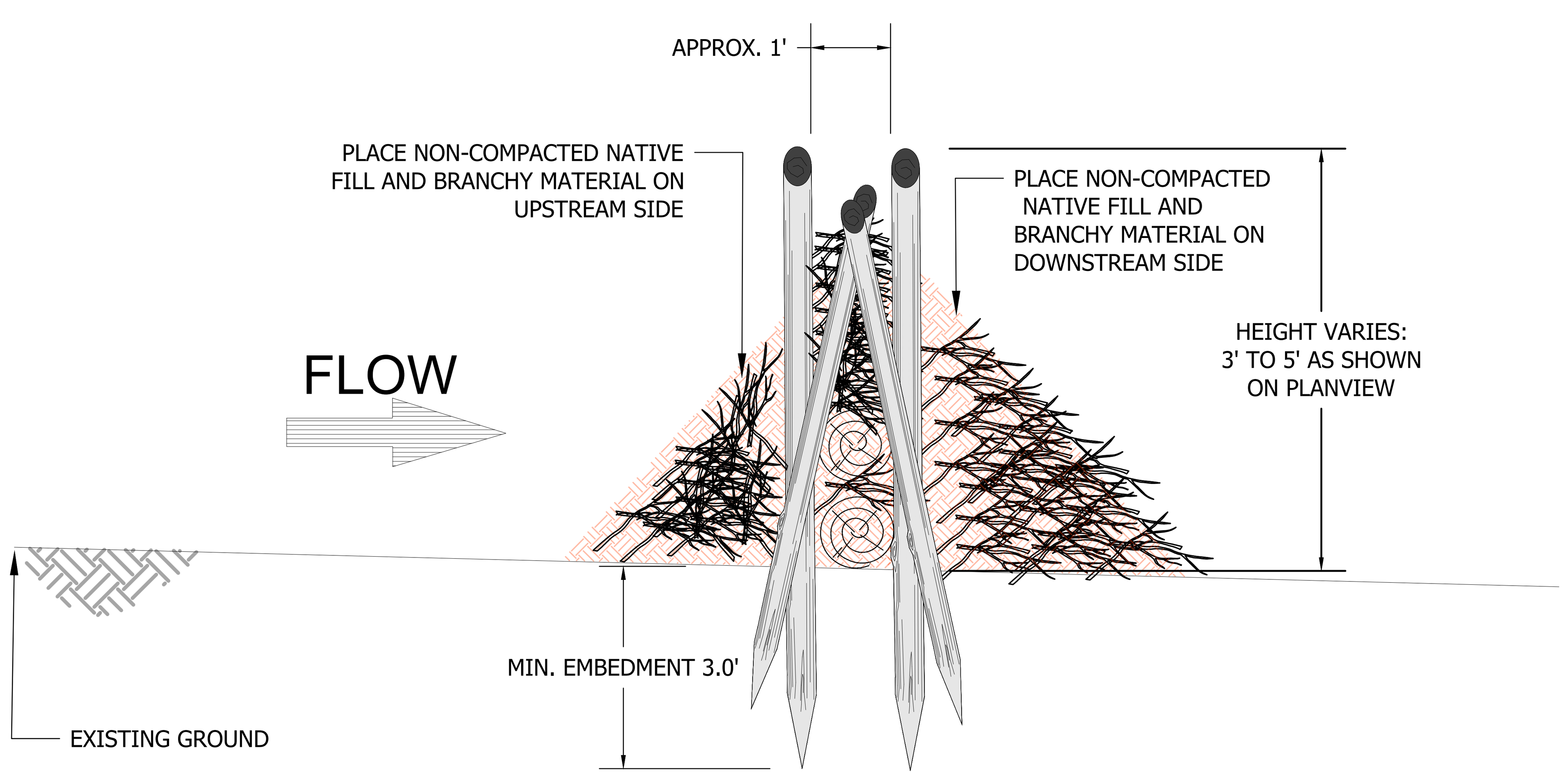
SHEET 19 OF 20



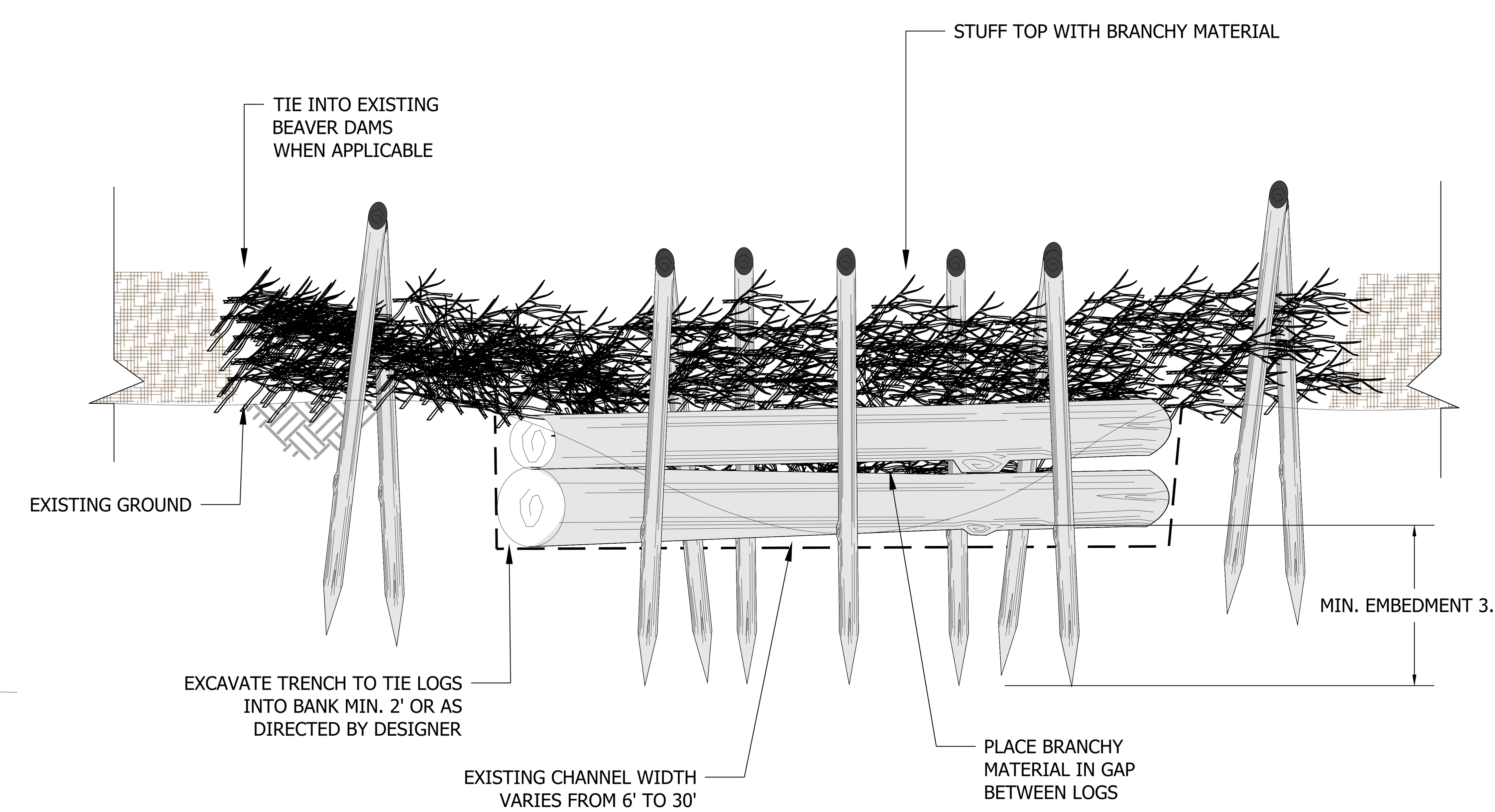
A **SIMULATED BEAVER STRUCTURE DETAIL**
PLAN VIEW
NTS

NOTES:
1. SIMULATED BEAVER STRUCTURES (SBS) TO BE CONSTRUCTED PER DESIGNER DIRECTION.
2. DRIVE PILES TO SPECIFIED DEPTH TO PREVENT OVERTOPPING.
3. PLACE NON-COMPACTED NATIVE FILL AND BRANCHY MATERIAL ON UPSTREAM SIDE OF STRUCTURE.
4. PLACE NON-COMPACTED NATIVE FILL AND BRANCHY MATERIAL ON DOWNSTREAM SIDE OF STRUCTURE.
5. TIE STRUCTURE INTO EXISTING BEAVER DAM WHEN APPLICABLE. OPTIONS FOR CONNECTIONS TO BE FIELD DETERMINED.

MATERIAL DIMENSION ESTIMATES:
1. WILLOW STAKES WILL BE SOURCED ON-SITE AND WILL BE MINIMUM 36" IN LENGTH. 1-3 WILLOW STAKES PER LINEAR FOOT, OR AS DIRECTED BY DESIGNER. ASSUME AVERAGE 2 WILLOW STAKES PER LINEAR FOOT FOR MATERIAL QUANTITIES.
2. LARGE WOOD USED IN SBS WILL RANGE BETWEEN 5' AND 10' IN LENGTH AND 6" TO 12" IN DIAMETER, OR AS DIRECTED BY DESIGNER.
3. BRANCHY MATERIAL WILL BE SOURCED ON-SITE AND VARY IN SIZE AND SHAPE DEPENDING ON AVAILABILITY.
4. DRIVEN PILES WILL BE IMPORTED AND ARE 2" IN DIAMETER AND 10' IN LENGTH. PILES MUST BE FREE OF HARMFUL CONTAMINANTS.



B **SIMULATED BEAVER STRUCTURE DETAIL**
PROFILE VIEW
NTS



C **SIMULATED BEAVER STRUCTURE DETAIL**
SECTION VIEW
NTS

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SIMULATED BEAVER STRUCTURE DETAIL

SHEET 20 OF 20

Appendix B

Historical Aerial Imagery and Scott River Alignment Changes

Appendix B

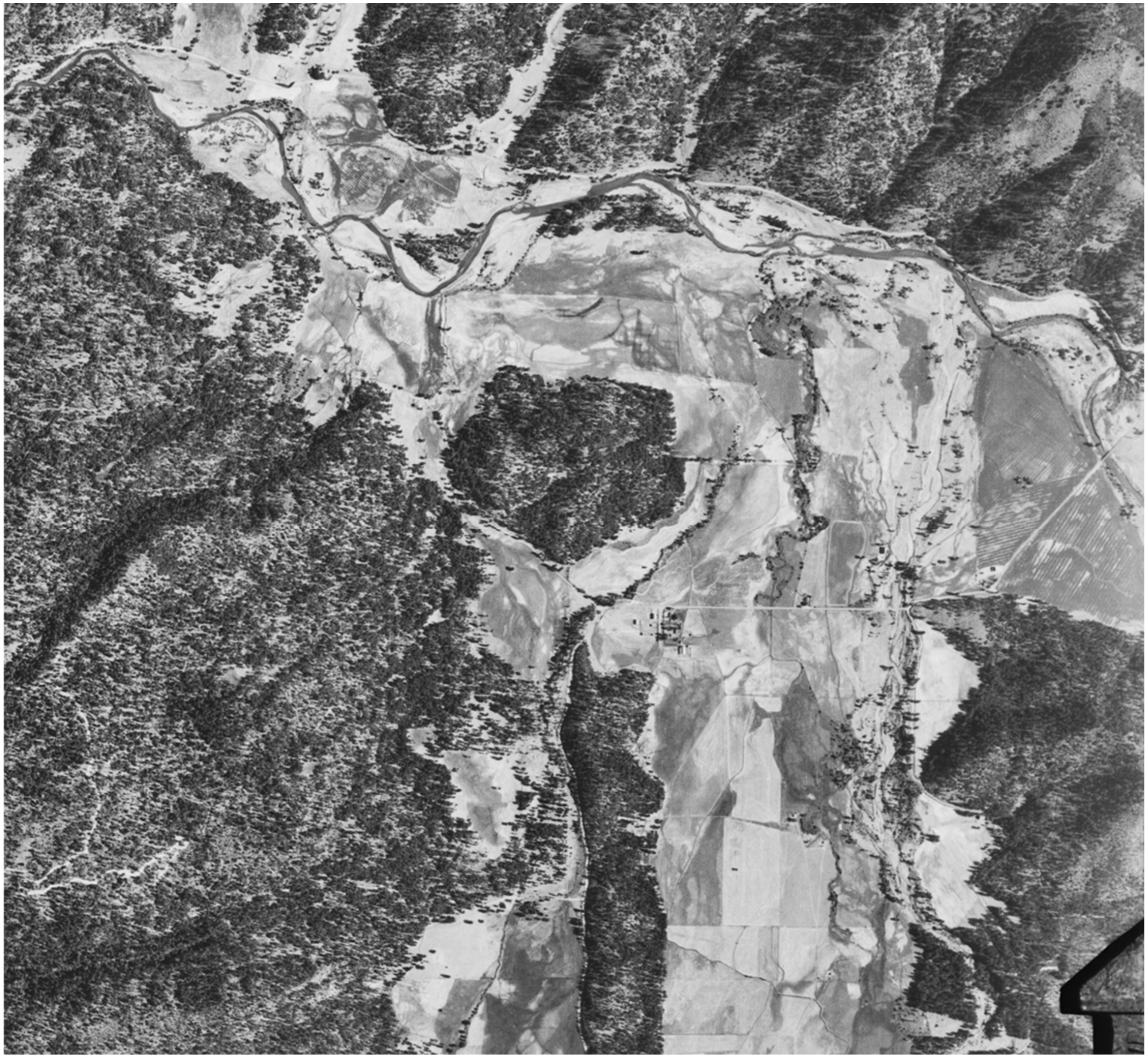
Historic Aerial Imagery and Scott River Alignment Changes

