



Nason Creek, Phase 2 RM 3.7-4.6 Floodplain Enhancement 60% Basis of Design Report

SUBMITTED TO
Yakama Nation UCHRP

January 14, 2026

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Confederated Tribes and
Bands of the Yakama Nation
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1. Preface

The Nason Creek Floodplain Project is located along Nason Creek between RM 3.2 and RM 4.6 in Chelan County, WA, along Highway 207 on land owned by a private landowner, the U.S. Forest Service, Chelan County and a Washington Department of Transportation (WSDOT) right of way (Figure 1). One privately owned parcel is located within the project area at the downstream end, east of Highway 207. Yakama Nation staff are in discussions with a second private landowner near RM 3.2 at the downstream end of the project area about adding large wood structures along approximately 1,000 ft of Nason Creek for habitat enhancements and address concerns with lateral migration.

The valley bottom within the project area is bisected by Highway 207, which was constructed circa 1942. Construction of Highway 207 significantly reduced the size of the river migration corridor, resulting in a reduction in stream length. This compressed migration corridor, and shortened channel appears to have disrupted geomorphic equilibrium at the site, putting Nason Creek in an unbalanced state. Nason Creek has repeatedly damaged the highway embankment in three locations during flood events. An existing side channel near RM 3.3 to 3.75, which was likely the historical main channel, is located east of Highway 207, and is connected to Nason Creek via two culverts approximately 12-feet in diameter under the highway at the inlet and outlet of the side channel.

The project is broken into three phases.

- Phase 1 includes relocating approximately one-half mile of Highway 207 out of the Nason Creek floodplain between RM 3.9 and 4.5. Designs to relocate the road and associated utilities are being prepared by Perteet.
- Phase 2 includes stream habitat enhancements between RM 3.7 and 4.6.
- Phase 3 includes stream habitat enhancements between RM 3.2 and 3.6.

This report summarizes Phase 2 site conditions and 60% designs and plans.

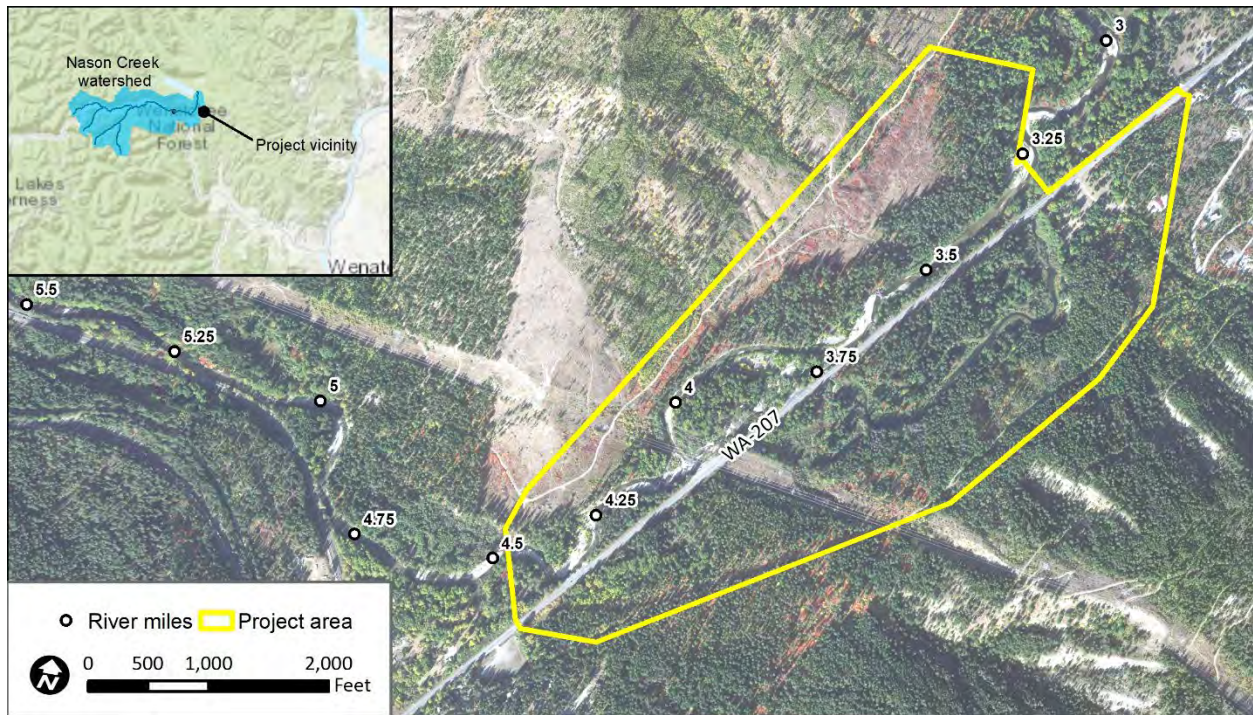


Figure 1. Nason Floodplain project area location.

The goal of the project is to create and enhance instream complexity and off channel aquatic habitats for salmon and steelhead, encourage floodplain connectivity, while also reducing river impacts to the Highway 207 embankment at three locations that have experienced repeated occurrences of erosion.

A number of alternatives for this project area were considered and documented by Inter-Fluve in a 2019 report. This current report documents 60% preliminary design for selected project features that are intended to enhance aquatic habitats while reducing conflicts between Nason Creek and Highway 207 for Phase 2 between RM 3.7 and 4.6 along the main stem, side channel and floodplain along the upstream half of the project area. Project elements for the downstream reach from RM 3.2 and 3.6 are documented in a Phase 3 report (Inter-Fluve, 2024) and will be updated in future design phases.

Currently, Nason Creek is contacting the Highway 207 road prism at three locations within the study area and has historically caused erosion of the road embankment. These locations have been designated as Chronic Environmental Deficiency (CED) sites by WSDOT. CED 1, 2 and 3 sites are located at RM 4.4, 4.1 and 3.7, respectively. CED 1 site is located at a mature meander bend near RM 4.4 (Figure 3b). CED 2 site is at an existing large and historically persistent log structure along the creek near RM 4.1 which directs a portion of Nason Creek flow into the highway embankment (Figure 2). CED 3 site is a riprapped bank along the road that appears stable. Both CED 1 and 2

locations have required emergency placement of rock by WSDOT to stabilize the road embankment. Phase 1 highway relocation will remove the road embankment at these two locations and allow restoration of a more natural geomorphic condition and dynamic stream processes.



Figure 2. Looking downstream at existing log structure, BPA powerlines, and Highway 207 CED 2 site near RM 4.1. Note riprap placed at right to reduce damage to highway embankment.

1.1 NAME AND TITLES OF SPONSOR, FIRMS AND INDIVIDUALS RESPONSIBLE FOR DESIGN

The project is sponsored by the Yakama Nation with Chris Butler as project manager. Inter-Fluve is the engineering design firm with Dan Miller (PE) the licensed engineer of record for this project and the main point of contact for Inter-Fluve.

1.2 LIST OF PROJECT ELEMENTS THAT HAVE BEEN DESIGNED BY A LICENSED PROFESSIONAL ENGINEER

Dan Miller (PE) is the licensed engineer of record for this project. Project elements include the following, with BPA HIP activity and risk category included:

Table 1. Activity categories and risk included in the Nason Floodplain project from RM 3.7 to 4.6.

Description of Proposed Enhancement	Work Element	HIP Category	HIP Risk Level
Relocate existing Highway 207 and remove road embankment, grade to adjacent floodplain elevations including microtopography, and creation of low flow channel and wetland areas. Place floodplain roughness and habitat wood along cut surfaces to reduce avulsion risk. Designs are not intended to prevent channel migration across the valley bottom.	Road relocation outside of floodplain	5b	Low
	Road embankment (levee) removal.	2b	Medium
	Create wetlands	2a	Medium
Place whole trees and large wood (LW) structures of various types in the main stem and side channels to increase hydraulic roughness for floodplain connection, instream habitats and encourage formation of vegetated gravel bars.	Improve floodplain interactions.	2a	Medium
	Install habitat forming instream structures	2d	Medium
Construct low flow/groundwater fed channel and create wetlands along road removal footprint	Improve secondary channel and floodplain interactions.	2a	Medium
	Create wetlands	2a	Medium
Provide separation of Highway 207 riprap-lined embankment from Nason Creek by creation of floodplain terrace with large wood fringe.	Install habitat-forming natural material instream structures	2d	Medium
Revegetation of all disturbed surfaces (designed and installed by others).	Riparian vegetation planting	2e	Low

1.3 IDENTIFICATION AND DESCRIPTION OF RISK TO INFRASTRUCTURE OR EXISTING RESOURCES

Existing infrastructure in the project vicinity includes Highway 207, two 12ft diameter corrugated metal pipe culverts under the road (RM 3.3 [Figure 3.A] and 3.75), miscellaneous existing concrete culverts ranging from 18" to 48" diameter located through the existing road embankment, a BPA powerline corridor which crosses Nason Creek at RM 4.1, miscellaneous overhead and buried utilities along Highway 207 and private residences downstream of the project area. Risk to Highway 207 is high and has historically been high under existing conditions, as evidenced by erosion damage at the three WSDOT CED sites (RM 3.7, 4.1 and 4.4) of the embankment incurred regularly during high-flow events. Relocating Highway 207 from RM 3.7 to 4.4 will move the highway out of harm's way from Nason Creek and eliminate CED 1 (RM 4.4) and CED 2 (RM 4.1) stream-road conflict areas. Risk to BPA powerlines is minimal because the towers are located outside of the present-day active channel and valley bottom. Risk to private residences is minimal because they are located on a higher terrace and well setback from the active channel.



Figure 3. Infrastructure within the project area includes (A) CMP culvert with concrete headwalls (RM 3.75) which provide connectivity to the side channel on the east side of the highway, and (B) Highway 207 (RM 4.4) which has been reinforced with rock in several locations and can be removed with highway relocation and allow hydrologic connection to historic floodplain areas.

1.4 EXPLANATION AND BACKGROUND ON FISHERIES USE (BY LIFE STAGE – PERIOD) AND LIMITING FACTORS ADDRESSED BY THE PROJECT

Current fish known to utilize the project area include ESA-listed spring Chinook (endangered), steelhead (threatened), Bull Trout (*Salvelinus confluentus*, threatened), species-of-concern Pacific Lamprey (*Lampetra tridentate*) and westslope cutthroat trout (*O. clarkii*), and non-listed summer Chinook, Coho Salmon (*O. kisutch*), mountain whitefish (*Prosopium williamsoni*), and non-native brook trout (*Salvelinus fontinalis*). Past redd counts show high Chinook Salmon and steelhead redd densities within the project area (Figure 4). The project reach is a low gradient reach with high quality spawning gravels located throughout.

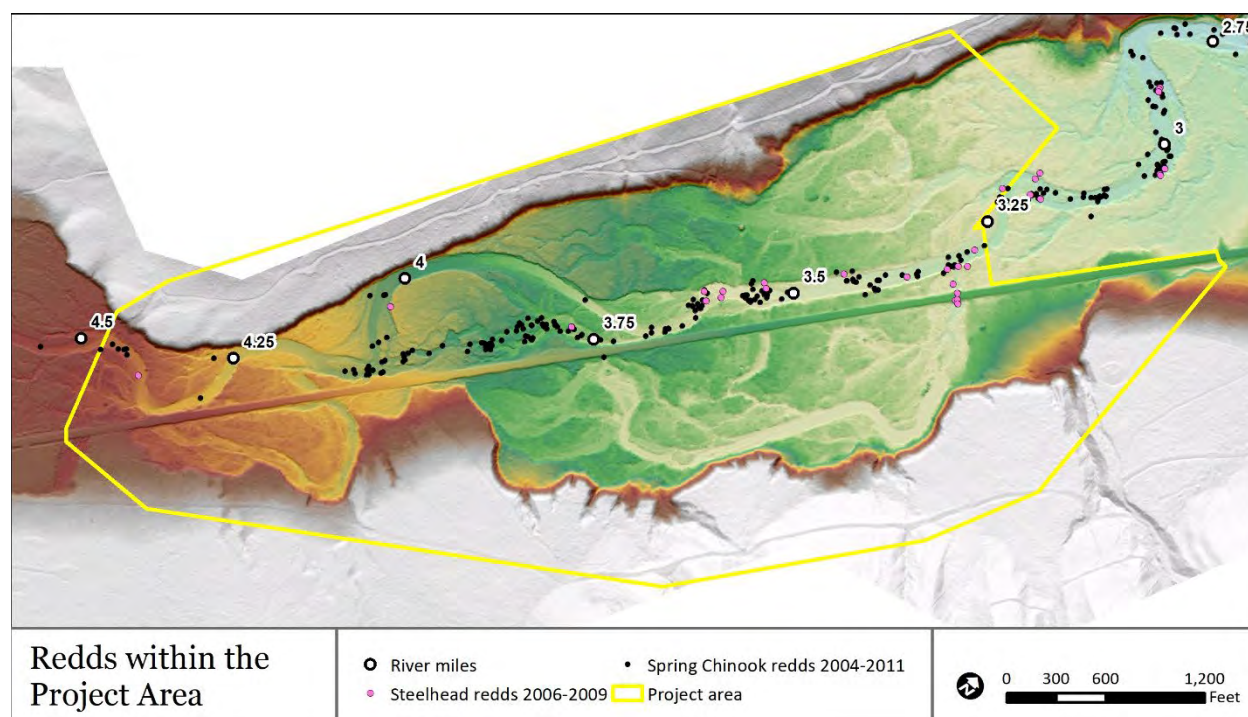
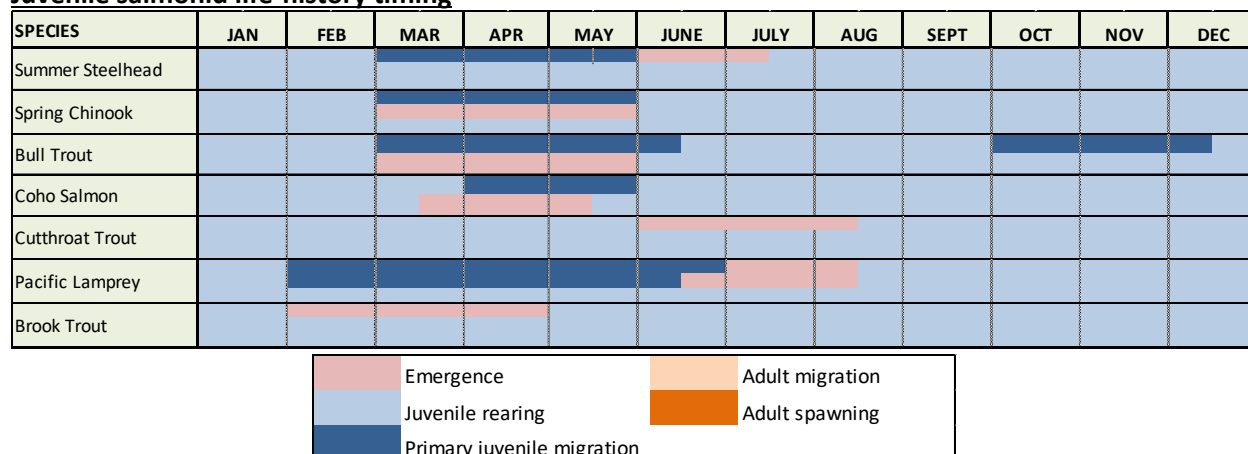
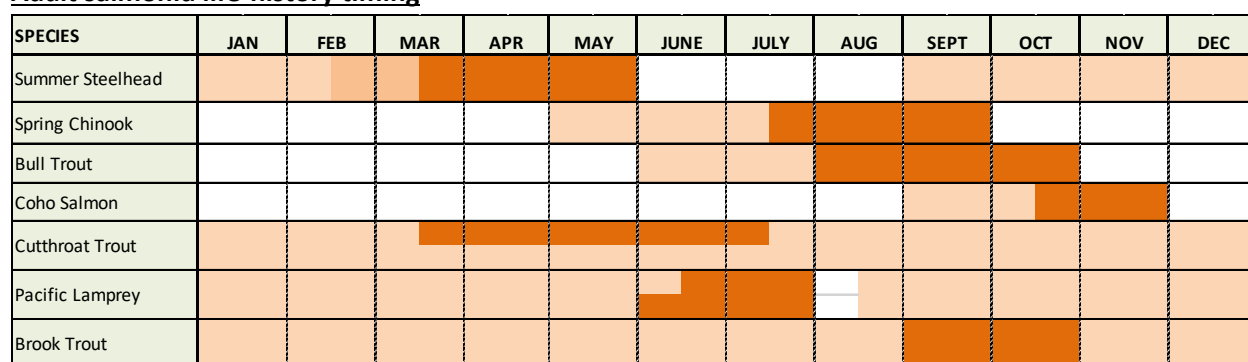


Figure 4. Steelhead and spring Chinook redds recorded in the project area for the specified years, displayed over LiDAR elevation data. The channel network is clearly visible in the LiDAR data. Redd data from Upper Columbia Salmon Recovery Board (2018).

According to the Subbasin Plan (NWPCC 2004), habitat in the project area has high potential to improve populations of aquatic species, including ESA-listed salmonids within the lower Nason Creek. Summary of life-history timing for aquatic species are presented below (Figure 5). Detailed descriptions of habitat requirements by life stage for ESA-listed species are included in the following sections.

Juvenile salmonid life-history timing**Adult salmonid life-history timing****Figure 5. Life history timing of target species within the project area.****1.4.1 Steelhead**

Adult steelhead enter the Wenatchee basin from August through April, holding in deep pools with overhead cover. Spawning begins in very late March, peaks in mid-April, and lasts through May. Egg survival is highly sensitive to intra-gravel flow and temperature (NWPCC 2004), and is particularly sensitive to siltation earlier in the incubation period (Healy 1991). Fry emerge from the redds 6-10 weeks after spawning (Peven 2003).

Age-0 juveniles spend their first year primarily in shallow riffle habitats, feeding on invertebrates and utilizing overhanging riparian vegetation and undercut banks for cover (Moyle et al. 2002, US Fish and Wildlife Service 1995). Age-0 steelhead use slower, shallower water than Chinook Salmon, preferring small boulder and large cobble substrate (Hillman et al. 1989). Older juveniles prefer faster moving water including deep pools and runs over cobble and boulder substrate (US Fish and Wildlife Service 1995). Juveniles outmigrate between ages one and three, though some hold over and display a resident life history form. Smolts begin migrating downstream from natal areas in March (NWPCC 2004).

1.4.2 Chinook Salmon

Adult spring Chinook enter the Wenatchee in May, holding in deeper pools with overhanging cover until water temperatures are suitable for spawning. Spawning typically begins in very late July, peaks in late August, and ends in late September (NWPCC 2004). Eggs are very sensitive to changes in oxygen levels and percolation, both of which are affected by sediment deposition and siltation in the redd (Healy 1991, Peven 2003). Fry emerge in June and July, which coincides with the rising hydrograph, forcing juveniles to seek out backwater or margin areas with lower velocities, dense cover, and abundant food (Quinn 2005). Fry are extremely vulnerable when they emerge, because their swimming ability is poor and flows are high. Near-shore areas with eddies, large woody debris, undercut tree roots, and other cover are very important for post-emergent fry (Hillman et al. 1989, Healy 1991). The proposed project features are expected to provide low velocity rearing habitat for post-emergent spring Chinook salmon fry because there are high redd densities immediately upstream, and the large woody material (LWM) features are on the outside of a meander bend and create scour pools where the majority of water and fry are expected to be during high flows (Figure 4).

As they increase in size, juveniles begin to select for deeper and faster moving water, particularly areas with overhanging cover (Moyle et al 2002b). These areas provide more holding and feeding habitat area for the larger juveniles to occupy. Upper-Columbia spring Chinook express a stream-type life history, meaning they rear in freshwater for at least one year before outmigrating as yearlings. Smolts begin migrating in March from natal areas (NWPCC 2004).



Figure 6. Chinook Salmon parr resting behind a constructed log structure in the Entiat River between feeding forays.

1.4.1 Bull trout

Nason Creek supports a population of resident and fluvial bull trout (NWPCC 2004). The project area is located in a reach of Nason Creek that is mapped as “possible bull trout spawning” in the Wenatchee Subbasin Plan (NWPCC 2004). Bull Trout spawn in the Wenatchee subbasin from August through October. Eggs incubate over the fall, winter, and spring, with fry emerging approximately 220 days after egg deposition. Juveniles select for margin habitat with overhanging cover, feeding primarily on aquatic insects until they grow larger and shift towards feeding on fish. Bull trout juveniles rear in headwater streams for at least two years before migrating downstream as adults or sub-adults to express fluvial life histories, or resident life histories in downstream reaches (McPhail and Baxter 1996). Downstream movement

of bull trout in the nearby Chiwawa River has been documented as bimodal, with one pulse in the spring and a second in the fall (NWPCC 2004).

1.4.2 Limiting factors

Regional objectives for salmonid habitat protection and restoration in the Upper Columbia Region have been evaluated and summarized in the document *A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region* (2017) by the Upper Columbia Salmon Recovery Board (UCSRB) Regional Technical Team (RTT). This Biological Strategy is part of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007) and recommends region-wide biological considerations and approaches for salmonid habitat restoration and protection actions. The RTT guides the development and evaluation of salmonid recovery projects within the Upper Columbia Region.

The Biological Strategy has identified several assessment units within the major watersheds of the Upper Wenatchee River. The Nason Floodplain project area falls within the Nason Creek Assessment Unit. Nason Creek is a Tier 1 watershed of highest priority for both protection and restoration.

All Chinook spawning that occurs in Nason Creek occurs in the lower 15 miles of the main stem, which also contains the poorest quality habitat (UCRTT 2017). The RTT has prioritized a list of restoration actions to address key ecological concerns in the Nason Creek Assessment Unit, and are listed below in priority order (UCRTT 2017):

1. **Peripheral and transitional habitat:** Reconnect side channels and off-channel habitat.
2. **Channel structure and form:** Increase large wood complexes, remove or modify levees and roads where feasible, restore channel structure and form to reduce sediment transport capacity to counteract recent incision and confinement.
3. **Riparian condition:** Improve riparian conditions to improve long term LWM recruitment.
4. **Channel structure and form:** Restore instream habitat diversity by enhancing large wood recruitment, retention, and complexity.
5. **Food**
6. **Sediment conditions:** Decommission roads that are affecting sediment delivery to the stream.
7. **Species interaction (competition)**

1.5 LIST OF PRIMARY PROJECT FEATURES INCLUDING CONSTRUCTED OR NATURAL ELEMENTS

Primary project features along the Phase 2 portion of the project from RM 3.7 to 4.6 consist of the following:

Remove existing Highway 207 and grade embankment to create floodplain and wetland areas:

Relocation of Hwy 207 and utilities is included in the Phase 1 portion of the project currently in design by Perteet, Inc. Relocation will allow removal of a portion of the existing road embankment and associated utilities along the abandoned length of highway, reestablishing floodplain elevations and floodplain side channel continuity. Portions of the abandoned road will be excavated to, or below adjacent floodplain to create a low flow/groundwater fed channel and adjacent wetland creation areas for additional complexity. Risk of avulsion along the road removal corridor will be reduced through selective grading and a dense placement of floodplain roughness wood and slash stabilized with log piles and log burial. Structures include: 1) **low flow floodplain roughness large wood structures**, 2) **low flow floodplain roughness large wood logs**, and 3) **low flow habitat wood**. Cut surfaces will be vegetated with appropriate wetland, riparian and upland species. Revegetation designs will be completed by others at future phases of the project.

- **Large wood installation:** A number of large wood structure types are proposed to be constructed in the main stem and side channel of Nason Creek to provide complex salmonid holding and rearing habitat, floodplain inundation, allow channel migration and manage risk of avulsion along the removed road at a range of flow conditions.
 - o **Apex jams:** are mid-channel structures intended to split flow, create scour and sediment deposition complexity to provide cover, rearing and spawning habitats. The structures are ballasted by burial in the stream bed with alluvial material, the face of the structures diverting flow energy away from the backfill materials. Log piles are included as supplemental ballast.
 - o **Inlet and bank buried log structures:** These are back fill ballasted structures built in the banks. Locations of structures were selected based on flow patterns to encourage scour and sediment deposition complexity, recruit floating debris, and enhance gaps in the riparian fringe. The structures are comprised of logs with rootwads, slash, whole trees and tree tops, which will be restrained by burial in the banks and backfill with alluvial material. Log piles installed with a vibratory pile driver will supplement ballast of racking type wood. Structures are included in the plans as **inlet jams**, **bank buried jams** and **small bank buried jams**.
 - o **Margin large wood structure:** These are partially buried and pile ballasted structures built against existing banks. Locations of structures were selected based on flow patterns to encourage flow energy complexity along the stream banks, scour and sediment deposition complexity, recruit floating debris, and enhance gaps in the riparian fringe. The structures are comprised of logs with rootwads, slash, whole trees and tree tops, which will be restrained by log piles installed with a vibratory pile driver and log ends buried into existing banks.

- o **Bar roughness jams:** are smaller structures comprised of partially buried logs with exposed rootwads. Burial will provide ballasting. Piles are included to aid in ballasting and recruiting debris. Slash is pinned under the rootwads. **Deflector jams** are similar structures, minus the partially buried logs. The intent of both structure types is to deflect flow and create lower energy areas downstream of the jam that will encourage deposition of fine sediments and formation of vegetated gravel bars. Racking of floating debris is encouraged to augment the function of these structures.
 - o **CED 2 existing jam:** an existing naturally occurring log jam is located under the BPA lines at CED 2 site. If clearance from the power lines allow, log piles will be installed along the edges as equipment reach allows without disturbing the existing jam. LW structures installed downstream of this jam along the side channel will have similar 'log drift' features by placing **racking wood** added to upstream face of individual structures to mimic this existing jam. The structures will provide ballasting of the racking wood.
 - o **Whole trees:** Whole trees are incorporated into many structures as shown on the plans as incidental item. Whole trees are anticipated to be sourced in part from on site salvage.
 - o **Floodplain roughness logs:** installed large wood restrained by bracing to existing trees will provide floodplain roughness across a meander bend at the upstream end of the project.
 - o **Tipped trees:** along an outside bank of a meander bend will provide hydraulic and habitat complexity. Candidate trees will be identified and pulled over using cables to reduce disturbance of bank and adjacent floodplain
 - **Bank habitat enhancements at existing riprap bank:** At the CED 3 (RM 3.7) site, bank habitat treatments are proposed to provide fish habitat, channel complexity and greater separation of flow from the highway where exposed riprap is currently armoring the road prism. The existing riprap would remain in-situ under the new bank treatment to serve as a failsafe protection for the highway embankment. Bank treatments include:
 - o Creation of floodplain terraces with large wood as shown in the plan set. Bank habitat includes constructing a series of meander bend structures along the length of the riprapped bank. These structures would be constructed of logs with rootwads, logs without rootwads, whole trees, log piles, and slash, and backfilled with large alluvial material and rounded alluvial small boulder material. The results would be to create a floodplain terrace ranging about 25 to 30 feet wide along the existing bank, with about 10 to 15 feet of LWM exposed to active flow. The fill would be revegetated with native live willow, dogwood and cottonwood cuttings, riparian trees and shrubs. Revegetation is planned to be designed by Yakama Nations revegetation consultant.
 - o To maintain channel flow conveyance, the opposing gravel bar on river left would be excavated to maintain a similar flow conveyance area and graded to blend to existing topography. The excavated bar material would be salvaged, sorted by size and used as log structure backfill. Nason Creek has dynamic sediment transport conditions with actively shifting gravel bars and is expected to transport material from the gravel bar naturally in response to encroachment into the main stem by the terrace. Excavation anticipates this future condition. Stream riffle and pool conditions are anticipated to be
-

- similar to existing conditions, with habitat improvement by converting river right bank from a riprap condition to riparian margin with large wood condition.
- **Wetland, riparian and upland revegetation:** Native species will be planted in all disturbed areas to promote riparian function and increase food production and habitat complexity for target species. The planting plan will be developed separately in a future phase by Yakama Nation's planting consultant.

1.6 DESCRIPTION OF DISTURBANCE INCLUDING TIMING AND AREAL EXTENT AND POTENTIAL IMPACTS ASSOCIATED WITH IMPLEMENTATION OF EACH ELEMENT

Project disturbance at the site will be from excavation and temporary access routes used to remove portions of the existing road embankment and revetment, install large wood structures, and install plantings. Access to many sites will be along the abandoned road alignment. Trees and vegetation removed during excavation will be salvaged and used to supplement constructed large wood habitat structures. Disturbance during construction to large trees and riparian zones will be minimized, and all disturbed areas will be re-vegetated.

