Attachment D

Geomorphology

ESA Geomorphic Conditions 2021-04

Final

GEOMORPHIC CONDITIONS UPDATE AND BASIS OF DESIGN FOR LITTLE SYCAMORE CREEK, CAMP HESS KRAMER

Prepared for
Wilshire Boulevard Temple Camps and Stantec

April 2021

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1. Background

Camp Hess Kramer is a recreational camp with overnight accommodations that has been owned and managed by the Wilshire Boulevard Temple (WBT) since the 1950s, located in the Santa Monica Mountains in Ventura County, 11 miles west of Malibu, CA. The lower and middle camps were constructed on the valley floor and side slopes of Little Sycamore Canyon, which drains a 4.8 square mile watershed to the Pacific Ocean via a culvert underneath Highway 1. In November 2018 the Woolsey Fire burned much of the Camp and the creek's watershed. When seasonal rains started in the weeks following the fire, the site experienced destructive flooding in the mainstem and a tributary on the east side of the creek, as well a landslide from Yerba Buena Road, debris flows from the valley sides, and channel erosion. Sediment from these processes deposited in the channel, completely blocking several bridge openings and causing flooding throughout parts of the lower camp. The Camp arranged an emergency response and performed work under emergency permits (Ventura County # PL19-0005 and USACE #SPL-2019-00052-GLH) which included removal of 14,000 cubic yards (approximately) of sediment and debris from the creek channel, as well as actions to temporarily stabilize the creek and reduce the vulnerability of the Camp to further flows, erosion and deposition.

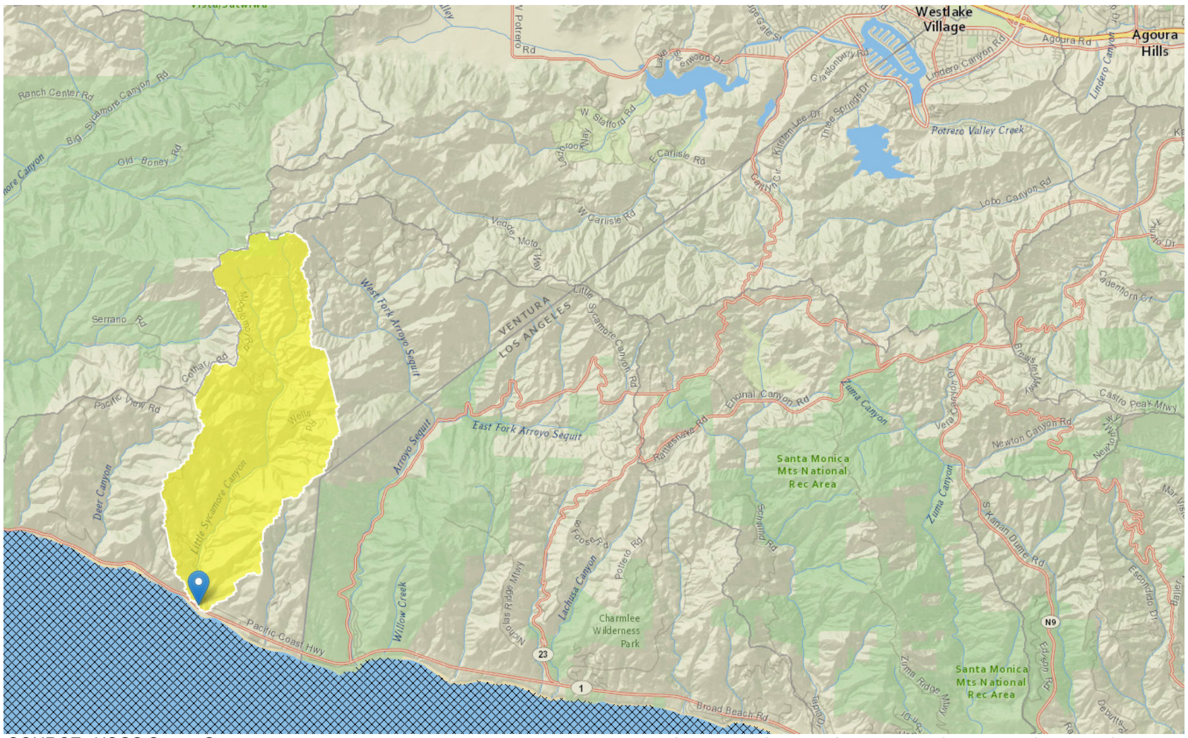
Following the fire and flood WBT undertook a planning process to rebuild the camp, including restoration and stabilization of Little Sycamore Creek. ESA was hired as part of a design and civil engineering team consisting of Stantec, Siegel and Strain Architects and Studio MLA landscape architects to design and integrate creek stabilization and enhancement elements into the site planning. This report serves two purposes: to document geomorphic changes at the site over the last few decades and to provide the geomorphic basis of design for the creek enhancement and stabilization measures proposed on the accompanying plans, Creek Restoration Plans dated April 2021. This report is part of a submittal package to the County of Ventura for environmental review and entitlements for the rebuild of Camp Hess Kramer and Gindling Hilltop Camp.

The current planning and design effort builds on previous work by ESA PWA (now ESA) to assess creek conditions and develop restoration concepts in 2012.

2. Geomorphic Setting

Little Sycamore Canyon drains a 4.8 square mile watershed in the Santa Monica Mountains, including a 0.3 square mile subwatershed that joins the creek near the Camp's downstream end (see Figure 1). The watershed is steep (maximum elevation of 2,955 feet with the outlet four miles away at sea level) and formed mostly in sedimentary rocks from the Topanga Formations, with parts of the upper watershed above the Camp being in the Conejo Volcanics and Diabase Intrusions. The watershed is mostly undeveloped (87% undeveloped, and approximately 0.7% impervious) with a mixture of chaparral and forest cover. Mean annual rainfall is 19.9 inches and typical of a Mediterranean climate falls mostly between November and May, leaving a hot, dry summer.

The watershed has a long history of fire: between 1925 and 2010 it experienced fires on average every 13-28 years (Figure 2; National Parks Service, 2020). Owing to its steepness, the underlying geology, and the fire frequency, the watershed is highly susceptible to debris flow and landslides. The United States Geological Service (USGS, 2003) maps most of the west side of Little Sycamore Canyon as having medium soil slip susceptibility with some areas of high susceptibility (Figure 2). The eastern side of the canyon is mostly classified as low susceptibility with some medium areas.



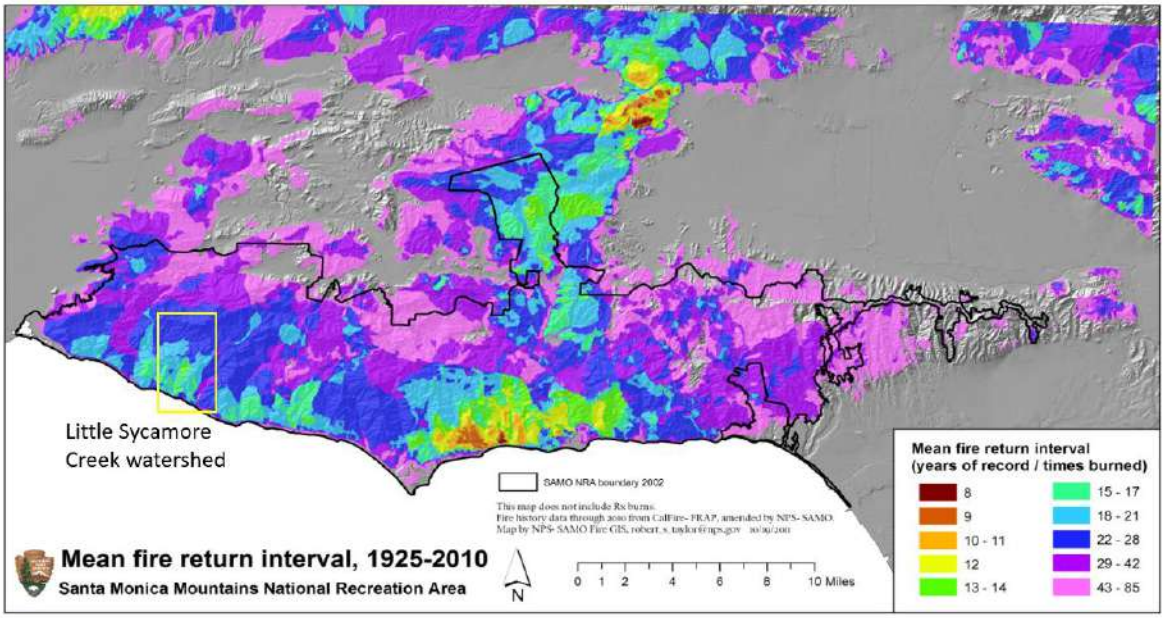
SOURCE: USGS StreamStats

Little Sycamore Canyon Geomorphic Conditions & Basis of Design

Figure 1
Watershed boundary of Little Sycamore Canyon

As a consequence of this geomorphic and climatic setting, Little Sycamore Creek is an ephemeral stream with a gravel to boulder bed. The channel has a gradient of 4% between the middle camp and the Pacific Ocean, and a sinuosity of 1.17, with a morphology that is mostly plane bed with occasional step-pools.

Channels of this type, gradient and watershed setting have a highly dynamic nature, experiencing cycles of deposition and erosion that is often described as a ‘punctuated equilibrium’. Periodic disturbances every few decades due to fires and debris flows generate large volumes of sediment from the watershed to be deposited in the valley floor, causing the creek to aggrade and form a wide, braided pattern. Between disturbances the creek re-works its sediment, creating low terraces and eventually cutting through the deposited sediment to have a more confined, single thread nature. This temporary equilibrium condition continues until being punctuated by the next



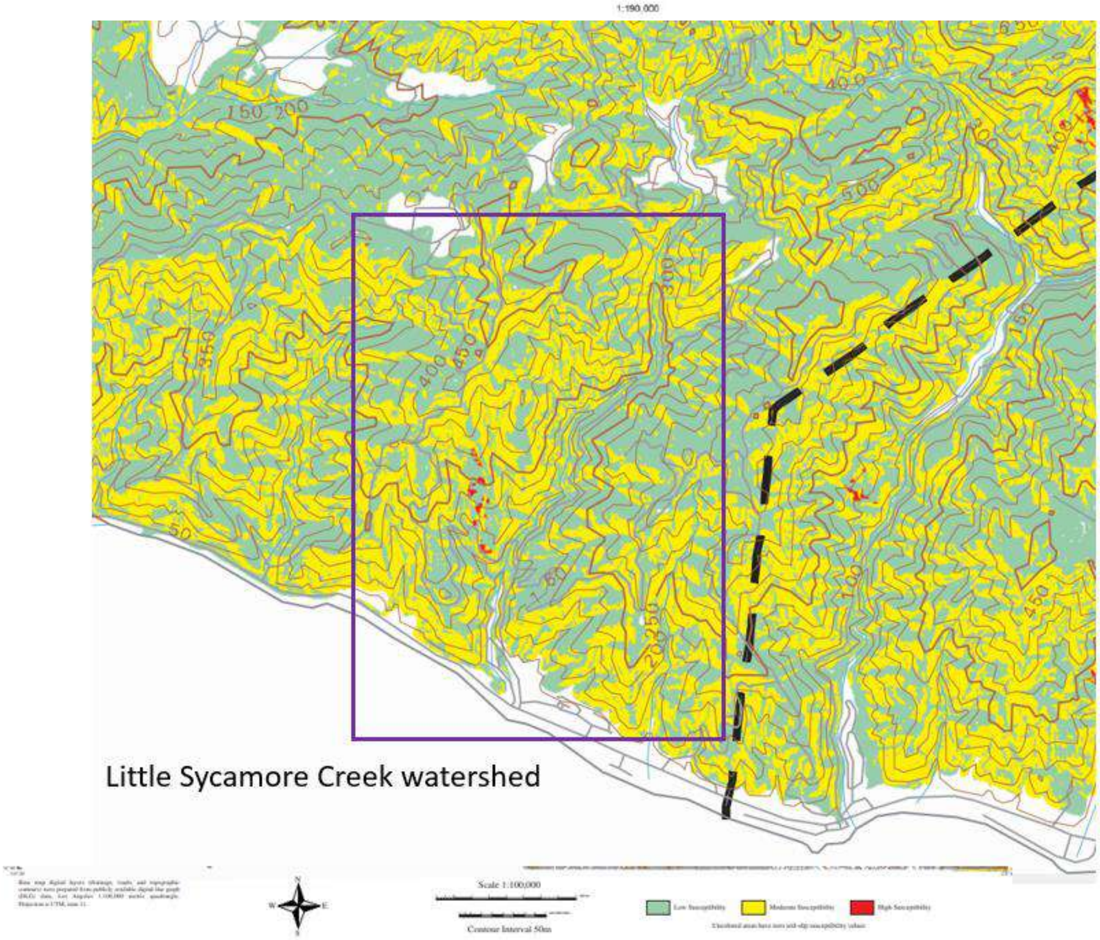


Plate 2. Soil-Slip Susceptibility Map for part of the Los Angeles 30' x 60' Quadrangle, Southern California

Preliminary Soil-Slip Susceptibility Maps, Southwestern California

SOURCE: National Parks Service 2020 (upper) and USGS 2003 (lower)

Figure 2

Fire frequency (upper) and landslide susceptibility (lower) for Little Sycamore Canyon disturbance, setting off a new cycle of deposition and erosion. The sycamore riparian woodland found in the valley floor is highly adapted to this geomorphic cycle, thriving in the coarse stream bed materials and able to withstand shifts in the stream bed.