1944

Scott River - Shackleford Creek Confluence - 1944

1951

1951



1955

Scott River - Shackleford Creek Confluence - 1955

Orthoimagery - 1955 Mosaic

E. Yokel - 3/20/2025

N

0 400 800 1,600 Feet

1965

Scott River - Shackleford Creek Confluence - 1965

Orthoimagery - 1965 Mosaic

E. Yokel - 3/20/2025

N

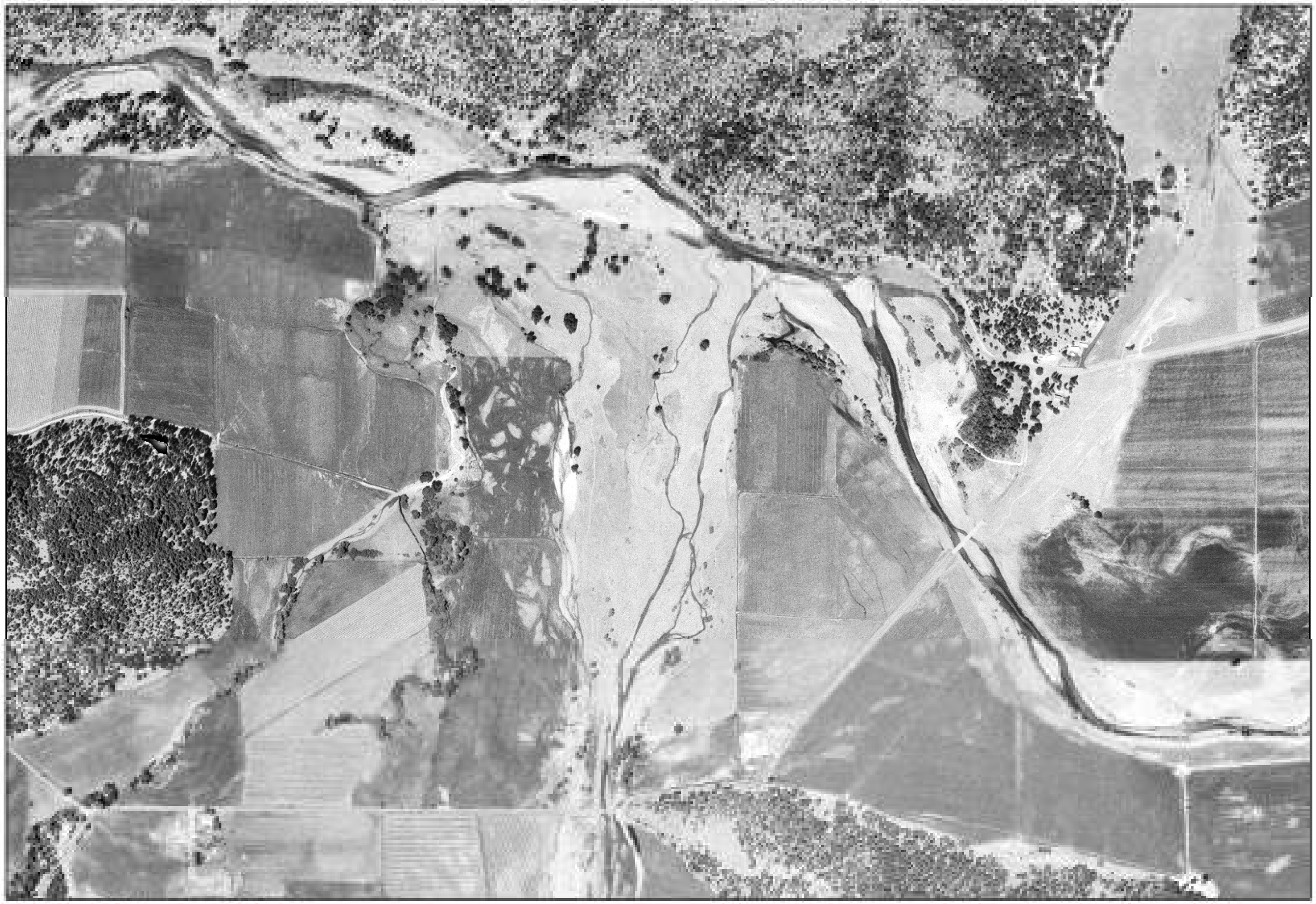
0 400 800 1,600 Feet

1973

1976

1976

Scott River - Shackleford Creek Confluence - 1976



Orthoimagery - 1976 Mosaic

E. Yokel - 3/20/2025

N

0 400 800 1,600 Feet

1980

1993

August 23,
1998

2003

June 30, 2004

2006

May 24, 2009

July 7, 2012

August 23, 2016

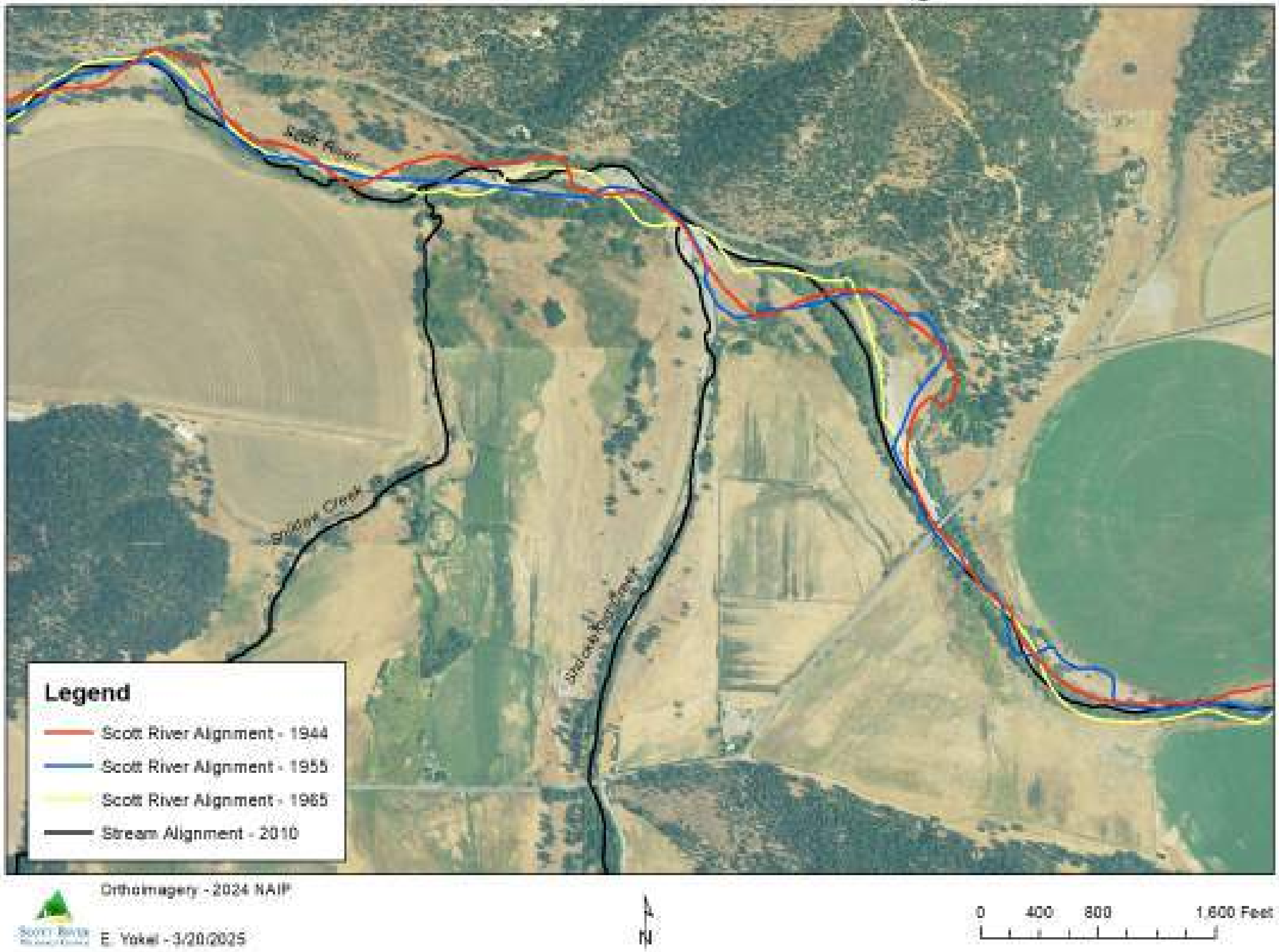
July 8, 2017

June 21, 2020

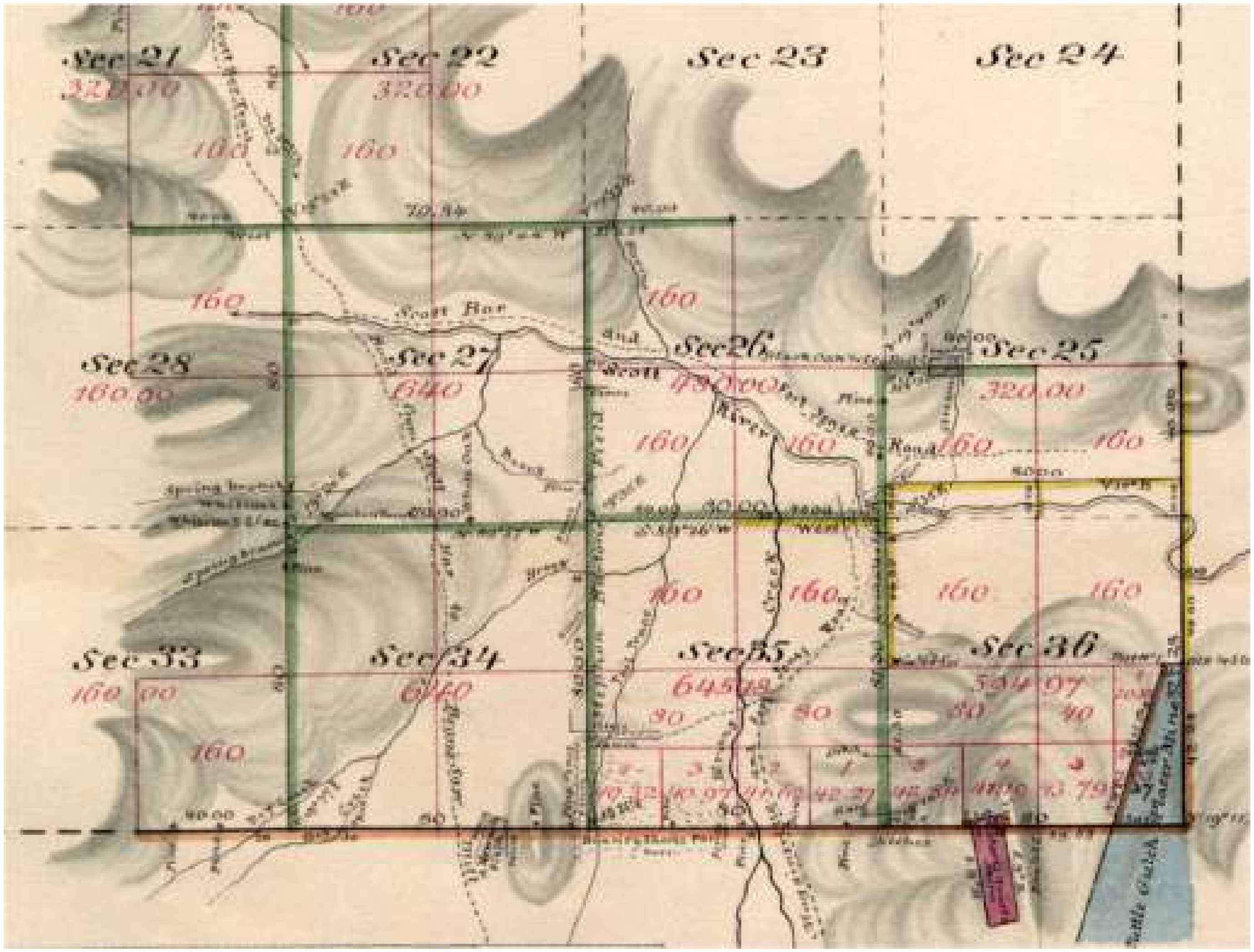
October 14, 2021