2. Resource inventory and evaluation

2.1 DESCRIPTION OF PAST AND PRESENT IMPACTS ON CHANNEL, RIPARIAN AND FLOODPLAIN CONDITIONS

Riparian and floodplain conditions in the project site and vicinity have been impacted most heavily by the construction of Highway 207 circa 1942 along the Nason Creek floodplain. The circa 1900 plat map indicates that the main stem of Nason Creek used to occupy the southeast side of the floodplain (Figure 7). The 1957 aerial shows Nason Creek in an alignment with planform similar to – though west of – what is seen today, and the BPA power corridor is also visible. Logging in the vicinity, and associated road building, has had impacts on large wood recruitment and sediment delivery to Nason Creek. Construction of the highway has reduced total off channel habitat connectivity, disconnected floodplain areas, and constricted channel migration zones, concentrated more flow into the main stem, and shortened overall channel length by cutting off a historical meander that is depicted in the circa 1900 plat map.

2.2 INSTREAM FLOW MANAGEMENT AND CONSTRAINTS IN THE PROJECT REACH

Not applicable to this project.

2.3 DESCRIPTION OF EXISTING GEOMORPHIC CONDITIONS AND CONSTRAINTS ON PHYSICAL PROCESSES

Figure 7, Figure 8, and Figure 9 show historical aerial imagery of the project area vicinity from 1957, 1963, 1974, 1991, 2006 and 2015. The 1942 Road Relocation plans include an indication of the Nason Creek alignment that appears similar to the 1957 photos. While in general the meandering plan form and bend locations are similar over the photographic history, the channel has migrated eastward closer to the highway. There appears to be a vegetated floodplain approximately 80- and 150-feet wide from the edge of Highway 207 to the right river bank at RM 4.4 and 4.1, respectively, in the 1942 plans (Chelan Co, 2012) and 1957 photos. It appears that Nason Creek encroached on to the road embankment during the time interval between the 1974 and 1991 photos. The side channel along the west side of highway between RM 3.7 to 4.1 is evident in all photos.

The Highway 207 embankment has prevented or limited flow to the east floodplain, leading to fewer off channel and side channel habitats. No pre-development survey is available to determine whether and to what degree incision may have occurred, however it is believed that this unnatural confinement has led to some level of incision (UCRTT 2017).

Nason Creek delivers a dynamic supply of substrate and wood to the project reach. Areas of wood accumulation exhibit defined scour pools and sediment deposit tail spills creating diverse habitats. The numbers and locations of redds mapped (Figure 4) indicate that diversity of LWM and bed forms provide spawning habitats.

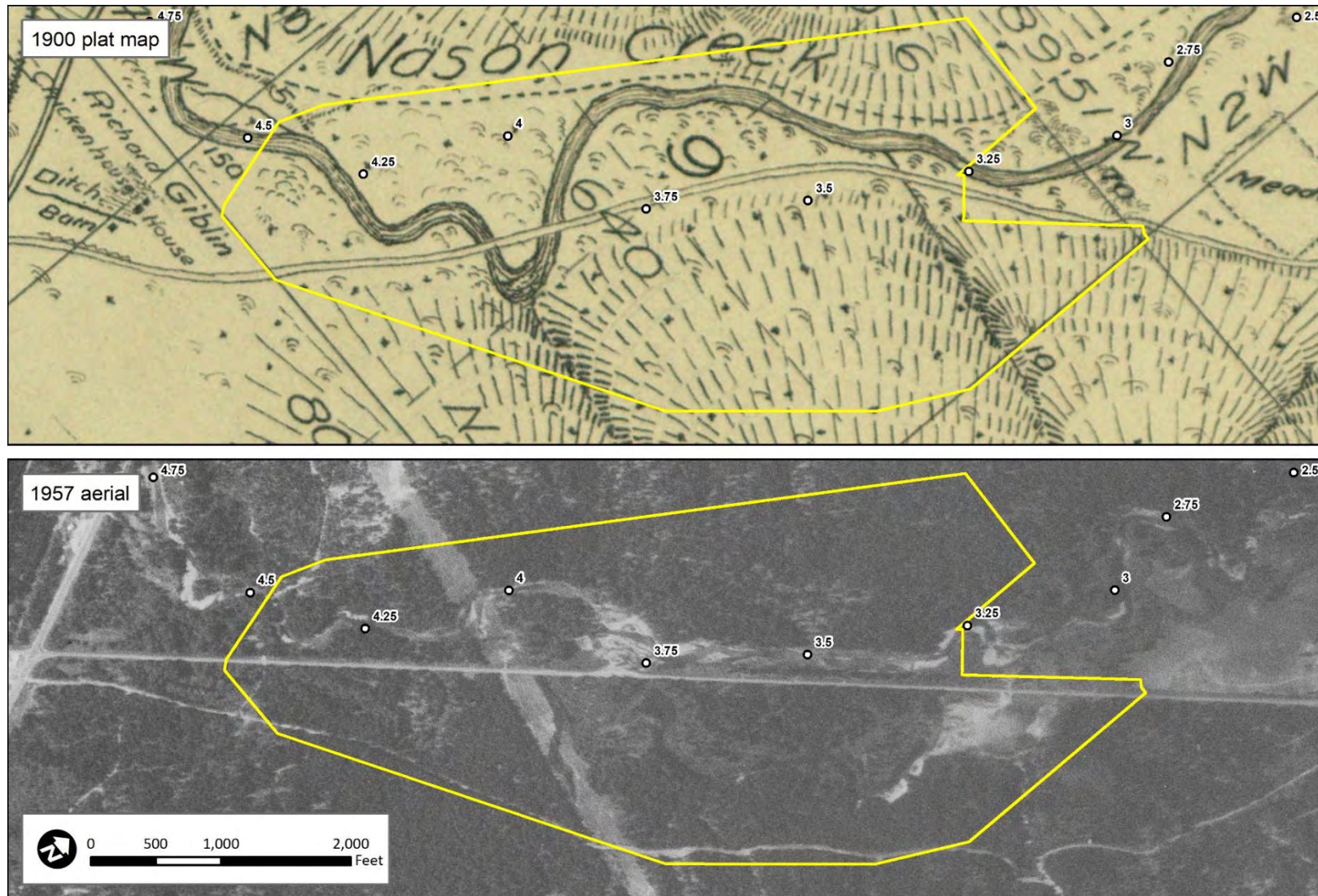


Figure 7. Historical plat map from 1900 and aerial image from 1957, project area boundary shown in yellow.

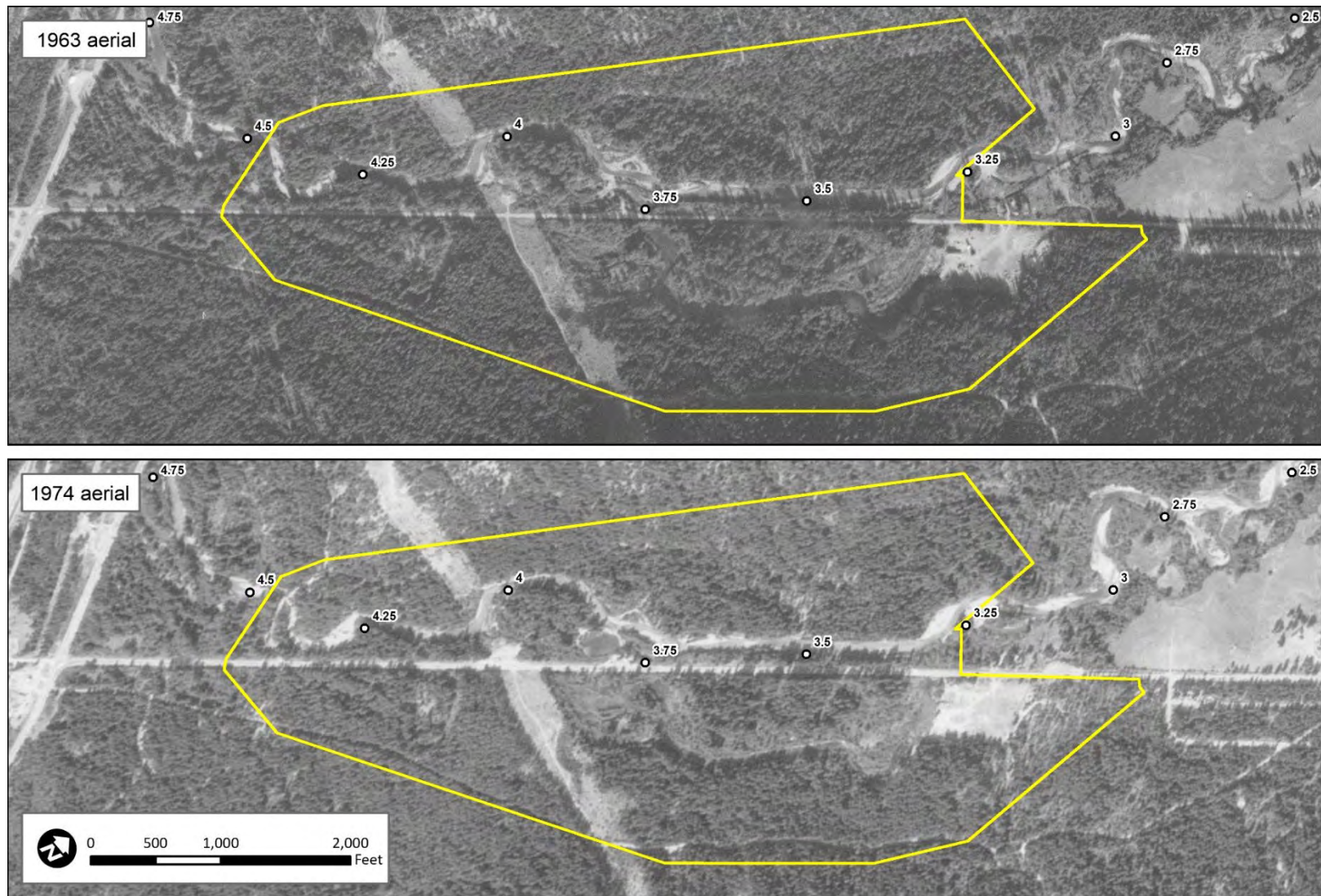


Figure 8. Aerial images from 1963 and 1974, project area boundary shown in yellow.

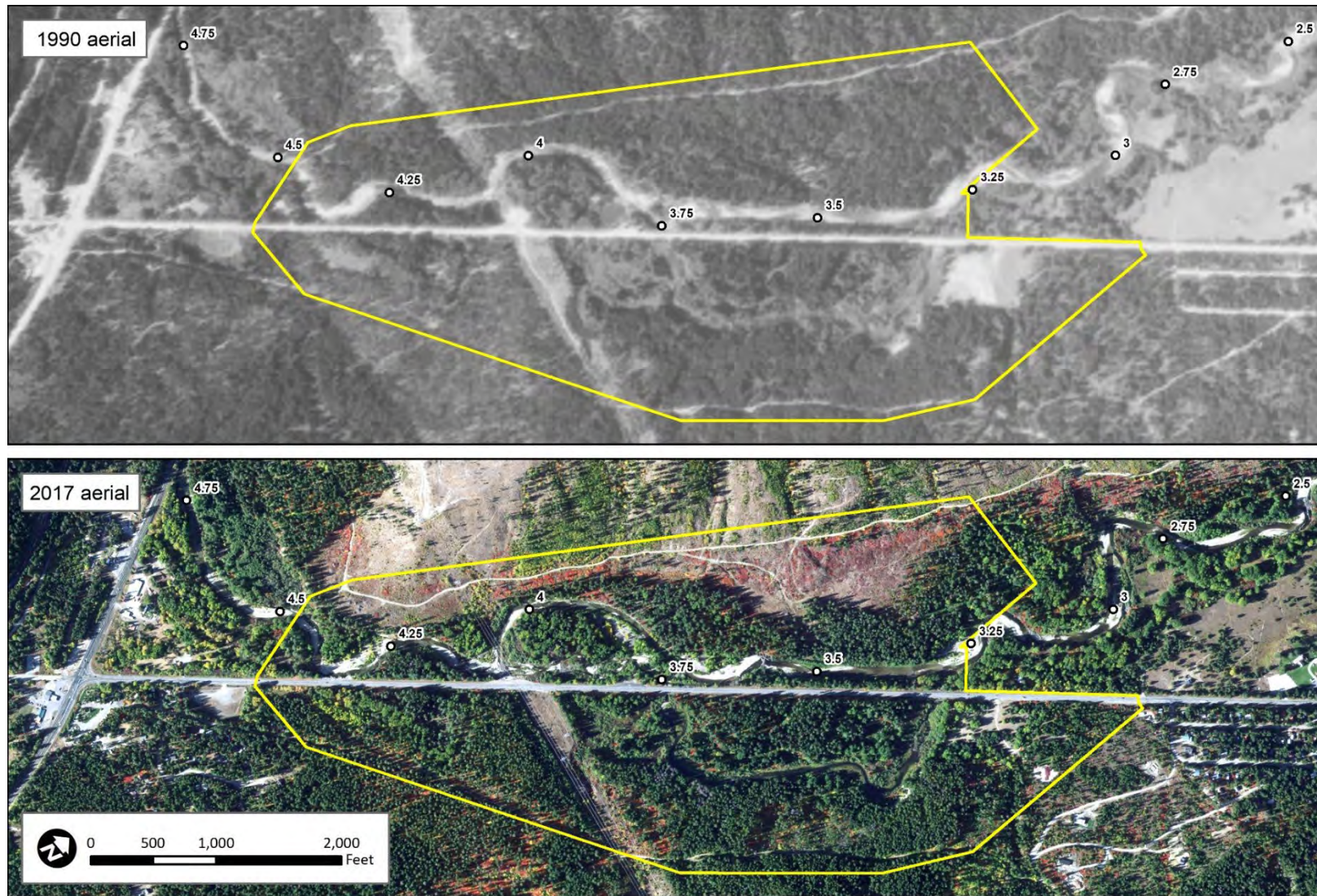


Figure 9. Aerial images from 1990 and 2017, project area boundary shown in yellow.

2.4 DESCRIPTION OF EXISTING RIPARIAN CONDITION AND HISTORICAL RIPARIAN IMPACTS

Riparian conditions in the project area are generally good. The forest is a mixed-age stand of Ponderosa Pine, Douglas fir, willow, dogwood and cottonwood. Typically, conifers occupy higher elevation terraces that have not been disturbed by river activity for a number of decades. Deciduous trees and woody shrubs occupy the riparian zones and areas disturbed by river migration in the recent past. Coniferous trees have been removed along the BPA power line corridor and recently logged at the western edge of the river left floodplain from approximately RM 3.2-3.7. Wetlands were delineated by Hamer Environmental and documented in January 2021 and January 14, 2022 reports.

2.5 DESCRIPTION OF LATERAL CONNECTIVITY TO FLOODPLAIN AND HISTORICAL FLOODPLAIN IMPACTS

Nason Creek historically had high floodplain connectivity with a myriad of off-channel wetlands, alcoves, and channels. This complexity was likely enhanced by large wood accumulations and beaver ponds. The current highway embankment and culvert system have reduced floodplain connectivity and eliminated lateral channel migration to the east of the highway by limiting water movement onto floodplain surfaces to areas east of the highway. Approximately 40.7-acres of active side channel, wetlands and floodplain are located east of the highway RM 3.3-3.9. Approximately 10.9-acres of inactive side channel, wetlands and floodplain are located east of the highway RM 4.15-4.4; which can be available to flow and channel migration with proposed highway relocation. The reduced floodplain width constricted by the highway embankment has reduced the available migration corridor.

2.6 TIDAL INFLUENCE IN PROJECT REACH AND INFLUENCE OF STRUCTURAL CONTROLS (DIKES OR GATES)

Not applicable to this project.

3. Technical data

3.1 INCORPORATION OF HIP SPECIFIC ACTIVITY CONSERVATION MEASURES FOR ALL INCLUDED PROJECT ELEMENTS

HIP conservation measures are included in preliminary project plans. If necessary, requests for variances will be submitted for any conservation measures that cannot be met.

3.2 SUMMARY OF SITE INFORMATION AND MEASUREMENTS (SURVEY, BED MATERIAL, ETC) USED TO SUPPORT ASSESSMENT AND DESIGN

3.2.1 Elevation data

A detailed topographic/bathymetric LiDAR data set collected in 2022 for the river corridor was supplemented with 2015 topographic LiDAR data set for floodplain areas was used to create an existing conditions surface and HEC-RAS model terrain. All data are referenced to the Washington State Plane North coordinate system, the NAVD88 vertical datum and US feet.

3.2.2 Fish use

Fish use data were collected from primary literature, the Wenatchee Subbasin Plan (NWPCC 2004), and the Upper Columbia biological strategy (UCRTT 2017).

3.2.3 Geomorphic data

A pebble count survey was conducted in the project area to evaluate existing substrate conditions. See section 3.4.

3.2.4 Hydrology data

Washington Department of Ecology (WDOE) records flows along Nason Creek at gage 45J070 located near the mouth. The WDOE gage has a period of record from 2002 to the present and is reported to have some inconsistencies – thus was not used solely for estimating flood peak flows. The WDOE gage does provide useful information on seasonal flow variation during the available period of record.

The USGS maintains a stream flow gage on nearby Icicle Creek (USGS Gage #12458000) which has a period of record from 1937 to present. The Icicle Creek watershed has many similarities to the Nason Creek watershed and is viable as a paired watershed to understand Nason Creek hydrology. The Icicle Creek data was used for paired watershed analyses for a number of studies including the U.S. Bureau of Reclamation Nason Creek Tributary Assessment (BOR, 2008).

No field flow measurements were collected for this preliminary analysis.

3.3 SUMMARY OF HYDROLOGIC ANALYSES CONDUCTED, INCLUDING DATA SOURCES AND PERIOD OF RECORD INCLUDING A LIST OF DESIGN DISCHARGE (Q) AND RETURN INTERVAL (RI) FOR EACH DESIGN ELEMENT

3.3.1 General Hydrology

Nason Creek drains high-elevation areas of the Chiwaukum Mountains and has a snowmelt-dominated hydrologic regime. Figure 10 shows typical seasonal median, high, and low exceedance flows for Nason Creek at RM 12.

Although peak flows typically occur due to snowmelt in the late spring or early summer, some of the largest floods have occurred from rain-on-snow events in late fall. Large past flood events occurred in May 1948, November 1990, November 1995, and November 2006. As noted in Chelan County's Feasibility Study (2012), the November 1995 event washed out portions of Highway 207. As of 2011, three repairs to the highway embankment in 10 years at this location led to nomination for the WSDOT Chronic Environmental Deficient (CED) program.

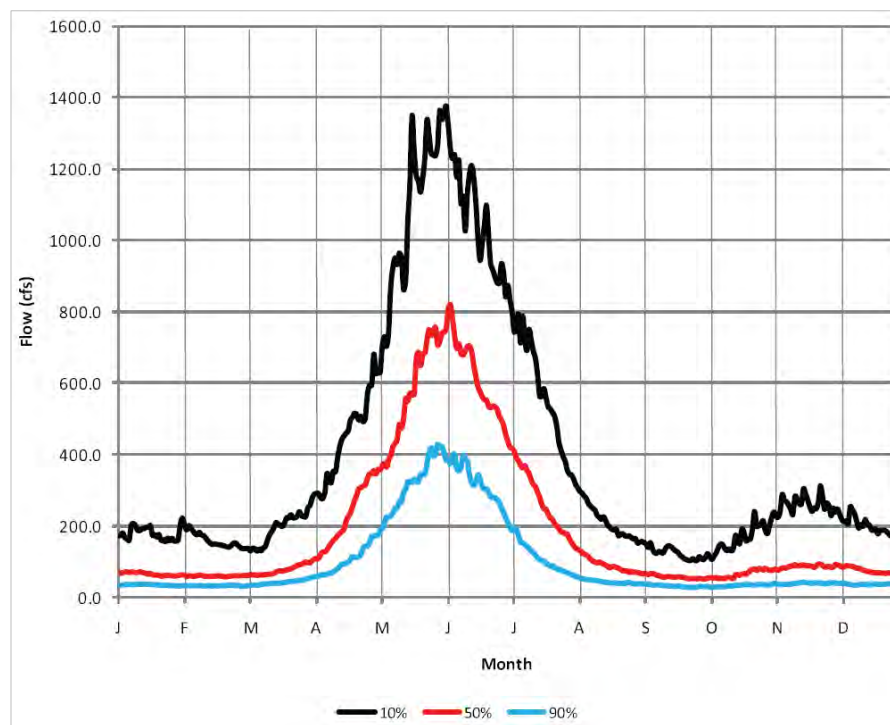


Figure 10. Modeled 10 percent, 50 percent, and 90 percent exceedance flows for RM 12 using data from 7 regional gages. Percentile flows represent the daily flow that is equaled or exceeded for the given percentage of time over the available period of record. Reprinted from Malmon (2010).

3.3.2 Peak Flow Hydrology

As noted in Section 3.2.4, Washington Department of Ecology operates gage 45J070 near the mouth of Nason Creek since 2002, but no long-term stream gage record is available on Nason to reliably estimate peak flows for the project reach. The US Bureau of Reclamation Nason Creek Tributary Assessment (Reclamation, 2008) completed a flood event peak flow analysis using data recorded at the nearby Icicle Creek USGS gage and considers the WDOE peak flow values. The Reclamation estimated flood magnitudes are presented in Table 2. These flows were used in the project hydraulic model.

Table 2. Peak flow estimates for Nason Creek at RM 4.0 (Reclamation, 2008. Appendix D, Table 5)

Recurrence Interval (years)	Estimated flow at RM 4 (cfs)
2	2,600
5	3,900
10	4,900
25	6,500
50	7,900
100	9,400

3.4 SUMMARY OF SEDIMENT SUPPLY AND TRANSPORT ANALYSES CONDUCTED, INCLUDING DATA SOURCES INCLUDING SEDIMENT SIZE GRADATION USED IN STREAMBED DESIGN

There are some bed rock expressions in the stream bed, banks and valley wall along the west edge of the Nason Creek flood plain. Occasional boulders that are not mobile during normal flood flows have been delivered to the valley bottom during much larger glacial outwash flows and delivered to the contemporary channel by being eroded out of the adjacent outwash terraces or exhumed as Nason Creek eroded down through the post glacial outwash. Upstream of the project reach, a number of actively eroding streambanks are seen which supply a significant volume of mobile sized sediments to the project reach. Placed riprap occurs at three locations along the Highway 207 embankment, some of which has moved downstream along the streambed a short distance.

With this understanding, substrate measured by the pebble count is a good approximation of mobile bedload sized sediments transported through the project reach and found in alluvial formed bed, bar and bank deposits. Wolman pebble counts were completed in Nason Creek near RM 4.45 to help estimate sediment particle sizes moving into and through the project reach. Pebble counts were performed at two locations along the river right bar surfaces at the crest (Figure 11.A) of a riffle and along the edge of the same riffle (Figure 11.B) to capture the range of substrates observed.

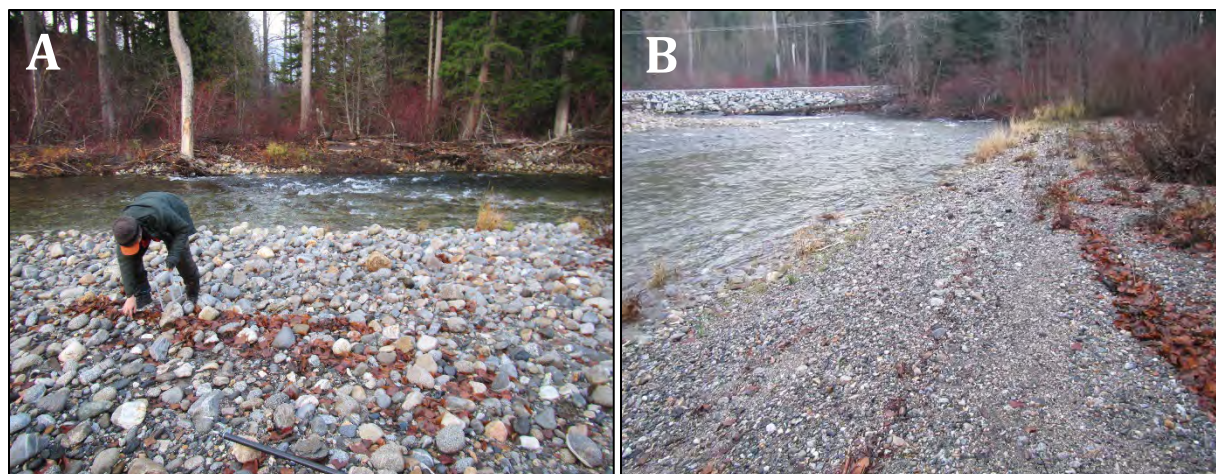


Figure 11. Location of pebble counts performed on Nason Creek. A) GC01 was performed on a gravel bar adjacent to a riffle, on river right of Nason Creek. B) GC02 was performed on a bar adjacent to a riffle on river left.

Results of the pebble count provide a grain size distribution. GC01 contained coarser material compared to GC02, with a d50 best described as very coarse gravel (Figure 12). Some sand and finer gravels were found within the interstices of larger material. GC02 contained finer material with a d50 best described as medium gravel.

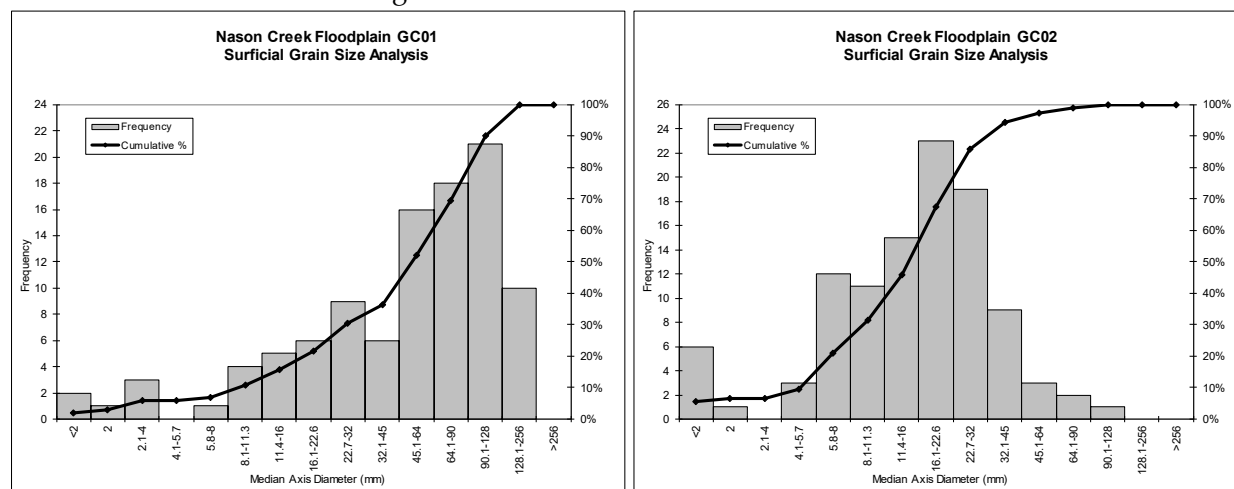


Figure 12. Grain size distribution at GC01 and GC02 based on Wolman pebble counts.

3.5 SUMMARY OF HYDRAULIC MODELING OR ANALYSES CONDUCTED AND OUTCOMES – IMPLICATIONS RELATIVE TO PROPOSED DESIGN

3.5.1 Hydraulic Modeling

The U.S. Army Corps of Engineers HEC-RAS 6.6 (USACE, September 2024) two-dimensional (2D) hydraulic model was used to develop model runs for existing and proposed conditions for the overall Nason Floodplain project reach. Existing conditions model geometry was copied and runs representing design features from RM 3.7-4.6 prepared. HEC-RAS computes hydraulic properties related to the physical processes governing water flow through natural rivers and other channels. Model runs for both existing and proposed conditions were used to assess the current and proposed channel dynamics, as well as assess the overall impacts of a wide range of flows on the existing landscape with and without the proposed design improvements.

The following sections describe the capabilities and limitations of HEC-RAS 6.6 and document the development and output processing of the project existing and proposed conditions models.

3.5.2 Model Capabilities and Limitations

HEC-RAS 6.6 was used in its two-dimensional (2D) unsteady flow simulation mode with the capacity to model the complex flow patterns, on-site water storage, spatial variation of hydraulic roughness and temporally variable boundary conditions. The 2D hydraulic model calculates depth averaged water velocities (including magnitude and direction), water surface elevation, and mesh cell face conveyance throughout the simulation. Other hydraulic parameters such as depth, shear stress, and stream power can be calculated by the model following completion of the simulation.