3. Creek Geomorphic Conditions Update

Pre 2019 Fire and Flood Conditions

In 2011 ESA PWA evaluated geomorphic conditions in the creek (ESA PWA, 2012) as part of a Master Plan for the site, providing a helpful pre-fire and flood baseline condition against which to assess more recent conditions. In general, the creek corridor experienced and was impacted by a range of ad hoc maintenance operations and channel and bank stabilization measures through the decades that the canyon has been operated as a camp. Prior to the Woolsey Fire and subsequent flood events the creek channel was confined and constrained by a series of undersized bridges, vertical walls (some constructed with concrete debris and old tires) and failing grouted rock sills in the creek bed. These conditions limited overall channel function by disconnecting segments of the channel from adjacent floodplain areas, altering hydraulic conditions, exacerbating channel incision and bank erosion, limiting the extents and quality of the overall riparian corridor.

Key observations from the 2012 assessment, with stationing from the current basemap, included (note that naming conventions for some site elements have changed):

1. Several areas of the creek were in good condition (defined as having an unconfined channel with stable banks and bed, and floodplain areas that were well connected to the channel) and could serve as potential reference reaches for future restoration. Those areas were between the former dance stage and the pedestrian bridge to the former archery area Station (Sta.) 25+00 to 29+00, approximately.
2. The channel had a much coarser bed than the post fire condition: most reaches had a cobble or boulder bed as illustrated in Figure 3. Similar conditions are visible in historic photos of the creek on the walls of Camp Hess Kramer (Figure 4).
3. The bed included a number of step pools and headcuts[1], especially downstream of bridges where plunge pools had formed. These features indicate a combination of local scour and potential channel incision[2].
4. Several reaches were confined and identified as likely to benefit from widening and enhancement actions.
5. Many areas of creek bank had accumulated layers of loose organic material which appeared to be lawn clippings, vegetation debris or other landscape debris that had historically been pushed to the bank top and encroached into the channel.
6. Several creek bank areas appeared to have been informally stabilized with rubble fill or riprap and even old tires stacked along the channel edge.

[1] Knickpoints (or headcuts) are vertical steps in the creek profile, indicating channel incision on the downstream side of the feature. Knickpoints often migrate upstream as the channel erodes.

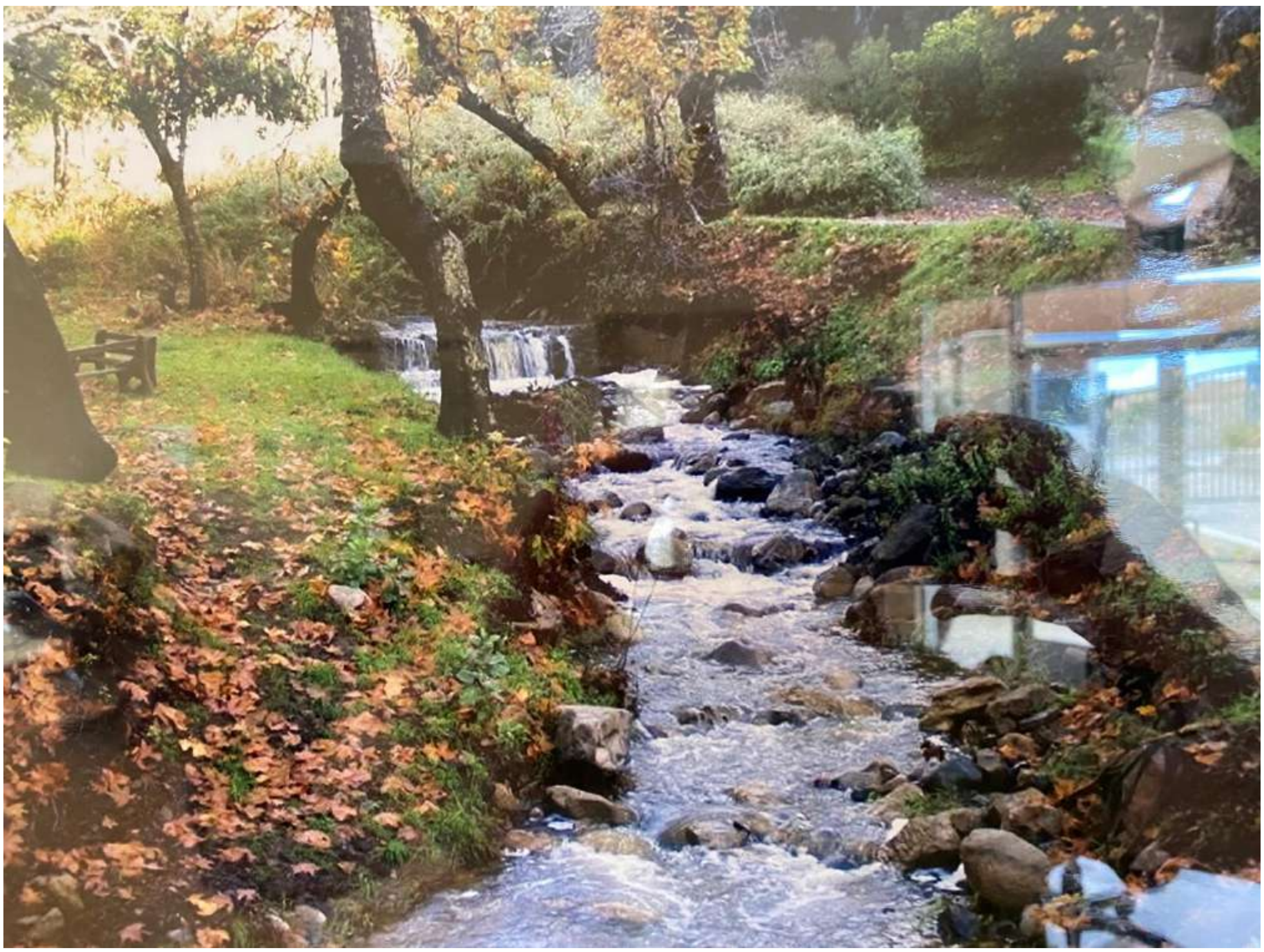
[2] Incision refers to vertical erosion by a creek into its bed, often resulting in steeper banks that are more prone to slumping or erosion

SOURCE: ESA

Camp Hess Kramer Geomorphic Conditions & Basis of Design

Figure 3

Boulder bed conditions and headcuts in 2011)



SOURCE: Camp Hess Kramer

Little Sycamore Canyon Geomorphic Conditions & Basis of Design

Figure 4

Step pool conditions in Little Sycamore Canyon prior to 2019 (date unknown)

7. Some bank areas had more formal and stable bank armor, for example around the upstream bridge.
8. Several bridges appeared to be undersized and constricting of a range of flows.
9. Several constructed drop and grade control structures in the channel appeared to be undercut and failing.

Key recommendations for stabilization and enhancement from the 2012 report include:

1. Widening Bridges 2-V, 4-V, and 6-V to match the average channel width at a minimum.
2. Expanding the creek in confined reaches and laying back oversteepened banks.
3. Removing historic debris and accumulated organic materials from creek banks.
4. Creating several lower floodplain areas adjacent to the creek.
5. Formalizing and reinforcing bed stabilization at knickpoints to prevent further channel incision.

Immediate Post-Fire and Flood Conditions (2019)

Following the 2018 Woolsey Fire and 2019 flood ESA revisited the creek to evaluate post-damage conditions and support WBT in developing emergency response plans to remove and relocate some of the deposited sediment from the creek, to increase conveyance and reduce the risk of flooding while the Camp recovery and long-term planning process took place. During this visit we observed that much of the channel was completely filled by boulders and coarse sediment originating from a landslide from Yerba Buena Road at Station (Sta,) 30+00 (approximately) that blocked the undersized bridges at Sta. 23+00 (Bridge 6-V) and Sta. 18+00 (Bridge 4-V). Paired before and after photos of these bridges are shown in Figure 5. Blockages had caused the creek to avulse[3] around the bridges and force a path near the old arts and crafts building, parking lot and lawn.

Upstream of the landslide the channel was partially to completely filled by debris flows that entered the creek around Sta. 37+00 (approximately), and from sediment entering the site from upstream, with the Arizona crossing being buried by several feet of sediment at the upstream boundary.

Downstream of Bridge 4-V, the pattern switched from channel deposition to primarily bank erosion, with a thinner layer of bed sediment in places. The banks of the creek adjacent to the parking lot were eroded where historic fill and organic matter had been placed, exposing unconsolidated and ad-hoc fill in vertical banks. Bridges 1-P and 2-V were destroyed. The transition from deposition to erosion was likely caused by the fact that two vehicular bridges (4-V and 6-V) blocked with debris and created backwater areas that induced sedimentation, while the downstream bridges failed and allowed the remaining sediment to pass through them, scouring the banks. Stantec produced a pair of creek profiles (Figure 6) using LiDAR topography from 2014 (pre flood) and 2020. The profiles show 2-3 feet of bed sedimentation in most areas of the creek, with 5-7 feet in reach between Bridge 6-V and the location where the Yerba Buena Road landslide entered the channel. Additional sedimentation of several feet occurred on floodplain areas as well as within the camp.

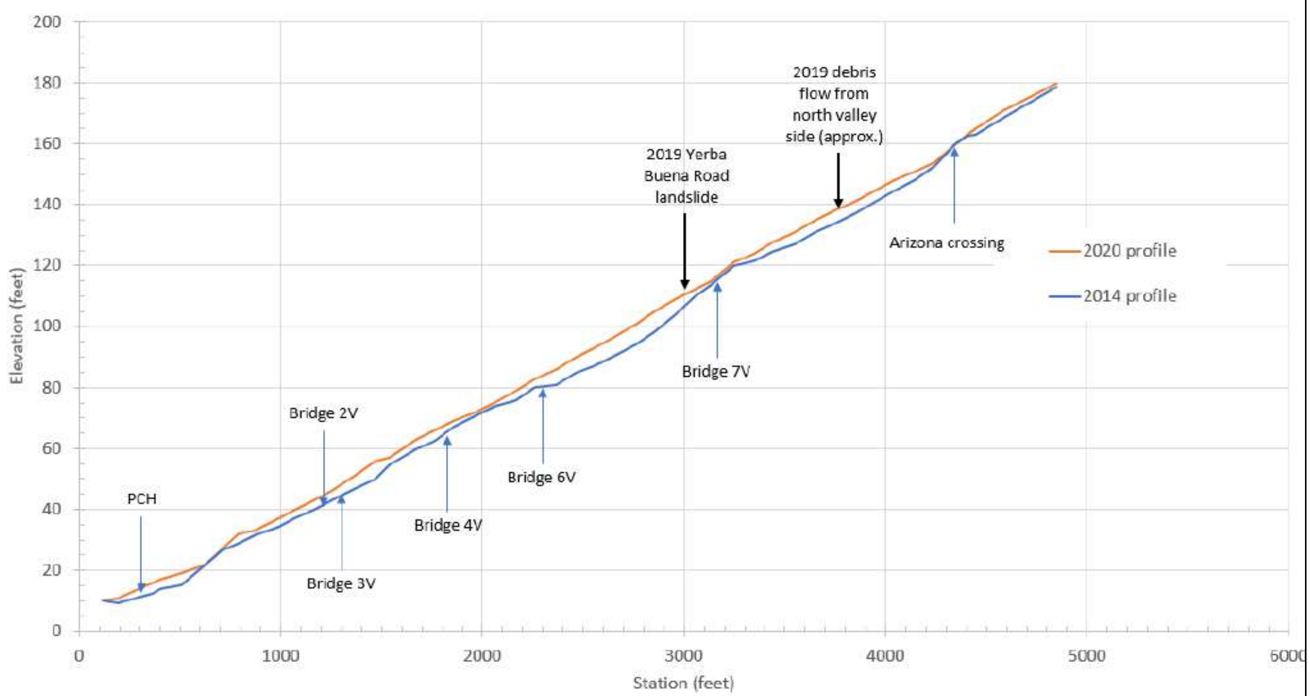
[3] A channel avulsion is a sudden, unpredictable switch in the location of a creek channel during a single flood event, in contrast to more gradual and predictable creek migration over the course of several flood events.

2011 Pre debris flow

2019 Post debris flow

SOURCE: ESA

Figure 5
Pre and post debris flow conditions



SOURCE: Stantec and ESA

Little Sycamore Canyon Geomorphic Conditions & Basis of Design

Figure 6

Creek Long Profile – Pre and Post 2019 Flood

4. Sediment Transport Analysis

ESA performed two sediment transport analyses using hydrologic and hydraulic data developed by Stantec to assess two design questions:

1. How much channel adjustment (e.g. deepening or widening) is likely in the short term? How erodible is the remaining sediment that was deposited in the channel during the 2019 flood event, and that was not excavated during the emergency recovery work or in the subsequent winter flows?
2. In the longer term, will the proposed project channel restoration and stabilization work combined with any changes in runoff from the project cause significant changes in sediment transport capacity within the creek corridor or off site?