August 15, 2023

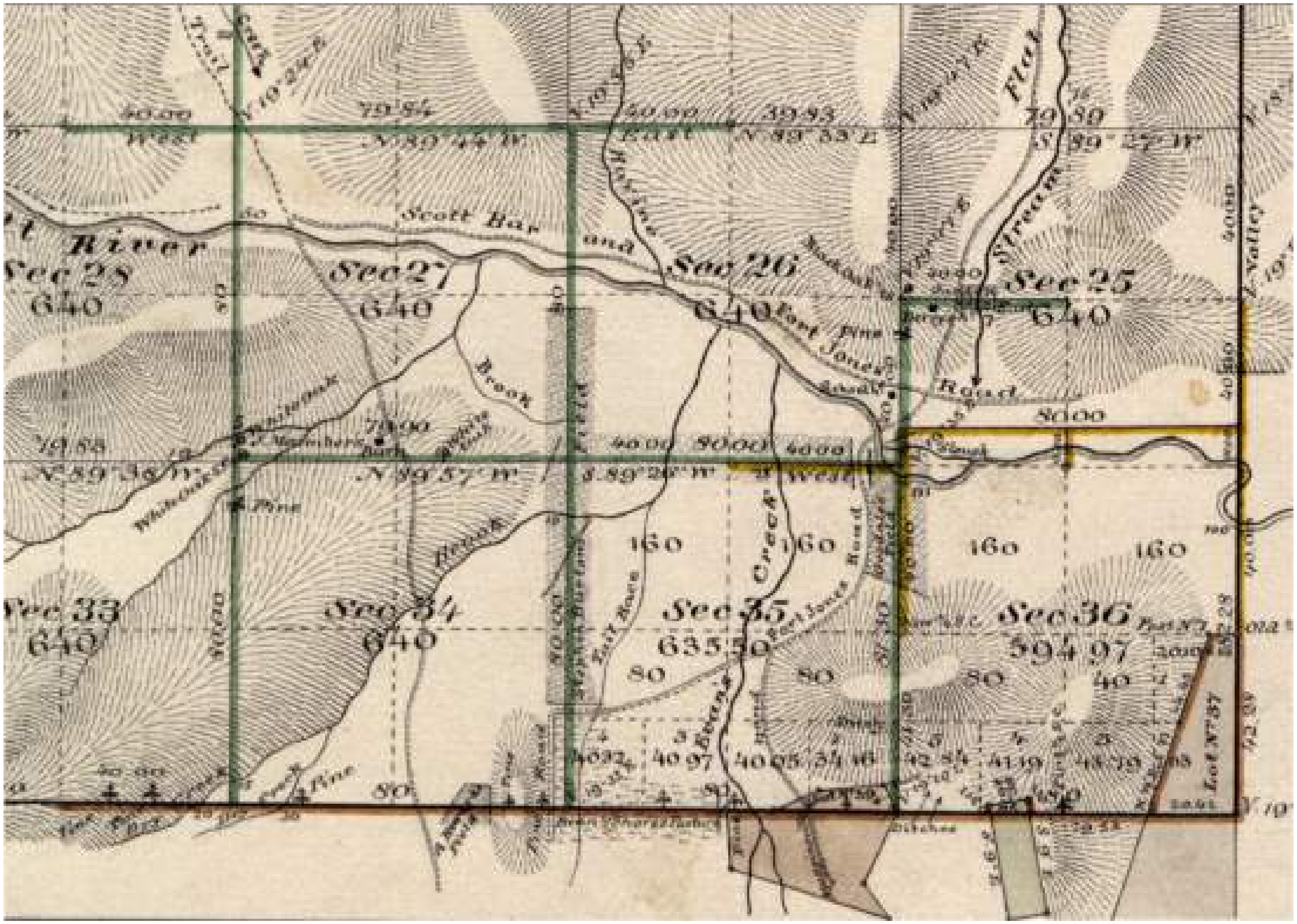
Scott River - Shackleford Creek Confluence - Scott River Alignment - 1944 - 2010



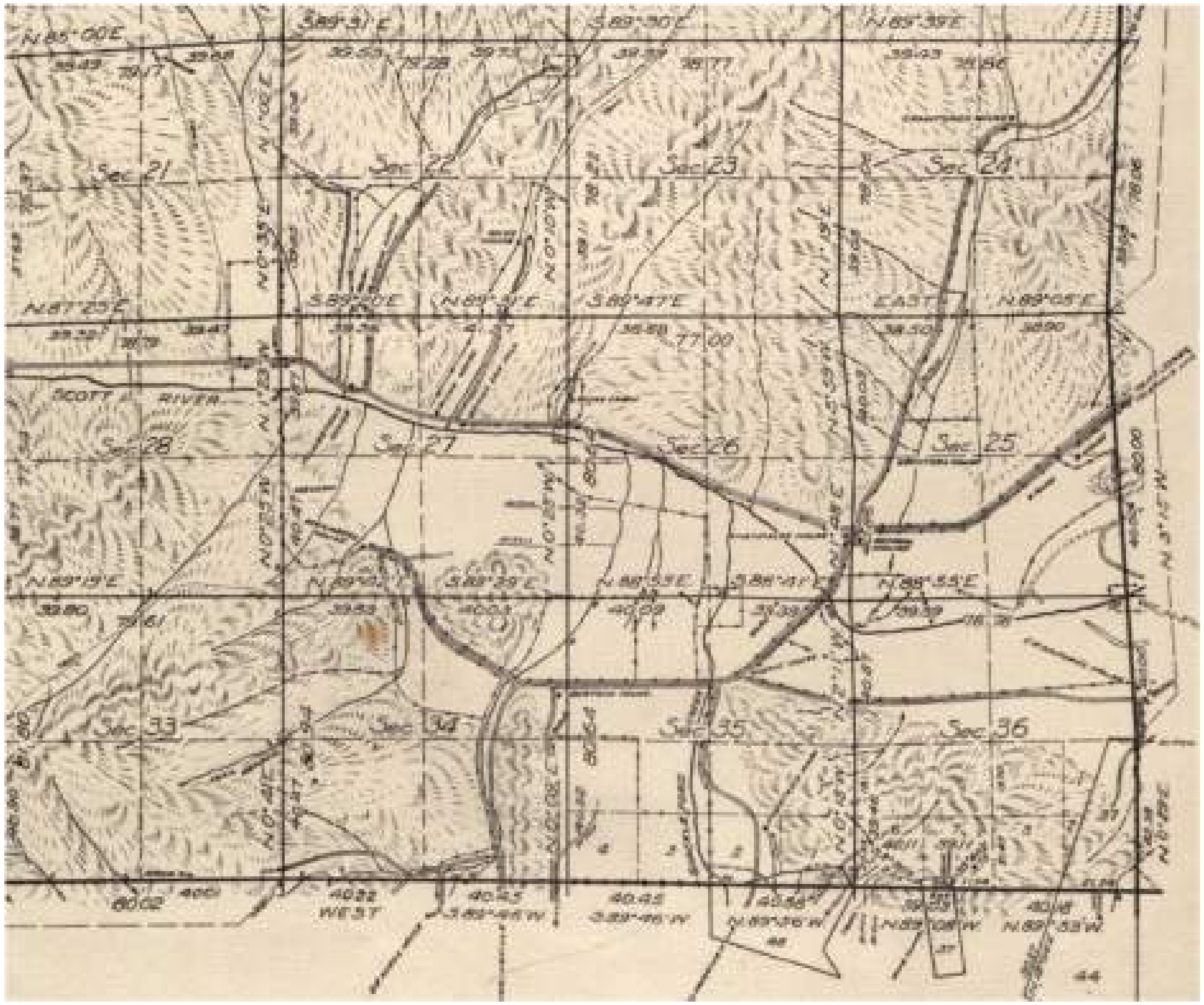
1876


Sec 21
320.00
160
Sec 22
320.00
160
Sec 23
Sec 24
160
Scott Bar
Sec 28
160.00
Sec 27
640
Sec 26
Sec 25
320.00
160
Sec 33
160.00
160
Sec 34
640
Sec 35
645.12
80
Sec 36
534.07
80
40

1883


River
Scott Bar
Sec 28
640
Sec 27
640
Sec 26
640
Sec 25
640
Sec 33
640
Sec 34
640
Sec 35
635.50
Sec 36
594.97
Lot No 37
Road
Brook
Creek
Stream
Flat
N 89°44' W
N 89°55' E
S 89°27' W
N 89°38' W
N 89°57' W
S 89°28' W
West
East

1927


Sec. 21
Sec. 22
Sec. 23
Sec. 24
Sec. 25
Sec. 26
Sec. 27
Sec. 28
Sec. 33
Sec. 34
Sec. 35
Sec. 36
SCOTT RIVER
N.87°25'E
EAST
WEST