3.5.3 Model Extent

The downstream extent of the model is near RM 2.9 about 1,750 feet downstream of the lower project boundary. The upstream extent is near RM 4.9 about 3,000 feet upstream of the upper project boundary. Width of the model is valley wide, encompassing channel and floodplain including east of the existing Highway 207. The overall mesh coverage is shown in Appendices C and D.

3.5.4 Model Terrain

The existing conditions model terrain was developed using 2022 bathymetric/topographic LiDAR (USBR 2022) combined with 2015 LiDAR (Quantum Spatial 2016). The LiDAR provided a 1 meter (3.28 feet) horizontal resolution bare earth digital elevation model (DEM) raster for the entire site, including floodplain areas and valley hillslopes. The 2022 LiDAR dataset includes topographic and bathymetric surfaces for the river corridor. The 2015 LiDAR dataset was used to represent the floodplain and hillslopes beyond the limits of the 2022 LiDAR coverage. No transitional buffer between the two LiDAR datasets was used, occasionally resulting in minor surface discontinuities. The proposed condition model terrains were copied from the existing conditions terrain and

modified to incorporate the design grading surfaces. Large wood structures were represented in the model as regions of extremely rough Manning's n coefficient values. The model terrains are projected on the Washington State Plane North Zone, North American Datum 1983 (NAD83), coordinate system with US feet distance units. The terrain elevations are in US feet relative to the North American Vertical Datum of 1988 (NAVD88).

3.5.5 Model Geometry

The 2D model geometry used a 40-ft square computational mesh for the entire area of interest with smaller mesh size for greater resolution along the main stem, side channels and road embankment. . A zoomed in view of the mesh shows an example of mesh detail as shown in Figure 13. The overall and example of mesh detail for existing conditions as seen in Appendix C. The modeling capabilities of HEC-RAS 6.6 integrates the sub-grid terrain into the computations and projects the results accordingly. The proposed conditions model domain mesh is seen in Appendix D.

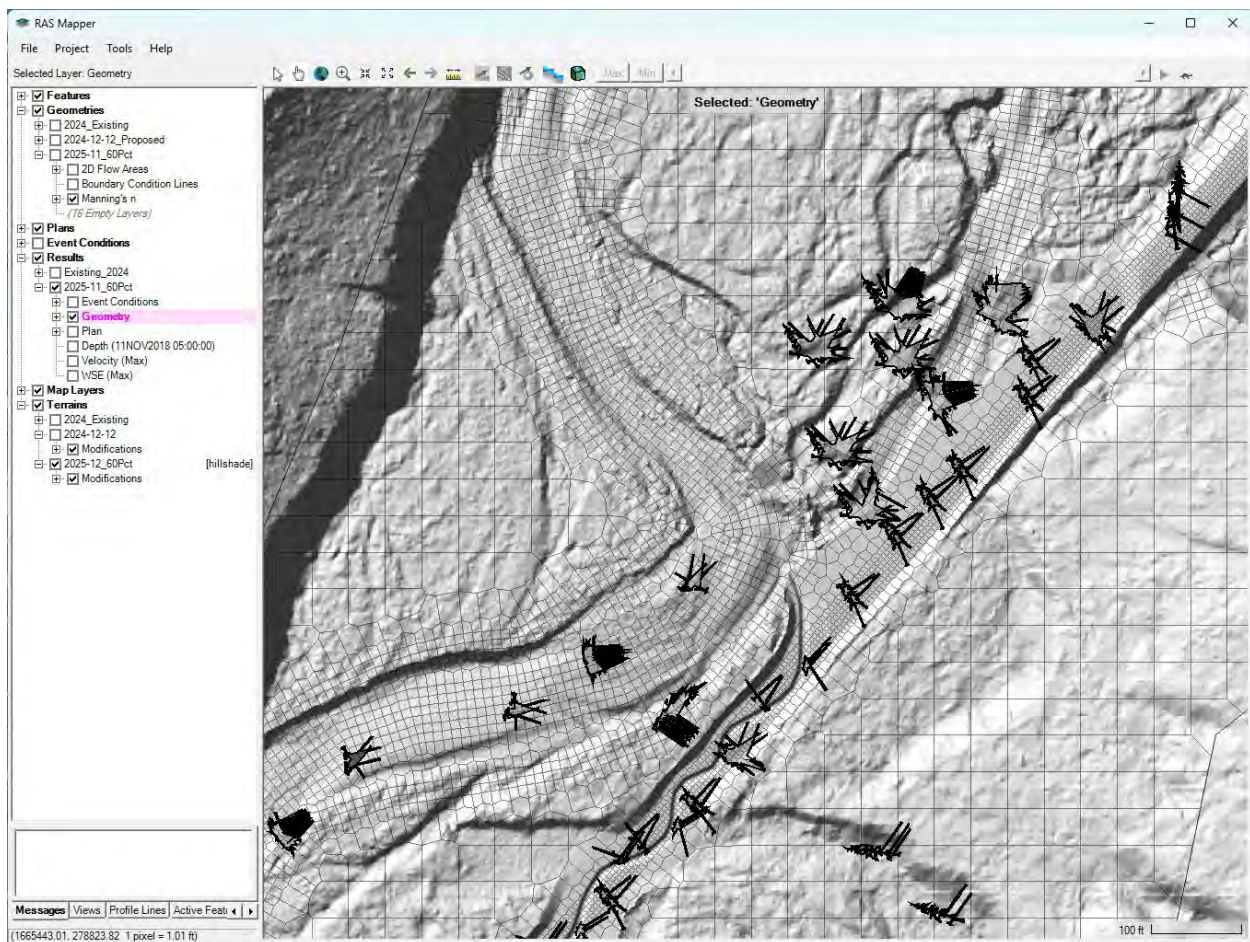


Figure 13. Detailed view of proposed conditions model mesh.

3.5.6 Model Roughness

Roughness coefficients (Manning's n values) are used by the 2D model to calculate flow energy losses, or frictional resistance, caused by channel bed materials, type and density of floodplain vegetation and large wood. Existing conditions roughness coefficients were applied across the model extent to represent the various types and densities of vegetation or surface conditions. Roughness coefficients were modified in the proposed conditions models to represent immediate post construction conditions. In general, roughness regions were delineated based on field observations, aerial photos, and proposed designs. Roughness values for each region were selected using professional judgment and guided by published guidelines (Arcement & Schneider 1989) for channel types and vegetation conditions. Manning's n values were assigned for:

- Main stem and side channel as 0.038-0.043 depending on complexity and amount of LWM.
- Forested bars as 0.055
- Forest and floodplain as 0.080
- LWM structures as 0.15 to 0.2.
- Floodplain roughness as 0.12

3.5.7 Model Boundary Conditions

HEC-RAS 6.6 2D models require boundary conditions at the upstream and downstream ends of the model to control the flow into and out of the model extent. The synthetic hydrograph described in the next section was applied as the upstream boundary condition. The flow was initially distributed along the boundary assuming normal flow depth at a friction slope estimated from topography to be approximately 0.005 feet per foot. The downstream boundary condition assumed normal flow depth at a friction slope estimated from topography to be 0.005 feet per foot. Boundary conditions were set far enough distant from the area of interest that potential uncertainties would be negligible within the project reach.

3.5.8 Model Discharges

The modeled discharges of interest included 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval peak flows listed in Table 2. Additional low flows of interest included summary low flow through extrapolated annual peak discharges and included: 20-, 50-, 100-, 200-, 300-, 600-, 1000-, and 2000--cfs. These discharges were incorporated into a synthetic hydrograph with periods of steady flow (at the discharges of interest) to create a stair-step like pattern similar to Figure 14. The periods of steady flow allow the model to come to a quasi-steady state condition, improving the interpretation of hydraulics at discharges of interest. It's worth noting that allowing the model to reach a steady state during large flood events may overestimate extents of flooding results, as floodplain storage throughout the model domain must reach capacity to reach steady-state conditions, which in reality may not occur during actual floods, especially short duration events. The receding limb of a typical flood hydrograph is also not represented when using this methodology.

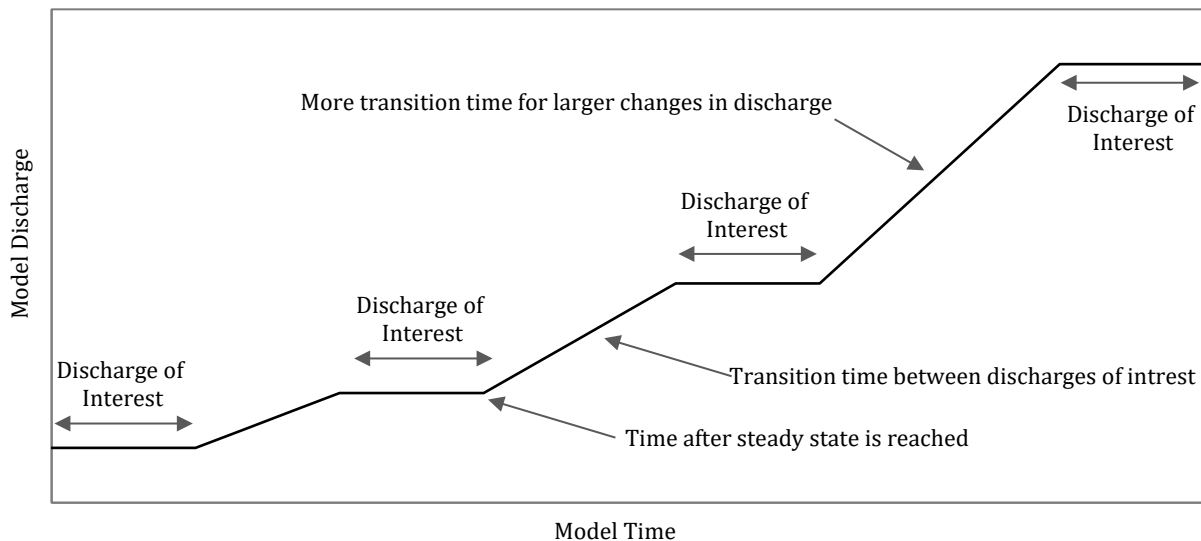


Figure 14. Stepped hydrograph Example

3.5.9 Model Output

To examine the inundation patterns, velocities, and other hydraulic parameters within the model extent for proposed conditions, the RAS Mapper utility of HEC-RAS 6.6 was used to view results in the form of raster data sets at the discharges of interest. Model output graphics for computational mesh, Manning's *n* coverage, water depths and velocities for the entire project area are included in Appendix C for existing conditions. Appendix D includes similar graphics for proposed conditions.

It should be noted that the 100-year water surface for proposed conditions is higher than existing conditions water surface elevations in several locations. A FEMA CLOMR/LOMR will be completed in a future design phase.

3.5.10 Model Findings

Model findings are preliminary, and the model will continue to be refined as the project progresses. Model results are used for design of LWM structures and evaluation of inundation limits and flow splits.

3.6 STABILITY ANALYSES AND COMPUTATIONS FOR PROJECT ELEMENTS, AND COMPREHENSIVE PROJECT PLAN

LWM structure stability analyses were prepared using guidelines for large wood design (Knutson et. al. 2014 and Reclamation/ERDC 2016). Calculations are included in Appendix E.

3.7 DESCRIPTION OF HOW PRECEDING TECHNICAL ANALYSIS HAS BEEN INCORPORATED INTO AND INTEGRATED WITH THE CONSTRUCTION – CONTRACT DOCUMENTATION

The preceding analysis is the basis for the project features shown in the design drawings. The drawings will be refined as the project progresses to final stamped construction drawing set with sufficient detail to allow contractors to bid and build the project.

3.8 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A LONGITUDINAL PROFILE OF THE STREAM CHANNEL THALWEG FOR 20 CHANNEL WIDTH UPSTREAM AND DOWNSTREAM OF THE STRUCTURE SHALL BE USED TO DETERMINE THE POTENTIAL FOR CHANNEL DEGRADATION

Not applicable to this project.

3.9 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A MINIMUM OF THREE CROSS-SECTIONS – ONE DOWNSTREAM OF THE STRUCTURE, ONE THROUGH THE RESERVOIR AREA UPSTREAM OF THE STRUCTURE, AND ONE UPSTREAM OF THE RESERVOIR AREA OUTSIDE OF THE INFLUENCE OF THE STRUCTURE) TO CHARACTERIZE THE CHANNEL MORPHOLOGY AND QUANTIFY THE STORED SEDIMENT

Not applicable to this project.

4. Construction – contract documentation

4.1 INCORPORATION OF HIP GENERAL AND CONSTRUCTION CONSERVATION MEASURES

General and construction conservation measures are included in the 60% level plans.

4.2 DESIGN – CONSTRUCTION PLAN SET INCLUDING BUT NOT LIMITED TO PLAN, PROFILE, SECTION AND DETAIL SHEETS THAT IDENTIFY ALL PROJECT ELEMENTS AND CONSTRUCTION ACTIVITIES OF SUFFICIENT DETAIL TO GOVERN COMPETENT EXECUTION OF PROJECT BIDDING AND IMPLEMENTATION

60% level plans are included in Appendix A.

4.3 LIST OF ALL PROPOSED PROJECT MATERIALS AND QUANTITIES

Proposed materials types and quantities are included in the plans and attached opinion of probable construction quantities. Materials include logs, logs with rootwads, slash, whole trees, tree tops, log piles, excavation and backfill of alluvial materials. Additional materials may include boulders and small boulder alluvial backfill if in sufficient sized material for backfill is encountered. The project area will be planted with native riparian plant species to be designed by Yakama Nation's vegetation consultant in a future phase.

4.4 DESCRIPTION OF BEST MANAGEMENT PRACTICES THAT WILL BE IMPLEMENTED AND IMPLEMENTATION RESOURCE PLANS INCLUDING:

HIP conservation measures are included in the preliminary plans including an erosion and sediment control plan using standard BMPs.

4.5 CALENDAR SCHEDULE FOR CONSTRUCTION/IMPLEMENTATION PROCEDURES

A construction timeframe has not been determined at this time.

4.6 SITE OR PROJECT SPECIFIC MONITORING TO SUPPORT POLLUTION PREVENTION AND/OR ABATEMENT

Standard erosion and pollution control measures by the contractor are specified in the construction drawing set.

5. Monitoring and adaptive management plan

The monitoring and adaptive management plan will be determined at the discretion of Yakama Nation Fisheries in subsequent design phases.

6. References

- Chelan County Natural Resources Department. May 8, 2012. Nason Creek River Mile 3.3-4.6 Feasibility Study.
- Healey, M. C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 313-393 IN: C. Groot and L. Margolis, Editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, Canada.
- Hillman, T. W. and M. D. Miller. 1989. Seasonal habitat use and behavioral interaction of juvenile chinook salmon and steelhead. I: Daytime habitat selection. Pages 42-82 IN: Don Chapman Consultants, Inc. Summer and winter ecology of juvenile chinook salmon and steelhead trout in the Wenatchee River, Washington. Final report to Chelan County PUD. Wenatchee, Washington.
- Inter-Fluve 2019. Nason Flood plain RM 3.4-4.6 10% Basis of Design Report.
- Inter-Fluve December 2024. Nason Creek Phase 3, RM 3.2-3.6 Floodplain Enhancement 30% Basis of Design Report.
- Malmon, D. 2010. Nason Creek Hydrology: Characterization of flow rates in the Lower White Pine Reach based on USGS and DOE stream gages. Technical Memo prepared by CH2M Hill for ICF International.
- Moyle P. 2002. Salmon and Trout, Salmonidae – Rainbow Trout, (*Oncorhynchus mykiss*) in Inland Fishes of California. Los Angeles, California: University of California Press, 271-282.
- Moyle P. 2002b. Salmon and Trout, Salmonidae - Chinook Salmon, (*Oncorhynchus tshawytscha*) in Inland Fishes of California. Los Angeles, California: University of California Press, 251-263.
- Northwest Power and Conservation Council (NWPCC). 2004. Wenatchee Subbasin Plan. May 28, 2004. Pages 1-394.
- Peven, C.M. 2003. Population structure, status and life histories of upper Columbia steelhead, spring and late-run chinook, sockeye, coho salmon, bull trout, westslope cutthroat trout, non-migratory rainbow trout, pacific lamprey, and sturgeon. Wenatchee, Washington.
- Quinn T. 2005. The Behavior and Ecology of Pacific Salmon and Trout. American Fisheries Society in Association with University of Washington Press. Seattle, WA.
- Upper Columbia Regional Technical Team (UCRTT). 2017. A Biological strategy to protect and restore salmonid habitat in Upper Columbia Region (revised). A Report to the Upper Columbia Salmon Recovery Board from the Upper Columbia Regional Technical Team.
- Upper Columbia Salmon Recovery Board (UCSRB). 2007. Upper Columbia salmon and Steelhead recovery plan: Upper Columbia Salmon Recovery Board, Wenatchee, Washington, 300 pp. Web site: <http://www.ucsrb.com/plan.asp>.
- U.S. Army Corps of Engineers. 2024. Hydrologic Engineering Center River Analysis System HEC-RAS, version 6.6.
- U.S. Geologic Survey. 2016. Stream Stats online.

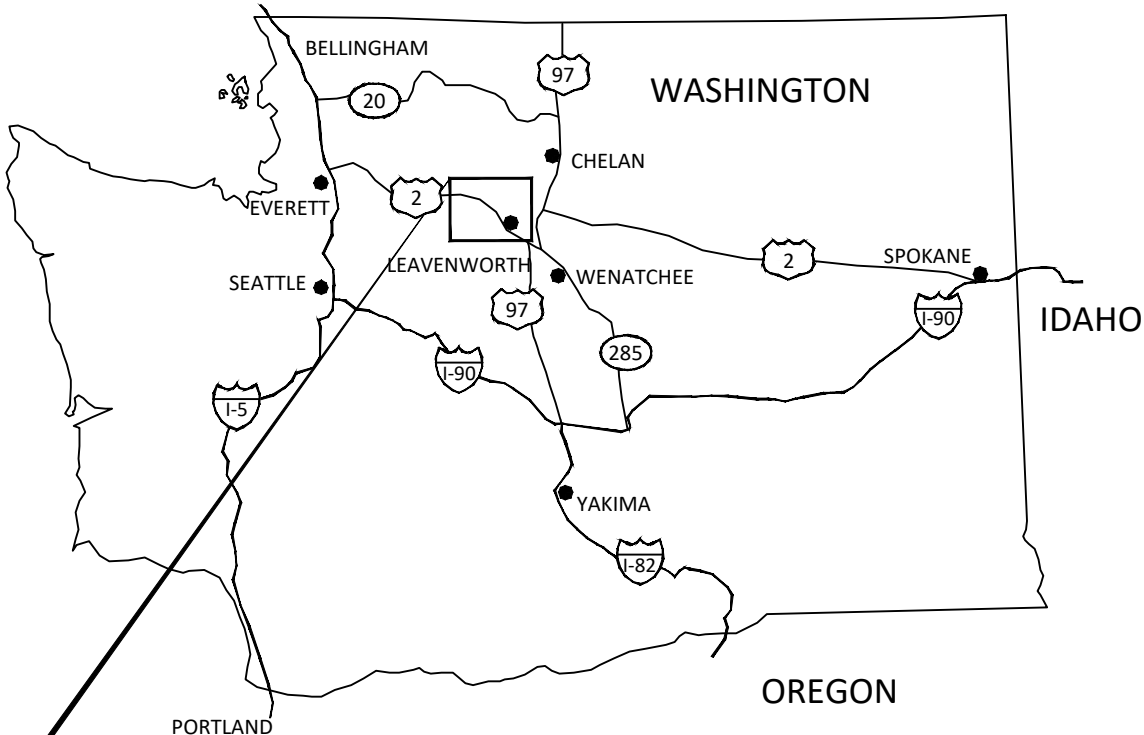
U.S. Bureau of Reclamation. July 2008. Nason Creek Tributary Assessment, Chelan County, Washington.

Appendix A – Phase 2 RM 3.7-4.6 60% project drawings

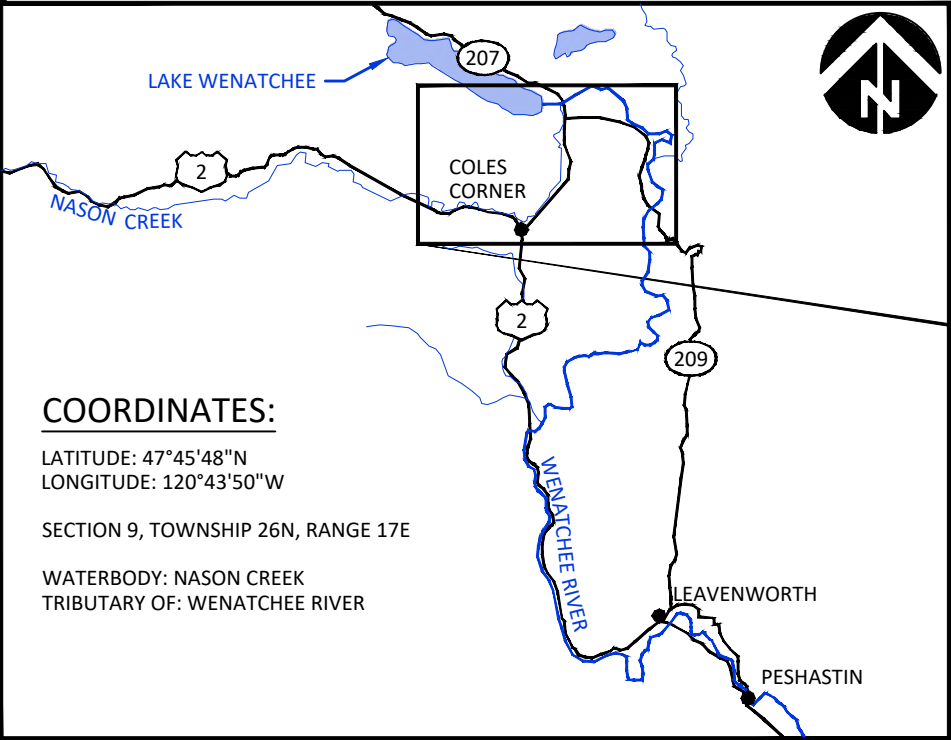
Plans submitted separately.

NASON CREEK RM 3.6-4.6 FLOODPLAIN ENHANCEMENT PHASE 2 - UPSTREAM STREAM ENHANCEMENT PROJECT 60% DESIGN

CHELAN COUNTY, WA
JANUARY 13, 2026



LOCATION MAP
STATE OF WASHINGTON
NOT TO SCALE



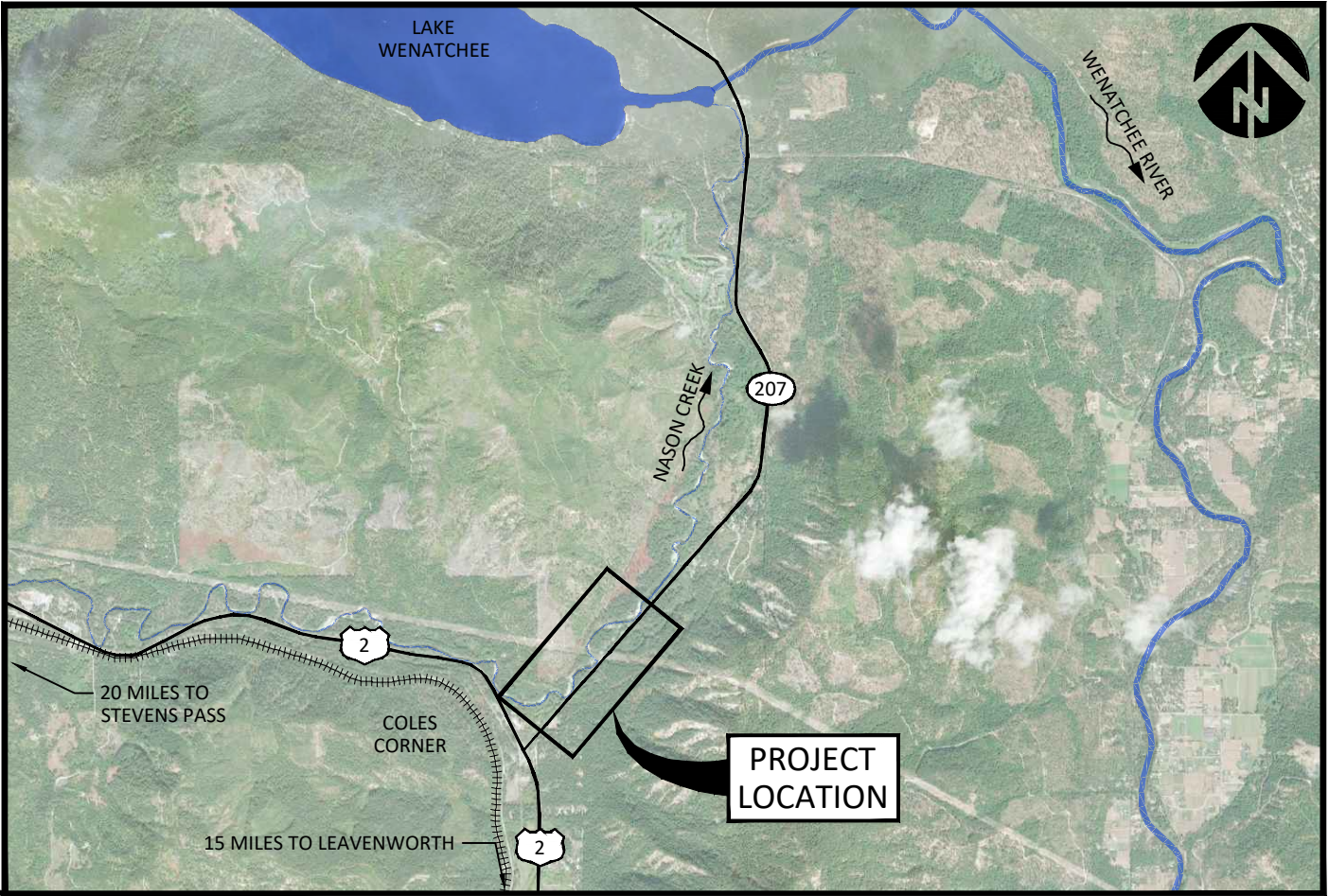
COORDINATES:

LATITUDE: 47°45'48"N
LONGITUDE: 120°43'50"W

SECTION 9, TOWNSHIP 26N, RANGE 17E

WATERBODY: NASON CREEK
TRIBUTARY OF: WENATCHEE RIVER

VICINITY MAP
NOT TO SCALE



SITE MAP

1" = 1 MILE

SHEET LIST:

- COVER, SHEET INDEX & VICINITY MAPS
- GENERAL NOTES (1 OF 2)
- GENERAL NOTES (2 OF 2)
- QUANTITIES ESTIMATES, & ABBREVIATIONS
- PERMITTING QUANTITIES
- HIP IV GENERAL CONSERVATION MEASURES (1 OF 3)
- HIP IV GENERAL CONSERVATION MEASURES (2 OF 3)
- HIP IV GENERAL CONSERVATION MEASURES (3 OF 3)
- TYPICAL DETAILS - EROSION CONTROL AND ENVIRONMENTAL PROTECTIONS
- TYPICAL DETAILS - DIVERSION COFFERDAMS & TEMPORARY CROSSING
- EXISTING CONDITIONS & PROPERTY OWNERSHIP
- PROPOSED CONDITIONS AND SHEET INDEX
- PROPOSED ACCESS, STAGING AND STOCKPILE AREAS
- PROPOSED CONDITIONS (1 OF 5)
- PROPOSED CONDITIONS (2 OF 5)
- PROPOSED CONDITIONS (3 OF 5)

- PROPOSED CONDITIONS (4 OF 5)
- PROPOSED CONDITIONS (5 OF 5)
- PROFILE - EXISTING ROAD PRISM
- ROAD CORSS SECTIONS
- CROSS SECTIONS
- LOW FLOW CHANNEL TYPICAL DETAIL
- LARGE WOOD TYPICAL DETAILS (1 OF 5)
- LARGE WOOD TYPICAL DETAILS (2 OF 5)
- LARGE WOOD TYPICAL DETAILS (3 OF 5)
- LARGE WOOD TYPICAL DETAILS (4 OF 5)
- LARGE WOOD TYPICAL DETAILS (5 OF 5)
- LOG PILE DETAILS
- SPECIFICATIONS (1 OF 3)
- SPECIFICATIONS (2 OF 3)
- SPECIFICATIONS (3 OF 3)

Preliminary
Not for Construction

THIS PROJECT WAS DESIGNED IN ACCORDANCE
WITH THE BPA HABITAT IMPROVEMENT PROGRAM,
PROGRAMMATIC BIOLOGICAL OPINION (HIP IV).