Modeling Short Term Channel Adjustment

The first question was addressed by comparing shear stresses across a range of flows under proposed project channel conditions with the shear resistance of the two types of bed material observed in the field: the underlying pre-2019 flood cobble-boulder bed and the overlying gravel deposited on top during the 2019 flood. The shear resistance for the two bed materials was estimated by taking a series of bed sediment samples in the field and calculating the critical shear stress using the following equation:

$$\tau c = \tau^*(102.6D)$$

Where τc = critical shear stress (lb/sq ft)

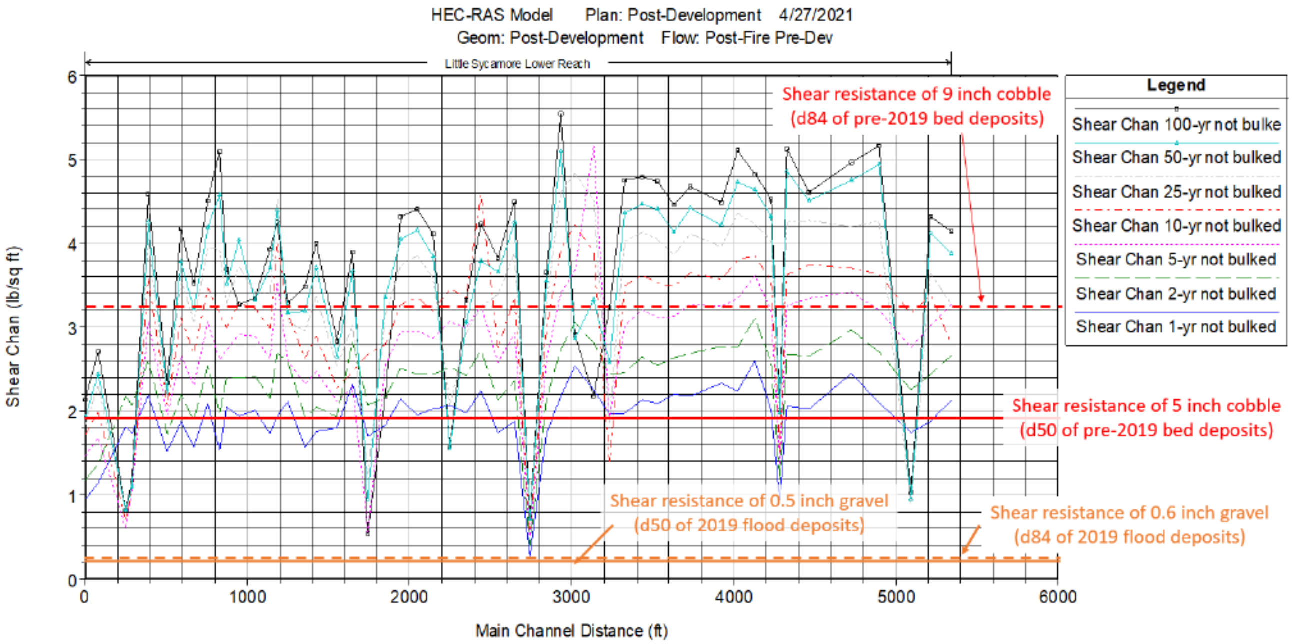
τ^* = Shields criterion for sediment of the relevant size (0.045)

D = median particle size of the bed d_{50} (inches)

A particle density of 165 lb/sq ft was assumed.

Based on the observed median particle size of around 0.5 inches for the overlying 2019 flood deposits the critical shear stress is about 0.2 lb/sq ft. For the underlying pre-2019 flood cobble-boulder bed the median diameter is 5 inches with a corresponding critical shear stress of 1.9 lb/sq ft. For the d84 (sometimes used to assess transport of poorly sorted beds where large particles shield the median sized particles from erosion) the respective values are 0.23 lb/sq ft for the 2019 flood deposits and 3.46 lb/sq ft for the underlying cobble-boulder bed.

Stantec used a HEC RAS model to generate shear stresses for proposed project conditions assuming the conceptual grading cross sections and assuming no channel adjustment post construction. Flows from the 1-year to the 100-year recurrence were simulated and compared with the shear resistances of the two bed types (Figure 7). As shown, even for small, frequent flows the shear resistance of the 2019 bed deposit is easily exceeded. The coarser underlying pre-flood sediments also had a low shear resistance relative to the estimated shear stresses based on its d_{50} particle size, but that observation is contradicted by the relative persistence of the coarse bed as demonstrated by repeated field observations and photos. Applying the d_{84} value for poorly



SOURCE: Stantec and ESA

Figure 7

Shear stress versus resistance of pre flood (cobble) and post flood (gravel) bed materials under post-project conditions sorted sediment equates to 9-inch cobble, which is mobilized by events between the 5 and 10-year flow. The boulder-cobble substrate is also more consolidated and interlocked than the recently deposited, unconsolidated gravel deposits, likely providing additional shear resistance that is not accounted for by the entrainment calculation. The conclusion of this initial sediment transport analysis is that the channel is likely to adjust rapidly over the next few years by eroding away the 2019 flood deposits until the pre-flood coarse bed sediment is exposed, at which time bed erosion will slow down significantly. The expected channel vertical scour can be approximated by the 2014 or 2018 bed profiles (Figure 6). Once exposed, the pre-2019 bed may self-armor over time as smaller cobble particles are eroded, leaving a lag of boulder-sized sediment as seen in historic photos.

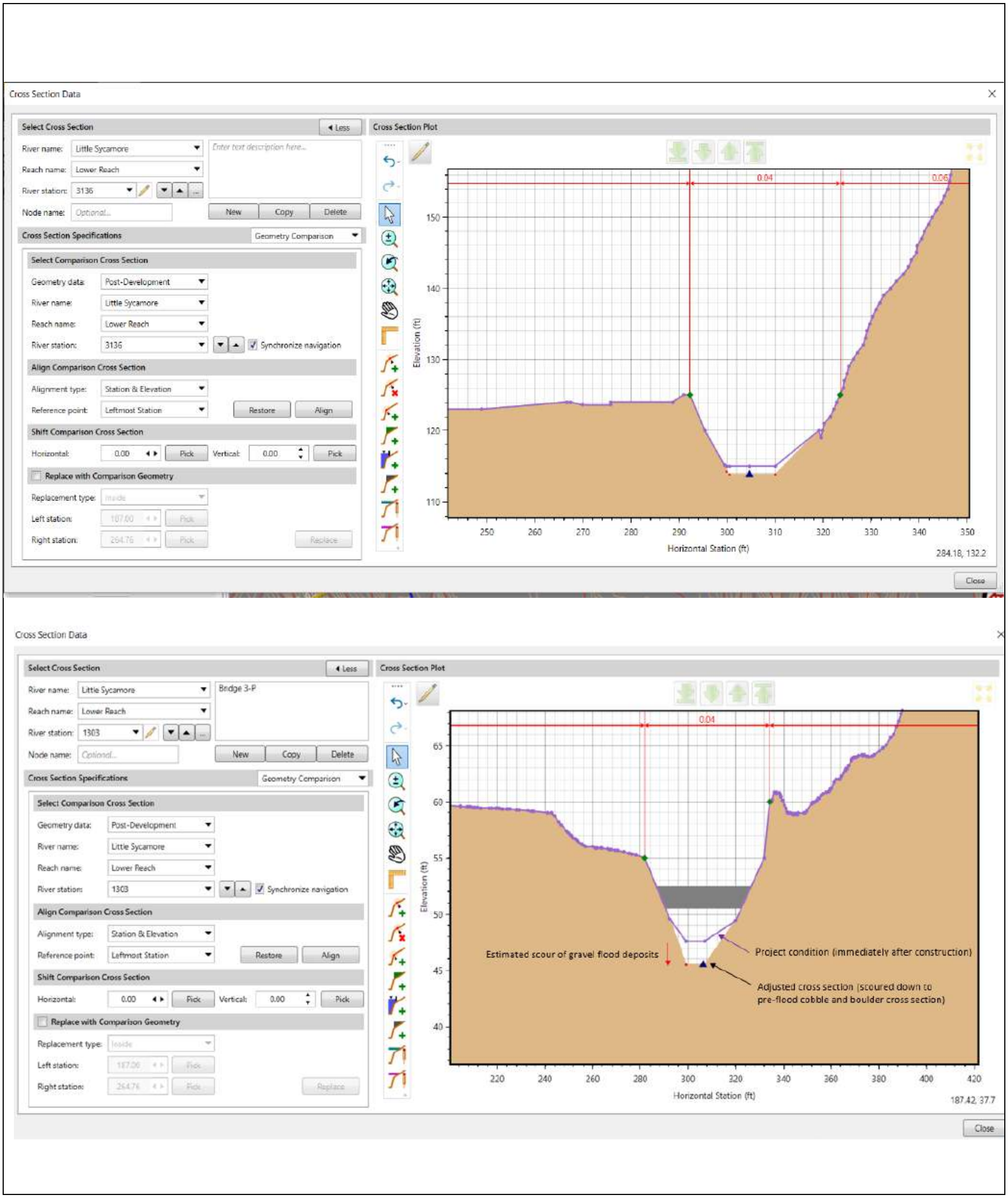
Modeling Long Term Project Effects on Sediment Transport

In order to assess whether the project would significantly change sediment transport conditions either on site or off site, a second analysis was performed. This compared the shear stresses under a pre-project baseline condition with two post-project conditions, one reflecting the design channel and one reflecting the design channel after short term adjustment to evacuate the 2019 flood deposits. The baseline condition was the channel as surveyed in 2020, post flood and pre project. The first project conditions version of the hydraulic model took the proposed channel cross sections without any adjustment, as with the model used for the short term analysis discussed above. The second version adjusted the proposed conditions cross sections by the estimated channel erosion amount as described above. Two example cross sections representing a range of adjustment levels are shown in Figure 8 to illustrate the three conditions modeled. For both post-project hydraulic models, Stantec evaluated whether flows would change under project conditions by adjusting the hydrologic inputs to account for the change in impervious area. The resulting changes in flow were negligible and within the 5 cfs rounding value.

The resulting shear stresses for a range of events are shown in Table 1 and Figure 9.

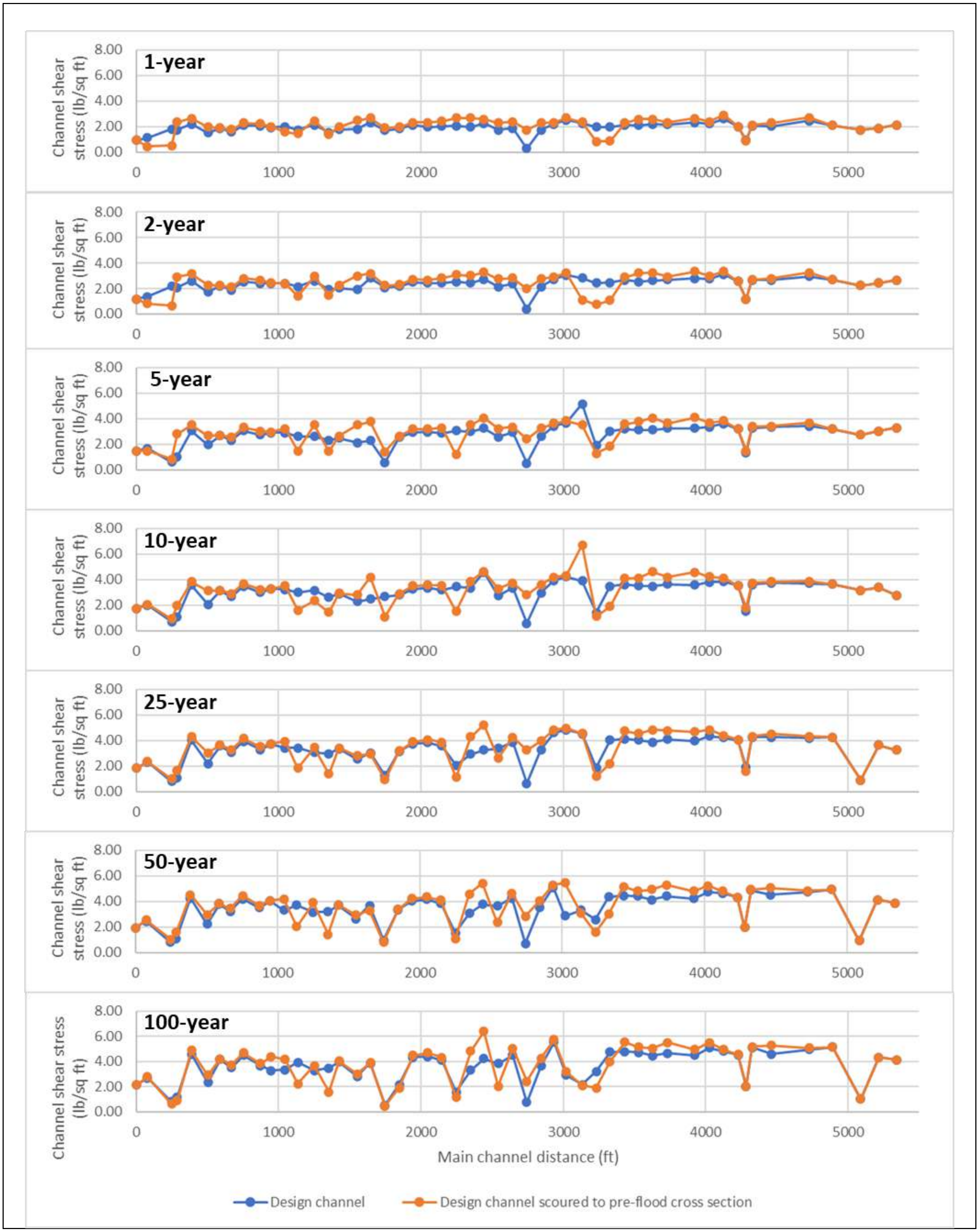
TABLE 1
SHEAR STRESS UNDER BASELINE AND POST-PROJECT CONDITIONS

	Average shear stress (lb/sq ft)			% change from baseline	
Event	Baseline (Post flood, pre project channel)	Design channel (no adjustment)	Design channel (assume all flood deposits eroded)	Design channel (no adjustment)	Design channel (assume all flood deposits eroded)
1-yr	2.04	1.92	2.07	2%	2%
2-yr	2.44	2.34	2.47	12%	13%
5-yr	2.90	2.70	2.94	-2%	7%
10-yr	3.13	3.03	3.24	4%	7%
25-yr	3.36	3.25	3.42	1%	6%
50-yr	3.55	3.44	3.64	0%	8%
100-yr	3.69	3.58	3.73	2%	4%
Average change in shear stress (all events)				3%	7%



SOURCE: Stantec and ESA

Figure 8
Example channel cross sections used in sediment transport analysis



SOURCE: Stantec and ESA

Figure 9

Shear stress of design channel and design channel following scour of flood deposits to pre-flood cross section

As the results show, under design conditions the channel will have a very similar sediment transport capacity to the existing condition, with only a 3% increase in shear stress across the events simulated. Once the flood deposit sediment washes out of the bed the channel will have a slightly, but less than significantly, increased sediment transport capacity, with an average 7% increase in shear stress over the range of events modeled. The estimated increase is not considered significant, but ESA recommends that the design team look for opportunities to reduce increases during subsequent design phases, for example by removing some of the flood deposits from the floodplain around the channel to reduce channel confinement. The sediment transport capacity changes near the Pacific Coast Highway culvert and the mouth of the creek, as well as at the upstream reach boundary, are very slight, indicating that there should be little change in offsite sediment transport patterns.