Appendix C

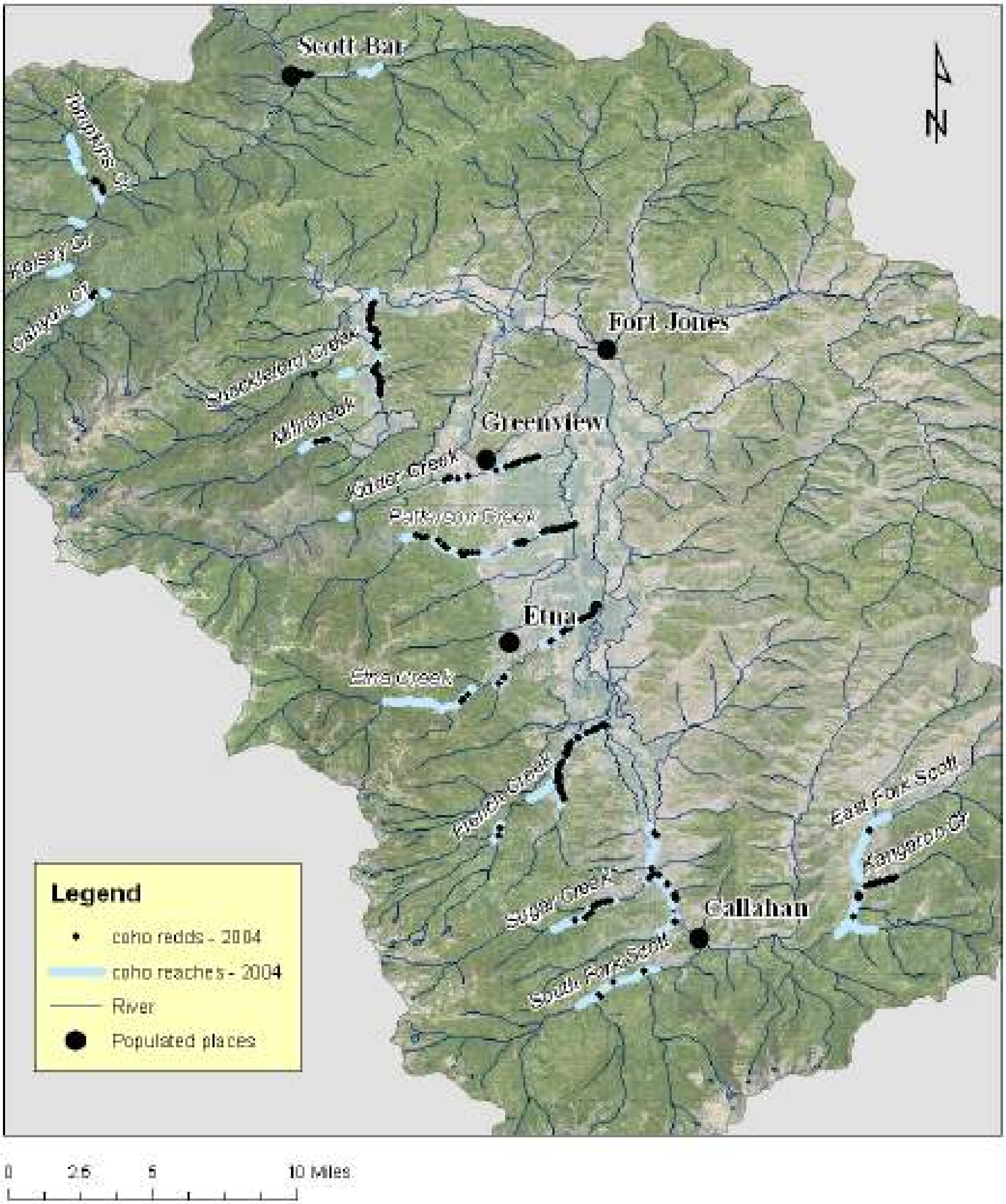
Excerpt from Scott River Habitat Mapping, May 2011

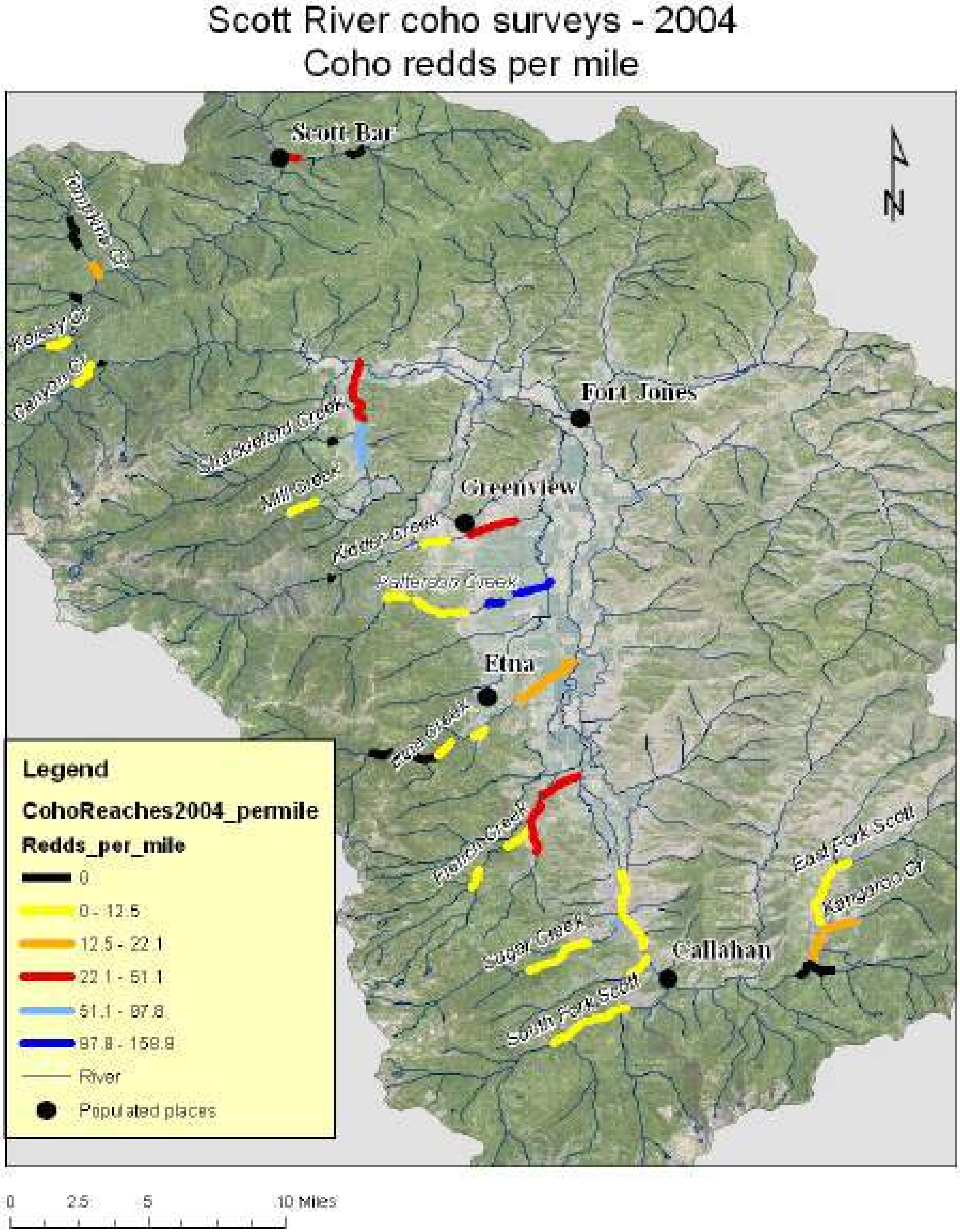
Excerpt from Scott River Habitat Mapping
Erich Yokel – Siskiyou RCD
Prepared for the United States Fish and Wildlife Service
May 2011
Spawning-

Coho spawning

Adult coho spawning ground surveys have been performed in the Scott River Watershed since the winter of 2001-2002. The coho spawning ground surveys have been performed every year up to the winter of 2010-2011 with extra emphasis paid during the strong brood (2001-2002, 2004-2005, 2007-2008 and 2010-2011). Surveys in the strong brood year indicate several reaches with consistently higher densities of adult coho spawning. Conversion of the individual redd data to densities (redds per mile) for each reach was performed in GIS.