NO.	BY	DATE	REVISION DESCRIPTION

CM	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

YAKAMA NATION FISHERIES
NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT
PHASE 2 60% DESIGN

 501 Portway Avenue, Suite 101
Hood River, OR 97031
541.386.9003
www.interfluv.com

 Yakama
Nation
Fisheries

POST OFFICE BOX 151
FORT ROAD
TOPPENISH, WA 98948
(509)865-5121

COVER, SHEET INDEX &
VICINITY MAPS

SHEET
1 OF 31

G:\M-P\Nason Creek Floodplain RM 3.4-4.6 Phase 3-200237\Drawings\JFL_NasonFP_NatRD_C.dwg -- emceconnell -- 1/13/26

THE OWNER (YAKAMA NATION UCHRP) WILL PROVIDE A PRE-BID SITE TOUR. THE CONTRACTOR SHALL ATTEND THIS PRE-BID TOUR FOR SITE FAMILIARIZATION AND TO POSE QUESTIONS TO THE OWNER AND OWNER'S REPRESENTATIVE.

THE SELECTED CONTRACTOR SHALL ATTEND A PRE-CONSTRUCTION MEETING WITH OWNER AND OWNER'S REPRESENTATIVE PRIOR TO MOBILIZING TO SITE AND BEGINNING CONSTRUCTION.

ALL WORK SHALL CONFORM TO THE 2026 EDITION OF STANDARD PLANS AND SPECIFICATIONS OF THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT), AND LOCAL STANDARDS UNLESS INDICATED OTHERWISE BY THE CONTRACT DOCUMENTS. IN CASE OF A CONFLICT BETWEEN THE REGULATORY STANDARDS OR SPECIFICATIONS, THE MORE STRINGENT SHALL PREVAIL.

IN CASE OF DISCREPANCY, BETWEEN NOTES, LOCAL REGULATIONS, OR OTHER CONTRACT DOCUMENTATION, CONTRACTOR SHALL OBTAIN CLARIFICATION/DIRECTION FROM OWNER.

IN WATER WORK PERIODS

IN WATER WORK SHALL OCCUR DURING THE PERMITTED IN-WATER WORK PERIOD AS STATED IN THE APPLICABLE PERMITS. (JULY 1-31)

FISH RESCUE

ALL FISH RESCUE EFFORTS SHALL BE SUPERVISED BY A QUALIFIED YAKAMA NATION FISHERIES/AQUATIC BIOLOGIST EXPERIENCED WITH THE COLLECTION AND HANDLING OF SALMONID FISHES FROM CONSTRUCTION SITES.

ALL FISH TRAPPED IN RESIDUAL POOLS WITHIN THE PROJECT AREA SHALL BE CAREFULLY COLLECTED BY SEINE AND/OR DIP NETS AND PLACED IN CLEAN TRANSFER CONTAINERS WITH ADEQUATE VOLUME OF WATER AND HELD WITHIN NO LONGER THAN 10 MINUTES.

CAPTURED FISHES SHALL BE IMMEDIATELY RELEASED INTO THE RIVER.

CONTRACTOR WILL PROVIDE AGREED UPON ADVANCE NOTICE TO OWNER PRIOR TO FISH RESCUE. CONTRACTOR IS RESPONSIBLE FOR ISOLATING THE CONSTRUCTION LOCATION FROM THE STREAM.

EXISTING DATA

TOPOGRAPHIC DATA WAS COLLECTED BY INTER-FLUVE USING RTK GPS EQUIPMENT ON NOVEMBER 14 & 15, 2018 AND NOVEMBER 2 & 3, 2020. DATA ARE REFERENCED TO NAD83, STATE PLANE, WASHINGTON NORTH, NAVD88, US SURVEY FEET.

2015 LIDAR. 2022 USBR RED/GREEN LIDAR

HYDRAULIC MODELING BY INTER-FLUVE USING USACE HEC-RAS 6.6.

WATERS OF THE U.S.

THE ORDINARY HIGH WATER (OHW) LINES DISPLAYED IN THE DESIGN PACKAGE ARE BASED UPON ANALYSIS, MODELING AND BEST PROFESSIONAL JUDGEMENT.

SOILS

SOILS WITHIN THE PROJECT AREA CONSIST OF BEVERLY FINE SANDY LOAM, BRIEF GRAVELLY SANDY LOAM, ALLUVIAL LAND, RIVERWASH, PEOH SILT LOAM, GODDARD COBBLY FINE SANDY LOAM, AS MAPPED BY NRCS.

HIGHWAY 207 EMBANKMENT MATERIALS

CONTRACTOR SHALL CONDUCT OWN SOILS INVESTIGATIONS AS NEEDED, AT NO ADDITIONAL COST.

WETLANDS

WETLANDS DELINEATIONS WERE COMPLETED BY HAMER ENVIRONMENT (JANUARY 2021, JANUARY 14, 2022) AND TETRATECH (NOVEMBER 2025).

CULTURAL RESOURCES

CULTURAL RESOURCE MONITORING TO BE PROVIDED BY OWNER DURING GROUND DISTURBING ACTIVITIES. THE CONTRACTOR SHALL ACCOMMODATE THE MONITORING PERSONNEL AND COMPLY WITH THEIR DIRECTION RELATIVE TO INTERACTIONS WITH POTENTIAL CULTURAL RESOURCES.

- IF WORK ENCOUNTERS ANY OF THE FOLLOWING CULTURAL RESOURCES:
- NATIVE AMERICAN CULTURAL ARTIFACTS (EXAMPLE: FLAKES, ARROWHEADS, STONE TOOLS, BONE TOOLS, POTTERY, HEARTH FEATURES, ETC)
- HISTORIC ERA ARTIFACTS (EXAMPLE: BUILDING FOUNDATIONS, HOMESTEADS, MINING CAMPS, ETC)
- HUMAN SKELETAL REMAINS AND BONE FRAGMENTS

IMMEDIATELY DISCONTINUE ALL GROUND-DISTURBING ACTIVITY. DO NOT TOUCH OR MOVE THE OBJECTS AND MAINTAIN THE CONFIDENTIALITY OF THE SITE. FOLLOW THE PROCEDURES LISTED IN THE INADVERTENT DISCOVERY PROCEDURE. THEN AWAIT FURTHER DIRECTION FROM THE OWNER'S CULTURAL RESOURCES STAFF.

TREE SALVAGE

ALL SAPLING AND TREES TO BE REMOVED SHALL BE APPROVED AND CLEARLY MARKED BY OWNER OR THEIR CONTRACTED REPRESENTATIVE.

ALL REMOVED NATIVE VEGETATION SHALL BE INCORPORATED INTO LOG STRUCTURES AS DIRECTED BY OWNER OR THEIR CONTRACTED REPRESENTATIVE. IF EXCESS VEGETATION MATERIAL NEEDS DISPOSAL OUTSIDE OF CHANNEL WORK, IT SHALL BE DISTRIBUTED IN DESIGNATED AREAS ON THE FLOODPLAIN OR ON THE FLOODPLAIN AS DIRECTED BY OWNER'S REPRESENTATIVE.

ALL TREES REMOVED WITHIN CLEARING LIMITS SHALL BE REMOVED WHOLE WITH ROOTS INTACT AND UTILIZED IN THE SIDE CHANNEL CONSTRUCTION OR IN MAINSTEM WORK AS DIRECTED BY CONTRACTING AGENT'S REPRESENTATIVE.

REMOVE SOIL FROM ROOTS OF SALVAGED TREES BEFORE PLACEMENT IN THE WATERWAY.

LIVE TREES

ALL TREES NOT MARKED FOR REMOVAL SHALL BE PRESERVED AND UNDISTURBED. CONSTRUCTION ACTIVITY SHALL NOT DEBARK OR DAMAGE LIVE TREES.

KEEP OUT OF DRIP LINE OF ALL PRESERVED EXISTING TREES.

CONTRACTOR'S PLANS

CONTRACTOR SHALL PREPARE AND SUBMIT FOR APPROVAL BY THE OWNER PRIOR TO COMMENCING WORK THE FOLLOWING PLANS:

- ACCESS, TRAFFIC CONTROL AND TEMPORARY STREAM CROSSING PLAN
- STOCKPILE AND STAGING PLAN
- CONSTRUCTION SEQUENCING PLAN
- STREAM DIVERSION AND SITE DEWATERING PLAN
- EROSION, SEDIMENT AND DUST CONTROL PLAN
- EARTHWORKS EXCAVATION, PLACEMENT, SALVAGE & REUSE, AND DISPOSAL PLAN

DESIGNS BY OTHERS

PHASE 1 HIGHWAY 207 RELOCATION IS DESIGNED BY PERTEET.

REVEGETATION OF DISTURBED AREAS WILL BE DESIGNED BY OTHERS

UTILITIES

THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR HAVING UTILITIES LOCATED PRIOR TO CONSTRUCTION ACTIVITIES.

THE CONTRACTOR SHALL CALL (800-424-5555 OR 811) FOR UTILITY LOCATE PRIOR TO CONSTRUCTION

THE CONTRACTOR SHALL IMMEDIATELY CONTACT THE AFFECTED UTILITY SERVICE TO REPORT ANY DAMAGED OR DESTROYED UTILITIES.

THE CONTRACTOR SHALL PROVIDE EQUIPMENT AND LABOR TO AID THE AFFECTED UTILITY SERVICE IN REPAIRING DAMAGED OR DESTROYED UTILITIES AT NO ADDITIONAL COST.

EXISTING UTILITIES WILL BE DECOMMISSIONED AND REMOVED/ABANDONED IN PHASE 1.

CONTRACTOR SHALL REMOVE AND DISPOSE OF ABANDONED UTILITIES THAT ARE LOCATED WITH IN PROPOSED WORK AREAS.

CONSTRUCTION STAKING

OWNER'S REPRESENTATIVE WILL PROVIDE ELEVATION CONTROL POINTS.

CONTRACTOR SHALL MEET WITH THE OWNER AND OWNER'S REPRESENTATIVE TO DEFINE AND MARK LIMITS OF DISTURBANCE PRIOR TO MOBILIZATION OF EQUIPMENT OR MATERIALS ONTO THE SITE.

CONTRACTOR SHALL STAKE PROJECT LIMITS AND GRADE STAKES BASED ON PROJECT ELEVATION CONTROL POINTS. THE CONTRACTOR SHALL REPLACE DAMAGED OR DESTROYED CONSTRUCTION STAKES AT NO ADDITIONAL COST.

CONTRACTOR SHALL COORDINATE WITH ENGINEER FOR INITIAL AND PERIODIC CHECKING OF CONTRACTOR'S STAKEOUT. SOME FIELD ADJUSTMENTS TO THE LINES AND GRADES ARE TO BE EXPECTED.

CONSTRUCTION MATERIALS

OWNER PROVIDED LOGS, LOGS WITH ROOTWADS AND LOG PILES WILL BE LOCATED IN A DESIGNATED STOCKPILE/STAGING AREA. CONTRACTOR SHALL HAUL WOOD FROM STAGING AREA AND INSTALL PER PLANS. CONTRACTOR SHALL PROCURE, PROVIDE AND PLACE SLASH MATERIALS.

LOCATION, ALIGNMENT, AND ELEVATION OF LOGS AND LOGS WITH ROOTWADS ARE SUBJECT TO ADJUSTMENT BASED ON FIELD CONDITIONS AND MATERIAL SIZE, PER DIRECTION BY OWNER OR OWNER'S REPRESENTATIVE.

ANY EXCESS CONSTRUCTION MATERIALS SHALL BE NEATLY STORED AT AN APPROVED STAGING LOCATION. UPON COMPLETION OF THE PROJECT ANY EXCESS MATERIALS, WITH THE EXCEPTION OF ANY LARGE WOODY MATERIAL (LWM), WILL BECOME THE PROPERTY OF THE CONTRACTOR AND HAULED OFFSITE IN A TIMELY MANNER AND LEGALLY DISPOSED OF.

CONTRACTOR SHALL HAUL EXCESS LWM AND PLACE IN OWNER PROVIDED STOCKPILE AREA AT NO ADDITIONAL COST.

PHASE 1 CONSTRUCTION WILL INCLUDE RELOCATING HIGHWAY 207 ROADWAY AND UTILITIES, DECOMMISSIONING AND REMOVAL OF UTILITIES.

EXISTING HIGHWAY 207 EMBANKMENT TO BE ABANDONED WILL BE REMOVED IN THIS PHASE 2 WORK.

Preliminary
Not for Construction

NO.	BY	DATE	REVISION DESCRIPTION

CM, NS	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

YAKAMA NATION FISHERIES

NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT

PHASE 2 60% DESIGN



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GENERAL NOTES (1 OF 2)

SHEET

2 OF 31

G:\M\PA\Nason Creek Floodplain RM 3.4-4.6 Phase 3 200237 Drawings\JFL NasonFP NotRD C.dwg -- emcconnell -- 1/13/26

CONSTRUCTION ACCESS/TRAFFIC CONTROL

CONTRACTOR SHALL SUBMIT AN ACCESS, STAGING, AND STOCKPILE PLAN TO THE OWNER'S REPRESENTATIVE FOR APPROVAL PRIOR TO MOBILIZATION.

THE CONTRACTOR IS SOLELY RESPONSIBLE FOR PROVIDING ANY REQUIRED TRAFFIC CONTROL INCLUDING, BUT NOT LIMITED TO, SIGNAGE AND FLAGGERS.

THE CONTRACTOR IS SOLELY RESPONSIBLE FOR DEVELOPING A TRAFFIC CONTROL PLAN ACCEPTABLE TO CHELAN COUNTY AND WSDOT AND SUBMIT TRAFFIC CONTROL PLAN TO THE OWNER A MINIMUM OF 30 DAYS PRIOR TO WORK.

CONTRACTOR SHALL IMPLEMENT MEASURES TO CONTROL AND MINIMIZE WIND BLOWN DUST FROM THE SITE AND ACCESS ROUTES.

AT PROJECT COMPLETION, ROADS AND ACCESS ROUTES SHALL BE CLEANED, GRADED, AND RESURFACED TO PRE-PROJECT CONDITION PER WASHINGTON DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATION OR USFS STANDARDS PER JURISDICTION. WORK SHALL BE INCIDENTAL TO MOBILIZATION/DEMOBILIZATION.

ALL DISTURBED AREAS INCLUDING, BUT NOT LIMITED TO: ROADS, DRIVEWAYS, TEMPORARY ACCESS ROUTES, STAGING AREAS AND STRUCTURE LOCATIONS SHALL BE RESTORED TO PRE-PROJECT CONDITION OR BETTER. THIS WILL INCLUDE, BUT IS NOT LIMITED TO ANY GRADING/BLADING OF DISTURBED AREAS AS WELL AS REMOVAL OF ANY TRASH AND DEBRIS. THE OWNER'S REPRESENTATIVE WILL CONDUCT A FINAL WALK THROUGH WITH THE CONTRACTOR PRIOR TO DEMOBILIZATION.

CONTRACTOR SHALL SEED AND MULCH ALL DISTURBED SURFACES EXCEPT CHANNEL BETWEEN TOPS OF BANK AND EXISTING GRAVEL ROADS.

ALL DISTURBED AREAS OUTSIDE THE LIMITS OF DISTURBANCE SHALL BE RESTORED TO ORIGINAL CONDITION OR BETTER AT NO ADDITIONAL COST.

EROSION CONTROL

CONTRACTOR SHALL BE SOLELY RESPONSIBLE AT OWN EXPENSE FOR PROVIDING AND MAINTAINING ALL NECESSARY EROSION CONTROL FACILITIES TO COMPLY WITH APPLICABLE EROSION CONTROL REGULATIONS AND TO MAINTAIN CLEAN ACCESS ROUTES.

EROSION/SEDIMENTATION CONTROL (ESC) PLAN

THE EROSION AND SEDIMENT CONTROL (ESC) PLAN PROVIDED IS FOR INFORMATIONAL PURPOSES ONLY, THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR PROVIDING EROSION CONTROL MEASURES TO COMPLY WITH APPLICABLE REGULATIONS.

THE RECOMMENDATIONS FOR AN ESC PLAN INCLUDED HEREIN WILL PROVIDE GUIDELINES FOR THE CONTRACTOR TO DEVELOP AND IMPLEMENT AN ESC PLAN. THE CONTRACTOR'S ESC PLAN SHALL BE SUBMITTED TO THE OWNER FOR APPROVAL 30 DAYS PRIOR TO MOBILIZATION. ESC MEASURES SHALL BE IN PLACE PRIOR TO GROUND DISTURBANCE.

A. THE ESC FACILITIES SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, THESE ESC FACILITIES SHALL BE UPGRADED AS NEEDED AT NO ADDITIONAL COST FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT-LADEN WATER DO NOT LEAVE THE SITE.

B. THE IMPLEMENTATION OF AN ESC PLAN AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC FACILITIES IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND VEGETATION/LANDSCAPING IS ESTABLISHED.

C. THE ESC FACILITIES ARE TO BE CONSTRUCTED PRIOR TO CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT ENTER THE DRAINAGE SYSTEM.

D. THE BOUNDARIES OF THE CLEARING LIMITS SHOWN ON THIS PLAN SHALL BE CLEARLY FLAGGED IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF CONSTRUCTION.

E. THE ESC FACILITIES SHALL BE INSPECTED DAILY BY THE CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.

F. THE ESC FACILITIES ON INACTIVE SITES SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE A MONTH OR WITHIN THE 24 HOURS FOLLOWING A STORM EVENT.

G. STABILIZED CONSTRUCTION ENTRANCES AND ADDITIONAL MEASURES MAY BE REQUIRED AND SHALL BE

MAINTAINED FOR THE DURATION OF THE PROJECT AT CONTRACTOR'S EXPENSE.

STABILIZE SOILS AND PROTECT SLOPES

FROM MAY 1 THROUGH SEPTEMBER 30, ALL EXPOSED SOILS SHALL BE PROTECTED FROM EROSION BY MULCHING, PLASTIC SHEETING, HYDROSEED COVERING, OR OTHER APPROVED MEASURES WITHIN THREE DAYS OF GRADING. FROM OCTOBER 1 THROUGH APRIL 30, ALL EXPOSED SOILS MUST BE PROTECTED WITHIN 2 DAYS OF GRADING. SOILS SHALL BE STABILIZED BEFORE A WORK SHUTDOWN, HOLIDAY OR WEEKEND IF NEEDED BASED ON THE WEATHER FORECAST. SOIL STOCKPILES MUST BE STABILIZED AND PROTECTED WITH SEDIMENT TRAPPING MEASURES. MULCH AS SOON AS PRACTICAL ALL DISTURBED AREAS NOT INDICATED IN THE CONTRACT DOCUMENTS FOR OTHER PERMANENT STABILIZATION MEASURES. HAY, STRAW, AND MULCH USED ON SITE MUST BE 99.9% WEED-FREE.

DESIGN, CONSTRUCT, AND PHASE CUT AND FILL SLOPES IN A MANNER THAT WILL MINIMIZE EROSION. REDUCE SLOPE VELOCITIES ON DISTURBED SLOPES BY PROVIDING TEMPORARY BARRIERS. STORMWATER FROM OFF SITE SHOULD BE HANDLED SEPARATELY FROM STORMWATER GENERATED ON SITE.

AFTER FINAL SITE STABILIZATION

ALL TEMPORARY EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE REMOVED WITHIN 30 DAYS AFTER FINAL SITE STABILIZATION IS ACHIEVED OR AFTER THE TEMPORARY BMPS ARE NO LONGER NEEDED. TRAPPED SEDIMENT SHALL BE REMOVED FROM THE SITE OR INCORPORATED INTO FINISHED GRADING. DISTURBED SOIL AREAS RESULTING FROM REMOVAL SHALL BE PERMANENTLY STABILIZED.

INVASIVE SPECIES CONTROL

THE FOLLOWING MEASURES WILL BE FOLLOWED TO AVOID INTRODUCTION OF INVASIVE PLANTS AND NOXIOUS WEEDS INTO PROJECT AREAS:

1. PRIOR TO ENTERING THE SITE, ALL VEHICLES AND EQUIPMENT WILL BE POWER WASHED, ALLOWED TO FULLY DRY, AND INSPECTED TO MAKE SURE NO PLANTS, SOIL, OR OTHER ORGANIC MATERIAL ADHERES TO THE SURFACE.

DUST CONTROL

THE CONTRACTOR SHALL CONTROL DUST FOR THE DURATION OF THE PROJECT. CONTROL MEASURES SHALL BE IN ACCORDANCE WITH APPLICABLE REGULATIONS, AND MAY INCLUDE WATERING, MULCH, AND SLOWER VEHICLE SPEEDS.

CONSTRUCTION DEWATERING

CONTRACTOR SHALL PERFORM CONSTRUCTION DEWATERING IN SUCH A MANNER AS TO AVOID THE RELEASE OF TURBID OR SEDIMENT-LADEN WATER IN ORDER TO PREVENT CONTAMINATION OR INCREASE TURBIDITY OF SURFACE WATERS. EXCAVATION OF DEWATERING SUMPS BEYOND LIMITS SHOWN SHALL BE AT NO ADDITIONAL COST. SEDIMENT LADEN WATER MAY BE PUMPED TO AN UPLAND DISCHARGE LOCATION AND ALLOWED TO SHEET FLOW THROUGH EXISTING VEGETATION BEFORE INFILTRATING INTO THE GROUND. IF THIS METHOD IS NOT SUFFICIENT TO PREVENT RETURN OF TURBID WATER TO SURFACE WATERS OR SENSITIVE FLOODPLAIN AREAS, A 'DIRT-BAG' OR SEDIMENT RETENTION STRUCTURE MAY BE REQUIRED AS NECESSARY TO COMPLY WITH LAWS AND PERMIT REQUIREMENTS AT NO ADDITIONAL COST. CONTRACTOR SHALL PROVIDE, OPERATE, AND MAINTAIN NUMBER AND SIZE OF PUMPS AS NECESSARY TO ACHIEVE DEWATERING NEEDS. AT A MINIMUM, CONTRACTOR SHALL PROVIDE A 6" DRI-PRIME DIESEL POWERED PUMP AND A PORTABLE 2" PUMP. ADDITIONAL PUMPS AND OF DIFFERENT CAPACITIES MAY BE REQUIRED AT CONTRACTOR'S EXPENSE.

OWNER, OR REPRESENTATIVE SHALL APPROVE DEWATERING DISCHARGE LOCATION PRIOR TO

IMPLEMENTATION.

SPILL PREVENTION, CONTROL, AND COUNTER MEASURES

THE USE OF MECHANIZED MACHINERY INCREASES THE RISK FOR ACCIDENTAL SPILLS OF FUEL, LUBRICANTS, HYDRAULIC FLUID, OR OTHER CONTAMINANTS INTO THE RIPARIAN ZONE OR DIRECTLY INTO THE WATER. THE CONTRACTOR SHALL ADHERE TO THE FOLLOWING MEASURES:

1. A DESCRIPTION OF HAZARDOUS MATERIALS THAT WILL BE USED, INCLUDING INVENTORY, STORAGE, AND HANDLING PROCEDURES SHALL BE AVAILABLE ON-SITE.

2. WRITTEN PROCEDURES FOR NOTIFYING ENVIRONMENTAL RESPONSE AGENCIES SHALL BE POSTED AT THE WORK SITE.

3. SPILL CONTAINMENT KITS (INCLUDING INSTRUCTIONS FOR CLEANUP AND DISPOSAL) ADEQUATE FOR THE TYPES AND QUANTITY OF HAZARDOUS MATERIALS USED AT THE SITE SHALL BE AVAILABLE AT THE WORK SITE.

4. WORKERS SHALL BE TRAINED IN SPILL CONTAINMENT PROCEDURES AND SHALL BE INFORMED OF THE LOCATION OF SPILL CONTAINMENT KITS.

5. ANY WASTE LIQUIDS GENERATED AT THE STAGING AREAS SHALL BE TEMPORARILY STORED UNDER AN IMPERVIOUS COVER, SUCH AS A TARPULIN, UNTIL THEY CAN BE PROPERLY TRANSPORTED TO AND DISPOSED OF AT A FACILITY THAT IS APPROVED FOR RECEIPT OF HAZARDOUS MATERIALS.

6. VEGETABLE BASED HYDRAULIC FLUIDS (BIODEGRADABLE OIL) SHALL BE USED IN ANY VEHICLE THAT WILL BE OPERATED NEAR THE WATER.

INSPECTION AND MAINTENANCE

ALL ESC FACILITIES SHALL BE INSPECTED, MAINTAINED, AND REPAIRED AS NEEDED TO ASSURE CONTINUED PERFORMANCE OF THEIR INTENDED FUNCTION. ALL ESC FACILITIES SHALL BE INSPECTED DAILY AND WITHIN 24 HOURS AFTER ANY STORM EVENT GREATER THAN 0.5 INCHES OF RAIN PER 24 HOUR PERIOD AND AFTER EVENTS EXCEEDING 2 HOURS DURATION.

CONTRACTOR'S ESC RECORD

WEEKLY REPORTS SUMMARIZING THE SCOPE OF INSPECTIONS, THE PERSONNEL CONDUCTING THE INSPECTION, THE DATE(S) OF THE INSPECTION, MAJOR OBSERVATIONS RELATING TO THE IMPLEMENTATION OF THE CONTRACTOR'S EROSION AND SEDIMENT CONTROL PLAN, AND ACTIONS TAKEN AS A RESULT OF THESE INSPECTIONS SHALL BE PREPARED AND RETAINED ON SITE BY THE CONTRACTOR. IN ADDITION, A RECORD OF THE FOLLOWING DATES SHALL BE INCLUDED IN THE REPORTS:

1. WHEN MAJOR GRADING ACTIVITIES OCCUR,

2. DATES OF RAINFALL EVENTS EITHER EXCEEDING 2 HOURS DURATION OR MORE THAN 0.5 INCHES/24 HOURS,

3. WHEN CONSTRUCTION ACTIVITIES TEMPORARILY OR PERMANENTLY CEASE ON SITE, OR ON A PORTION OF THE SITE,

4. WHEN STABILIZATION MEASURES ARE INITIATED FOR PORTIONS OF THE SITE. ESC RECORDS SHALL BE MADE AVAILABLE TO THE OWNER AND OWNER'S REPRESENTATIVE ON REQUEST AND SHALL BE PROVIDED FOR REVIEW AND APPROVAL PRIOR TO APPLICATION FOR PAYMENT.

Preliminary
Not for Construction

				CM, NS DRAWN			DM DESIGNED			DM CHECKED			YAKAMA NATION FISHERIES NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT PHASE 2 60% DESIGN			 501 Portway Avenue, Suite 101 Hood River, OR 97031 541.386.9003 www.interfluve.com			 POST OFFICE BOX 151 FORT ROAD TOPPENISH, WA 98948 (509)865-5121			GENERAL NOTES (2 OF 2)			SHEET			
				DM APPROVED			01/13/2026 DATE			200237 PROJECT															3 OF 31			
NO.	BY	DATE	REVISION DESCRIPTION																									

G:\M-P\Nason Creek Floodplain RM 3.4-4.6 Phase 3 200237 Drawings\JFL NasonFP_NorRD_C.dwg -- emcconnell -- 1/13/26

QUANTITIES ESTIMATE - LARGE WOOD STRUCTURES

				Item:	Log w/RW	Surface single log	Log pile	Slash dense bundle:	Tipped/ Salvaged tree	Total earthworks per each		
Location	Structure	ID code	quantity	units	size:	18"dbh x 40'	18"dbh x 40'	16" dbh x 20'	4' diameter x 12' long		Excavation (CY)	Backfill (CY)
Phase 2 - River Left												
	Apex jams	Apex	2	ea		14		7	4		300	300
	Bar roughness wood structures	BR	5	ea		5		5			50	50
	FP roughness logs	FP	4	ea		1						
	Tipped trees	TT	4	ea						1		
Phase 2 RL subtotal = Sum [(# of structures) * (Qty per structure)]						57	0	39	8	4	850	850
Phase 2 - River Right												
	Apex jams	Apex	4	ea		14		7	4		300	300
	Bank buried jam	BB	3	ea		9			4	2	300	300
	Bank buried jam w/trees	BB	2	ea		9		4	4	6	300	300
	Small bank buried jam	SM-BB	9	ea		2		2	2	1	40	40
	Bank margin wood	M	7	ea		7		12	3	3	50	50
	Bar roughness wood structures	BR	12	ea		5		5	1		42	42
	BR and SM-BB racking wood	RW	4	ea		6		7		2	42	42
	CED3 Bank barb structure	CED3	4	ea		12	1	14	3	6	0	590
	Deflector jam	DFL	3	ea		2		9	2		0	0
	Inlet structure	Inlet	2	ea		14		6	6		290	290
	low flow channel floodplain roughness LW	LFFP	11	ea		7		8	1		70	70
	low flow channel habitat cover logs	LFHC	11	ea		3		1	1		28	28
	low flow channel floodplain roughness log	LFRL	18	ea		3		2			28	28
	FP roughness logs	FP	9	ea		1						
Phase 2 RR subtotal = Sum [(# of structures) * (Qty per structure)]						507	4	456	139	80	6244	8604
Phase 2 Total = (RR + RL subtotals)						564	4	495	147	84	7094	9454

QUANTITIES ESTIMATE - EARTHWORKS

Item	Description	Quantity	Units	Notes
River Right project components				
	CED-1 & 2 Riprap removal and salvage	700	CY	Approximately 225+250LF x 3ft thick x 12ft high, plus barbs
	CED-1 & 2 Road embankment removal, low flow channel and wetland creation excavation and off site disposal	29300	CY	CADD volume
	CED-1 Mainstem Meander excavation	2950	CY	CADD volume minus volume of riprap removal
	CED-1 Mainstem Meander gravel bar alluvial material fill	2330	CY	CADD volume
	CED-1 Inlet swale	82	CY	CADD volume
	CED-3 Mainstem Meander gravel bar alluvial material excavation	1850	CY	CADD volume
	CED-2 bank revetment for Phase 1 road	1050	CY	42" thick Class B stone; approximately 400ft long

NOTES:

1. ESTIMATED MATERIAL VOLUMES ARE IN-PLACE QUANTITIES AND NOT FACTORED FOR EXPANSION OF EXCAVATED MATERIAL OR COMPACTION OF PLACED MATERIAL. MEASUREMENT AND PAYMENT SHALL NOT BE BASED ON WEIGHT TICKETS OR TRUCK MEASURE
2. PLANTING PLAN AND REVEGETATION ARE DESIGNED BY OTHERS.