5. Geomorphic Design Principles for Little Sycamore Canyon

The opportunity to make detailed geomorphic observations in the creek before and after the disturbance events of 2018 and 2019, and to talk with Camp staff who have a long history of observing creek conditions, has given the team significant insight into how the creek functions over time and specifically the ten-year period between 2011 and 2021. The observations made can be distilled into a set of geomorphic principles to underpin the restoration design for the channel and riparian corridor:

- *Little Sycamore Canyon is a highly dynamic creek corridor: periodic watershed disturbances from fire, flash floods and debris flows are part of the natural cycle, and the unique sycamore riparian woodland found here is an adaptation to the resulting cycles of erosion, deposition and channel migration or avulsion.*
- *For the creek corridor and surrounding camp to be resilient, the design should anticipate and account for further periods of erosion, deposition and channel avulsion within the next few decades, and where practical, should allow open space for those processes to operate. This includes sizing bridges based on the bankfull channel dimensions, and removing channel constrictions where possible. Where the site constraints bring the creek and infrastructure or buildings into close proximity, the creek banks should be stabilized robustly to account for high levels of channel erosion or deposition and lateral migration.*
- *At the time of the design process, there was still excess flood-deposited sediment in the channel that is finer than the original substrate: the design should anticipate near-term adjustments in channel invert elevation and bank erosion as the channel adjusts and finer sediment from the 2019 flood is eroded out of the channel.*
- *Stormwater runoff from the site and adjacent properties including Yerba Buena Road should be accounted for and integrated with the creek restoration design. Stormwater management measures should consider potential scour and energy dissipation as part of a holistic approach to channel stabilization and enhancement.*

6. Existing Conditions (Summer 2020) and Recommended Restoration and Stabilization Actions

ESA revisited the site again in summer and fall of 2020 to reassess and map post-flood geomorphic conditions. Key observations are mapped in Figure 10. CHK Geomorphic Conditions Plans, illustrated in Figures 11-14, and described below, along with implications for the channel design approach. The design recommendations described below are mapped in Figure 15. Creek Enhancement Plans and summarized in Table 2, and are based on the geomorphic design principles outlined in Section 5 of this report. The proposed actions and measures to enhance and stabilize Little Sycamore Creek and the riparian corridor generally are based on the geomorphic assessment and integrated engineering design presented in the project Creek Restoration Plans (ESA, dated April 2021).

Channel bed composition. The 2019 flood deposited several feet (up to 7') of gravel over the much coarser cobble-boulder bed observed in 2011, between the former bridge 2-V at Sta. 12+00, approximately, and a location upstream of the Arizona crossing located at Sta. 43+50, approximately. ESA took eight (8) surface sediment samples for particle size analysis between these two points (see data in Appendix A, Figure A-1 and A-2). Seven of the eight surface samples were classified as gravel or gravel with sand (d_{50} of 7-40mm), while one was classified as sand with gravel (d_{50} of 4mm). Downstream of Sta. 12+00 and upstream of the Highway 1 undercrossing three (3) bed samples were measured which were assumed based on their similarity to field photos and observations from 2011 to be consistent with the exposed pre-flood channel: these additional samples had a d_{50} ranging from 100 to 150 mm. The channel from Sta. 12+00 to the ocean was a mixture of cobble bed and a veneer of gravel.

Channel Design Recommendations: Because the blocked bridges have mostly been cleared of flood-deposited debris, reducing the backwater effect caused by their temporary obstruction, we expect the gravel sediment to erode out of the channel during high flows over the next 5-10 years, eventually re-exposing the underlying boulder-cobble bed observed in 2011 and surveyed in 2014 and 2018. However, if new debris flows enter the site from upstream the site could experience renewed deposition, especially upstream of bridges V-4 and V-6, which are narrower than the average bankfull channel width. <u>The channel design (e.g. bank stabilization sections, toe protection, grade control and active floodplain areas) should allow for the channel to incise back down to the pre-flood invert elevation, which may be between two (2) and seven (7) feet in places. Bank stabilization and channel grade control measures should be over-excavated to expose the pre-flood boulder/cobble bed and keyed in below that surface (3'-4')</u>. Consideration of these conditions and geomorphic criteria will support long term channel stability and resilience including limiting future potential channel incision and bank erosion which in turn protects and enhances creek functions by accounting for episodic deposition, erosion and overall system dynamism which lead to reduced maintenance requirements over time. <u>The proposed measures to stabilize and enhance Little Sycamore Creek are shown on sheets R1-R8 of the Creek Restoration Grading Plans and Sections, R9-R14 of the Creek Restoration Typical Details and R14-R20 of the Creek Restoration Revegetation Plans and are consistent with Ventura County policies *COS-1.1, COS-1.7*</u> and *Sec. 8178-2.4 – Specific Standards* <u>as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.</u>

Channel bed stability. As the pre-flood channel bed is exposed we expect the knickpoints observed in 2011 and surveyed in 2014 and 218 to re-emerge, and potentially migrate, expand or erode, reducing bank stability and increasing scour risk for some upstream bridges.

Channel Design Recommendations: We recommend channel grade control where knickpoints were observed previously prior to the 2019 flood events. Grade control structures include boulder step-pool, roughened ramp and boulder weir structures constructed in the channel that mimic natural step-pools and act as grade control to protect against future channel incision below the documented pre flood invert. We also recommend that any bridges that constrict flow should incorporate design of and include channel bed armor beneath and downstream of the bridges since these areas are especially vulnerable to future channel incision. The sizing and geometry of the in-channel structures will be informed by hydraulic analysis, estimated scour and geomorphic considerations. These measures will support overall channel stability for effective flood conveyance and protection against debris flows as well as to help maintain integrity of the riparian corridor including restored floodplain areas and revegetation zones. The proposed channel grade control measures are shown on plan sheets R1-R8 of the Creek Restoration Grading Plans and Sections and R9-R14 of the Creek Restoration Typical Details and are consistent with Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.7, COS-1.8* and *Sec. 8178-2.4 – Specific Standards* as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Bridge dimensions. The debris flows of 2019 confirmed that bridges V-2, V-4 and V-6 have openings that constrict flow and cause upstream deposition, increasing the risk of flooding and channel avulsions.

Channel Design Recommendations: We recommend that all replacement or new bridges fully span the bankfull channel and do not intrude into the functional channel cross section. Based on the geomorphic assessments conducted for this project, the bankfull channel cross section is estimated to be 40 feet (minimum) wide at top of bank, and 15-20 feet wide at the channel bed based on the dimensions of channel cross sections that were considered to be moderately confined or less confined (ESA PWA 2012). Constructing wider bridges should reduce, though not eliminate, the risk of future deposition and channel avulsion or flooding in addition to protecting and enhancing overall creek function. The proposed measures are shown on plan sheets R1-R8 of the Creek Restoration Grading Plans and Sections and are consistent with Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.7 COS-1.8* and *Sec. 8178-2.4 – Specific Standards* as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Bank erosion and bank stability. Many of the banks where organic and other landscape debris as well as other unconsolidated fill materials had accumulated were scoured bare by the 2019 flooding, especially around the lower camp area and at the middle camp where the proposed road realignment is proposed. Several areas of bank (see examples in Figure 11) remain in oversteepened condition and are prone to future erosion.

Channel Design Recommendations: We recommend utilizing a combination of actions and measures to stabilize oversteepened and eroding banks. The measures include grading to lay back oversteepened banks back to a shallower and more stable profile to support native revegetation and biotechnical stabilization measures, and in several select areas where infrastructure (roadway, bridges, etc) is directly adjacent to the channel, we recommend installation of rock toe protection to prevent bank retreat that could pose a risk to the camp infrastructure and programs. Biotechnical stabilization includes vegetated soil lifts (VSL), brush mat and live pole planting. More structural measures include vegetated rock slope protection and rock slope protection (transitions to, from and under bridges). Rock structures should be designed to account for up to seven feet of bed scour depending on location as flood-deposited gravels are washed out, in addition to the standard scour estimates below the pre-flood channel bed (3'-4'). For the bank stabilization areas shown in Figure 15 and summarized in Table 2 the profile was set to be as shallow as feasible. Bank stabilization measures were designated to steeper design gradients where either infrastructure impeded or cut slopes would have been excessively long before conforming to the valley side slopes or were in conflict with other project elements. These bank stabilization measures, based on natural analogs observed within the corridor utilize living plant materials to supplement structural elements and provide long term and resilient stability as the trees and plants establish. The bank stabilization structures shall be designed to account for specific geomorphic and hydraulic conditions in Little Sycamore Creek in order to protect and enhance creek functions within the creek corridor. Once established, biotechnical stabilization structures will also augment the overall revegetation plan to improve habitat complexity and linkages. The proposed actions and measures for bank stabilization are shown on sheets R1-R8 of the Creek Restoration Grading Plans and Sections and R9-R14 of the Creek Restoration Typical Details and are consistent with Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.7* and *Sec. 8178-2.4 – Specific Standards* as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Tree preservation. There are several areas where the banks are eroding into the root balls of high value trees, for example in the parking lot area of the lower camp (Figure 12). The erosion threatens long-term stability of the trees and presents risk for significant loss of existing habitat values. In general, proposed actions for creek stabilization and enhancement are intended to protect, preserve and stabilize existing trees.

Channel Design Recommendations: Where high value trees or other constraints prevent comprehensive bank regrading we recommend selective grading around tree crowns to remove stockpiled debris and overburden bank soils while preserving the root structure. The conform grading at select trees within the bank stabilization and channel widening areas will establish 'tree islands' to preserve the trees to incorporate and maintain existing riparian structure and to support complexity within the riparian corridor. In some areas such as the parking lot we recommend reconstructing severely eroded banks around high value trees utilizing a combination of vegetated rock slope protection and vegetated soil lifts (VSL) to reestablish stable and resilient banks. These actions protect and enhance creek functions by developing detailed grading plans and bank stabilization measures that prioritize the preservation of the limited number of mature trees within the creek corridor. In most locations tree preservation will be augmented with specific complimentary plantings of other native tree and understory species which will enhance habitat complexity and linkages. The proposed grading and tree protection measures are shown on sheets R1-R8 of the Creek Restoration Grading Plans and Sections and R9-R14 of the Creek Restoration Typical Details and are consistent with Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.7,* *Sec. 8178-2.4 – Specific Standards* and *Sec. 8178-7.4.1 - General Standards* as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Removal of invasive vegetation. There are a number of reaches of Little Sycamore Creek where non-native invasive plant species dominate and out-compete native riparian species. The non-native species limit the ecological value and functions of the creek channel and riparian corridor and prevent beneficial native plant and tree species that can reduce erosion from establishing.

Channel Design Recommendations: We recommend removing invasive vegetation, conducting targeted invasive species management and revegetating the riparian corridor based on a palette of native riparian species, see Table 3. Little Sycamore Creek – Provisional Plant Lists, to enhance habitat values and reduce erosion risk. The actions to remove invasive species from the creek banks will allow for implementation of a comprehensive revegetation plan based on appropriate and beneficial native tree and plant species that can support a range of functions including bank stabilization, roosting, cover and forage habitats and improved connectivity including corridors for wildlife movement. In addition, removal of invasive vegetation aligns with project priorities for fuel modification. The proposed measures are shown on sheets R14-R20 of the Creek Restoration Revegetation Plans and are consistent with Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.7* and *Sec. 8178-8.4.2.5 - Slope Planting and Erosion Control* as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Channel and floodplain restoration. There are several confined reaches where the channel appears to be artificially narrow and poorly connected to any floodplain and transitional bank areas (see example in Figure 13). Comparison of the pre flood (2014 and 2018) and post flood (2020) LiDAR surfaces shows that up to seven (7) feet of sedimentation occurred on some floodpain areas, including some sediment that was side cast out of the channel to restore flood conveyance capacity during the emergency flood recover work.

Channel Design Recommendations: Where feasible, ESA recommends that confined and/or buried channel reaches are widened and low floodplain areas actively graded out to at least the pre-flood level or deeper, to provide areas where the channel can migrate, expend excess energy and deposit sediment in the future at low risk to camp infrastructure and operations. Floodplain and channel widening elevations should be set based on the pre-flood channel profile since we expect the channel to incise into recent gravel deposits over the next 5-10 years, becoming less connected to the floodplain than under existing post-flood conditions. We recommend setting the floodplain elevations 1-2 feet (approximately) above the pre-flood channel invert where space allows, to compensate for expected future channel incision through the recent sediment deposits. These actions protect and enhance creek functions by actively removing flood-deposited sediments to reset and enhance channel capacity, reducing shear stress and improving conditions for natural regimes of deposition and erosion within the channel. In addition, channel grading and widening and bank set backs will support overall resilience and sustainability within the corridor in terms of future flood conveyance and debris flows leading to reduced maintenance requirements over time. The proposed actions are shown on sheets R1-R8 of the Creek Restoration Grading Plans and Sections and R9-R14 of the Creek Restoration Typical Details and are consistent with

Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.7* and *Sec. 8178-2.4 – Specific* Standards as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Removal of debris. The 2019 debris flows and subsequent clearing of 14,000 cubic yards of sediment from the creek channel (Ventura County Emergency Permit #PL19-0005) have resulted in areas of sedimentation and debris stockpiling along the channel banks and floodplain in some areas (Figure 14) within the creek corridor.