Scott River coho surveys - 2004
Coho redds



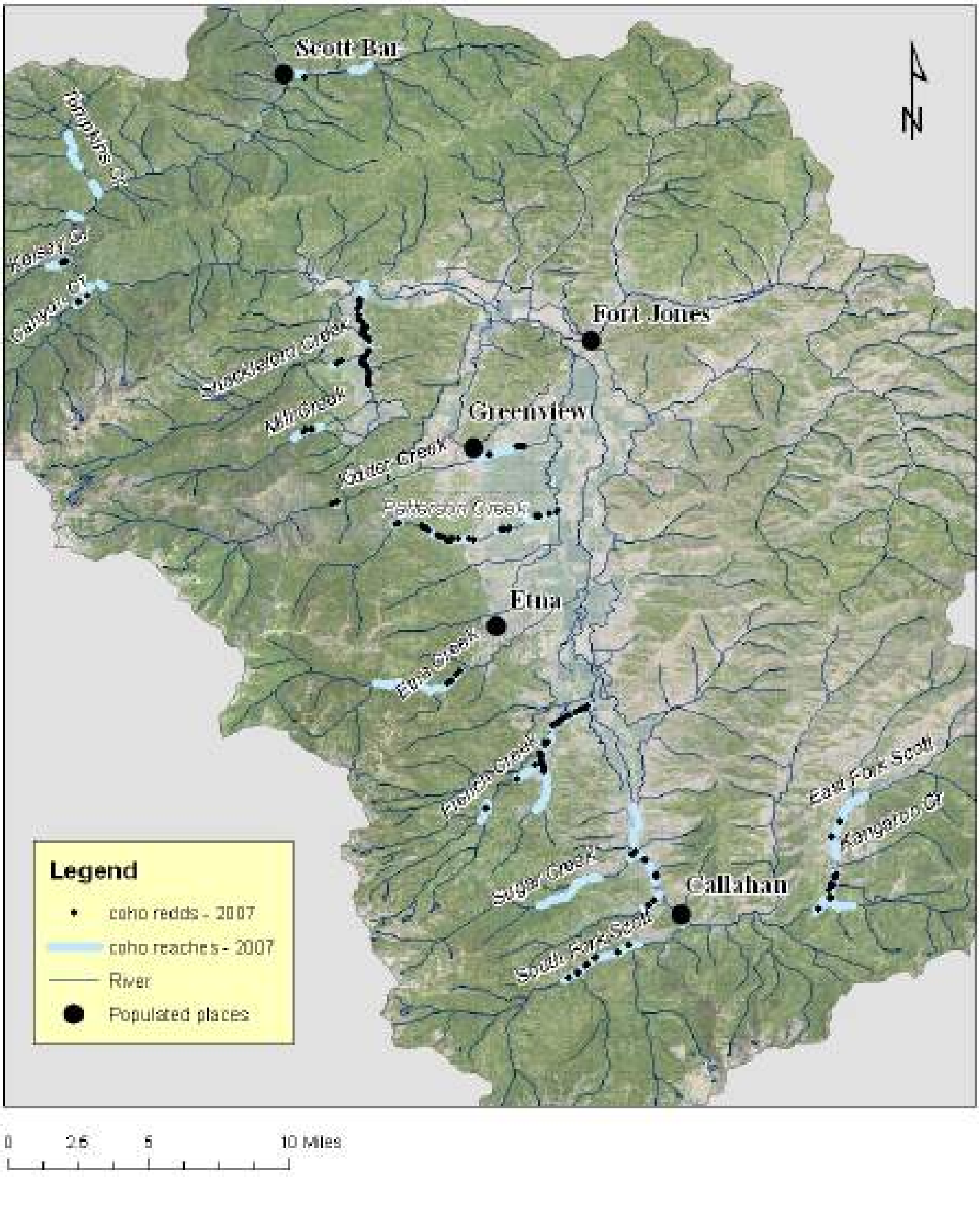


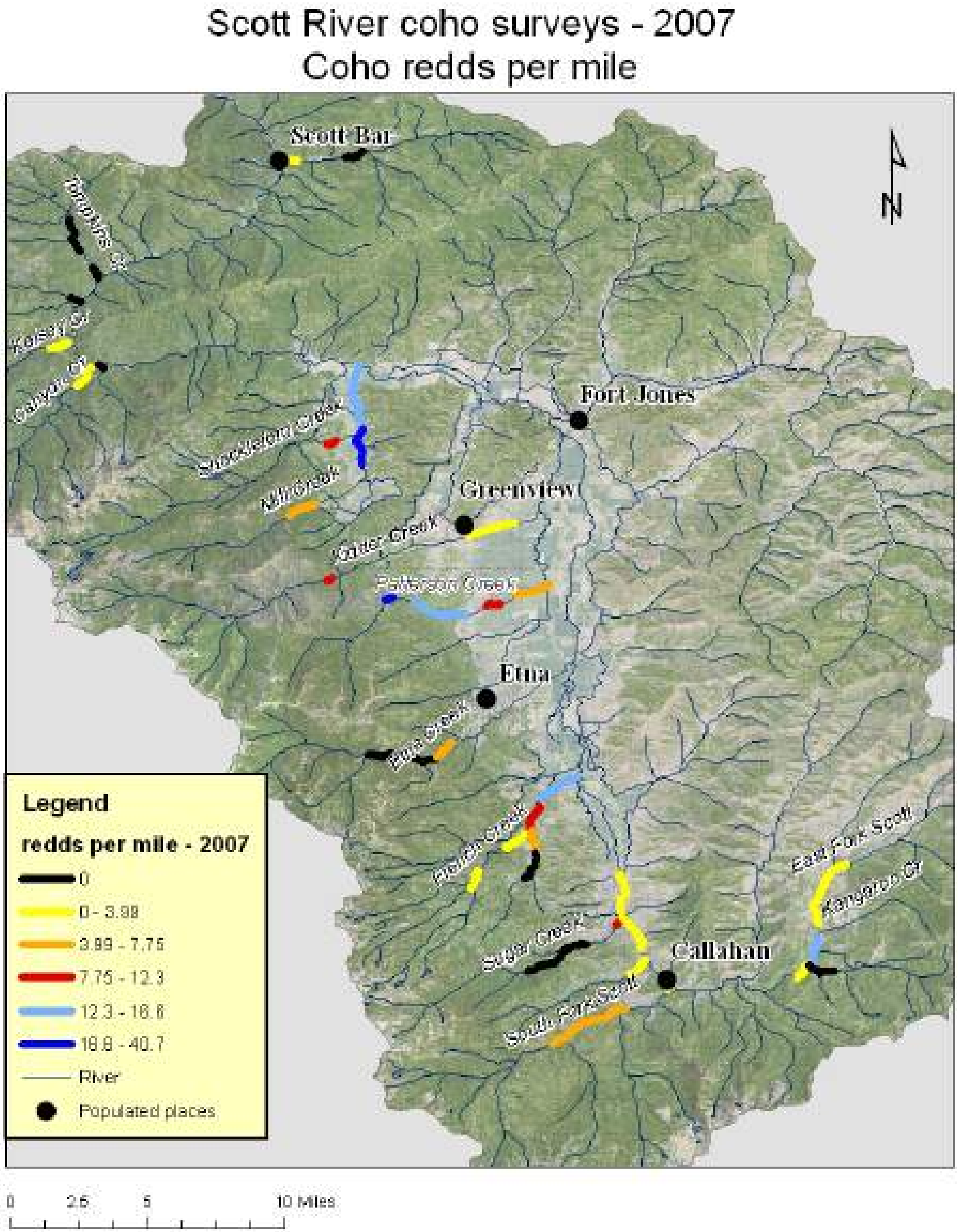
Map – coho redds per mile – 2004

Coho redds per mile - 2004 - 05

Reach	Length (mi.)	# Redds	Redds/mile
Upper Mill Creek (Scott Bar Mill)	0.7	0	0.0
Upper Thompkins Creek	1.0	0	0.0
Middle Creek	0.4	0	0.0
Boulder Creek	0.2	0	0.0
Middle Etna (above Etna Diversion)	1.6	0	0.0
East Fork - below Grouse Creek	0.6	0	0.0
Upper Kidder Creek	0.5	0	0.0
Grouse Creek	0.6	0	0.0
East Fork - below Rail	5.1	1	0.2
Wildcat Creek	2.0	1	0.5
Upper French Creek - N. Fork to Miners	1.0	1	1.0
Kelsey Creek	0.6	1	1.7
Canyon Creek	1.1	2	1.8
Upper French Creek - Horse Range Cr	0.5	2	4.0
Lower Thompkins Creek	1.8	8	4.4
Middle Etna	1.0	7	7.0
Scott River - Tailings	2.8	21	7.6
South Fork	1.9	15	7.9
Upper Mill Creek (Shackleford)	0.5	5	10.0
Middle Patterson	1.6	19	11.9
Mid Sugar Creek	2.1	26	12.4
Upper Patterson	0.3	6	20.0
East Fork - above Grouse Creek	1.1	23	20.0
Lower Etna Creek	2.3	50	22.2
Lower French Creek	0.6	20	28.6
Mid French Creek	1.6	49	30.1
Shackleford Creek	2.2	76	34.5
Lower Mill Creek (Scott Bar Mill)	0.4	15	37.5
Miners Creek	0.9	43	47.8
Lower Kidder Creek	1.1	56	50.9
Lower Sugar Creek	0.3	26	86.7
Lower Mill Creek (Shackleford)	1.4	127	90.7
Lower Patterson	1.3	232	178.5

Scott River coho surveys - 2007
Coho redds



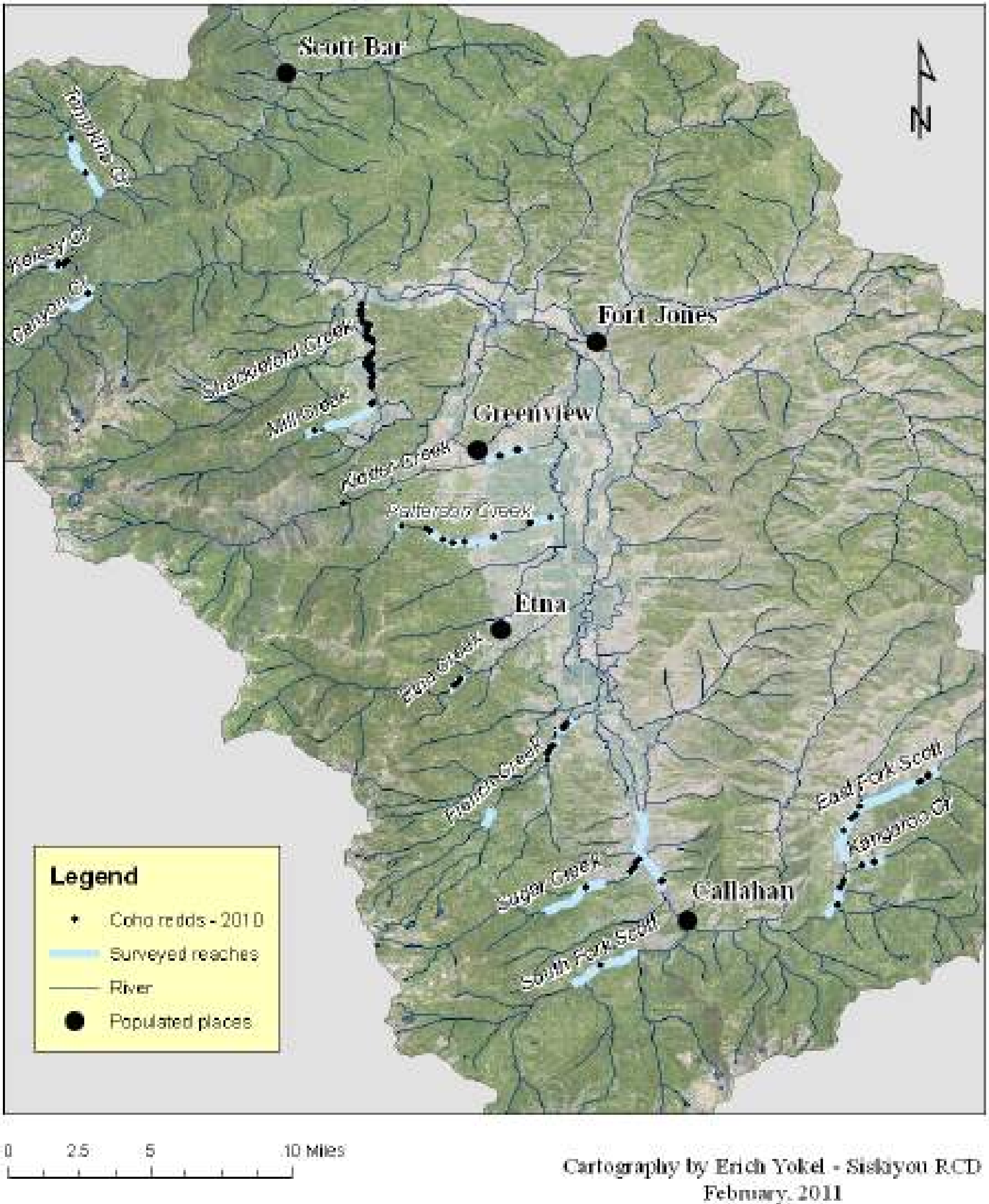


Map – coho redds per mile – 2007

Coho redds per mile - 2007 - 08

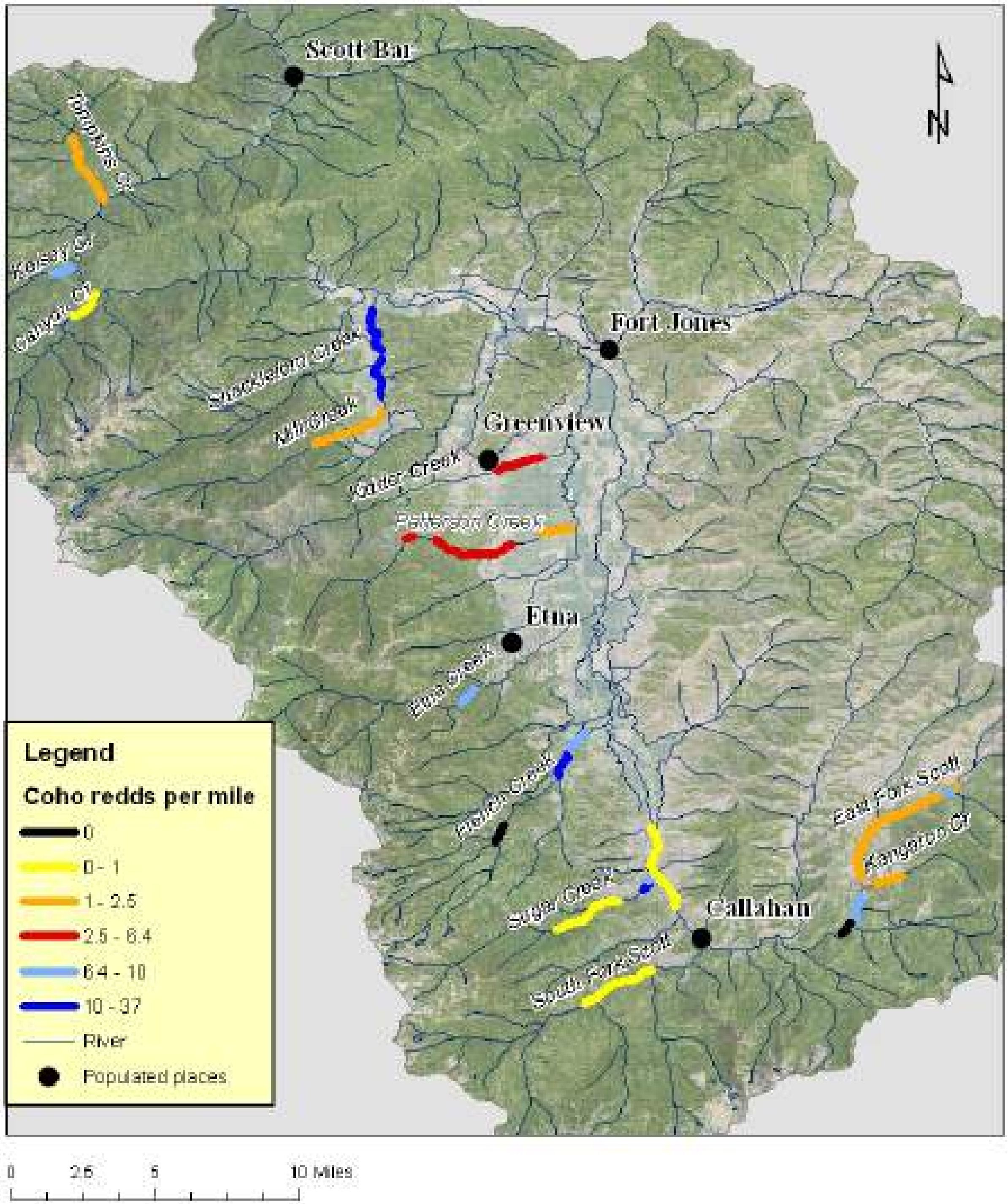
Reach	Length (mi.)	# Redds	Redds/mile
Upper Mill Creek (Scott Bar Mill)	0.6	0	0.0
Upper Thompkins Creek	1.3	0	0.0
Lower Thompkins Creek	0.5	0	0.0
Middle Creek	0.3	0	0.0
Boulder Creek	0.2	0	0.0
Middle Etna (above Etna Diversion)	2.2	0	0.0
Middle Miners Creek	1.1	0	0.0
Middle Sugar Creek	2.1	0	0.0
Grouse Creek	0.9	0	0.0
East Fork below Rail Cr.	2.6	2	0.8
Upper French Cr. - Horse Range Cr.	0.7	1	1.5
East Fork below Grouse Cr.	0.6	1	1.6
Canyon Creek	0.9	2	2.3
Lower South Fork Scott River	0.4	1	2.6
Scott River - Tailings	3.1	8	2.6
Upper French Creek - N. Fork to Miners	1.0	3	2.9
Lower Mill Creek (Scott Bar Mill)	0.3	1	3.1
Kelsey Creek	0.6	2	3.2
Lower Kidder Creek	1.3	5	3.7
Wildcat Creek	0.8	3	4.0
Upper Mill Creek (Shackleford)	0.9	4	4.6
Lower Patterson	1.1	5	4.7
South Fork Scott River	2.5	16	6.3
Middle Etna (below Etna Diversion)	0.7	5	7.5
Lower Miners Creek	0.9	7	7.8
Shackleford Creek	0.3	3	10.0
Upper Kidder Creek	0.2	2	10.3
Mid French Creek	1.0	10	10.4
Lower Sugar Creek	0.3	3	11.3
Lower Patterson Creek	0.4	5	12.3
Lower French Creek	0.6	9	13.8
East Fork above Grouse Creek	1.1	16	14.2
Mid French Creek	0.6	10	15.6
Middle Patterson Creek	1.7	27	15.7
Shackleford Creek	2.3	39	16.6
Upper Patterson Creek	0.3	9	30.2
Lower Mill Creek (Shackleford)	1.4	57	40.7