ABBREVIATIONS

APPROX	APPROXIMATE
BMP	BEST MANAGEMENT PRACTICE
CY	CUBIC YARDS
°	DEGREE
DBH	DIAMETER AT BREAST HEIGHT
DIA	DIAMETER
EA	EACH
ELEV	ELEVATION
ESC	EROSION AND SEDIMENT CONTROL
' or FT	FOOT
GIS	GEOGRAPHIC INFORMATION SYSTEM
HWY	HIGHWAY
" or IN	INCH
LWM	LARGE WOODY MATERIAL
LWS	LARGE WOOD STRUCTURE
LS	LUMP SUM
MAX	MAXIMUM
MIN	MINIMUM
MP	MILEPOST
MSF	THOUSAND SQUARE FEET
NAD 83	NORTH AMERICAN DATUM OF 1983
NAVD88	NORTH AMERICAN VERTICAL DATUM OF 1988
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
OHW	ORDINARY HIGH WATER
OLW	ORDINARY LOW WATER
%	PERCENT
LBS	POUNDS
RD	ROAD
RM	RIVER MILE
RTK GPS	REAL TIME KINEMATIC GLOBAL POSITIONING
SYSTEM	
STA	STATION
TBM	TEMPORARY BENCHMARK
TYP	TYPICAL
US	UNITED STATES
USACE	UNITED STATES ARMY CORPS OF ENGINEERS
USFS	UNITED STATES FOREST SERVICE
WDFW	WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

Preliminary
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CM, NS	DM	DM
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YAKAMA NATION FISHERIES

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QUANTITIES
ESTIMATES, &
ABBREVIATIONS

PERMITTING QUANTITIES

Sheet	structure	cofferdam		existing OHW impact		Wetland impact	
		L (ft)	Area (s.f.)	Cut (cy)	Fill (cy)	Area (s.f.)	Type (T/P)
14	BR-1	n/a	0	0	0	0	n/a
	BR-2	n/a	0	0	0	0	n/a
	BR-3	n/a	0	20	20	0	n/a
	TT-1	n/a	0	0	0	0	n/a
	TT-2	n/a	0	0	0	0	n/a
	TT-3	n/a	0	0	0	0	n/a
	TT-4	n/a	0	0	0	0	n/a
	FP-1	n/a	0	0	0	0	n/a
	FP-2	n/a	0	0	0	0	n/a
	FP-3	n/a	0	0	0	0	n/a
	FP-4	n/a	0	0	0	0	n/a
	BR-4	n/a	0	35	35	0	n/a
	BR-5	n/a	0	0	0	0	n/a
	BR-6	n/a	0	50	50	0	n/a
	BR-7	n/a	0	25	25	0	n/a
	BR-8	n/a	0	50	50	0	n/a
	BR-9	n/a	0	25	25	0	n/a
	BR-10	n/a	0	0	0	0	n/a
	BR-11	n/a	0	5	5	0	n/a
	Apex-1	87	1025	100	100	0	n/a
	M-1	n/a	0	0	0	0	n/a
	Inlet-1	n/a	0	0	0	1083	permanent
	BB-1	n/a	0	0	0	914	permanent
	BB-2	n/a	0	0	0	369	permanent
	BB-3	n/a	0	0	0	0	n/a
	BB-4	n/a	0	0	0	0	n/a
	Apex-2	80	970	60	60	0	n/a
	LFRL-1	n/a	0	0	0	0	n/a
	LFRL-2	n/a	0	0	0	0	n/a
	LFHC-1	n/a	0	0	0	0	n/a
	LFRL-3	n/a	0	0	0	0	n/a
	LFFP-1	n/a	0	0	0	0	n/a
	LFFP-2	n/a	0	0	0	0	n/a
	LFRL-4	n/a	0	0	0	0	n/a
	LFHC-2	n/a	0	0	0	0	n/a
	LFRL-5	n/a	0	0	0	0	n/a
	LFFP-3	n/a	0	0	0	0	n/a
	LFFP-4	n/a	0	0	0	0	n/a
	LFHC-3	n/a	0	0	0	0	n/a
	LFRL-6	n/a	0	0	0	0	n/a
	LFHC-4	n/a	0	0	0	0	n/a
	LFRL-7	n/a	0	0	0	0	n/a
	LFHC-5	n/a	0	0	0	0	n/a
	LFHC-6	n/a	0	0	0	0	n/a

Sheet	structure	cofferdam		existing OHW impact		Wetland impact	
		L (ft)	Area (s.f.)	Cut (cy)	Fill (cy)	Area (s.f.)	Type (T/P)
15	BR-12	n/a	0	25	25	0	n/a
	BR-13	n/a	0	3	3	0	n/a
	Apex-3	142	2555	300	300	0	0
	BB-5	59	411	10	10	0	0
	BR-14	n/a	0	8	8	0	n/a
	Inlet-2	61	403	0	0	0	0
	BR-15	n/a	0	0	0	0	n/a
	SM_BB-1	68	449	0	0	0	n/a
	SM_BB-2	60	505	0	0	0	n/a
	BR-16	n/a	0	0	0	0	n/a
	BR-17	n/a	0	0	0	0	n/a
	Apex-4	88	966	75	75	0	n/a
	Apex-5	119	2011	75	75	0	n/a
	Apex-6	72	703	30	30	0	n/a
	LFRL-8	n/a	0	0	0	0	n/a
	LFHC-7	n/a	0	0	0	0	n/a
	LFHC-8	n/a	0	0	0	0	n/a
	LFRL-9	n/a	0	0	0	0	n/a
	LFHC-9	n/a	0	0	0	0	n/a
	LFRL-10	n/a	0	0	0	0	n/a
	LFHC-10	n/a	0	0	0	0	n/a
	LFRL-11	n/a	0	0	0	0	n/a
	LFFP-5	n/a	0	0	0	0	n/a
	LFRL-12	n/a	0	0	0	0	n/a
	LFHC-11	n/a	0	0	0	0	n/a
	LFRL-13	n/a	0	0	0	0	n/a
	LFRL-14	n/a	0	0	0	0	n/a
	LFRL-15	n/a	0	0	0	0	n/a
	LFRL-16	n/a	0	0	0	0	n/a
	LFRL-17	n/a	0	0	0	0	n/a
	LFRL-18	n/a	0	0	0	0	n/a
	LFFP-6	n/a	0	0	0	0	n/a
	LFFP-7	n/a	0	0	0	0	n/a
	LFFP-8	n/a	0	0	0	0	n/a
	LFFP-9	n/a	0	0	0	0	n/a
	LFFP-10	n/a	0	0	0	0	n/a
	LFFP-11	n/a	0	0	0	0	n/a
16	SM_BB-3	n/a	0	0	0	1218	permanent
	SM_BB-4	n/a	0	0	0	1649	permanent
	SM_BB-5	n/a	0	0	0	414	permanent
	SM_BB-6	n/a	0	0	0	336	permanent
	SM_BB-7	n/a	0	0	0	441	permanent
	SM_BB-8	n/a	0	0	0	336	permanent
	SM_BB-9	n/a	0	0	0	485	permanent
17	DFL-1	n/a	0	0	0	0	0
	M-2	116	1754	50	50	0	0
	M-3	155	3241	50	50	0	0
	DFL-2	n/a	0	0	0	0	0
	M-4	n/a	0	0	0	0	0
	M-5	109	1570	0	0	0	0
	M-6	n/a	0	0	0	0	0
	DFL-3	n/a	0	0	0	0	0
	M-7	112	1707	0	0	0	0

Preliminary
Not for Construction

G:\M-P\Nason Creek Floodplain RM 3.4-4.6 Phase 3 200237\Drawings\JFL NasonFP NoRD_C.dwg -- cmcconnell -- 1/13/26

NO.	BY	DATE	REVISION DESCRIPTION

CM, NS	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

YAKAMA NATION FISHERIES
NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT
PHASE 2 60% DESIGN



501 Portway Avenue, Suite 101
Hood River, OR 97031
541.386.9003
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PERMITTING
QUANTITIES

G:\M-P\Nason Creek Floodplain RM 3.4-4.6 Phase 3 200237 Drawings\JFL NasonFP_NorRD_C.dwg -- emceconnell -- 1/13/26

HIP IV GENERAL CONSERVATION MEASURES APPLICABLE TO ALL ACTIONS

THE ACTIVITIES COVERED UNDER THE HIP ARE INTENDED TO PROTECT AND RESTORE FISH AND WILDLIFE HABITAT WITH LONG-TERM BENEFITS TO ESA-LISTED SPECIES. THE FOLLOWING GENERAL CONSERVATION MEASURES (DEVELOPED IN COORDINATION WITH USFWS AND NMFS) WILL BE APPLIED TO ALL ACTIONS OF THIS PROJECT.

PROJECT DESIGN AND SITE PREPARATION.

1. STATE AND FEDERAL PERMITS.

- A. ALL APPLICABLE REGULATORY PERMITS AND OFFICIAL PROJECT AUTHORIZATIONS WILL BE OBTAINED BEFORE PROJECT IMPLEMENTATION.
- B. THESE PERMITS AND AUTHORIZATIONS INCLUDE, BUT ARE NOT LIMITED TO, NATIONAL ENVIRONMENTAL POLICY ACT, NATIONAL HISTORIC PRESERVATION ACT, THE APPROPRIATE STATE AGENCY REMOVAL AND FILL PERMIT, USACE CLEAN WATER ACT (CWA) 404 PERMITS, CWA SECTION 401 WATER QUALITY CERTIFICATIONS, AND FEMA NO-RISE ANALYSES.

2. TIMING OF IN-WATER WORK.

- A. APPROPRIATE STATE (OREGON DEPARTMENT OF FISH AND WILDLIFE (ODFW), WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW), IDAHO DEPARTMENT OF FISH AND GAME (IDFG), AND MONTANA FISH WILDLIFE AND PARKS (MFWP)) GUIDELINES FOR TIMING OF IN-WATER WORK WINDOWS (IWW) WILL BE FOLLOWED.
- B. CHANGES TO ESTABLISHED WORK WINDOWS WILL BE APPROVED BY REGIONAL STATE BIOLOGISTS AND BPA'S EC LEAD.
- C. BULL TROUT. FOR AREAS WITH DESIGNATED IN-WATER WORK WINDOWS FOR BULL TROUT OR AREAS KNOWN TO HAVE BULL TROUT, PROJECT PROPONENTS WILL CONTACT THE APPROPRIATE USFWS FIELD OFFICE TO INSURE THAT ALL REASONABLE IMPLEMENTATION MEASURES ARE CONSIDERED AND AN APPROPRIATE IN-WATER WORK WINDOW IS BEING USED TO MINIMIZE PROJECT EFFECTS.
- D. LAMPREY. WORKING IN STREAM OR RIVER CHANNELS THAT CONTAIN PACIFIC LAMPREY WILL BE AVOIDED FROM MARCH 1 TO JULY 1 FOR REACHES <5,000 FEET IN ELEVATION AND FROM MARCH 1 TO AUGUST 1 FOR REACHES >5,000 FEET. IF EITHER TIMEFRAME IS INCOMPATIBLE WITH OTHER OBJECTIVES, THE AREA WILL BE SURVEYED FOR NESTS AND LAMPREY PRESENCE, AND AVOIDED IF POSSIBLE. IF LAMPREYS ARE KNOWN TO EXIST, THE PROJECT SPONSOR WILL UTILIZE DEWATERING AND SALVAGE PROCEDURES (SEE FISH SALVAGE AND ELECTROFISHING SECTIONS) TO MINIMIZE ADVERSE EFFECTS.
- E. THE IN-WATER WORK WINDOW WILL BE PROVIDED IN THE CONSTRUCTION PLANS.

3. CONTAMINANTS.

- A. EXCAVATION OF MORE THAN 20 CUBIC YARDS WILL REQUIRE A SITE VISIT AND DOCUMENTED ASSESSMENT FOR POTENTIAL CONTAMINANT SOURCES. THE SITE ASSESSMENT WILL BE STORED WITH PROJECT FILES OR AS AN APPENDIX TO THE BASIS OF DESIGN REPORT.
- B. THE SITE ASSESSMENT WILL SUMMARIZE:
 - 1. THE SITE VISIT, CONDITION OF THE PROPERTY, AND IDENTIFICATION OF ANY AREAS USED FOR VARIOUS INDUSTRIAL PROCESSES;
 - 2. AVAILABLE RECORDS, SUCH AS FORMER SITE USE, BUILDING PLANS, AND RECORDS OF ANY PRIOR CONTAMINATION EVENTS;
 - 3. INTERVIEWS WITH KNOWLEDGEABLE PEOPLE, SUCH AS SITE OWNERS, OPERATORS, OCCUPANTS, NEIGHBORS, OR LOCAL GOVERNMENT OFFICIALS; AND
 - 4. THE TYPE, QUANTITY, AND EXTENT OF ANY POTENTIAL CONTAMINATION SOURCES.

4. SITE LAYOUT AND FLAGGING.

- A. CONSTRUCTION AREAS TO BE CLEARLY FLAGGED PRIOR TO CONSTRUCTION.
- B. AREAS TO BE FLAGGED WILL INCLUDE:
 - 1. SENSITIVE RESOURCE AREAS, SUCH AS AREAS BELOW ORDINARY HIGH WATER, SPAWNING AREAS, SPRINGS, AND WETLANDS;
 - 2. EQUIPMENT ENTRY AND EXIT POINTS;
 - 3. ROAD AND STREAM CROSSING ALIGNMENTS;
 - 4. STAGING, STORAGE, AND STOCKPILE AREAS; AND
 - 5. NO-SPRAY AREAS AND BUFFERS.

5. TEMPORARY ACCESS ROADS AND PATHS.

- A. EXISTING ACCESS ROADS AND PATHS WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER AND LENGTH OF TEMPORARY ACCESS ROADS AND PATHS THROUGH RIPARIAN AREAS AND FLOODPLAINS WILL BE MINIMIZED.
- B. VEHICLE USE AND HUMAN ACTIVITIES, INCLUDING WALKING, IN AREAS OCCUPIED BY TERRESTRIAL ESA-LISTED SPECIES WILL BE MINIMIZED.
- C. TEMPORARY ACCESS ROADS AND PATHS WILL NOT BE BUILT ON SLOPES WHERE GRADE, SOIL, OR OTHER FEATURES SUGGEST A LIKELIHOOD OF EXCESSIVE EROSION OR FAILURE. IF SLOPES ARE STEEPER THAN 30%, THEN THE ROAD WILL BE DESIGNED BY A CIVIL ENGINEER WITH EXPERIENCE IN STEEP ROAD DESIGN.
- D. THE REMOVAL OF RIPARIAN VEGETATION DURING CONSTRUCTION OF TEMPORARY ACCESS ROADS WILL BE MINIMIZED. WHEN TEMPORARY VEGETATION REMOVAL IS REQUIRED, VEGETATION WILL BE CUT AT GROUND LEVEL (NOT GRUBBED).
- E. AT PROJECT COMPLETION, ALL TEMPORARY ACCESS ROADS AND PATHS WILL BE OBLITERATED, AND THE SOIL WILL BE STABILIZED AND REVEGETATED. ROAD AND PATH OBLITERATION REFERS TO THE MOST COMPREHENSIVE DEGREE OF DECOMMISSIONING AND INVOLVES DECOMPACTING THE SURFACE AND DITCH, PULLING THE FILL MATERIAL ONTO THE RUNNING SURFACE, AND RESHAPING TO MATCH THE ORIGINAL CONTOUR.
- F. HELICOPTER FLIGHT PATTERNS WILL BE ESTABLISHED IN ADVANCE AND LOCATED TO AVOID TERRESTRIAL ESA-LISTED SPECIES AND THEIR OCCUPIED HABITAT DURING SENSITIVE LIFE STAGES.

6. TEMPORARY STREAM CROSSINGS.

- A. EXISTING STREAM CROSSINGS OR BEDROCK WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER OF TEMPORARY STREAM CROSSINGS WILL BE MINIMIZED.
- B. TEMPORARY BRIDGES AND CULVERTS WILL BE INSTALLED TO ALLOW FOR EQUIPMENT AND VEHICLE CROSSING OVER PERENNIAL STREAMS DURING CONSTRUCTION. TREATED WOOD SHALL NOT BE USED ON TEMPORARY BRIDGE CROSSINGS OR IN LOCATIONS IN CONTACT WITH OR DIRECTLY OVER WATER.
- C. FOR PROJECTS THAT REQUIRE EQUIPMENT AND VEHICLES TO CROSS IN THE WET:
 - 1. THE LOCATION AND NUMBER OF ALL WET CROSSINGS SHALL BE APPROVED BY THE OWNER;
 - 2. ONLY TRACKED EQUIPMENT SHALL CROSS THE STREAM;
 - 3. VEHICLES AND MACHINERY SHALL CROSS STREAMS AT RIGHT ANGLES TO THE MAIN CHANNEL WHENEVER POSSIBLE;
 - 4. NO STREAM CROSSINGS WILL OCCUR 300 FEET UPSTREAM OR 100 FEET DOWNSTREAM OF AN EXISTING REDD OR SPAWNING FISH; AND
 - 5. AFTER PROJECT COMPLETION, TEMPORARY STREAM CROSSINGS WILL BE OBLITERATED AND BANKS RESTORED.

7. STAGING, STORAGE, AND STOCKPILE AREAS.

- A. STAGING AREAS (USED FOR CONSTRUCTION EQUIPMENT STORAGE, VEHICLE STORAGE, FUELING, SERVICING, AND HAZARDOUS MATERIAL STORAGE) WILL BE 150 FEET OR MORE FROM ANY NATURAL WATER BODY OR WETLAND. STAGING AREAS CLOSER THAN 150 FEET WILL BE APPROVED BY THE EC LEAD.
- B. NATURAL MATERIALS USED FOR IMPLEMENTATION OF AQUATIC RESTORATION, SUCH AS LARGE WOOD, GRAVEL, AND BOULDERS, MAY BE STAGED WITHIN 150 FEET IF CLEARLY INDICATED IN THE PLANS THAT AREA IS FOR NATURAL MATERIALS ONLY.
- C. ANY LARGE WOOD, TOPSOIL, AND NATIVE CHANNEL MATERIAL DISPLACED BY CONSTRUCTION WILL BE STOCKPILED FOR USE DURING SITE RESTORATION AT A SPECIFICALLY IDENTIFIED AND FLAGGED AREA.
- D. ANY MATERIAL NOT USED IN RESTORATION, AND NOT NATIVE TO THE FLOODPLAIN, WILL BE DISPOSED OF OUTSIDE THE 100-YEAR FLOODPLAIN.

8. EQUIPMENT.

- A. MECHANIZED EQUIPMENT AND VEHICLES WILL BE SELECTED, OPERATED, AND MAINTAINED IN A MANNER THAT MINIMIZES ADVERSE EFFECTS ON THE ENVIRONMENT (E.G., MINIMALLY-SIZED, LOW PRESSURE TIRES; MINIMAL HARD-TURN PATHS FOR TRACKED VEHICLES; TEMPORARY MATS OR PLATES WITHIN WET AREAS OR ON SENSITIVE SOILS).
- B. EQUIPMENT WILL BE STORED, FUELED, AND MAINTAINED IN AN CLEARLY IDENTIFIED STAGING AREA THAT MEETS STAGING AREA CONSERVATION MEASURES.

- C. EQUIPMENT WILL BE REFUELED IN A VEHICLE STAGING AREA OR IN AN ISOLATED HARD ZONE, SUCH AS A PAVED PARKING LOT OR ADJACENT, ESTABLISHED ROAD (THIS MEASURE APPLIES ONLY TO GAS-POWERED EQUIPMENT WITH TANKS LARGER THAN 5 GALLONS).
- D. BIODEGRADABLE LUBRICANTS AND FLUIDS WILL BE USED ON EQUIPMENT OPERATING IN AND ADJACENT TO THE STREAM CHANNEL AND LIVE WATER.
- E. EQUIPMENT WILL BE INSPECTED DAILY FOR FLUID LEAKS BEFORE LEAVING THE VEHICLE STAGING AREA FOR OPERATION WITHIN 150 FEET OF ANY NATURAL WATER BODY OR WETLAND.
- F. EQUIPMENT WILL BE THOROUGHLY CLEANED BEFORE OPERATION BELOW ORDINARY HIGH WATER, AND AS OFTEN AS NECESSARY DURING OPERATION, TO REMAIN GREASE FREE.

9. EROSION CONTROL.

- A. TEMPORARY EROSION CONTROL MEASURES INCLUDE:
 - 1. TEMPORARY EROSION CONTROLS WILL BE IN PLACE BEFORE ANY SIGNIFICANT ALTERATION OF THE ACTION SITE AND APPROPRIATELY INSTALLED DOWNSLOPE OF PROJECT ACTIVITY WITHIN THE RIPARIAN BUFFER AREA UNTIL SITE REHABILITATION IS COMPLETE;
 - 2. IF THERE IS A POTENTIAL FOR ERODED SEDIMENT TO ENTER THE STREAM, SEDIMENT BARRIERS WILL BE INSTALLED AND MAINTAINED FOR THE DURATION OF PROJECT IMPLEMENTATION;
 - 3. TEMPORARY EROSION CONTROL MEASURES MAY INCLUDE SEDGE MATS, FIBER WATTLES, SILT FENCES, JUTE MATTING, WOOD FIBER MULCH AND SOIL BINDER, OR GEOTEXTILES AND GEOSYNTHETIC FABRIC;
 - 4. SOIL STABILIZATION UTILIZING WOOD FIBER MULCH AND TACKIFIER (HYDRO-APPLIED) MAY BE USED TO REDUCE EROSION OF BARE SOIL IF THE MATERIALS ARE NOXIOUS WEED FREE AND NONTOXIC TO AQUATIC AND TERRESTRIAL ANIMALS, SOIL MICROORGANISMS, AND VEGETATION;
 - 5. SEDIMENT WILL BE REMOVED FROM EROSION CONTROLS ONCE IT HAS REACHED 1/3 OF THE EXPOSED HEIGHT OF THE CONTROL; AND
 - 6. ONCE THE SITE IS STABILIZED AFTER CONSTRUCTION, TEMPORARY EROSION CONTROL MEASURES WILL BE REMOVED.
- B. EMERGENCY EROSION CONTROLS. THE FOLLOWING MATERIALS FOR EMERGENCY EROSION CONTROL WILL BE AVAILABLE AT THE WORK SITE:
 - 1. A SUPPLY OF SEDIMENT CONTROL MATERIALS; AND
 - 2. AN OIL-ABSORBING FLOATING BOOM WHENEVER SURFACE WATER IS PRESENT.

10. DUST ABATEMENT.

- A. THE PROJECT SPONSOR WILL DETERMINE THE APPROPRIATE DUST CONTROL MEASURES BY CONSIDERING SOIL TYPE, EQUIPMENT USAGE, PREVAILING WIND DIRECTION, AND THE EFFECTS CAUSED BY OTHER EROSION AND SEDIMENT CONTROL MEASURES.
- B. WORK WILL BE SEQUENCED AND SCHEDULED TO REDUCE EXPOSED BARE SOIL SUBJECT TO WIND EROSION.
- C. DUST-ABATEMENT ADDITIVES AND STABILIZATION CHEMICALS (TYPICALLY MAGNESIUM CHLORIDE, CALCIUM CHLORIDE SALTS, OR LIGNINSULFONATE) WILL NOT BE APPLIED WITHIN 25 FEET OF WATER OR A STREAM CHANNEL AND WILL BE APPLIED SO AS TO MINIMIZE THE LIKELIHOOD THAT THEY WILL ENTER STREAMS. APPLICATIONS OF LIGNINSULFONATE WILL BE LIMITED TO A MAXIMUM RATE OF 0.5 GALLONS PER SQUARE YARD OF ROAD SURFACE, ASSUMING MIXED 50:50 WITH WATER.
- D. APPLICATION OF DUST ABATEMENT CHEMICALS WILL BE AVOIDED DURING OR JUST BEFORE WET WEATHER, AND AT STREAM CROSSINGS OR OTHER AREAS THAT COULD RESULT IN UNFILTERED DELIVERY OF THE DUST ABATEMENT MATERIALS TO A WATERBODY (TYPICALLY THESE WOULD BE AREAS WITHIN 25 FEET OF A WATERBODY OR STREAM CHANNEL; DISTANCES MAY BE GREATER WHERE VEGETATION IS SPARSE OR SLOPES ARE STEEP).
- E. SPILL CONTAINMENT EQUIPMENT WILL BE AVAILABLE DURING APPLICATION OF DUST ABATEMENT CHEMICALS.
- F. PETROLEUM-BASED PRODUCTS WILL NOT BE USED FOR DUST ABATEMENT.



				BPA DRAWN			BPA DESIGNED			BPA CHECKED			YAKAMA NATION FISHERIES NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT PHASE 2 60% DESIGN			 501 Portway Avenue, Suite 101 Hood River, OR 97031 541.386.9003 www.interfluve.com			 POST OFFICE BOX 151 FORT ROAD TOPPENISH, WA 98948 (509)865-5121			HIP IV GENERAL CONSERVATION MEASURES (1 OF 3)			SHEET						
				BPA APPROVED						200237 PROJECT														6 OF 31							
NO.	BY	DATE	REVISION DESCRIPTION																												

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PROJECT DESIGN AND SITE PREPARATION (CONTINUED).

11. SPILL PREVENTION, CONTROL, AND COUNTER MEASURES.

- A. A DESCRIPTION OF HAZARDOUS MATERIALS THAT WILL BE USED, INCLUDING INVENTORY, STORAGE, AND HANDLING PROCEDURES WILL BE AVAILABLE ON-SITE.
- B. WRITTEN PROCEDURES FOR NOTIFYING ENVIRONMENTAL RESPONSE AGENCIES WILL BE POSTED AT THE WORK SITE.
- C. SPILL CONTAINMENT KITS (INCLUDING INSTRUCTIONS FOR CLEANUP AND DISPOSAL) ADEQUATE FOR THE TYPES AND QUANTITY OF HAZARDOUS MATERIALS USED AT THE SITE WILL BE AVAILABLE AT THE WORK SITE.
- D. WORKERS WILL BE TRAINED IN SPILL CONTAINMENT PROCEDURES AND WILL BE INFORMED OF THE LOCATION OF SPILL CONTAINMENT KITS.
- E. ANY WASTE LIQUIDS GENERATED AT THE STAGING AREAS WILL BE TEMPORARILY STORED UNDER AN IMPERVIOUS COVER, SUCH AS A TARPULIN, UNTIL THEY CAN BE PROPERLY TRANSPORTED TO AND DISPOSED OF AT A FACILITY THAT IS APPROVED FOR RECEIPT OF HAZARDOUS MATERIALS.
- F. PUMPS USED ADJACENT TO WATER SHALL USE SPILL CONTAINMENT SYSTEMS.