Channel Design Recommendations: We recommend removal of excess sediment and overburden materials from the areas adjacent the channel including floodplain and transitional bank zones to 1) expand the creek corridor where appropriate, 2) to restore connected floodplain habitat and function where possible, and 3) to reduce the risk of sediment remobilizing and re-depositing downstream. Paired with channel and floodplain restoration actions, the sediment removal will protect and enhance creek functions by reducing shear stress and improving conditions for natural regimes of deposition and erosion within the channel. Debris removal will reestablish and expand areas for revegetation with native trees and plants. In addition, the sediment removal directly integrates and supports channel widening and bank set back actions to support overall resilience and sustainability within the corridor in terms of future flood conveyance and debris flows leading to reduced maintenance requirements over time. The proposed measures are shown on sheets R1-R8 of the Creek Restoration Grading Plans and Sections and R9-R14 of the Creek Restoration Typical Details and are consistent with Ventura County's policies *COS-1.1, COS-1-3, COS-1.4, COS-1.07, COS-1.8* and *Sec. 8178-2.4 – Specific* Standards as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

Stormwater management. Site flooding, erosion and deposition in Lower Camp appears to have been exacerbated by stormwater and sediment entering the site via Yerba Buena Road. The ad hoc drainage system concentrates and outlets untreated flows onto creek banks causing erosion and local bank instability.

Channel Design Recommendations: We recommend that stormwater from on and off-site be integrated into the channel design including measures designed and constructed to collect stormwater runoff rather than current conditions that sheetflow directly over creek banks and into the channel. However, in a few areas, such as the Sports Field, the runoff will remain as existing and sheetflow onto the creek The stormdrains and stormwater outlet structures should be integrated with other creek channel enhancement elements to discharge into rock slope protection, boulder step pools and other channel grade control structures that dissipate excess energy and reduce the risk of channel and bank erosion. These measures, paired with bio-retention basins within the project will lead to improved water quality and flow conditions. The proposed measures are shown on sheets R1-R8 of the Creek Restoration Grading Plans and Sections and R9-R14 of the Creek Restoration Typical Details and are consistent with Ventura County policies *COS-1.1, COS-1-3, COS-1.4, COS-1.07, COS-1.8* and *Sec. 8178-8.4.2.6 - Stormwater Management* Landscaping as discussed in the accompanying Wilshire Boulevard Temple Camps – Camp Hess Kramer and Gindling Hilltop Woolsey Fire Rebuild Policy Consistency Analysis.

TABLE 2
RECOMMENDED CHANNEL RESTORATION AND STABILIZATION ACTIONS

Bank	Station		Action
	From	To	
LEFT	03+47	05+72	REMOVE INVASIVES AND REVEGETATE
RIGHT	03+47	05+72	REMOVE INVASIVES AND REVEGETATE
LEFT	05+72	07+00	LAYBACK AND REVEGETATE
RIGHT	05+72	06+57	LAYBACK AND REVEGETATE
LEFT	07+00	07+87	LAYBACK AND REVEGETATE AND BANK RECONSTRUCTION
RIGHT	06+57	08+54	LAYBACK AND REVEGETATE
LEFT	07+87	08+66	LAYBACK AND REVEGETATE
RIGHT	08+54	09+51	REMOVE INVASIVES AND REVEGETATE
LEFT	08+66	09+51	REMOVE INVASIVES AND REVEGETATE
RIGHT	09+51	12+00	LAYBACK AND REVEGETATE
LEFT	09+51	11+09	REMOVE INVASIVES AND REVEGETATE
LEFT	11+09	12+00	LAYBACK AND REVEGETATE
RIGHT	12+00	12+26	REMOVE INVASIVES AND REVEGETATE
LEFT	12+00	13+00	REMOVE INVASIVES AND REVEGETATE
RIGHT	12+26	13+19	SELECTIVE GRADING AND REVEGETATE
LEFT	12+26	13+23	SELECTIVE GRADING AND REVEGETATE
RIGHT	13+19	13+81	LAYBACK AND REVEGETATE
LEFT	13+23	14+26	REMOVE DEBRIS AND REVEGETATE
LEFT	13+58	15+04	REMOVE INVASIVES AND REVEGETATE
RIGHT	13+81	15+64	LOWER FLOODPLAIN
LEFT	15+04	17+20	REMOVE INVASIVES AND REVEGETATE
LEFT	15+04	17+20	LAYBACK AND REVEGETATE AND BANK RECONSTRUCTION
RIGHT	15+40	16+89	REMOVE INVASIVES AND REVEGETATE
LEFT	16+89	17+60	LAYBACK AND REVEGETATE
RIGHT	16+89	18+63	LAYBACK AND REVEGETATE
LEFT	17+60	19+79	LAYBACK AND REVEGETATE
RIGHT	18+63	22+34	REMOVE INVASIVES AND REVEGETATE
LEFT	19+79	20+42	REMOVE INVASIVES AND REVEGETATE
LEFT	20+44	22+44	REMOVE DEBRIS AND REVEGETATE
LEFT	21+99	22+44	REMOVE INVASIVES AND REVEGETATE
RIGHT	22+34	24+06	LAYBACK AND REVEGETATE
LEFT	22+44	23+37	LAYBACK AND REVEGETATE
LEFT	23+19	25+78	REMOVE INVASIVES AND REVEGETATE
RIGHT	24+06	24+47	REMOVE INVASIVES AND REVEGETATE
RIGHT	24+06	27+50	REMOVE DEBRIS AND REVEGETATE
LEFT	24+06	25+78	REMOVE DEBRIS AND REVEGETATE
RIGHT	25+65	26+99	REMOVE INVASIVES AND REVEGETATE
LEFT	25+78	26+73	LOWER FLOODPLAIN
LEFT	26+00	27+71	REMOVE DEBRIS AND REVEGETATE
RIGHT	27+50	28+00	REMOVE INVASIVES AND REVEGETATE
LEFT	27+71	29+13	LOWER FLOODPLAIN AND CONSTRUCT CHANNEL
RIGHT	27+87	29+34	REMOVE DEBRIS AND REVEGETATE
RIGHT	28+00	30+11	REMOVE INVASIVES AND REVEGETATE
LEFT	29+13	29+64	REMOVE INVASIVES AND REVEGETATE
RIGHT	32+36	34+55	LAYBACK AND REVEGETATE
RIGHT	34+55	35+10	REMOVE INVASIVES AND REVEGETATE
RIGHT	35+10	37+49	LAYBACK AND REVEGETATE
RIGHT	37+49	38+83	REMOVE INVASIVES AND REVEGETATE
RIGHT	38+83	40+38	LAYBACK AND REVEGETATE
RIGHT	40+38	41+98	REMOVE INVASIVES AND REVEGETATE
RIGHT	41+98	43+27	SELECTIVE GRADING AND REVEGETATE

TABLE 3
LITTLE SYCAMORE CREEK - PROVISIONAL PLANT LISTS

Scientific Name	Common Name
Container Plantings	
Trees / Canopy	
Acer macrphyllum	Big leaf maple
Alnus rhombifolia	White alder
Platanus racemosa	California sycamore
Populus trichocarpa	Black cottonwood
Quercus agrifolia	Coast live oak
Salix laevigata	Red willow / Polished willow
Salix lasiolepis	Arroyo willow
Salix exigua	Narrowleaf willow
Understory	
Artemisia douglasiana	California mugwort
Baccharis salicifolia	Mule fat
Carex praegracilis	Field sedge
Clematis ligustifolia	Creek clematis
Distichlis spicata	Salt grass
Heteromeles arbutifolia	Toyon
Juncus patens	Common rush
Juncus xiphioides	Iris leaved rush
Ribes aureum	Golden currant
Rubus ursinus	California blackberry
Rosa californica	California wild rose
Sambucus nigra ssp. *caerulea*	Blue elderberry
Solanum douglasii	Douglas' nightshade
Solidago velutina ssp. *californica*	California goldenrod
Stachys ajugoides	Hedge nettle
Verbena lasiostachys	Western vervain
Seed	
Agrostis exarata	Spike bentgrass
Artemisia douglasiana	California mugwort
Elymus triticoides	Creeping wildrye
Eschscholzia californica	California poppy
Festuca (Vulpia) microstachys	Three weeks fescue
Hordeum brachyantherum	Meadow barley
Lupinus bicolor	Miniature lupine
Melica imperfecta	Coast range melic
Muhlenbergia rigens	Deer grass
Stipa pulchra	Purple needle grass
Trifolium wildenovii	Tomcat clover

NOTES:
1. SELECTIVE GRADING IS TARGETED TO REMOVE DEBRIS, OVERBURDEN. LESS THAN 2 FT OF GRADING TO ADDRESS UNSTABLE MATERIAL

SCALE: 1"=20'
0 20 40 60

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FIIGURE 10 – GEOMORPHIC CONDITIONS
CAMP HESS KRAMER/GINDLING HILLTOP CAMP
11495 & 11677 PACIFIC COAST HWY
WOOLSEY FIRE REBUILD
VENTURA COUNTY, CA

PRELIMINARY

STANTEC PROJECT NO.

SHEET 1 OF 7

PLAN DATE 03/03/2021

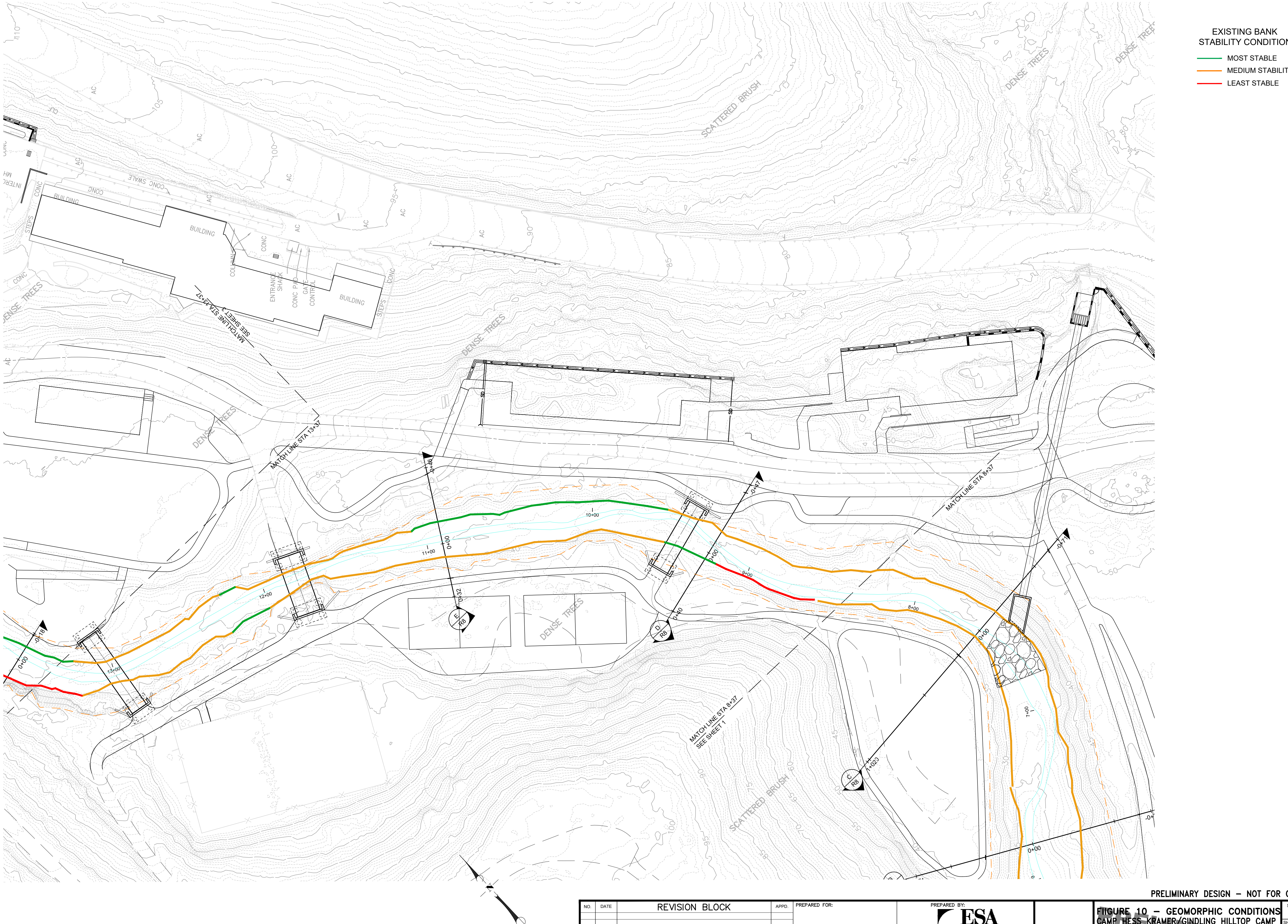

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FIGURE 10 – GEOMORPHIC CONDITIONS
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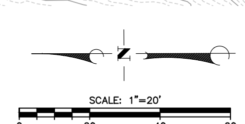

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EXISTING BANK
STABILITY CONDITION