Scott River coho surveys - 2010
Coho redds



Cartography by Erich Yokel - Siskiyou RCD
February, 2011

Scott River coho surveys - 2010
Coho redds per mile



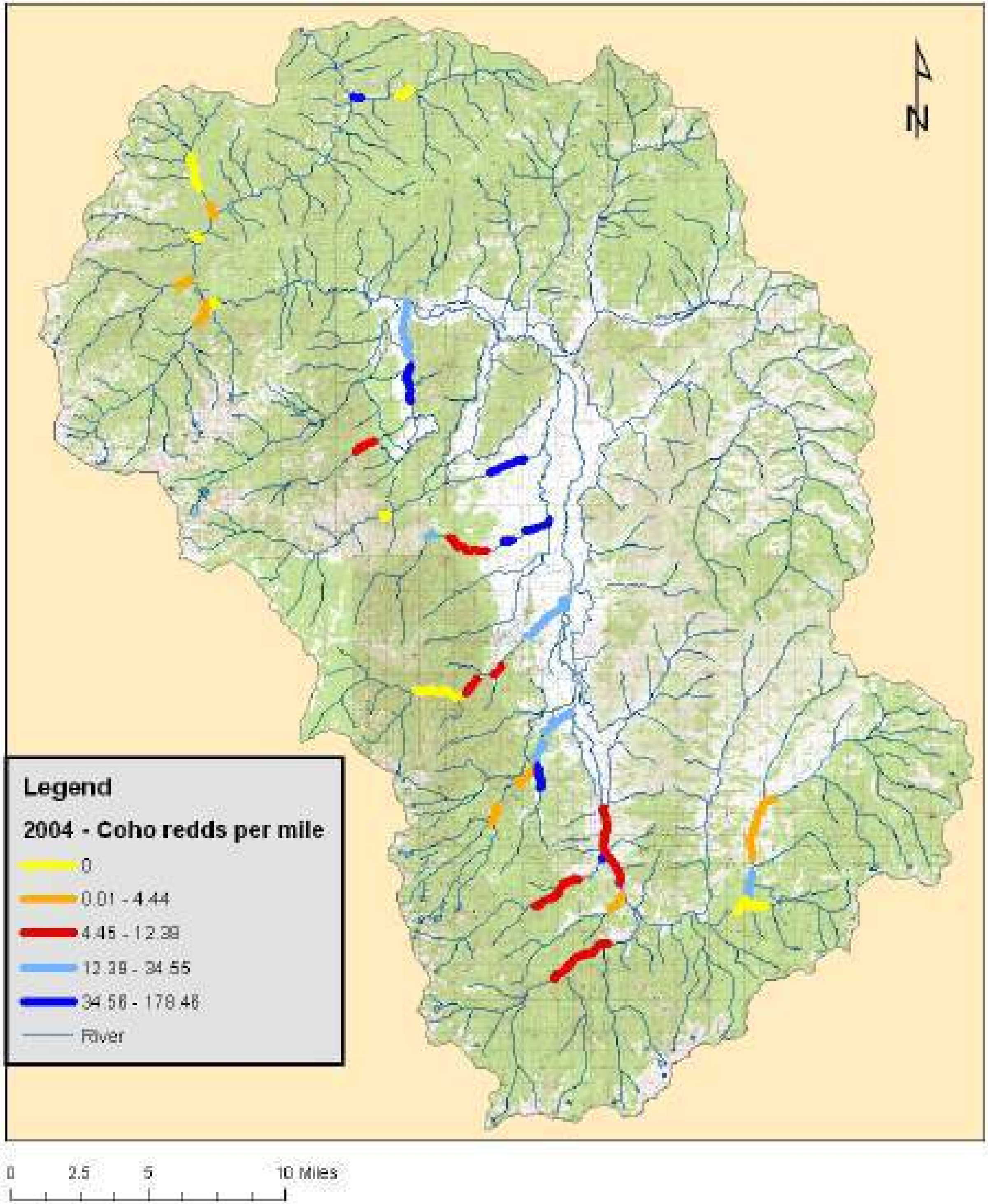
Map – coho redds per mile – 2010

Coho redds per mile - 2010 - 11

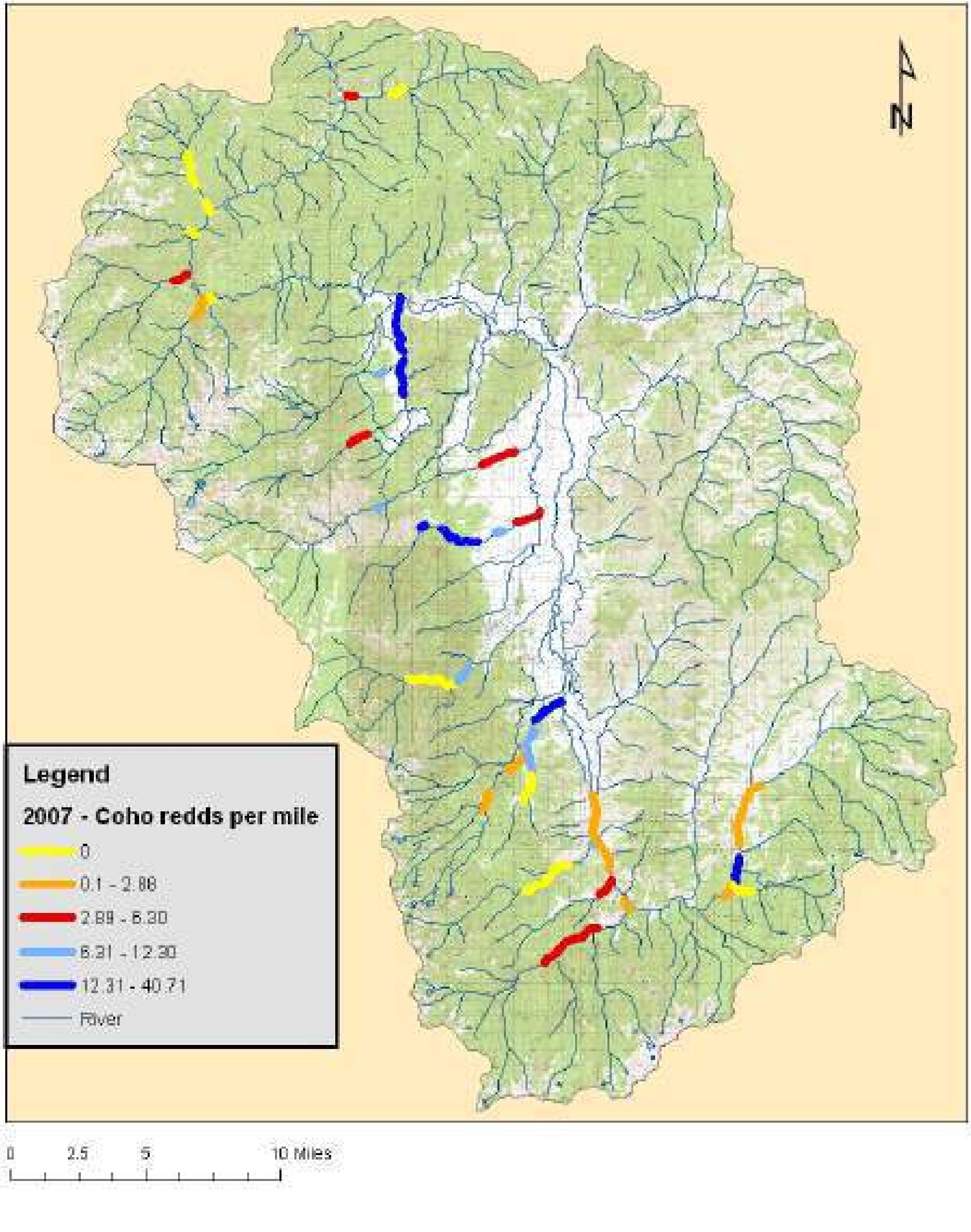
Reach	Distance (mi.)	# Redds	Redds/Mile
East Fork Scott River - below Grouse Cr.	0.5	0	0
Upper French Cr. - Horse Range Cr.	0.7	0	0.0
Upper Kidder Creek	Spot	1	NA
Middle Sugar Creek	2.1	1	0.5
South Fork Scott River	2.2	1	0.5
Canyon Creek	1.1	1	0.9
Scott River - Tailings	3.1	3	1.0
Tompkins Creek	2.6	3	1.2
East Fork Scott River - below Rail Cr.	4.8	8	1.7
Upper Middle Mill Cr.	1.7	4	2.4
Lower Patterson Creek	0.8	2	2.5
Kangaroo Creek	0.8	2	2.5
Upper Mill Creek	0.4	1	2.5
Middle Patterson	0.7	2	2.9
Lower Kidder Creek	1.3	4	3.1
Upper Patterson Creek	0.3	1	3.3
Middle Patterson	1.7	6	3.5
East Fork - above Grouse	1.1	7	6.4
Middle Etna Cr - below Etna diversion	0.6	4	6.7
Kelsey Creek	0.6	5	8.3
Middle French Creek	0.6	6	10.0
Lower Sugar Creek - below HWY3	0.3	3	10.0
Rail Creek	0.2	2	10.0
Middle French Creek	0.8	10	12.5
Lower Sugar Creek - above HWY3	0.3	5	16.7
Shackleford Creek	1.6	32	20.0
Loweer Mill Creek	1.4	52	37.1