12. INVASIVE SPECIES CONTROL.

- A. PRIOR TO ENTERING THE SITE, ALL VEHICLES AND EQUIPMENT WILL BE POWER WASHED, ALLOWED TO FULLY DRY, AND INSPECTED TO MAKE SURE NO PLANTS, SOIL, OR OTHER ORGANIC MATERIAL ADHERES TO THE SURFACE.
- B. WATERCRAFT, WADERS, BOOTS, AND ANY OTHER GEAR TO BE USED IN OR NEAR WATER WILL BE INSPECTED FOR AQUATIC INVASIVE SPECIES.
- C. WADING BOOTS WITH FELT SOLES ARE NOT TO BE USED DUE TO THEIR PROPENSITY FOR AIDING IN THE TRANSFER OF INVASIVE SPECIES UNLESS DECONTAMINATION PROCEDURES HAVE BEEN APPROVED BY THE EC LEAD.

WORK AREA ISOLATION AND FISH SALVAGE.

1. WORK AREA ISOLATION.

- A. ANY WORK AREA WITHIN THE WETTED CHANNEL WILL BE ISOLATED FROM THE ACTIVE STREAM WHENEVER ESA-LISTED FISH ARE REASONABLY CERTAIN TO BE PRESENT, OR IF THE WORK AREA IS LESS THAN 300-FEET UPSTREAM FROM KNOWN SPAWNING HABITATS.
- B. WORK AREA ISOLATION AND FISH SALVAGE ACTIVITIES WILL COMPLY WITH THE IN-WATER WORK WINDOW.
- C. DESIGN PLANS WILL INCLUDE ALL ISOLATION ELEMENTS AND AREAS (COFFER DAMS, PUMPS, DISCHARGE AREAS, FISH SCREENS, FISH RELEASE AREAS, ETC.).
- D. WORK AREA ISOLATION AND FISH CAPTURE ACTIVITIES WILL OCCUR DURING PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES POSSIBLE, NORMALLY EARLY IN THE MORNING VERSUS LATE IN THE DAY, AND DURING CONDITIONS APPROPRIATE TO MINIMIZE STRESS AND DEATH OF SPECIES PRESENT.

2. FISH SALVAGE.

- A. MONITORING AND RECORDING WILL TAKE PLACE FOR DURATION OF SALVAGE. THE SALVAGE REPORT WILL BE COMMUNICATED TO AGENCIES VIA THE PROJECT COMPLETION FORM (PCF).
- B. SALVAGE ACTIVITIES SHOULD TAKE PLACE DURING CONDITIONS TO MINIMIZE STRESS TO FISH SPECIES, TYPICALLY PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES WHICH OCCUR IN THE MORNING VERSUS LATE IN THE DAY.
- C. SALVAGE OPERATIONS WILL FOLLOW THE ORDERING, METHODS, AND CONSERVATION MEASURES SPECIFIED BELOW:
 - 1. SLOWLY REDUCE WATER FROM THE WORK AREA TO ALLOW SOME FISH TO LEAVE VOLITIONALLY.
 - 2. BLOCK NETS WILL BE INSTALLED AT UPSTREAM AND DOWNSTREAM LOCATIONS AND MAINTAINED IN A SECURED POSITION TO EXCLUDE FISH FROM ENTERING THE PROJECT AREA.
 - 3. BLOCK NETS WILL BE SECURED TO THE STREAM CHANNEL BED AND BANKS UNTIL FISH CAPTURE AND TRANSPORT ACTIVITIES ARE COMPLETE. BLOCK NETS MAY BE LEFT IN PLACE FOR THE DURATION OF THE PROJECT TO EXCLUDE FISH AS LONG AS PASSAGE REQUIREMENTS ARE MET.
 - 4. NETS WILL BE MONITORED HOURLY DURING IN-STREAM DISTURBANCE.
 - 5. IF BLOCK NETS REMAIN IN PLACE MORE THAN ONE DAY, THE NETS WILL BE MONITORED AT LEAST

DAILY TO ENSURE THEY ARE SECURED AND FREE OF ORGANIC ACCUMULATION. IF BULL TROUT ARE PRESENT, NETS ARE TO BE CHECKED EVERY 4 HOURS FOR FISH IMPINGEMENT.

- 6. CAPTURE FISH THROUGH SEINING AND RELOCATE TO STREAMS.
- 7. WHILE DEWATERING, ANY REMAINING FISH WILL BE COLLECTED BY HAND OR DIP NETS.
- 8. SEINES WITH A MESH SIZE TO ENSURE CAPTURE OF THE RESIDING ESA-LISTED FISH WILL BE USED.
- 9. MINNOW TRAPS WILL BE LEFT IN PLACE OVERNIGHT AND USED IN CONJUNCTION WITH SEINING.
- 10. ELECTROFISH TO CAPTURE AND RELOCATED FISH NOT CAUGHT DURING SEINING PER ELECTROFISH CONSERVATION MEASURES.
- 11. CONTINUE TO SLOWLY DEWATER STREAM REACH.
- 12. COLLECT ANY REMAINING FISH IN COLD-WATER BUCKETS AND RELOCATED TO THE STREAM.
- 13. LIMIT THE TIME FISH ARE IN A TRANSPORT BUCKET.
- 14. MINIMIZE PREDATION BY TRANSPORTING COMPARABLE SIZES IN BUCKETS.
- 15. BUCKET WATER TO BE CHANGED EVERY 15 MINUTES OR AERATED.
- 16. BUCKETS WILL BE KEPT IN SHADED AREAS OR COVERED.
- 17. DEAD FISH WILL NOT BE STORED IN TRANSPORT BUCKETS, BUT WILL BE LEFT ON THE STREAM BANK TO AVOID MORTALITY COUNTING ERRORS.

D. SALVAGE GUIDELINES FOR BULL TROUT, LAMPREY, MUSSELS, AND NATIVE FISH.

- 1. CONDUCT SITE SURVEY TO ESTIMATE SALVAGE NUMBERS.
- 2. PRE-SELECT SITE(S) FOR RELEASE AND/OR MUSSEL BED RELOCATION.
- 3. SALVAGE OF BULL TROUT WILL NOT TAKE PLACE WHEN WATER TEMPERATURES EXCEED 15 DEGREES CELSIUS.
- 4. IF DRAWDOWN LESS THAN 48 HOURS, SALVAGE OF LAMPREY AND MUSSELS MAY NOT BE NECESSARY IF TEMPERATURES SUPPORT SURVIVAL IN SEDIMENTS.
- 5. SALVAGE MUSSELS BY HAND, LOCATING BY SNORKELING OR WADING.
- 6. SALVAGE LAMPREY BY ELECTROFISHING (SEE ELECTROFISHING FOR LARVAL LAMPREY SETTINGS AND LARVAL LAMPREY DRY SHOCKING SETTINGS).
- 7. SALVAGE BONY FISH AFTER LAMPREY WITH NETS OR ELECTROFISHING (SEE ELECTROFISHING FOR APPROPRIATE SETTINGS).
- 8. REGULARLY INSPECT DEWATERED SITE SINCE LAMPREY LIKELY TO EMERGE AFTER DEWATERING AND MUSSELS MAY BECOME VISIBLE.
- 9. MUSSELS MAY BE TRANSFERRED IN COOLERS.
- 10. MUSSELS WILL BE PLACED INDIVIDUALLY TO ENSURE ABILITY TO BURROW INTO NEW HABITAT.

3. ELECTROFISHING.

- A. INITIAL SITE SURVEY AND INITIAL SETTINGS.
 - 1. IDENTIFY SPAWNING ADULTS AND ACTIVE REDDS TO AVOID.
 - 2. RECORD WATER TEMPERATURE. ELECTROFISHING WILL NOT OCCUR WHEN WATER TEMPERATURES ARE ABOVE 18 DEGREES CELSIUS.
 - 3. IF POSSIBLE, A BLOCK NET WILL BE PLACED DOWNSTREAM AND CHECKED REGULARLY TO CAPTURE STUNNED FISH THAT DRIFT DOWNSTREAM.
 - 4. INITIAL SETTINGS WILL BE 100 VOLTS, PULSE WIDTH OF 500 MICRO SECONDS, AND PULSE RATE OF 30 HERTZ.
 - 5. RECORDS FOR CONDUCTIVITY, WATER TEMPERATURE, AIR TEMPERATURE, ELECTROFISHING SETTINGS, ELECTROFISHER MODEL, ELECTROFISHER CALIBRATION, FISH CONDITIONS, FISH MORTALITIES, AND TOTAL CAPTURE RATES WILL BE INCLUDED IN THE SALVAGE LOG BOOK.
- B. ELECTROFISHING TECHNIQUE.
 - 1. SAMPLING WILL BEGIN USING STRAIGHT DC. POWER WILL REMAIN ON UNTIL THE FISH IS NETTED

WHEN USING STRAIGHT DC. GRADUALLY INCREASE VOLTAGE WHILE REMAINING BELOW MAXIMUM LEVELS.

- 2. MAXIMUM VOLTAGE WILL BE 1100 VOLTS WHEN CONDUCTIVITY IS <100 MILLISECONDS, 800 VOLTS WHEN CONDUCTIVITY IS BETWEEN 100 AND 300 MILLISECONDS, AND 400 VOLTS WHEN CONDUCTIVITY IS >300 MILLISECONDS.
- 3. IF FISH CAPTURE IS NOT SUCCESSFUL USING STRAIGHT DC, THE ELECTROFISHER WILL BE SET TO INITIAL VOLTAGE FOR PDC. VOLTAGE, PULSE WIDTH, AND PULSE FREQUENCY WILL BE GRADUALLY INCREASED WITHIN MAXIMUM VALUES UNTIL CAPTURE IS SUCCESSFUL.
- 4. MAXIMUM PULSE WIDTH IS 5 MILLISECONDS. MAXIMUM PULSE RATE IS 70 HERTZ
- 5. ELECTROFISHING WILL NOT OCCUR IN ONE AREA FOR AN EXTENDED PERIOD.
- 6. THE ANODE WILL NOT INTENTIONALLY COME INTO CONTACT WITH FISH. THE ZONE FOR POTENTIAL INJURY OF 0.5 M FROM THE ANODE WILL BE AVOIDED.
- 7. SETTINGS WILL BE LOWERED IN SHALLOWER WATER SINCE VOLTAGE GRADIENTS LIKELY TO INCREASE.
- 8. ELECTROFISHING WILL NOT OCCUR IN TURBID WATER WHERE VISIBILITY IS POOR (I.E. UNABLE TO SEE THE BED OF THE STREAM).
- 9. OPERATIONS WILL IMMEDIATELY STOP IF MORTALITY OR OBVIOUS FISH INJURY IS OBSERVED. ELECTROFISHING SETTINGS WILL BE REEVALUATED.
- C. SAMPLE PROCESSING.
 - 1. FISH SHALL BE SORTED BY SIZE TO AVOID PREDATION DURING CONTAINMENT.
 - 2. SAMPLERS WILL REGULARLY CHECK CONDITIONS OF FISH HOLDING CONTAINERS, AIR PUMPS, WATER TRANSFERS, ETC.
 - 3. FISH WILL BE OBSERVED FOR GENERAL CONDITIONS AND INJURIES
 - 4. EACH FISH WILL BE COMPLETELY REVIVED BEFORE RELEASE. ESA-LISTED SPECIES WILL BE PRIORITIZED FOR SUCCESSFUL RELEASE.
- D. BULL TROUT ELECTROFISHING.
 - 1. ELECTROFISHING FOR BULL TROUT WILL ONLY OCCUR FROM MAY 1 TO JULY 31. NO ELECTROFISHING WILL OCCUR IN ANY BULL TROUT OCCUPIED HABITAT AFTER AUGUST 15. IN FMO HABITATS ELECTROFISHING MAY OCCUR ANY TIME.
 - 2. ELECTROFISHING OF BULL TROUT WILL NOT OCCUR WHEN WATER TEMPERATURES EXCEED 15 DEGREES CELSIUS.
- E. LARVAL LAMPREY ELECTROFISHING.
 - 1. PERMISSION FROM EC LEAD WILL BE OBTAINED IF LARVAL LAMPREY ELECTROFISHER IS NOT ONE OF FOLLOWING PRE-APPROVED MODELS: ABP-2 "WISCONSIN", SMITH-ROOT LR-24, OR SMITH-ROOT APEX BACKPACK.
 - 2. LARVAL LAMPREY SAMPLING WILL INCORPORATE 2-STAGE METHOD: "TICKLE" AND "STUN".
 - 3. FIRST STAGE: USE 125 VOLT DC WITH A 25 PERCENT DUTY CYCLE APPLIED AT A SLOW RATE OF 3 PULSES PER SECOND. IF TEMPERATURES ARE BELOW 10 DEGREES CELSIUS, VOLTAGE MAY BE INCREASED GRADUALLY (NOT TO EXCEED 200 VOLTS). BURSTED PULSES (THREE SLOW AND ONE SKIPPED) RECOMMENDED TO INCREASE EMERGENCE.
 - 4. SECOND STAGE (OPTIONAL FOR EXPERIENCED NETTERS): IMMEDIATELY AFTER LAMPREY EMERGE, USE A FAST PULSE SETTING OF 30 PULSES PER SECOND.
 - 5. USE DIP NETS FOR VISIBLE LAMPREY. SIENES AND FINE MESH NET SWEEPS MAY BE USED IN POOR VISIBILITY.

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				DRAWN	DESIGNED	CHECKED	NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT							7 OF 31						
				BPA		200237	PHASE 2 60% DESIGN													
				APPROVED	DATE	PROJECT														
NO.	BY	DATE	REVISION DESCRIPTION																	

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WORK AREA ISOLATION AND FISH SALVAGE (CONTINUED).

6. SAMPLING WILL OCCUR SLOWLY (>60 SECONDS PER METER) STARTING AT UPSTREAM AND WORKING DOWNSTREAM.
7. MULTIPLE SWEEPS TO OCCUR WITH 15 MINUTES BETWEEN SWEEPS.
8. POST-DRAWDOWN "DRY-SHOCKING" WILL BE APPLIED IF LARVAL LAMPREY CONTINUE TO EMERGE. ANODES TO BE PLACED ONE METER APART TO SAMPLE ONE SQUARE METER AT A TIME FOR AT LEAST 60 SECONDS. FOR TEMPERATURES LESS THAN 10 DEGREES CELSIUS, MAXIMUM VOLTAGE MAY BE GRADUALLY INCREASED TO 400 VOLTS (DRY-SHOCKING ONLY).
4. DEWATERING.

A. DEWATERING WILL OCCUR AT A RATE SLOW ENOUGH TO ALLOW SPECIES TO NATURALLY MIGRATE OUT OF THE WORK AREA.

B. WHERE A GRAVITY FEED DIVERSION IS NOT POSSIBLE, A PUMP MAY BE USED. PUMPS WILL BE INSTALLED TO AVOID REPETIVE DEWATERING AND REWATERING.

C. WHEN FISH ARE PRESENT, PUMPS WILL BE SCREENED IN ACCORDANCE WITH NMFS FISH SCREEN CRITERIA. NMFS ENGINEERING REVIEW AND APPROVAL WILL BE OBTAINED FOR PUMPS EXCEEDING 3 CUBIC FEET PER SECOND.

D. DISSIPATION OF FLOW ENERGY AT THE BYPASS OUTFLOW WILL BE PROVIDED TO PREVENT DAMAGE TO THE STREAM CHANNEL AND RIPARIAN VEGETATION.

E. SEEPAGE WATER WILL BE PUMPED TO A TEMPORARY STORAGE AND TREATMENT SITE OF INTO UPLAND AREAS TO ALLOW WATER TO PERCOLATE THROUGH SOIL AND VEGETATION PRIOR TO REENTERING THE STREAM CHANNEL.

CONSTRUCTION AND POST CONSTRUCTION CONSERVATION MEASURES.

1. FISH PASSAGE.

A. FISH PASSAGE WILL BE PROVIDED FOR ADULT AND JUVENILE FISH LIKELY TO BE PRESENT DURING CONSTRUCTION UNLESS PASSAGE DID NOT EXIST BEFORE CONSTRUCTION, THE STREAM IS NATURALLY IMPASSABLE, OR PASSAGE WILL NEGATIVELY IMPACT ESA-LISTED SPECIES OR THEIR HABITAT.

B. FISH PASSAGE ALTERNATIVES WILL BE APPROVED BY THE OWNER UNDER ADVISEMENT BY THE NMFS HABITAT BIOLOGIST.
2. CONSTRUCTION AND DISCHARGE WATER.

A. SURFACE WATER MAY BE DIVERTED TO MEET CONSTRUCTION NEEDS ONLY IF DEVELOPED SOURCES ARE UNAVAILABLE OR INADEQUATE.

B. DIVERSIONS WILL NOT EXCEED 10% OF THE AVAILABLE FLOW.

C. CONSTRUCTION DISCHARGE WATER WILL BE COLLECTED AND TREATED TO REMOVE DEBRIS, NUTRIENTS, SEDIMENT, PETROLEUM HYDROCARBONS, METALS, AND OTHER POLLUTANTS.
3. TIME AND EXTENT OF DISTURBANCE.

A. EARTHWORK REQUIRING IN-STREAM MECHANIZED EQUIPMENT (INCLUDING DRILLING, EXCAVATION, DREDGING, FILLING, AND COMPACTING) WILL BE COMPLETED AS QUICKLY AS POSSIBLE.

B. MECHANIZED EQUIPMENT WILL WORK FROM TOP OF BANK UNLESS WORK FROM ANOTHER LOCATION WILL RESULT IN LESS HABITAT DISTURBANCE (TURBIDITY, VEGETATION DISTURBANCE, ETC.).
4. CESSATION OF WORK.

A. PROJECT OPERATIONS WILL CEASE WHEN HIGH FLOW CONDITIONS MAY RESULT IN INUNDATION OF THE PROJECT AREA (FLOOD EFFORTS TO DECREASE DAMAGES TO NATURAL RESOURCES PERMITTED).

B. WATER QUALITY LEVELS EXCEEDED. SEE CWA SECTION 401 WATER QUALITY CERTIFICATION AND TURBIDITY MEASURES.
5. SITE RESTORATION.

A. DISTURBED AREAS, STREAM BANKS, SOILS, AND VEGETATION WILL BE CLEANED UP AND RESTORED TO IMPROVED OR PRE-PROJECT CONDITIONS.

B. PROJECT-RELATED WASTE WILL BE REMOVED.

C. TEMPORARY ACCESS ROADS AND STAGING WILL BE DECOMPACTED AND RESTORED. SOILS WILL BE LOOSENEED IF NEEDED FOR REVEGETATION OR WATER INFILTRATION.

- D. THE PROJECT SPONSOR WILL RETAIN THE RIGHT OF REASONABLE ACCESS TO THE SITE TO MONITOR AND MAINTAIN THE SITE OVER THE LIFE OF THE PROJECT.
6. REVEGETATION.

A. PLANTING AND SEEDING WILL OCCUR PRIOR TO OR AT THE BEGINNING OF THE FIRST GROWING SEASON AFTER CONSTRUCTION.

B. A MIX OF NATIVE SPECIES (INVASIVE SPECIES NOT ALLOWED) APPROPRIATE TO THE SITE WILL BE USED TO REESTABLISH VEGETATION, PROVIDE SHADE, AND REDUCE EROSION. REESTABLISHED VEGETATION SHOULD BE AT LEAST 70% OF PRE-PROJECT CONDITIONS WITHIN THREE YEARS.

C. VEGETATION SUCH AS WILLOWS, SEDGES, OR RUSH MATS WILL BE SALVAGED FROM DISTURBED OR ABANDONED AREAS TO BE REPLANTED.

D. SHORT-TERM STABILIZATION MEASURE MAY INCLUDE THE USE OF NON-NATIVE STERILE SEED MIX (WHEN NATIVE NOT AVAILABLE), WEED-FREE CERTIFIED STRAW, OR OTHER SIMILAR TECHNIQUES.

E. SURFACE FERTILIZER WILL NOT BE APPLIED WITHIN 50 FEET OF ANY STREAM, WATE BODY, OR WETLAND.

F. FENCING WILL BE INSTALLED AS NECESSARY TO PREVENT ACCESS TO REVEGETATED SITES BY LIVESTOCK OR UNAUTHORIZED PERSONS.

G. INVASIVE PLANTS WILL BE REMOVED OR CONTROLLED UNTIL NATIVE PLANT SPECIES ARE WELL ESTABLISHED (TYPICALLY THREE YEARS POST-CONSTRUCTION).

SITE ACCESS AND IMPLEMENTATION MONITORING.

- A. THE PROJECT SPONSOR WILL PROVIDE CONSTRUCTION MONITORING DURING IMPLEMENTATION TO ENSURE ALL CONSERVATION MEASURES ARE ADEQUATELY FOLLOWED, EFFECTS TO LISTED SPECIES ARE NOT GREATER THAN PREDICTED, AND INCIDENTAL TAKE LIMITATIONS ARE NOT EXCEEDED.
- B. THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL SUBMIT THE PROJECT COMPLETION FORM (PCF) WITHIN 30 DAYS OF PROJECT COMPLETION.
8. CWA SECTION 401 WATER QUALITY CERTIFICATION.

A. THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL COMPLETE AND RECORD WATER QUALITY OBSERVATIONS (SEE TURBIDITY MONITORING) TO ENSURE IN-WATER WORK IS NOT DEGRADING WATER QUALITY.

B. DURING CONSTRUCTION, WATER QUALITY PROVISIONS PROVIDED BY THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY, WASHINGTON DEPARTMENT OF ECOLOGY, IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY WILL BE FOLLOWED.

STAGED REWATERING PLAN.

- A. WHEN REINTRODUCING WATER TO DEWATERED AREAS AND NEWLY CONSTRUCTED CHANNELS, A STAGED REWATERING PLAN WILL BE APPLIED.
- B. THE FOLLOWING WILL BE APPLIED TO ALL REWATERING EFFORTS. COMPLEX REWATERING EFFORTS MAY REQUIRE ADDITIONAL NOTES OR A DEDICATED SHEET IN THE CONSTRUCTION DETAILS.
1. TURBIDITY MONITORING PROTOCOL WILL BE APPLIED TO REWATERING EFFORTS.
2. PRE-WASH THE AREA BEFORE REWATERING. TURBID WASH WATER WILL BE DETAINED AND PUMPED TO THE FLOODPLAIN OR SEDIMENT CAPTURE AREAS RATHER THAN DISCHARGING TO FISH-BEARING STREAMS.
3. INSTALL SEINE NETS AT UPSTREAM END TO PREVENT FISH FROM MOVING DOWNSTREAM UNTIL 2/3 OF TOTAL FLOW IS RESTORED TO THE CHANNEL.
4. STARTING IN EARLY MORNING INTRODUCE 1/3 OF NEW CHANNEL FLOW OVER PERIOD OF 1-2 HOURS.
5. INTRODUCE SECOND THIRD OF FLOW OVER NEXT 1 TO 2 HOURS AND BEGIN FISH SALVAGE OF BYPASS CHANNEL IF FISH ARE PRESENT.
6. REMOVE UPSTREAM SEINE NETS ONCE 2/3 FLOW IN REWATERED CHANNEL AND DOWNSTREAM TURBIDITY IS WITHIN ACCEPTABLE RANGE (LESS THAN 40 NTU OR LESS THAN 10% BACKGROUND).
7. INTRODUCE FINAL THIRD OF FLOW ONCE FISH SALVAGE EFFORTS ARE COMPLETE AND DOWNSTREAM TURBIDITY VERIFIED TO BE WITHIN ACCEPTABLE RANGE.
8. INSTALL PLUG TO BLOCK FLOW INTO OLD CHANNEL OR BYPASS. REMOVE ANY REMAINING SEINE NETS.

9. IN LAMPREY SYSTEMS, LAMPREY SALVAGE AND DRY SHOCKING MAY BE NECESSARY.

TURBIDITY MONITORING.

- A. RECORD THE READING, LOCATION, AND TIME FOR THE BACKGROUND READING APPROXIMATELY 100 FEET UPSTREAM OF THE PROJECT AREA USING A RECENTLY CALIBRATED TURBIDIMETER OR VIA VISUAL OBSERVATION (SEE THE HIP HANDBOOK TURBIDITY MONITORING SECTION FOR A VISUAL OBSERVATION KEY).
- B. RECORD THE TURBIDITY READING, LOCATION, AND TIME AT THE MEASUREMENT COMPLIANCE LOCATION POINT.
1. 50 FEET DOWNSTREAM FOR STREAMS LESS THAN 30 FEET WIDE.
2. 100 FEET DOWNSTREAM FOR STREAMS BETWEEN 30 AND 100 FEET WIDE.
3. 200 FEET DOWNSTREAM FOR STREAMS GREATER THAN 100 FEET WIDE.
4. 300 FEET FROM THE DISCHARGE POINT OR NONPOINT SOURCE FOR LOCATIONS SUBJECT TO TIDAL OR COASTAL SCOUR.
- C. TURBIDITY SHALL BE MEASURED (BACKGROUND LOCATION AND COMPLIANCE POINTS) EVERY 4 HOURS WHILE WORK IS BEING IMPLEMENTED.
- D. IF THERE IS A VISIBLE DIFFERENCE BETWEEN A COMPLIANCE POINT AND THE BACKGROUND, THE EXCEEDANCE WILL BE NOTED IN THE PROJECT COMPLETION FORM (PCF). ADJUSTMENTS OR CORRECTIVE MEASURES WILL BE TAKEN IN ORDER TO REDUCE TURBIDITY.
- E. IF EXCEEDANCES OCCUR FOR MORE THAN TWO CONSECUTIVE MONITORING INTERVALS (AFTER 8 HOURS), THE ACTIVITY WILL STOP UNTIL THE TURBIDITY LEVEL RETURNS TO BACKGROUND. THE OWNER WILL BE NOTIFIED OF ALL EXCEEDANCES AND CORRECTIVE ACTIONS AT PROJECT COMPLETION.
- F. IF TURBIDITY CONTROLS (COFFER DAMS, WADDLES, FENCING, ETC.) ARE DETERMINED INEFFECTIVE, CREWS WILL BE MOBILIZED TO MODIFY AS NECESSARY. OCCURRENCES WILL BE DOCUMENTED IN THE PROJECT COMPLETION FORM (PCF).
- G. FINAL TURBIDITY READINGS, EXCEEDANCES, AND CONTROL FAILURES WILL BE SUBMITTED TO THE OWNER USING THE PROJECT COMPLETION FORM (PCF).