MOST STABLE
MEDIUM STABILITY
LEAST STABLE

SCALE: 1"=20'
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SHEET
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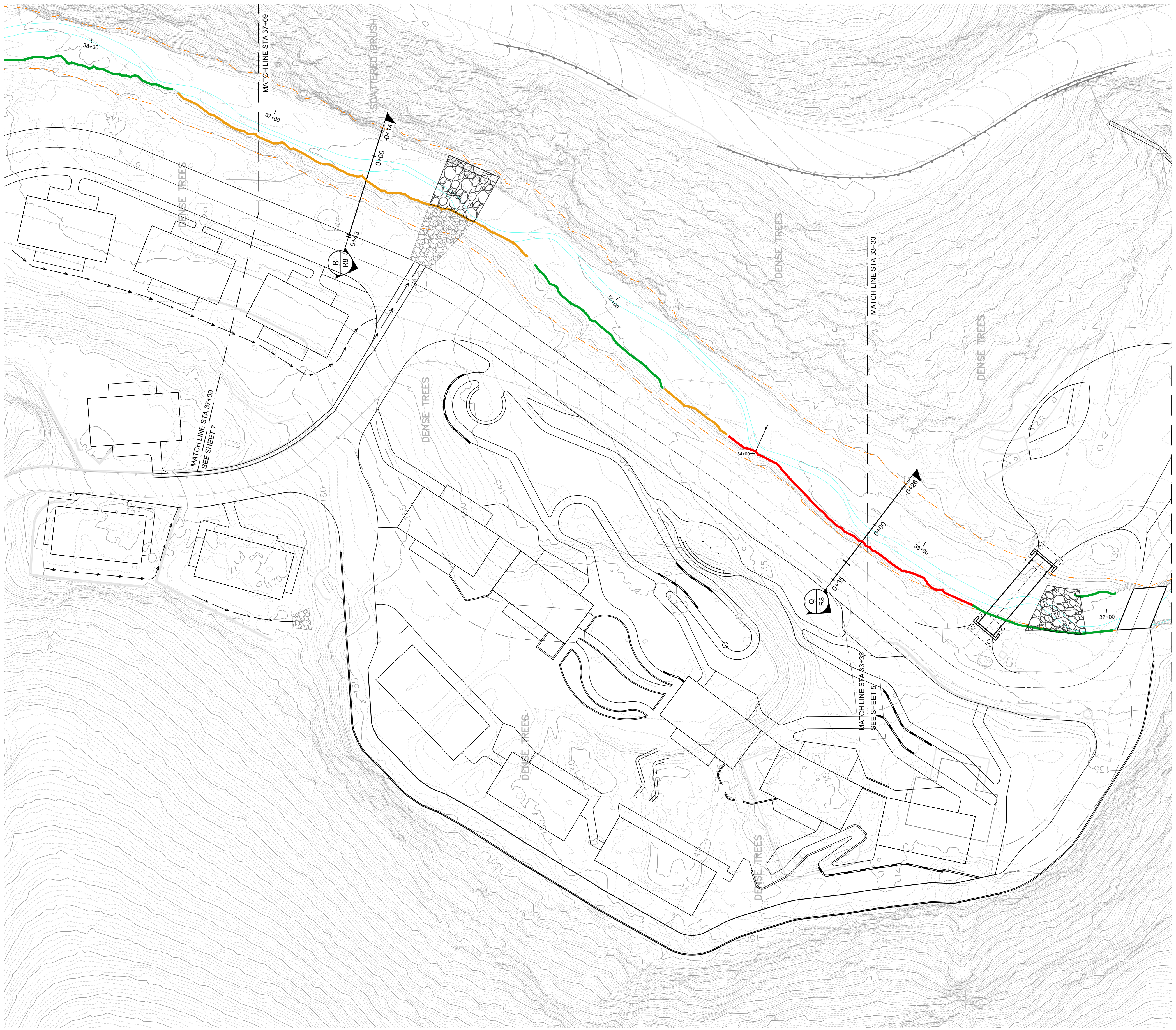

EXISTING BANK STABILITY CONDITION

- MOST STABLE
- MEDIUM STABILITY
- LEAST STABLE

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SOURCE:ESA

Little Sycamore Canyon Geomorphic Conditions & Basis of Design

Figure 11

Example of bank erosion site where stabilization is proposed

SOURCE: ESA

Camp Hess Kramer Geomorphic Conditions & Basis of Design

Figure 12

Example of a site where selective grading to remove fill plus placement of rock protection around tree roots is proposed

SOURCE:ESA

Camp Hess Kramer Geomorphic Conditions & Basis of Design

Figure 13
Proposed area for floodplain lowering to reduce confinement (left bank)

SOURCE:ESA

Little Sycamore Canyon Geomorphic Conditions & Basis of Design

Figure 14

Area of proposed sediment and debris removal

LEGEND

- (E) TOP OF BANK
- (N) ENHANCEMENT/STABILIZATION MEASURE
- (N) CHANNEL STRUCTURE/OUTFALL
- (N) VEGETATED ROCK SLOPE PROTECTION
- (N) BANK RECONSTRUCTION (PERMITTED PREVIOUSLY, 2018)
- (N) BOULDER TOE PROTECTION
- (N) LAYBACK AND REVEGETATE
- (N) SELECTIVE GRADING AND REVEGETATE
- (N) REMOVE DEBRIS AND REVEGETATE
- (N) REMOVE INVASIVES AND REVEGETATE
- FLOODPLAIN GRADING AND HABITAT PLANTING
- (N) MAJOR CONTOUR
- (N) MINOR CONTOUR
- (E) TREE
- (N) TREE ISLAND
- DETAIL NUMBER / SHEET NUMBER
- CROSS SECTION NUMBER / SHEET NUMBER

NOTES:
1. SELECTIVE GRADING IS TARGETED TO REMOVE DEBRIS, OVERBURDEN. LESS THAN 2 FT OF GRADING TO ADDRESS UNSTABLE MATERIAL

SCALE: 1"=20'
0 20 40 60

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FIGURE 15 – ENHANCEMENT PLAN
CAMP HESS KRAMER/GINDLING HILLTOP CAMP
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WOOLSEY FIRE REBUILD
VENTURA COUNTY, CA

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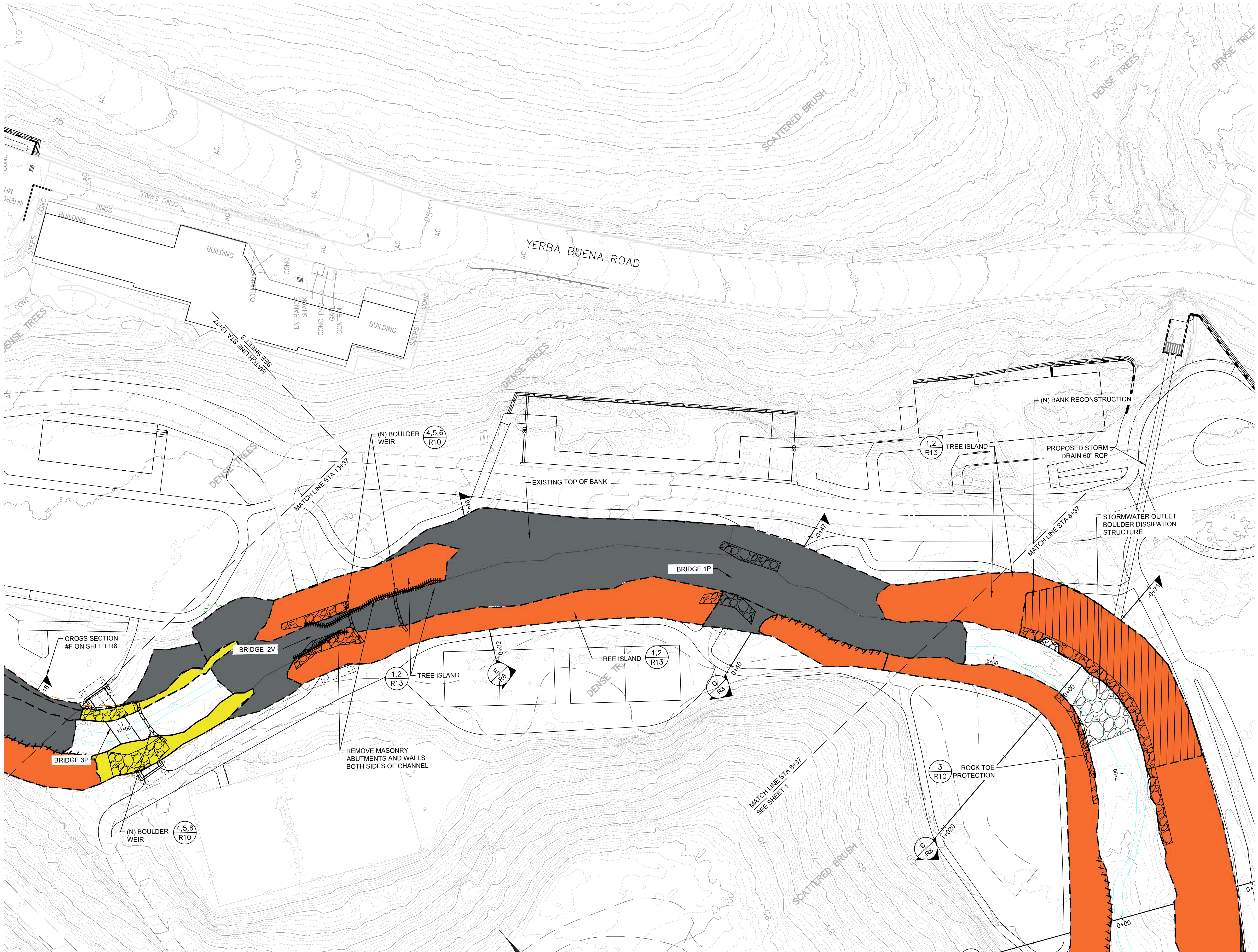

LEGEND

- (E) TOP OF BANK
- (N) ENHANCEMENT/STABILIZATION MEASURE
- (N) CHANNEL STRUCTURE/OUTFALL
- (N) VEGETATED ROCK SLOPE PROTECTION
- (N) BANK RECONSTRUCTION (PERMITTED PREVIOUSLY, 2018)
- (N) BOULDER TOE PROTECTION
- (N) LAYBACK AND REVEGETATE
- (N) SELECTIVE GRADING AND REVEGETATE
- (N) REMOVE DEBRIS AND REVEGETATE
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- (N) MAJOR CONTOUR
- (N) MINOR CONTOUR
- (E) TREE
- (N) TREE ISLAND
- DETAIL NUMBER / SHEET NUMBER
- CROSS SECTION NUMBER / SHEET NUMBER

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FIGURE 15 – ENHANCEMENT PLAN

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LEGEND

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- (N) CHANNEL STRUCTURE/OUTFALL
- (N) VEGETATED ROCK SLOPE PROTECTION
- (N) BANK RECONSTRUCTION (PERMITTED PREVIOUSLY, 2018)
- (N) BOULDER TOE PROTECTION
- (N) LAYBACK AND REVEGETATE
- (N) SELECTIVE GRADING AND REVEGETATE
- (N) REMOVE DEBRIS AND REVEGETATE
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SCALE: 1"=20'
0 20 40 60

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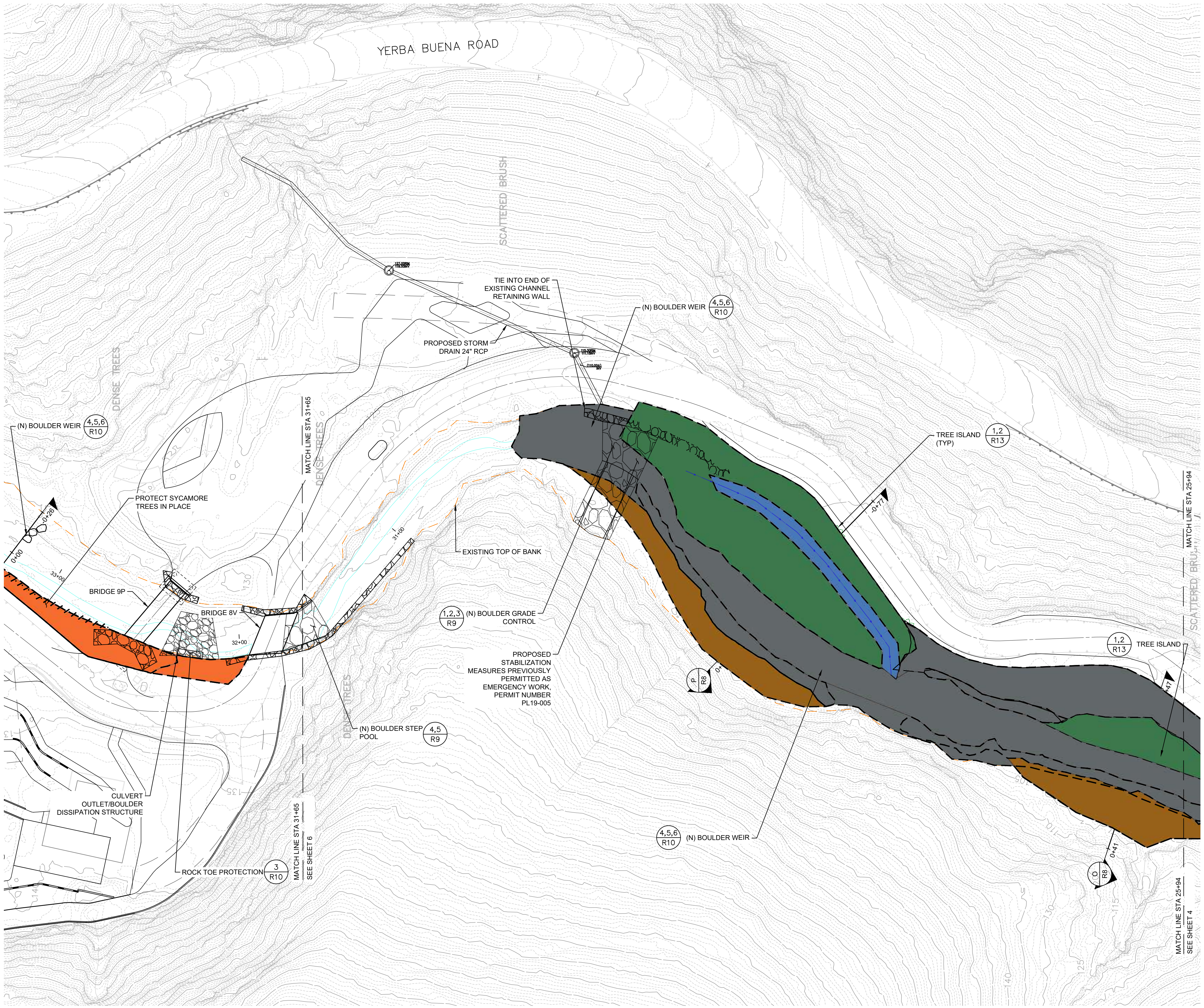