Table – Coho redds 2010

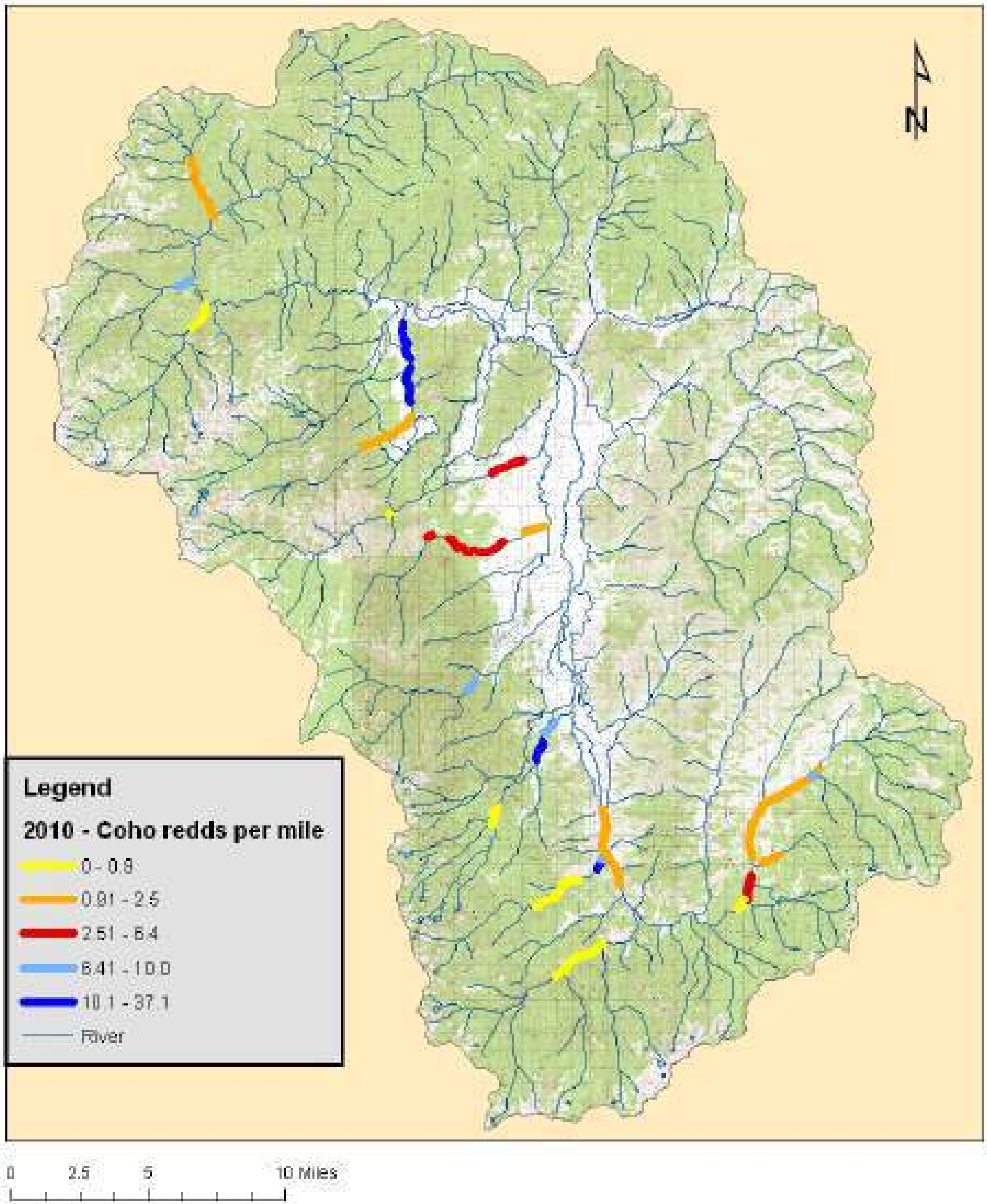
Scott River coho redds per mile - 2004
quantile classification



Scott River coho redds per mile - 2007
quantile classification



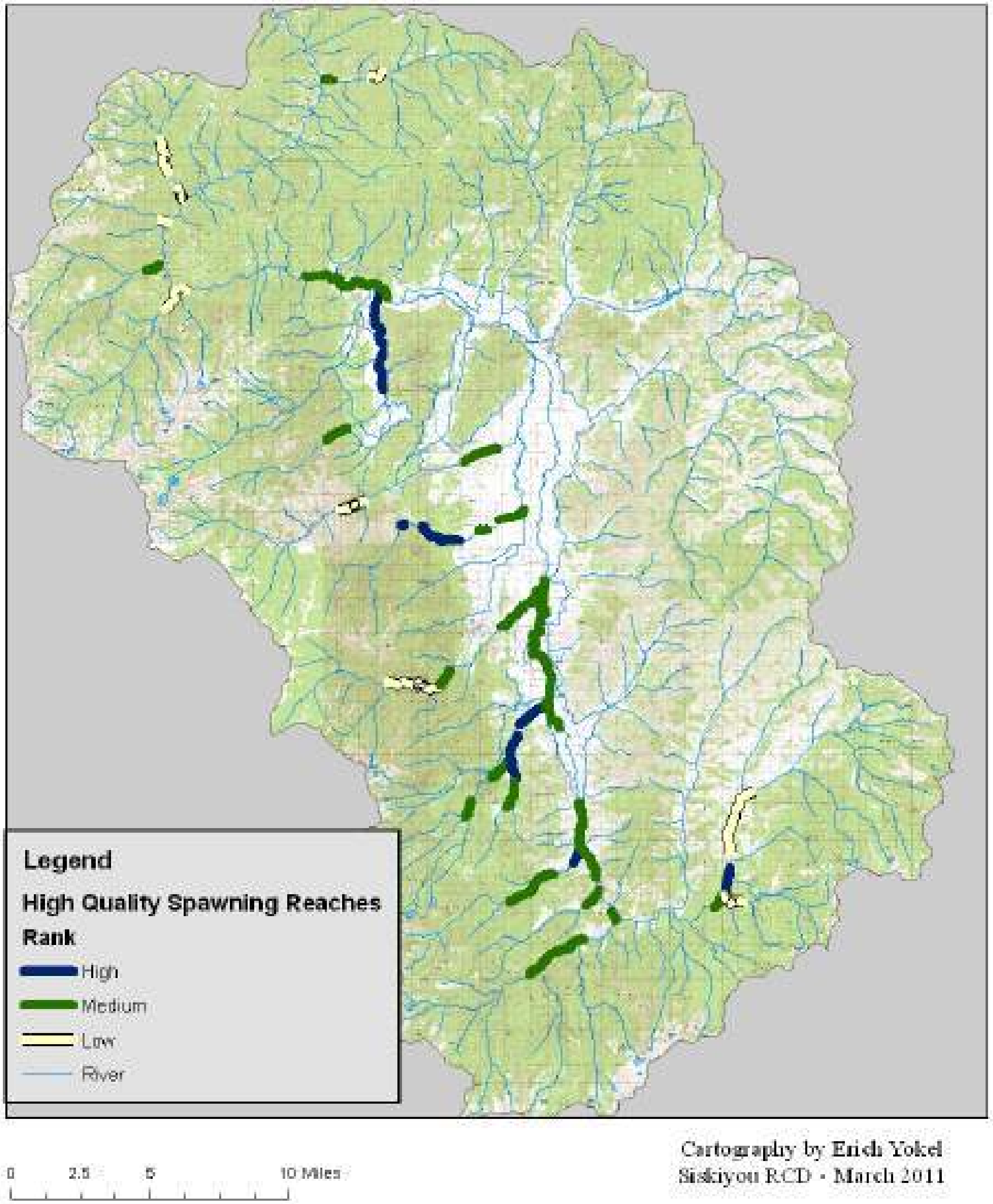
Scott River coho redds per mile - 2010
quantile classification



	2004	2007	2010
5th Quintile	**Lower Mill Creek (Shackleford)**	**Lower Mill Creek (Shackleford)**	**Lower Mill Creek (Shackleford)**
	Lower Miners Creek	**Shackleford-Mill Creek**	**Shackleford-Mill Creek**
	Lower Sugar Creek	**Mid French Creek**	**Mid French Creek**
	Lower Patterson Creek	**East Fork above Grouse Creek**	**Lower Sugar Creek**
	Lower Kidder Creek	**Lower French Creek**	
	Lower Mill Creek (Scott Bar)	Upper Patterson Creek	
		Mid Patterson Creek	

	2004	2007	2010
4th Quintile	**Shackleford-Mill Creek**	**Mid French Creek**	**Mid French Creek**
	Mid French Creek	**Lower Sugar Creek**	**Lower Sugar Creek**
	East Fork above Grouse Creek	**Lower Miners Creek**	**East Fork above Grouse Creek**
	Lower French Creek	Shackleford Creek	Lower Kelsey Creek
	Upper Patterson Creek	Lower Patterson Creek	Etna Creek below Diversion Dam
	Lower Etna Creek	Etna Creek below Diversion Dam	

Scott River Watershed - High Quality Spawning Habitat



Cartography by Erich Yokel
Siskiyou RCD - March 2011

Appendix D

Sediment Transport Incipient Motion Analysis

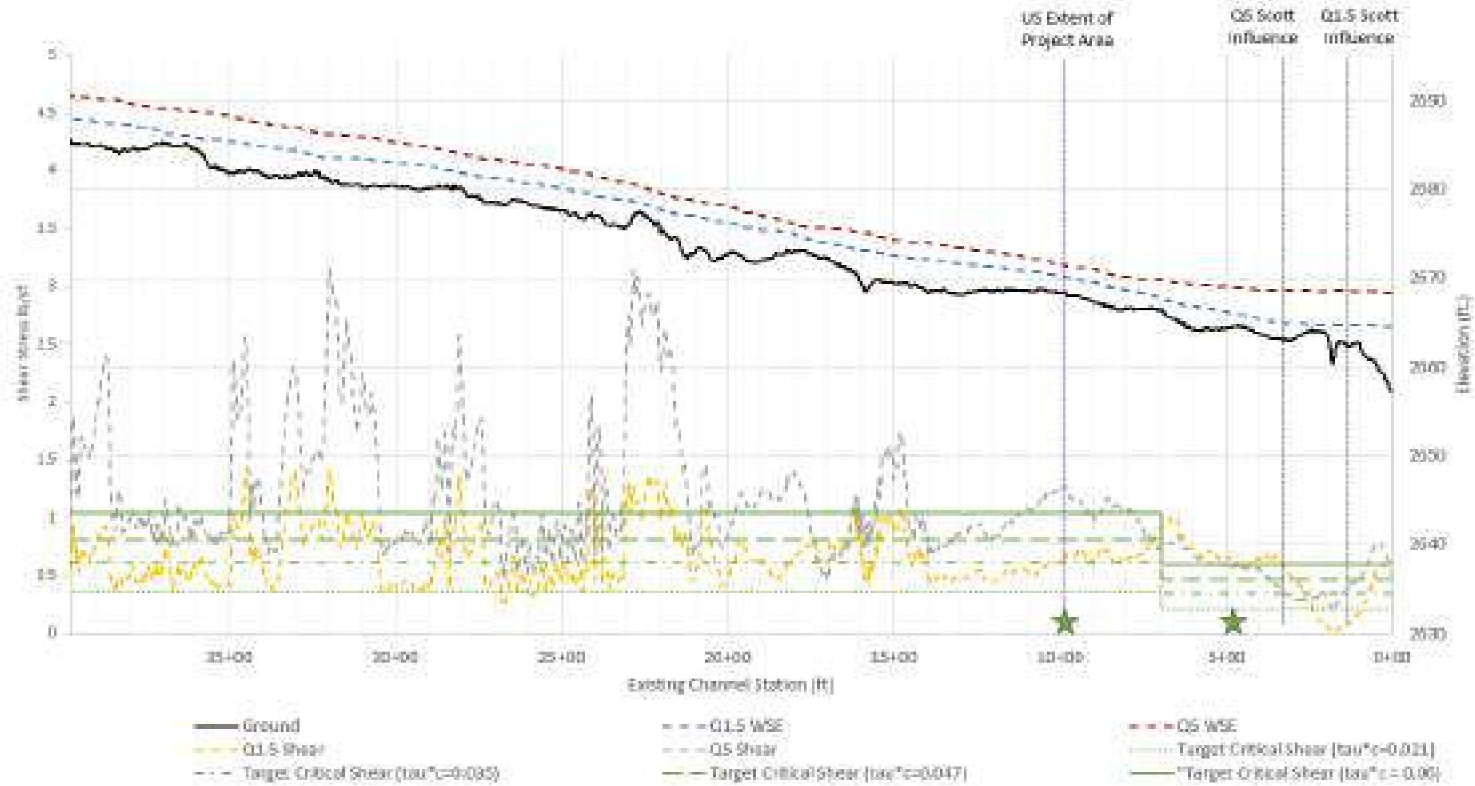


Figure D1. Shackleford Creek EC incipient motion analysis results for the Q1.5 and Q5 peak flow events showing thalweg elevation, water-surface elevations, shear stress results, and calculated critical shear stress thresholds. The green stars indicate approximate locations of pebble count surveys.