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BPA		200237
APPROVED	DATE	PROJECT

YAKAMA NATION FISHERIES

NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT

PHASE 2 60% DESIGN



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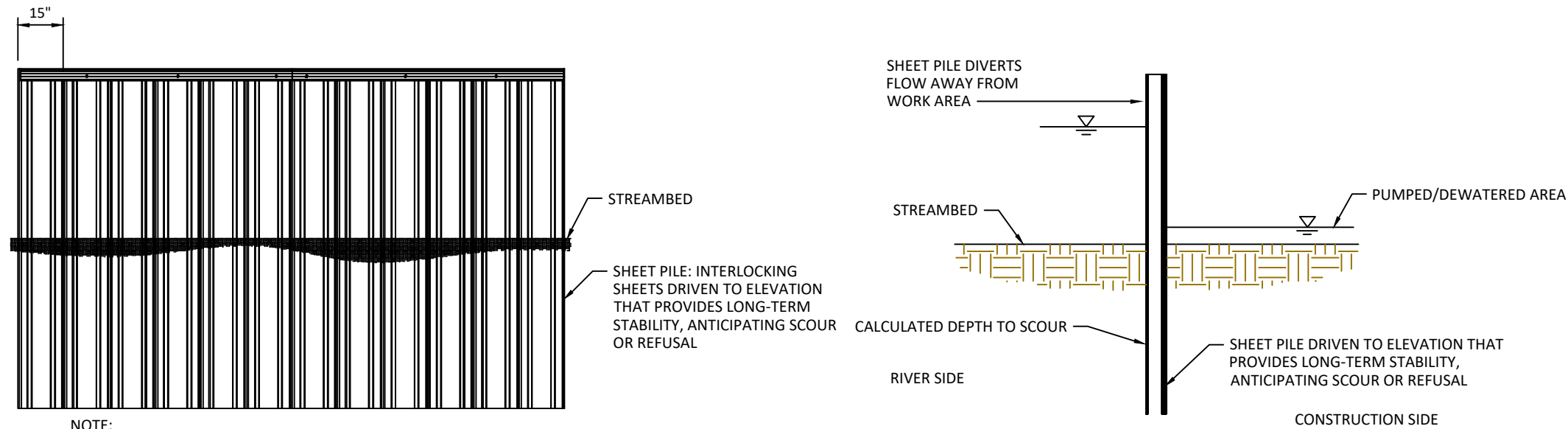


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HIP IV GENERAL
CONSERVATION
MEASURES (3 OF 3)

SHEET
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NOTE:
INDIVIDUAL SHEET WEIGHT 45 LBS PER LINEAR FOOT

ELEVATION

1
10

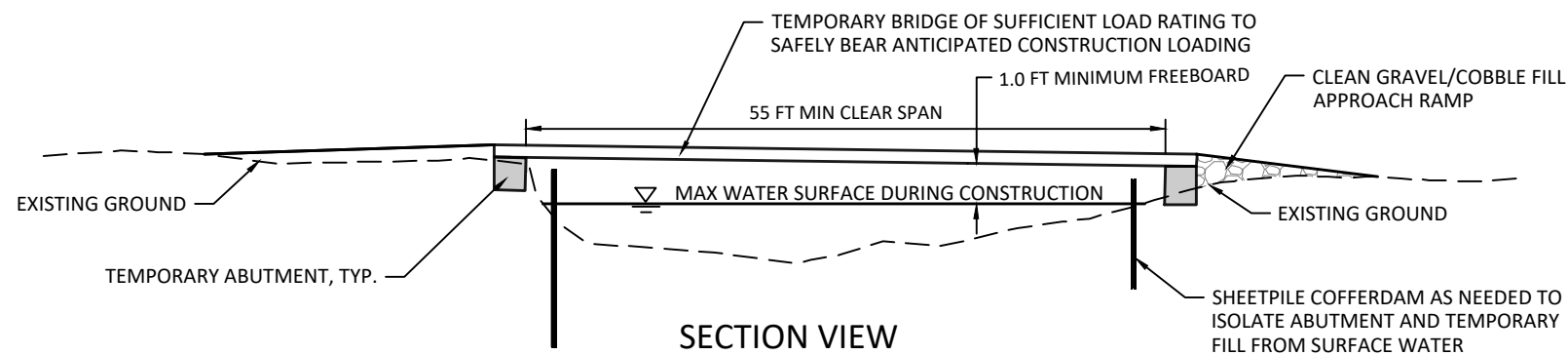
TYPICAL DETAIL - SHEET PILE COFFERDAM

NOT TO SCALE

SECTION

COFFERDAM NOTES:

1. TEMPORARY SHEET PILE IS REQUIRED TO ISOLATE CONSTRUCTION WATER FROM THE WATERWAY.
2. CONTRACTOR SHALL PROVIDE PUMPING SUFFICIENT FOR A NET INFLOW TO THE WORK AREA, AND DISCHARGE TURBID WATER TO UPLAND FLOODPLAIN.
3. COFFERDAM AND ALL MATERIALS SHALL BE COMPLETELY REMOVED FROM THE SITE AFTER CONSTRUCTION IS COMPLETED AND TURBIDITY HAS BEEN REMOVED.

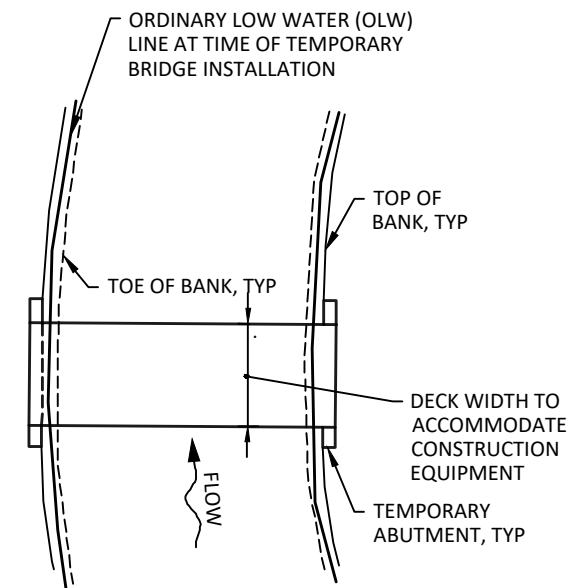


SECTION VIEW

2
10

TYPICAL DETAIL - TEMPORARY CROSSING

NOT TO SCALE



PLAN VIEW

NOTES:

1. TEMPORARY BRIDGE, ABUTMENTS, CLEAN GRAVEL/COBBLE FILL SHALL BE REMOVED AT PROJECT COMPLETION AND SITE RESTORED TO EXISTING GRADE AND CONDITIONS.
2. BRIDGE INSTALLATION AND REMOVAL, INCLUDING ABUTMENTS, SHALL BE ACCOMPLISHED WITH NO MORE THAN FOUR (4) EQUIPMENT CROSSINGS THROUGH THE CHANNEL.

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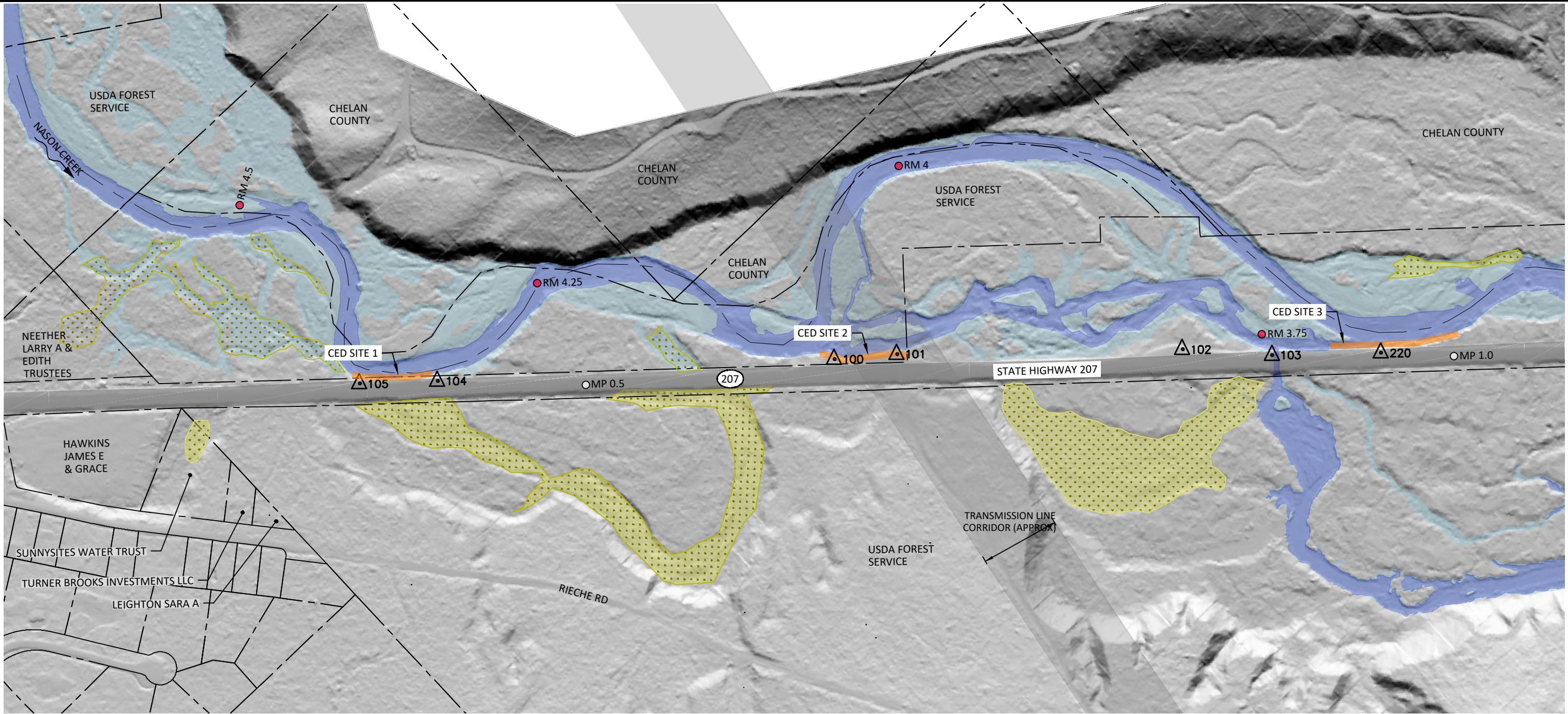
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TYPICAL DETAILS - DIVERSION
COFFERDAMS & TEMPORARY
CROSSING

SHEET

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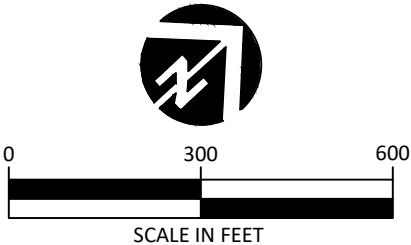
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LEGEND

- APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS
- APPROXIMATE ORDINARY HIGH WATER
- EXISTING WETLANDS
- WSDOT CHRONIC ENVIRONMENT DEFICIENCY SITE (CED)
- TAXLOTS
- NASON CREEK RIVER MILE
- HIGHWAY 207 MILEPOST
- SURVEY CONTROL POINT

SURVEY CONTROL				
Point #	Northing	Easting	Elevation	Description
220	279771.70	1666807.18	1945.45	NAIL
100	278552.01	1665695.91	1954.74	REBAR
101	278700.56	1665813.38	1952.82	STAKE
102	279340.25	1666390.48	1947.28	NAIL
103	279526.92	1666588.17	1946.14	REBAR
104	277630.52	1664927.19	1964.70	REBAR
105	277452.23	1664772.04	1966.58	REBAR



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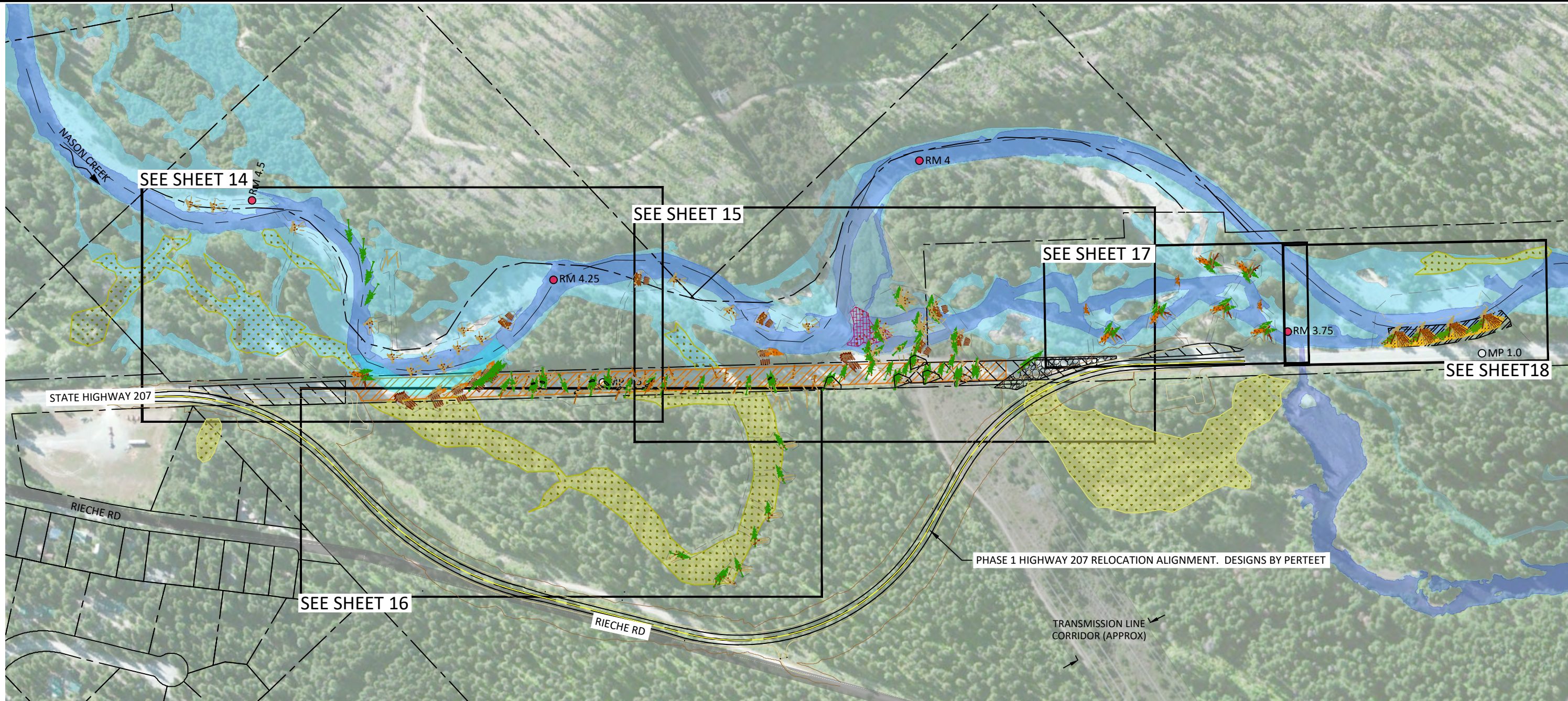
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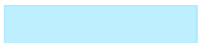
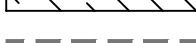
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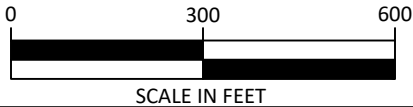
EXISTING CONDITIONS &
PROPERTY OWNERSHIP

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LEGEND

- | | | | |
|--|---|--|---|
|  | APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS |  | EXISTING ROAD PRISM REMOVAL |
|  | APPROXIMATE ORDINARY HIGH WATER |  | STABILIZE EXISTING LOG JAM WITH LOG PILES |
|  | EXISTING WETLANDS |  | LARGE WOOD STRUCTURES (TYPE VARIES) |
|  | TAXLOTS |  | STAGING AND STOCKPILE AREA |
|  RM XX | NASON CREEK RIVER MILE |  | ACCESS ROUTE |
|  OMP XX | HIGHWAY 207 MILEPOST |  | LIMITS OF DISTURBANCE (LOD) |
| | |  | COFFERDAM |



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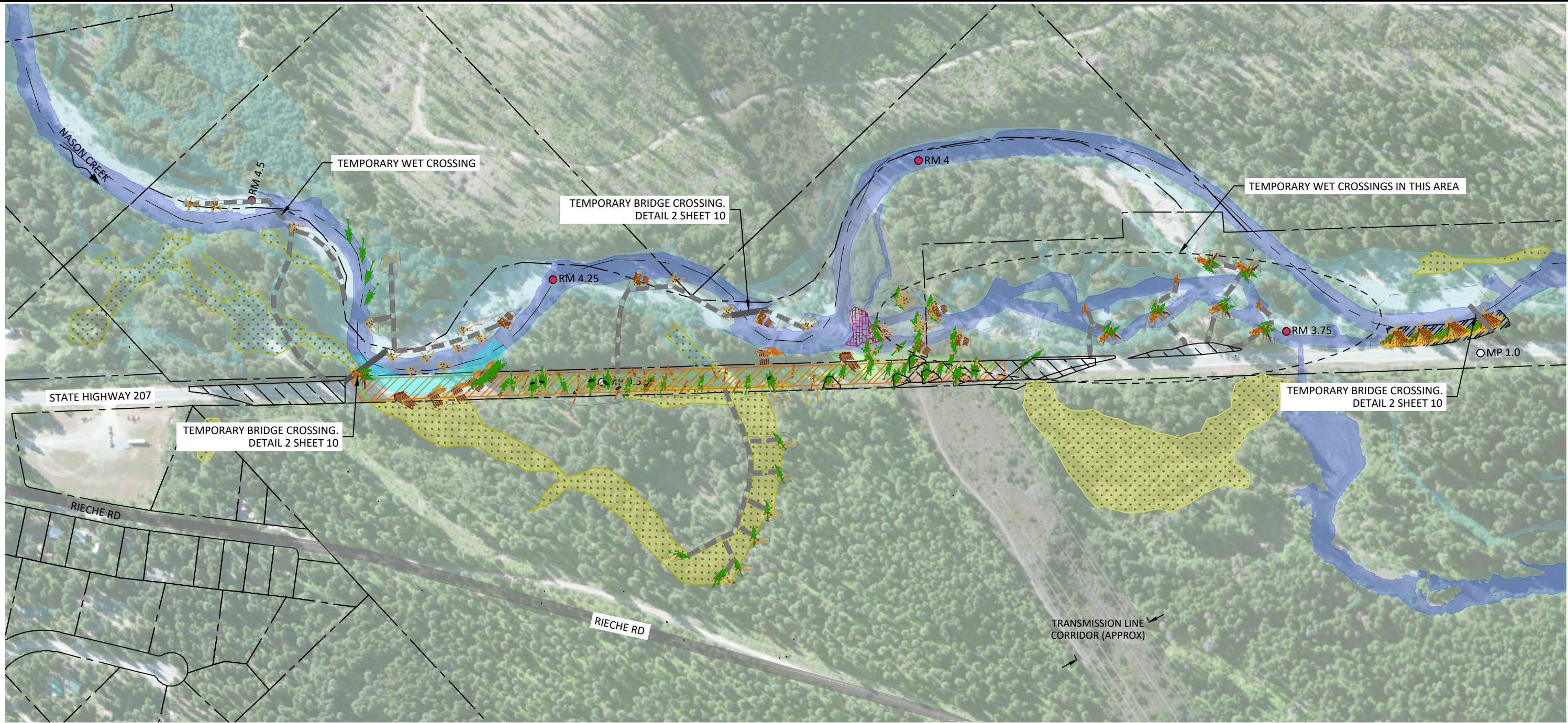


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PROPOSED CONDITIONS AND
SHEET INDEX

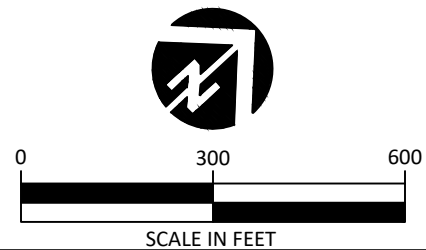
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LEGEND

- | | | | |
|--|---|--|---|
| | APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS | | EXISTING ROAD PRISM REMOVAL |
| | APPROXIMATE ORDINARY HIGH WATER | | STABILIZE EXISTING LOG JAM WITH LOG PILES |
| | EXISTING WETLANDS | | LARGE WOOD STRUCTURES (TYPE VARIES) |
| | WETLAND CREATION | | STAGING AND STOCKPILE AREA |
| | TAXLOTS | | ACCESS ROUTE |
| | RM XX NASON CREEK RIVER MILE | | LIMITS OF DISTURBANCE (LOD) |
| | OMP XX HIGHWAY 207 MILEPOST | | COFFERDAM |



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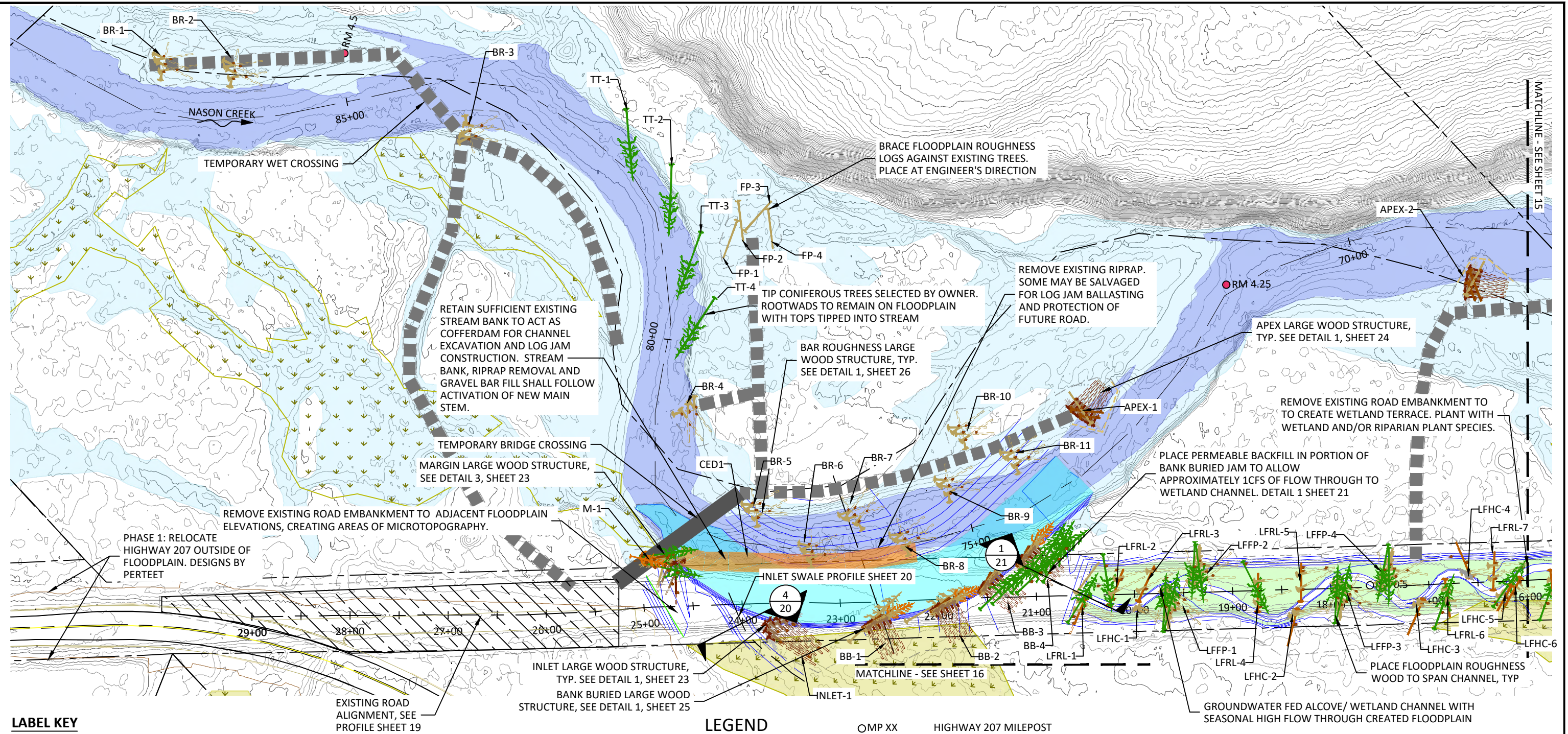


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PROPOSED ACCESS, STAGING
AND STOCKPILE AREAS

SHEET
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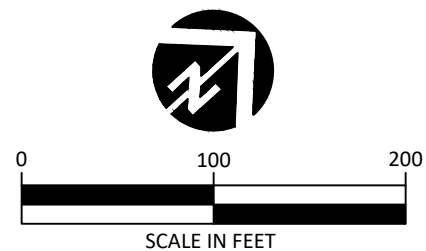
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LABEL KEY	
APEX	APEX JAMS
BB	BANK BURIED JAM
BBT	BANK BURIED JAM W/TREES
SM-BB	SMALL BANK BURIED JAM
M	BANK MARGIN WOOD
BR	BAR ROUGHNESS WOOD STRUCTURES
RW	BR AND SM-BB RACKING WOOD
CED3	CED3 BANK BARB STRUCTURE
DFL	DEFLECTOR JAM
FP	FLOODPLAIN ROUGHNESS LOGS
INLET	INLET STRUCTURE
LFFP	LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LW
LFHC	LOW FLOW CHANNEL HABITAT COVER LOGS
LFRL	LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LOG
TT	TIPPED TREE

LEGEND	
	EXISTING CONTOURS (1 FT)
	PROPOSED CONTOURS (1 FT)
	APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS
	APPROXIMATE ORDINARY HIGH WATER
	EXISTING WETLANDS
	WETLAND CREATION
	TAXLOTS
	RM XX NASON CREEK RIVER MILE

	OMP XX
	PROPOSED NEW CHANNEL
	LARGE WOOD STRUCTURES (TYPE VARIES)
	STAGING AND STOCKPILE AREA
	ACCESS ROUTE
	LIMITS OF DISTURBANCE (LOD)
	COFFERDAM



NOTE: DETAILS OF REMOVING ABANDONED UTILITIES TO BE PROVIDED IN THE NEXT PHASE.

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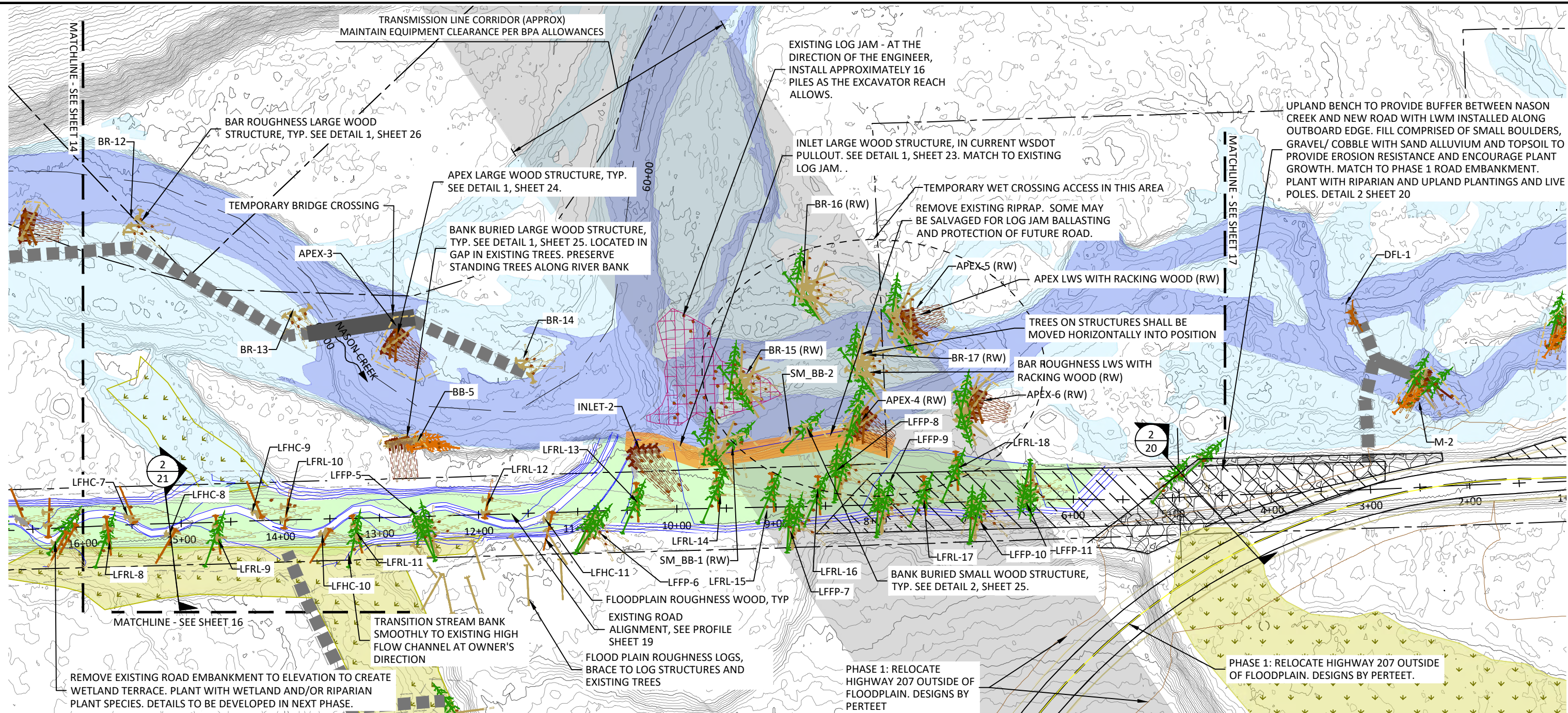
PROPOSED CONDITIONS
(1 OF 5)

SHEET
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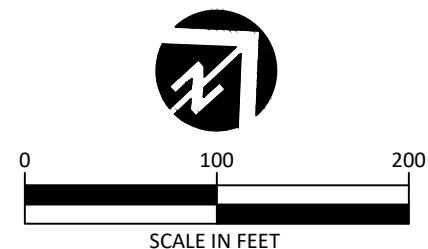


LEGEND

- | | | | |
|---------|---|--------|---|
| — | EXISTING CONTOURS (1 FT) | OMP XX | HIGHWAY 207 MILEPOST |
| — | PROPOSED CONTOURS (1 FT) | | STAGING AND STOCKPILE AREA |
| | APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS | | ACCESS ROUTE |
| | APPROXIMATE ORDINARY HIGH WATER | | LIMITS OF DISTURBANCE (LOD) |
| | EXISTING WETLANDS | | COFFERDAM |
| --- | TAXLOTS | | STABILIZE EXISTING LOG JAM WITH LOG PILES |
| ● RM XX | NASON CREEK RIVER MILE | | |
| | WETLAND CREATION | | |

LABEL KEY

- | | |
|-------|---|
| APEX | APEX JAMS |
| BB | BANK BURIED JAM |
| BBT | BANK BURIED JAM W/TREES |
| SM-BB | SMALL BANK BURIED JAM |
| M | BANK MARGIN WOOD |
| BR | BAR ROUGHNESS WOOD STRUCTURES |
| RW | BR AND SM-BB RACKING WOOD |
| CED3 | CED3 BANK BARB STRUCTURE |
| DFL | DEFLECTOR JAM |
| FP | FLOODPLAIN ROUGHNESS LOGS |
| INLET | INLET STRUCTURE |
| LFPP | LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LW |
| LFHC | LOW FLOW CHANNEL HABITAT COVER LOGS |
| LFRL | LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LOG |
| TT | TIPPED TREE |



NOTE: DETAILS OF REMOVING ABANDONED UTILITIES TO BE PROVIDED IN THE NEXT PHASE.