LEGEND

- (E) TOP OF BANK
- (N) ENHANCEMENT/STABILIZATION MEASURE
- (N) CHANNEL STRUCTURE/OUTFALL
- (N) VEGETATED ROCK SLOPE PROTECTION
- (N) BANK RECONSTRUCTION (PERMITTED PREVIOUSLY, 2018)
- (N) BOULDER TOE PROTECTION
- (N) LAYBACK AND REVEGETATE
- (N) SELECTIVE GRADING AND REVEGETATE
- (N) REMOVE DEBRIS AND REVEGETATE
- (N) REMOVE INVASIVES AND REVEGETATE
- FLOODPLAIN GRADING AND HABITAT PLANTING
- (N) MAJOR CONTOUR
- (N) MINOR CONTOUR
- (E) TREE
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PRELIMINARY

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LEGEND

- (E) TOP OF BANK
- (N) ENHANCEMENT/STABILIZATION MEASURE
- (N) CHANNEL STRUCTURE/OUTFALL
- (N) VEGETATED ROCK SLOPE PROTECTION
- (N) BANK RECONSTRUCTION (PERMITTED PREVIOUSLY, 2018)
- (N) BOULDER TOE PROTECTION
- (N) LAYBACK AND REVEGETATE
- (N) SELECTIVE GRADING AND REVEGETATE
- (N) REMOVE DEBRIS AND REVEGETATE
- (N) REMOVE INVASIVES AND REVEGETATE
- FLOODPLAIN GRADING AND HABITAT PLANTING
- (N) MAJOR CONTOUR
- (N) MINOR CONTOUR
- (E) TREE
- (N) TREE ISLAND
- DETAIL NUMBER / SHEET NUMBER
- CROSS SECTION NUMBER / SHEET NUMBER

SCALE: 1"=20'
0 20 40 60

PRELIMINARY DESIGN – NOT FOR CONSTRUCTION

NO.	DATE	REVISION BLOCK	APPD.

PREPARED FOR:

PREPARED BY: ESA

PROJECT ENGINEER R.C.E. DATE

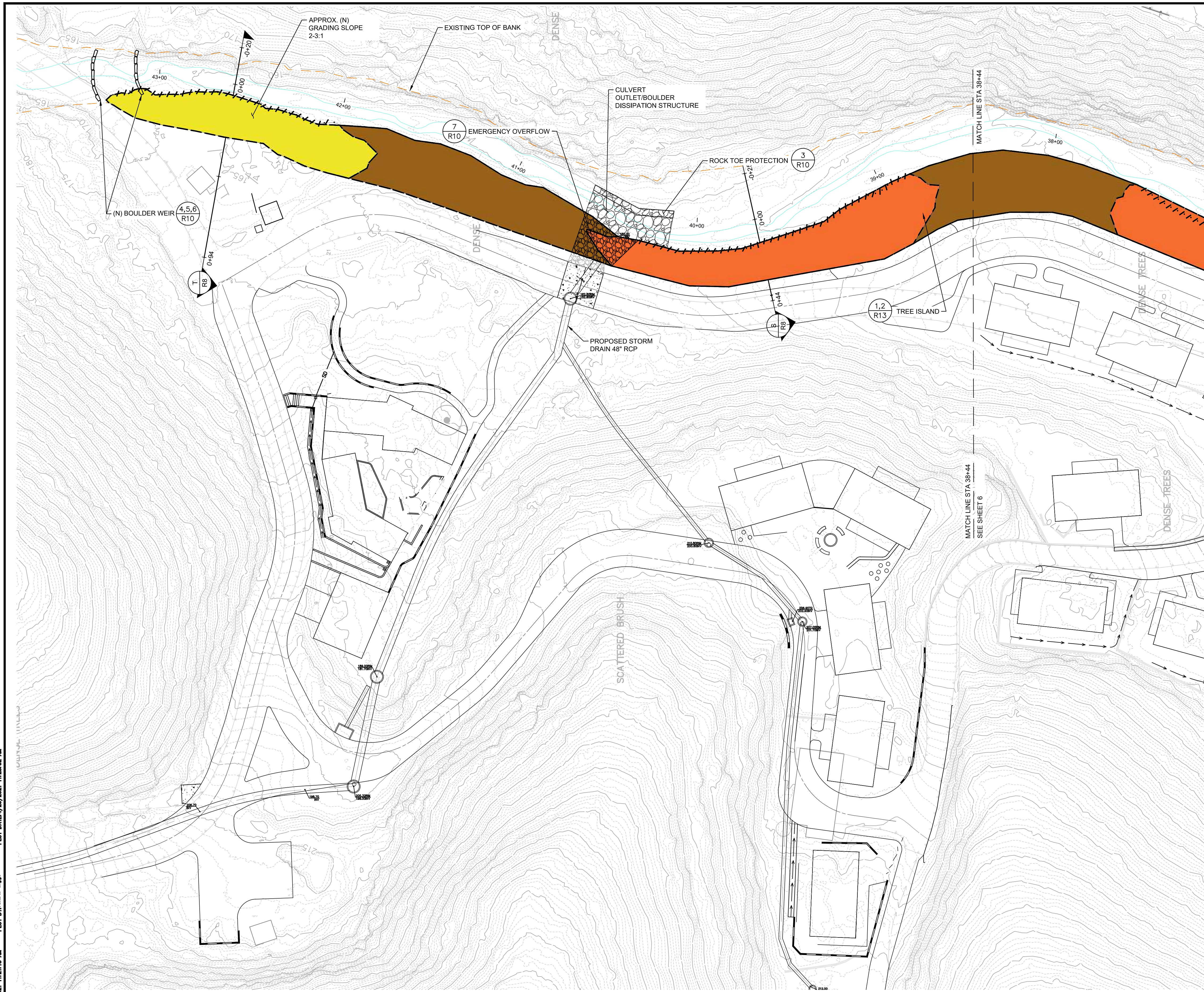
FIGURE 15 – ENHANCEMENT PLAN
CAMP HESS KRAMER/GINDLING HILLTOP CAMP
11495 & 11677 PACIFIC COAST HWY
WOOLSEY FIRE REBUILD
VENTURA COUNTY, CA

PRELIMINARY

STANTEC PROJECT NO.

SHEET 6 OF 7

PLAN DATE 03/03/2021



LEGEND

	(E) TOP OF BANK
	(N) ENHANCEMENT/STABILIZATION MEASURE
	(N) CHANNEL STRUCTURE/OUTFALL
	(N) VEGETATED ROCK SLOPE PROTECTION
	(N) BANK RECONSTRUCTION (PERMITTED PREVIOUSLY, 2018)
	(N) BOULDER TOE PROTECTION
	(N) LAYBACK AND REVEGETATE
	(N) SELECTIVE GRADING AND REVEGETATE
	(N) REMOVE DEBRIS AND REVEGETATE
	(N) REMOVE INVASIVES AND REVEGETATE
	FLOODPLAIN GRADING AND HABITAT PLANTING
	(N) MAJOR CONTOUR
	(N) MINOR CONTOUR
	(E) TREE
	(N) TREE ISLAND
	DETAIL NUMBER SHEET NUMBER
	CROSS SECTION NUMBER SHEET NUMBER

SCALE: 1"=20'
0 20 40 60

PRELIMINARY DESIGN – NOT FOR CONSTRUCTION

NO.	DATE	REVISION BLOCK	APPD.

PREPARED FOR:

PREPARED BY: ESA

PROJECT ENGINEER R.C.E. DATE

FIGURE 15 – ENHANCEMENT PLAN
CAMP HESS KRAMER/GINDLING HILLTOP CAMP
11495 & 11677 PACIFIC COAST HWY
WOOLSEY FIRE REBUILD
VENTURA COUNTY, CA

PRELIMINARY

STANTEC PROJECT NO.
SHEET 7 OF 7
PLAN DATE 03/03/2021

DESIGN CHECKED
42-ENG SAVE DATE 4/26/2021 11:21:15 AM PLOT BY:Amber Inggs PLOT DATE:4/26/2021 11:25:02 AM

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APPENDIX A
Particle Size Distribution Data

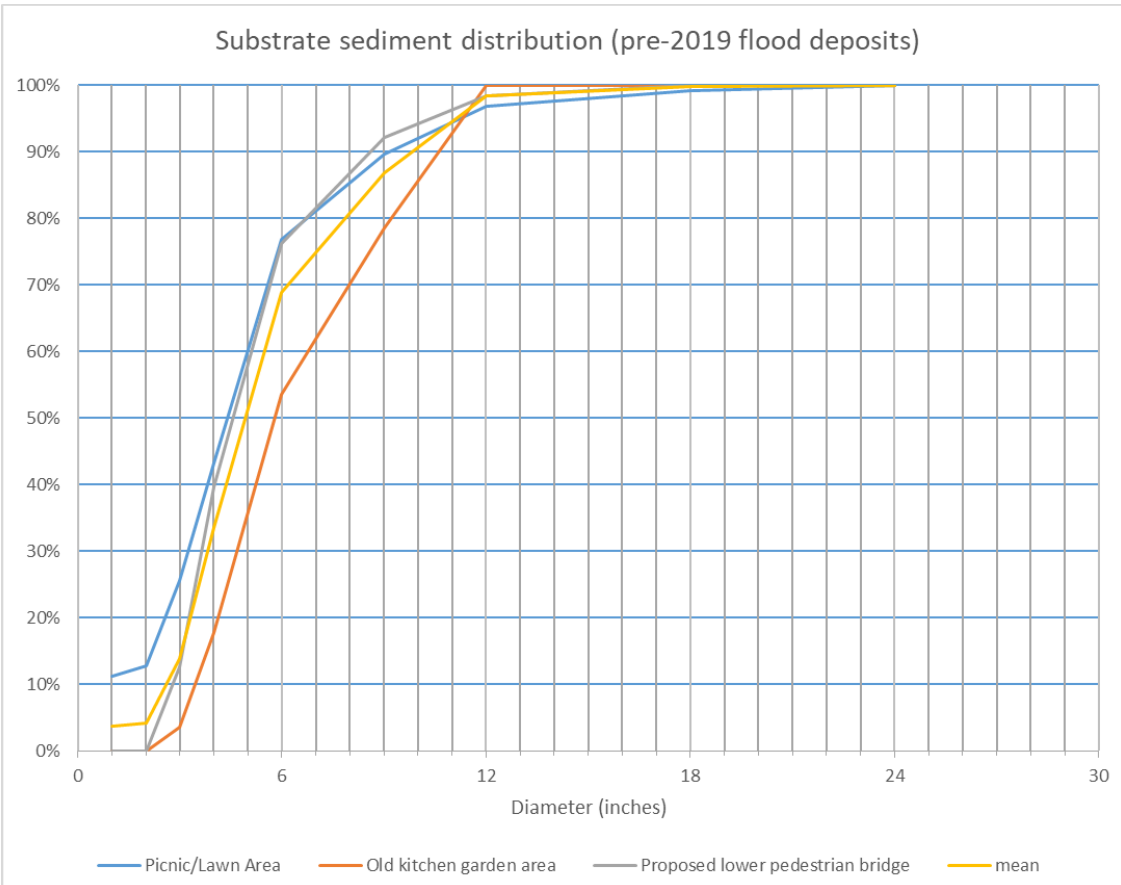
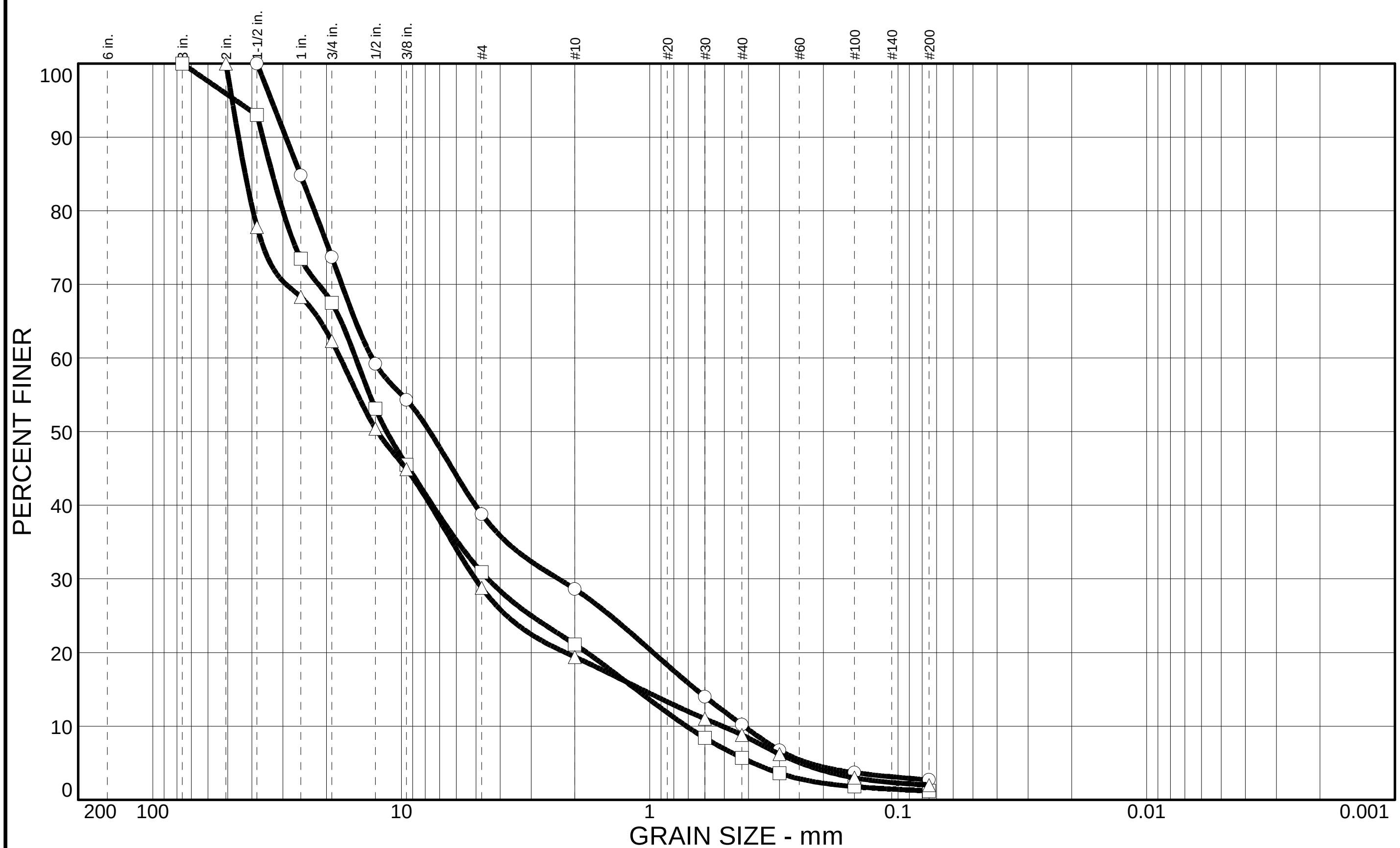