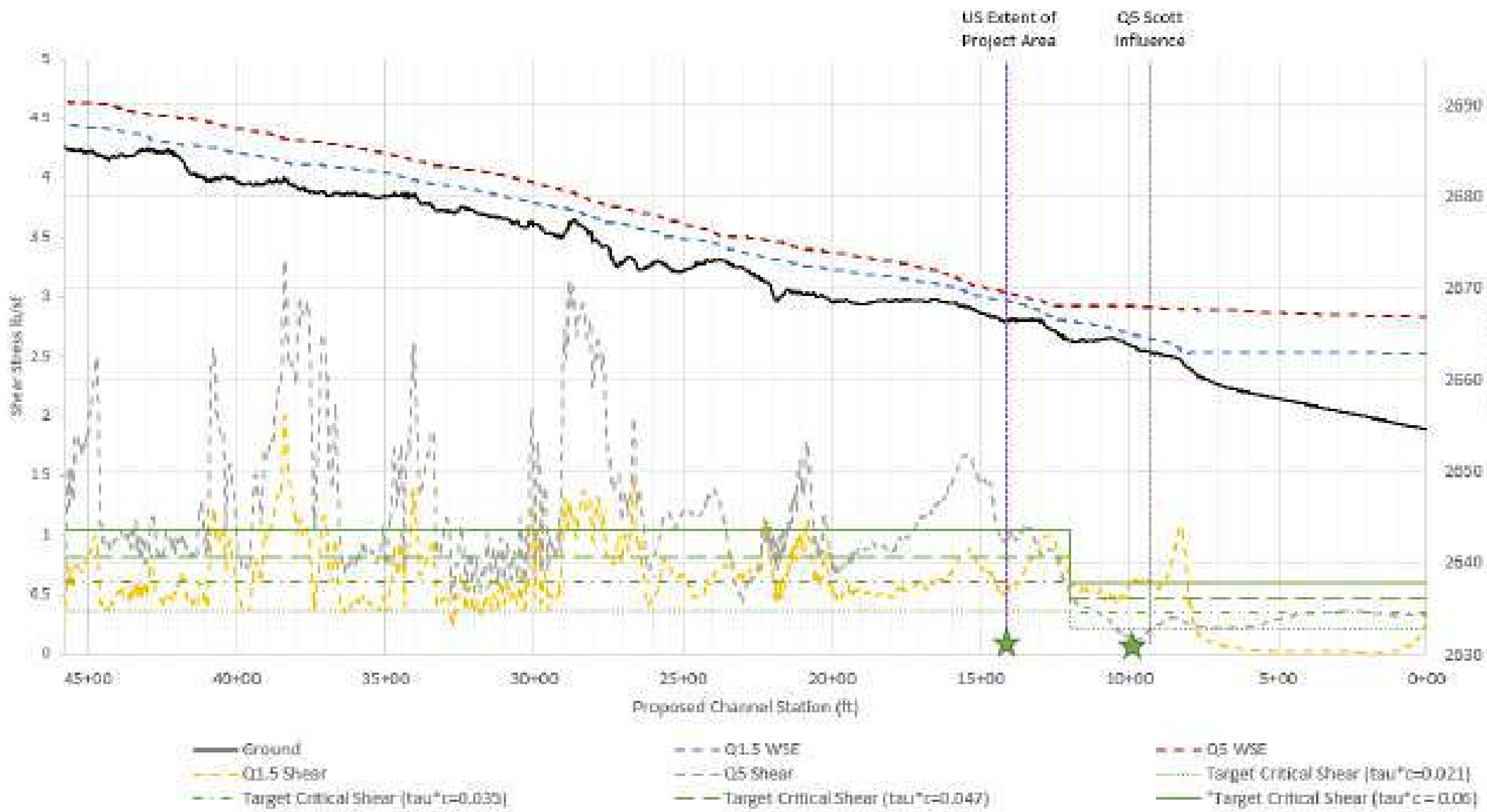


Figure D2. Shackleford Creek PC incipient motion analysis results for the Q1.5 and Q5 peak flow events showing thalweg elevation, water-surface elevations, shear stress results, and calculated critical shear stress thresholds. The green stars indicate approximate locations of pebble count surveys.

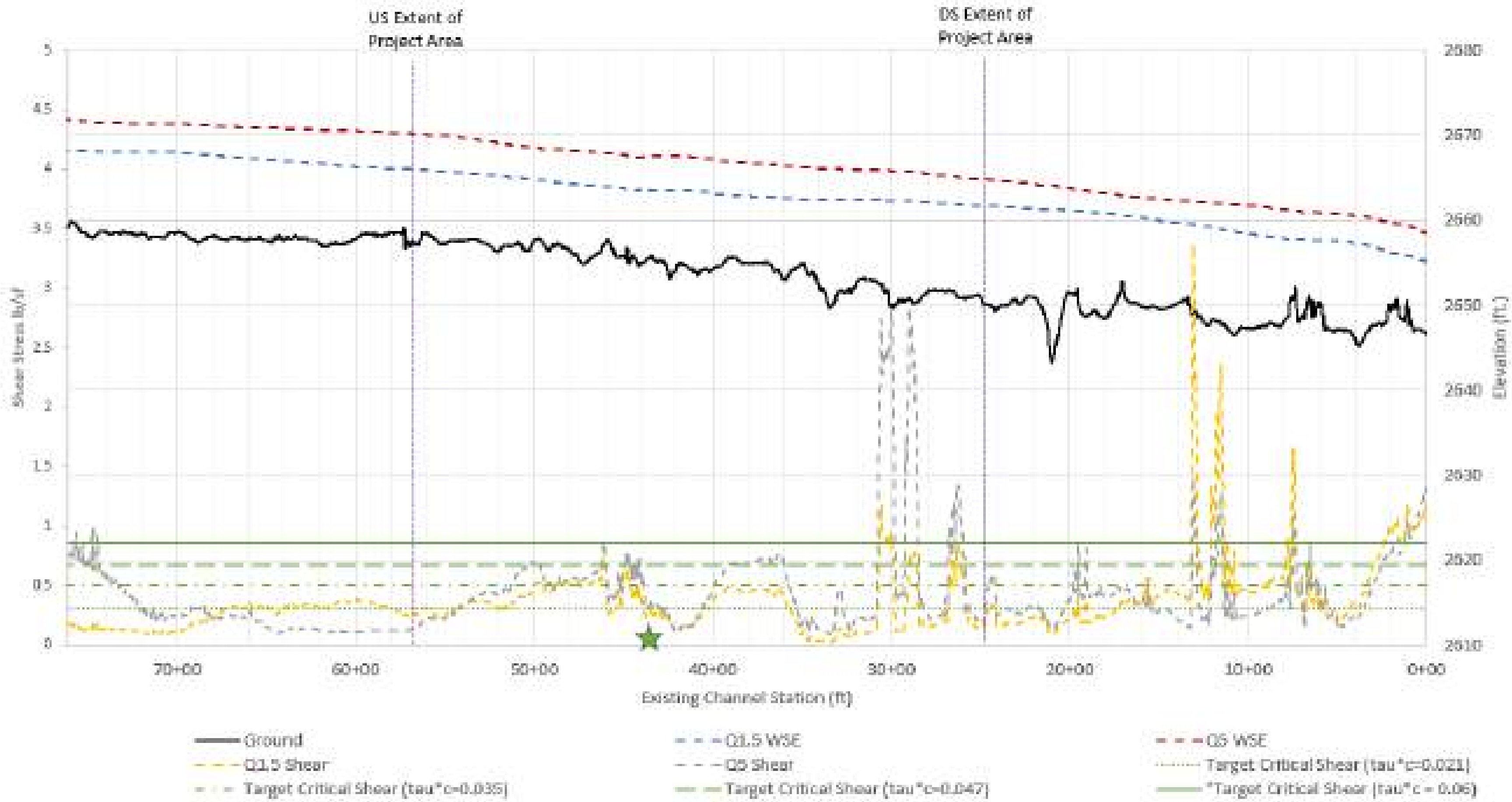


Figure D-3. Scott River EC incipient motion analysis results for the Q1.5 and Q5 peak flow events showing thalweg elevation, water-surface elevations, shear stress results, and calculated critical shear stress thresholds. The green stars indicate approximate locations of pebble count surveys.

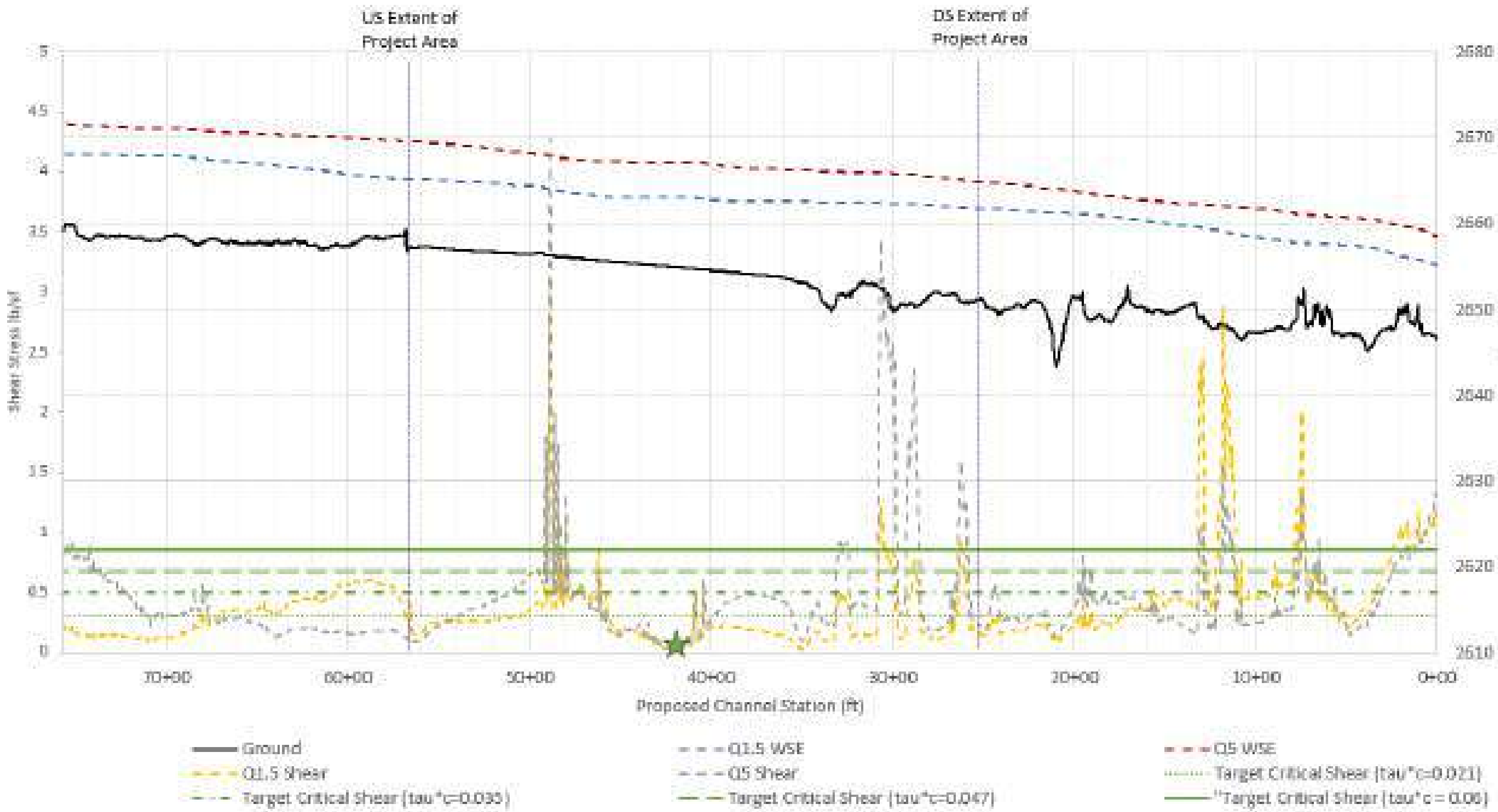


Figure D-4. Scott River PC incipient motion analysis results for the Q1.5 and Q5 peak flow events showing thalweg elevation, water-surface elevations, shear stress results, and calculated critical shear stress thresholds. The green stars indicate approximate locations of pebble count surveys.