Figure A-1
Particle size distribution for coarse (pre-flood) channel bed

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		61.2	36.1	2.7					
□		69.1	29.7	1.2					
△		71.2	26.8	2.0					

SIEVE inches size	PERCENT FINER ○	□	△
3"		100.0	
2			100.0
1.5"	100.0	93.0	77.8
1"	84.8	73.5	68.3
3/4"	73.7	67.5	62.3
1/2"	59.2	53.1	50.4
3/8"	54.3	45.5	44.9
	GRAIN SIZE		
D_{60}	13.1	15.3	17.6
D_{30}	2.33	4.49	5.04
D_{10}	0.417	0.712	0.510
	COEFFICIENTS		
C_c	0.99	1.85	2.82
C_u	31.41	21.45	34.50

SIEVE number size	PERCENT FINER ○	□	△
#4	38.8	30.9	28.8
#10	28.6	21.1	19.4
#30	14.0	8.4	11.0
#40	10.2	5.7	8.8
#50	6.7	3.6	6.2
#100	3.7	1.8	3.0
#200	2.7	1.2	2.0

SOIL DESCRIPTION

○ Yellowish Brown Poorly Graded GRAVEL w/ Sand

□ Brown Well-Graded GRAVEL w/ Sand

△ Yellowish Brown Well-Graded GRAVEL w/ Sand

REMARKS:

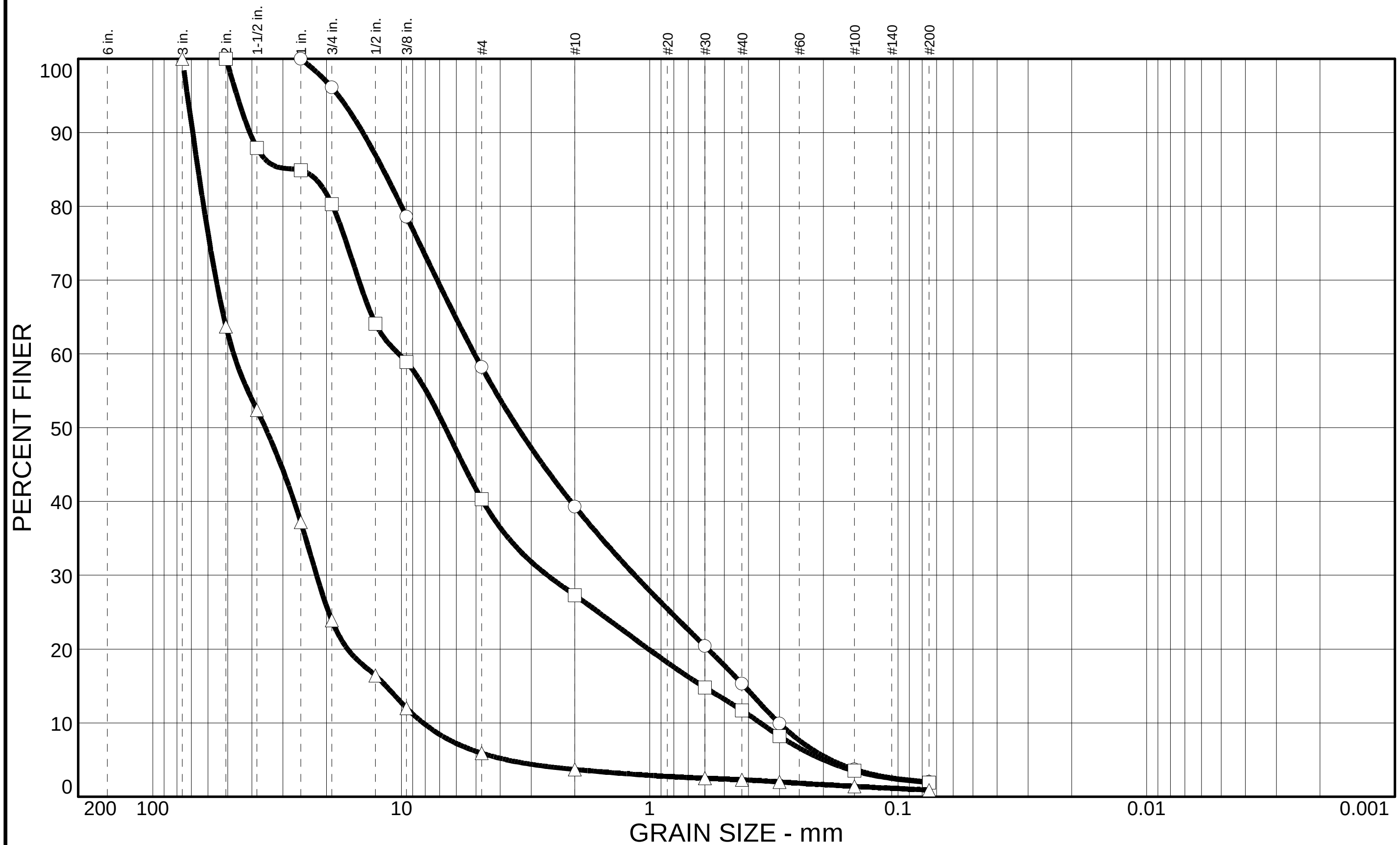
○ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.
□ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.
△ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

○ Source: 1
□ Source: 2
△ Source: 4

COOPER TESTING LABORATORY

Client: ESA
Project: Camp Hess Kramer - D201900176
Project No.: 381-038
Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		41.8	56.2	2.0					
□		59.7	38.4	1.9					
△		94.1	5.0	0.9					

SIEVE inches size	PERCENT FINER ○	□	△
3			100.0
2		100.0	63.7
1.5"		87.9	52.4
1"	100.0	84.9	37.2
3/4"	96.1	80.3	23.9
1/2"		64.1	16.4
3/8	78.6	58.9	12.0
	GRAIN SIZE		
D_{60}	5.08	10.2	47.3
D_{30}	1.15	2.58	21.9
D_{10}	0.302	0.359	8.18
	COEFFICIENTS		
C_c	0.86	1.81	1.24
C_u	16.80	28.51	5.79

SIEVE number size	PERCENT FINER ○	□	△
#4	58.2	40.3	5.9
#10	39.3	27.3	3.7
#30	20.4	14.8	2.5
#40	15.3	11.7	2.3
#50	9.9	8.2	2.0
#100	3.7	3.5	1.4
#200	2.0	1.9	0.9

SOIL DESCRIPTION

○ Brown Poorly Graded SAND w/ Gravel

□ Brown Well-Graded GRAVEL w/ Sand

△ Brown Well-Graded GRAVEL

REMARKS:

○ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

□ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

△ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

○ Source: 6

□ Source: 7

△ Source: 8

COOPER TESTING LABORATORY

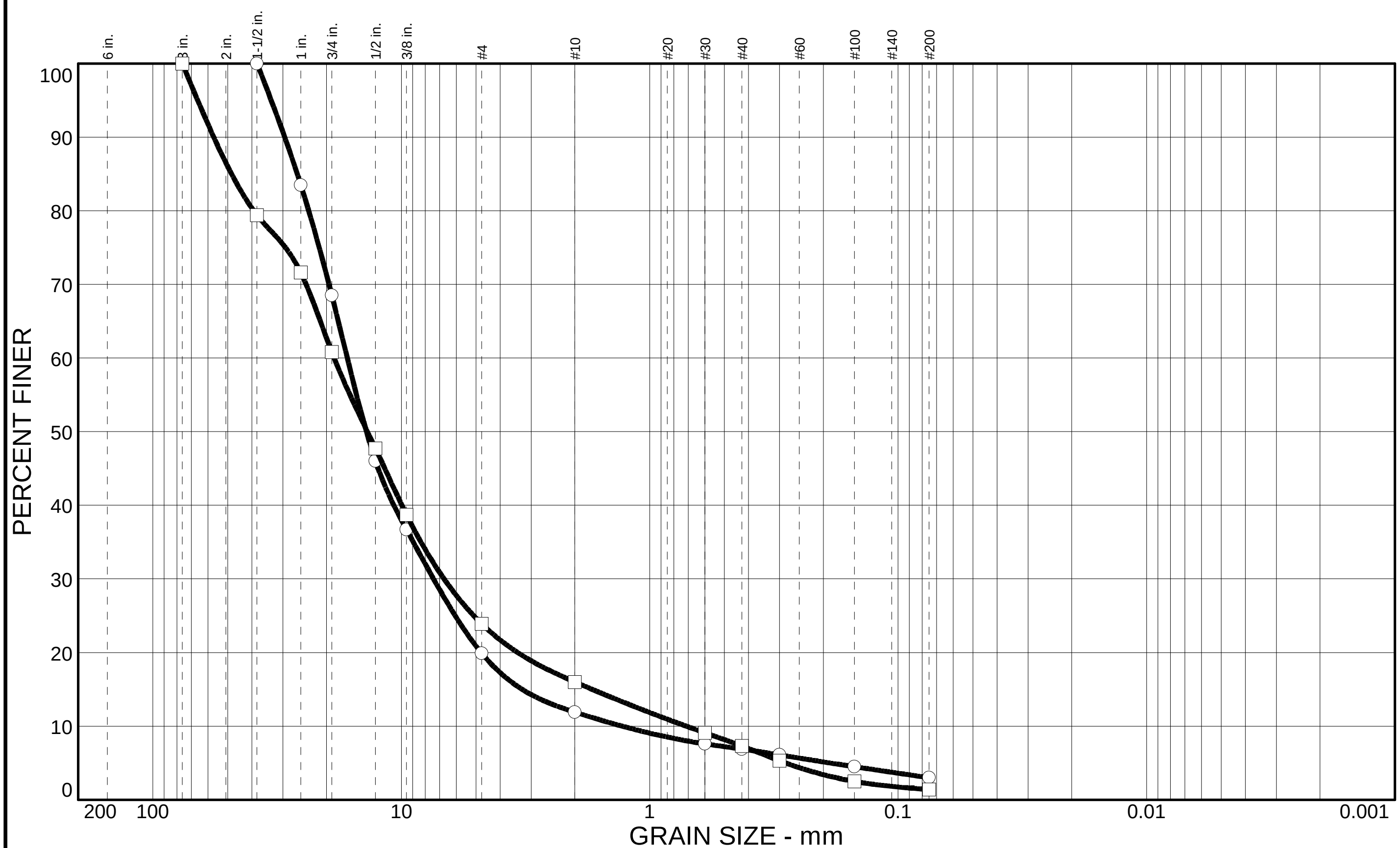
Client: ESA

Project: Camp Hess Kramer - D201900176

Project No.: 381-038

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		80.1	16.9	3.0					
□		76.1	22.5	1.4					

SIEVE inches size	PERCENT FINER ○	□	
3"		100.0	
1.5"	100.0	79.4	
1"	83.5	71.6	
3/4"	68.5	60.8	
1/2"	46.0	47.7	
3/8"	36.7	38.7	
	GRAIN SIZE		
D_{60}	16.5	18.6	
D_{30}	7.42	6.73	
D_{10}	1.29	0.713	
	COEFFICIENTS		
C_c	2.58	3.41	
C_u	12.79	26.15	

SIEVE number size	PERCENT FINER ○	□	
#4	19.9	23.9	
#10	11.9	16.0	
#30	7.6	9.1	
#40	6.9	7.3	
#50	6.1	5.3	
#100	4.5	2.5	
#200	3.0	1.4	

SOIL DESCRIPTION

○ Brown Well-Graded GRAVEL w/ Sand

□ Brown Poorly Graded GRAVEL w/ Sand

REMARKS:

○ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

□ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

○ Source: 9

□ Source: 10

COOPER TESTING LABORATORY

Client: ESA

Project: Camp Hess Kramer - D201900176

Project No.: 381-038

Figure