Preliminary
Not for Construction

YAKAMA NATION FISHERIES
NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT
PHASE 2 60% DESIGN



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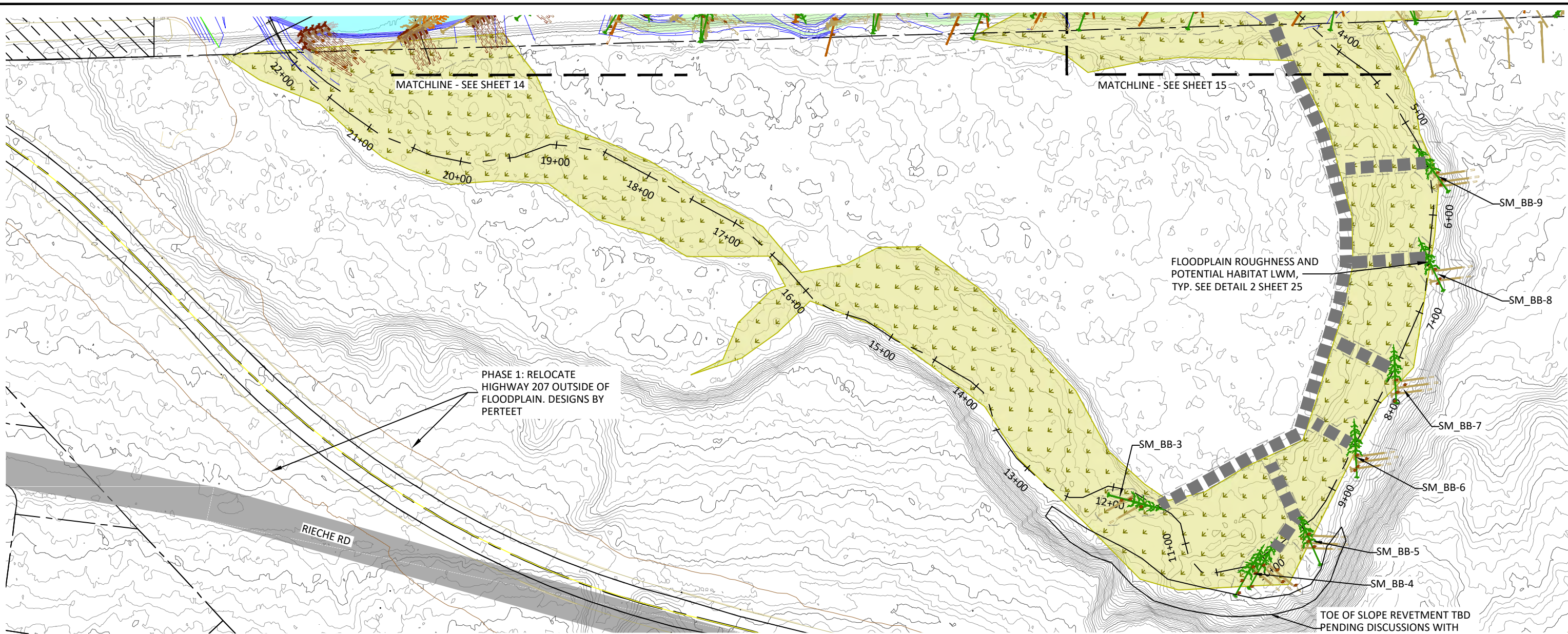


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PROPOSED CONDITIONS
(2 OF 5)

SHEET
15 OF 31

G:\M-P\Nason Creek Floodplain RM 3.4-4.6 Phase 3 200237 Drawings\JFL NasonFP_NaRD_C.dwg - 1/13/26

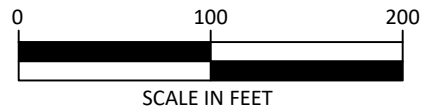


LEGEND

- EXISTING CONTOURS (1 FT)
- PROPOSED CONTOURS (1 FT)
- APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS
- APPROXIMATE ORDINARY HIGH WATER
- EXISTING WETLANDS
- TAXLOTS
- RM XX NASON CREEK RIVER MILE
- OMP XX HIGHWAY 207 MILEPOST
- STAGING AND STOCKPILE AREA
- ACCESS ROUTE
- LIMITS OF DISTURBANCE (LOD)
- COFFERDAM

LABEL KEY

- APEX APEX JAMS
- BB BANK BURIED JAM
- BBT BANK BURIED JAM W/TREES
- SM-BB SMALL BANK BURIED JAM
- M BANK MARGIN WOOD
- BR BAR ROUGHNESS WOOD STRUCTURES
- RW BR AND SM-BB RACKING WOOD
- CED3 CED3 BANK BARB STRUCTURE
- DFL DEFLECTOR JAM
- FP FLOODPLAIN ROUGHNESS LOGS
- INLET INLET STRUCTURE
- LFFP LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LW
- LFHC LOW FLOW CHANNEL HABITAT COVER LOGS
- LFRL LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LOG
- TT TIPPED TREE



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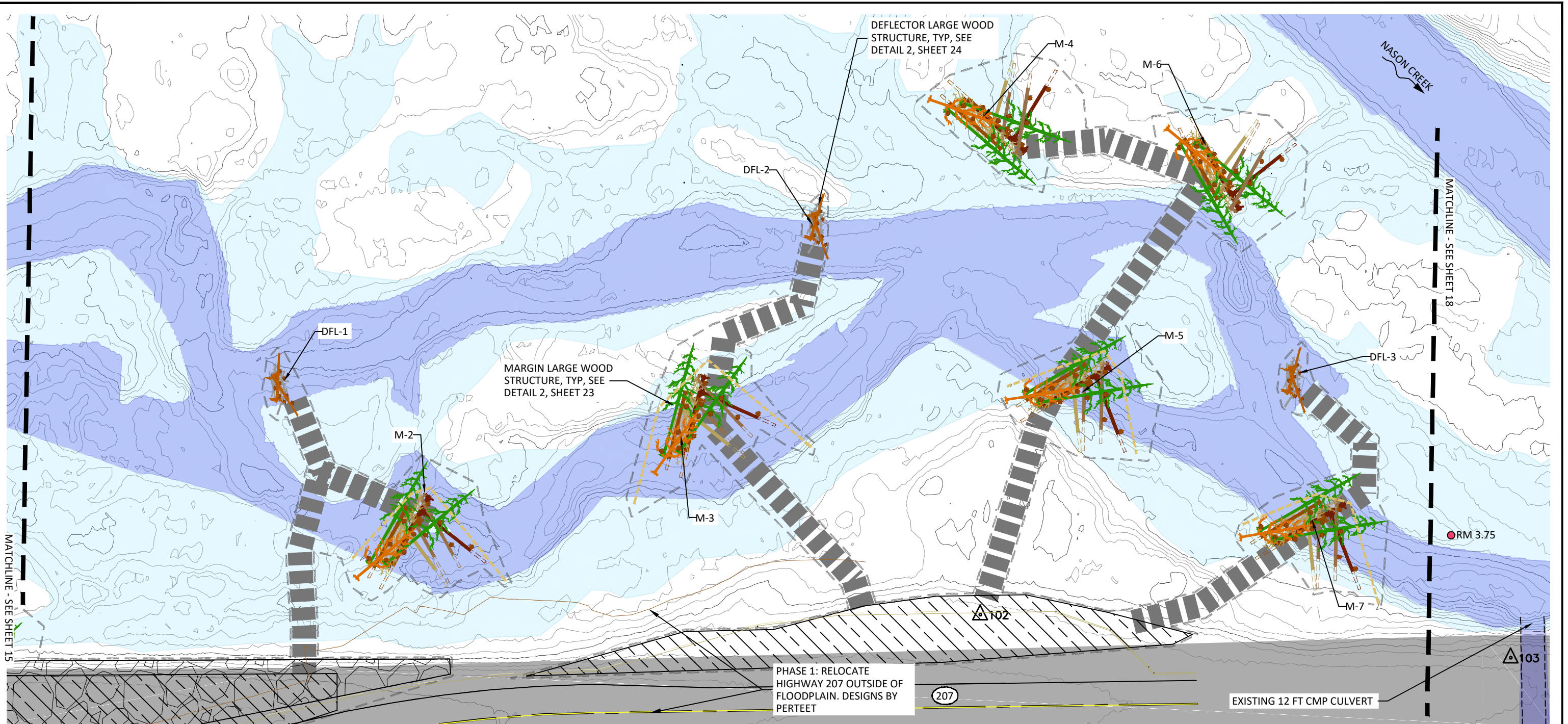


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LEGEND

- EXISTING CONTOURS (1 FT)
- APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS
- APPROXIMATE ORDINARY HIGH WATER
- RM XX NASON CREEK RIVER MILE
- 100 SURVEY CONTROL POINT

- STAGING AND STOCKPILE AREA
- ACCESS ROUTE
- LIMITS OF DISTURBANCE (LOD)
- COFFERDAM

LABEL KEY

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- BB BANK BURIED JAM
- BBT BANK BURIED JAM W/TREES
- SM-BB SMALL BANK BURIED JAM
- M BANK MARGIN WOOD
- BR BAR ROUGHNESS WOOD STRUCTURES
- RW BR AND SM-BB RACKING WOOD
- CED3 CED3 BANK BARB STRUCTURE
- DFL DEFLECTOR JAM
- FP FLOODPLAIN ROUGHNESS LOGS
- INLET INLET STRUCTURE
- LFFP LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LW
- LFHC LOW FLOW CHANNEL HABITAT COVER LOGS
- LFRL LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LOG
- TT TIPPED TREE

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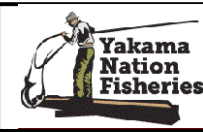
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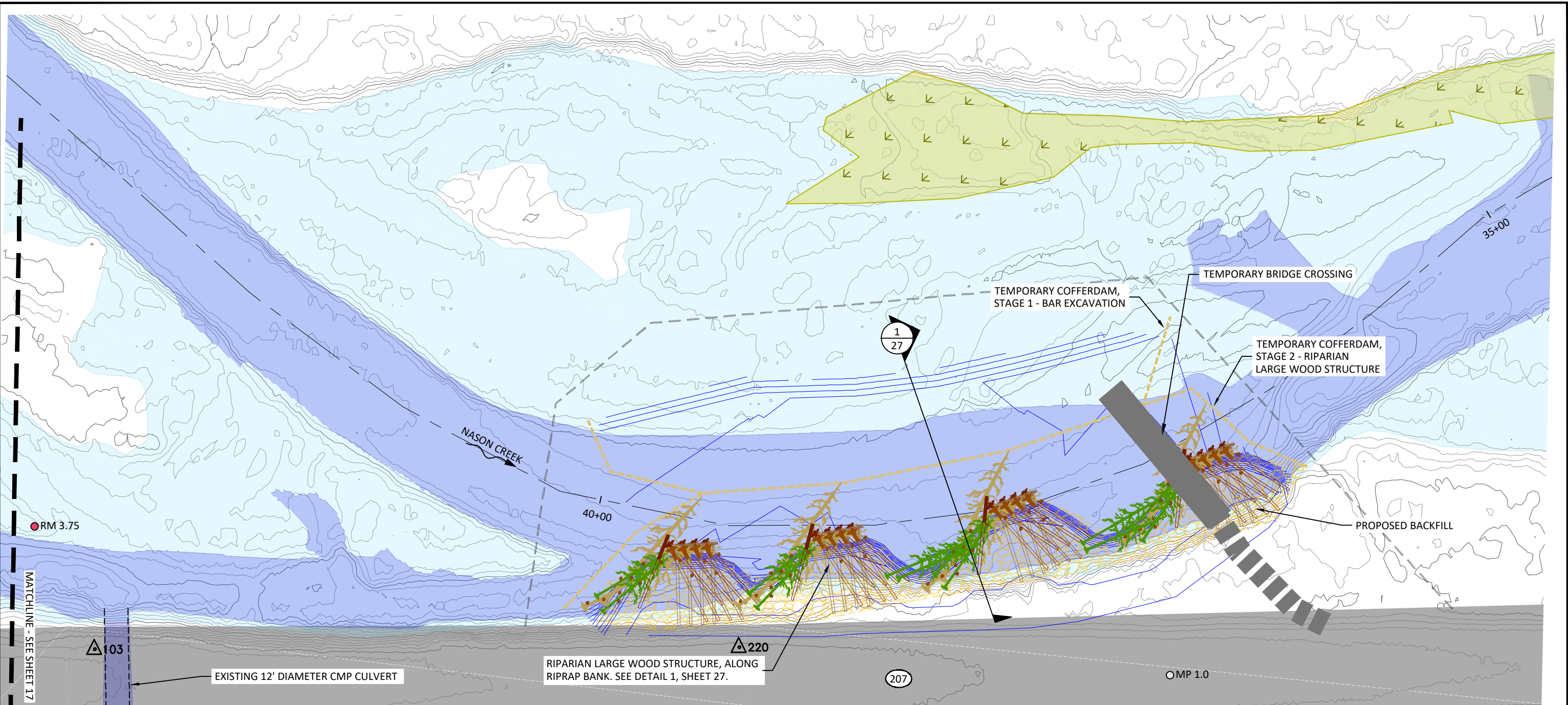


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(4 OF 5)

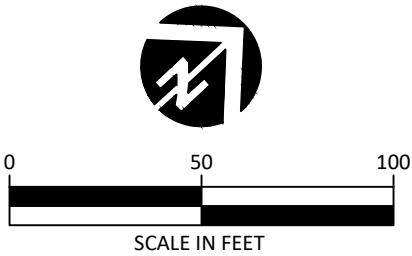
SHEET
17 OF 31

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LEGEND

- EXISTING CONTOURS (1 FT)
- PROPOSED CONTOURS (1 FT)
- APPROXIMATE 1.5-YEAR EVENT FLOW INUNDATION LIMITS FOR EXISTING CONDITIONS
- APPROXIMATE ORDINARY HIGH WATER
- EXISTING WETLANDS
- RM XX NASON CREEK RIVER MILE
- OMP XX HIGHWAY 207 MILEPOST
- △100 SURVEY CONTROL POINT
- STAGING AND STOCKPILE AREA
- ACCESS ROUTE
- LIMITS OF DISTURBANCE (LOD)
- COFFERDAM



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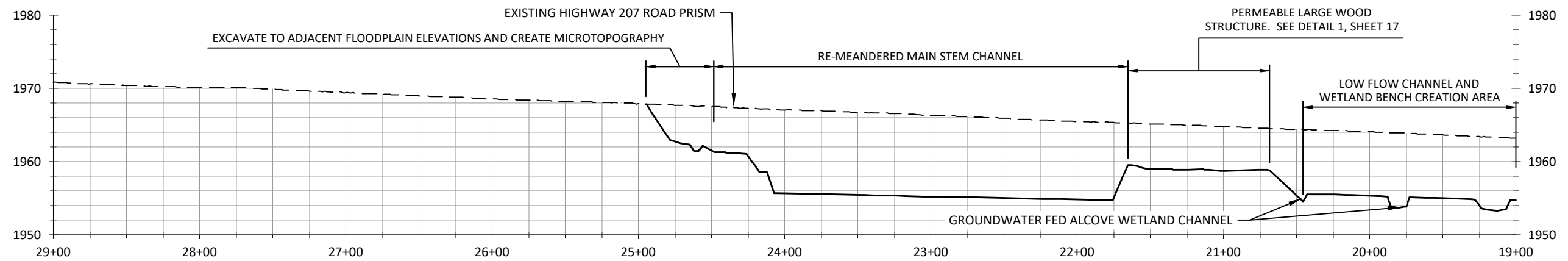
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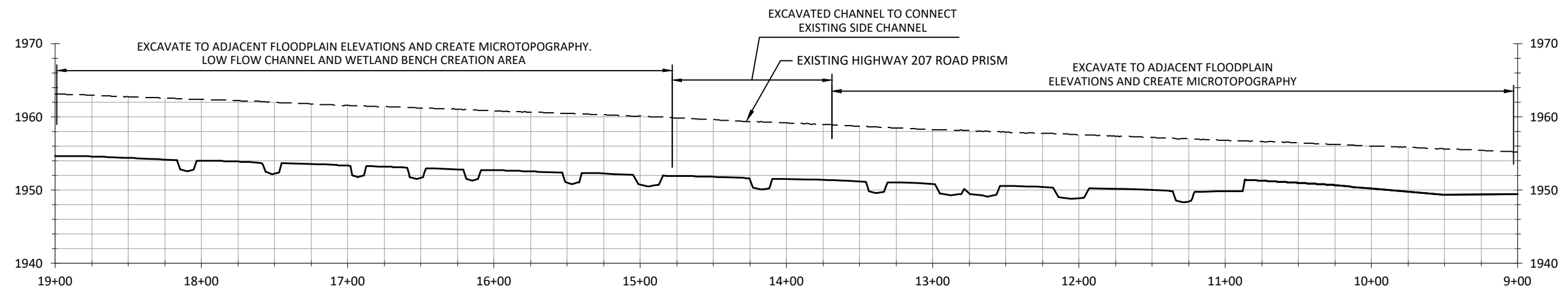
PROPOSED CONDITIONS
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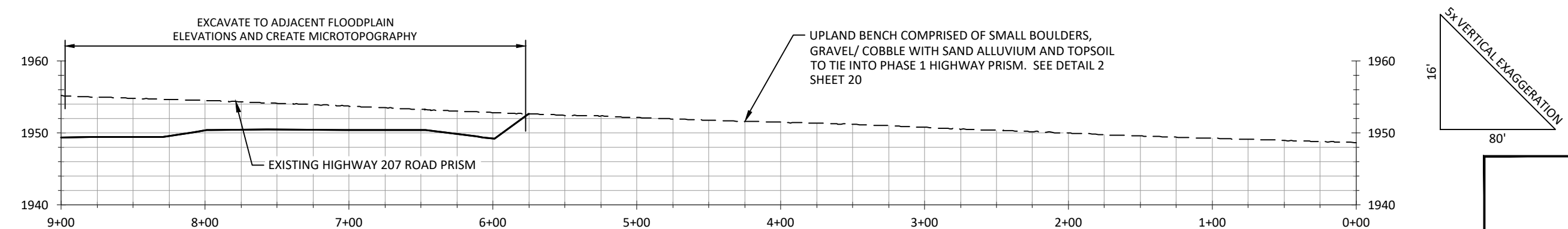
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PROFILE - EXISTING ROAD PRISM, STA 29+00 - 19+00



PROFILE - EXISTING ROAD PRISM, STA 19+00 - 9+00



PROFILE - EXISTING ROAD PRISM, STA 9+00 - 0+00

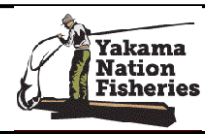
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PHASE 2 60% DESIGN

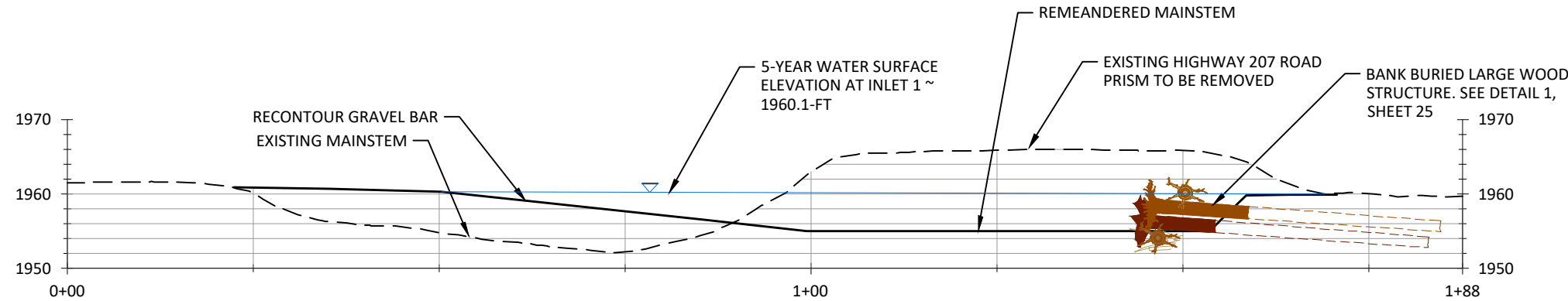
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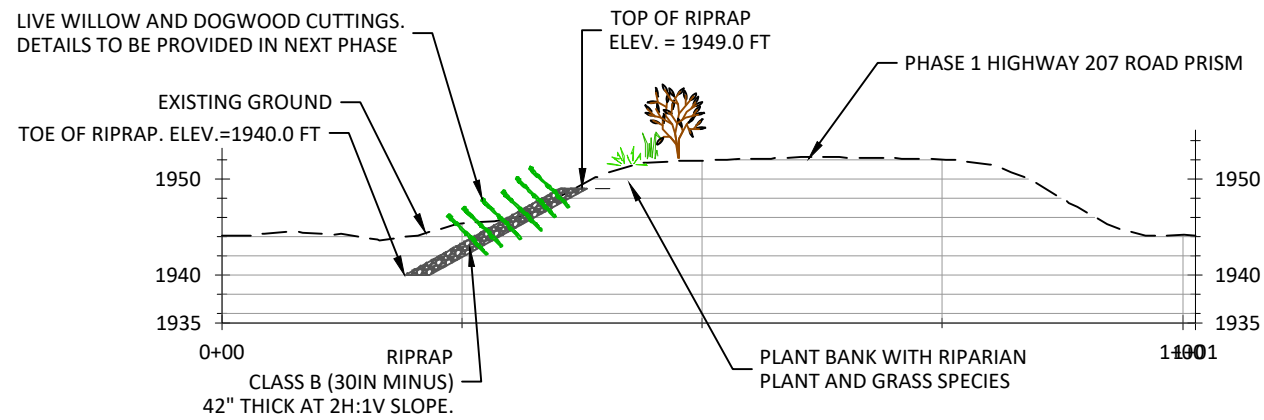
PROFILE - EXISTNG ROAD
PRISM

SHEET
19 OF 31

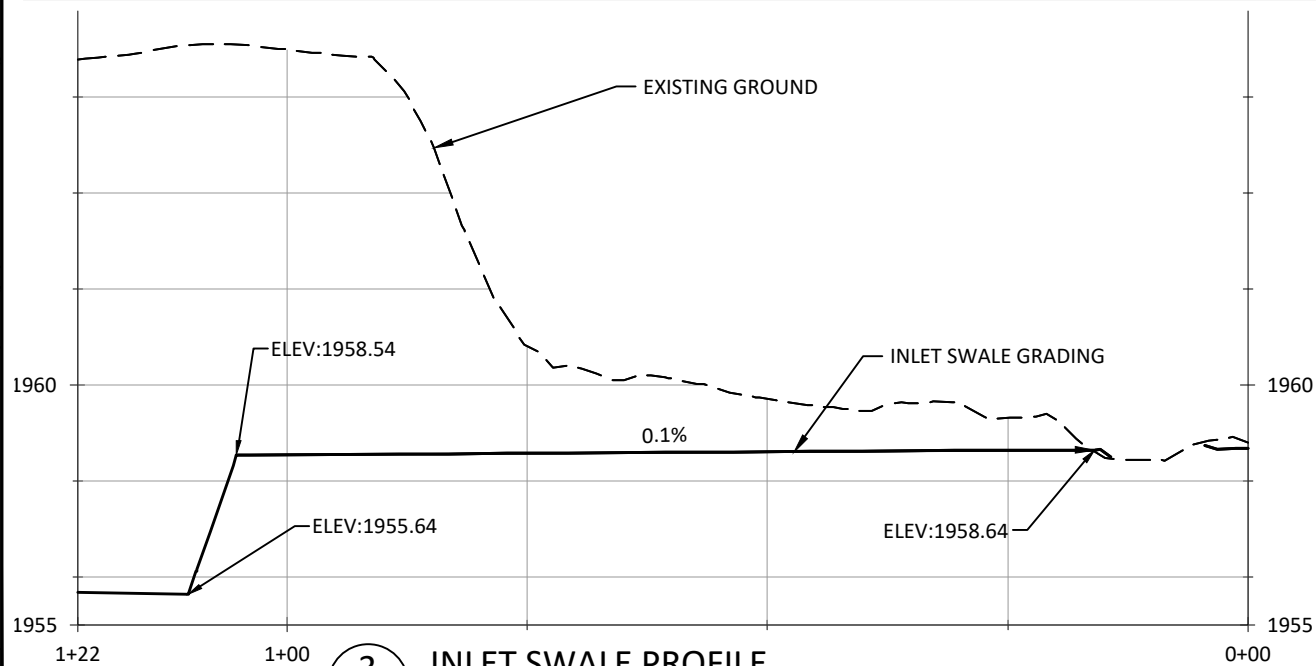
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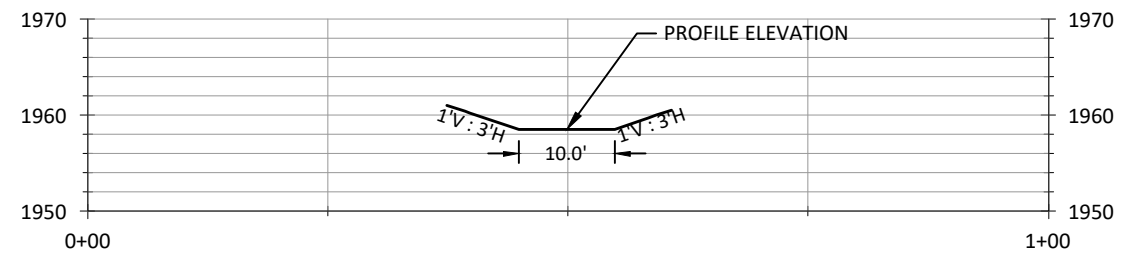
1
20 TYPICAL SECTION - MAINSTEM/ROAD REMOVAL
1"=20'



2
20 TYPICAL SECTION - ROAD BUFFER
1"=20'



3
20 INLET SWALE PROFILE
5 X VERTICAL EXAGGERATION (1"=20')



4
20 TYPICAL SECTION - INLET SWALE
1"=20'

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PHASE 2 60% DESIGN



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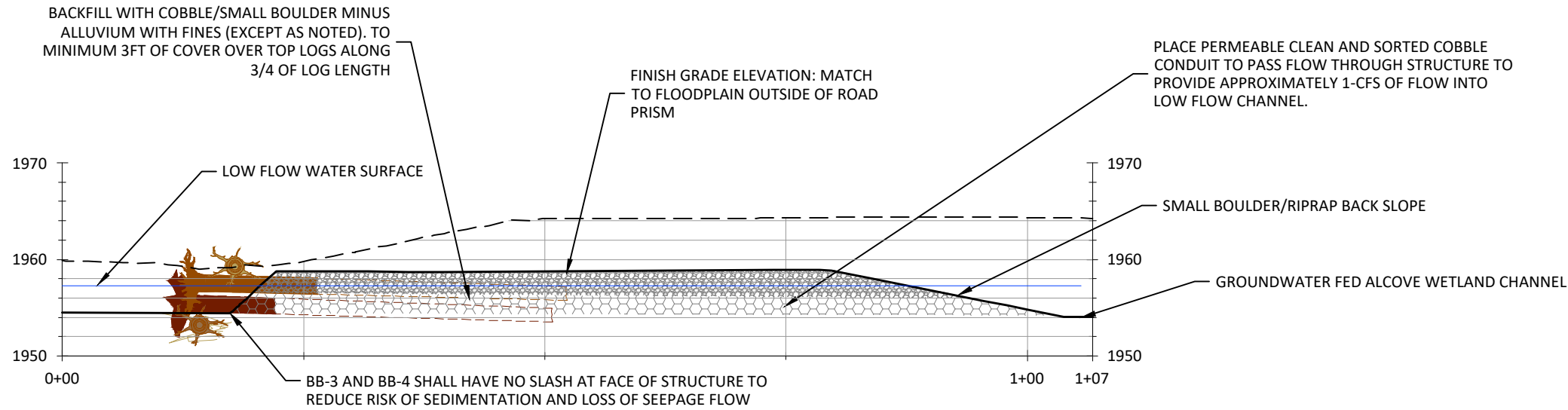


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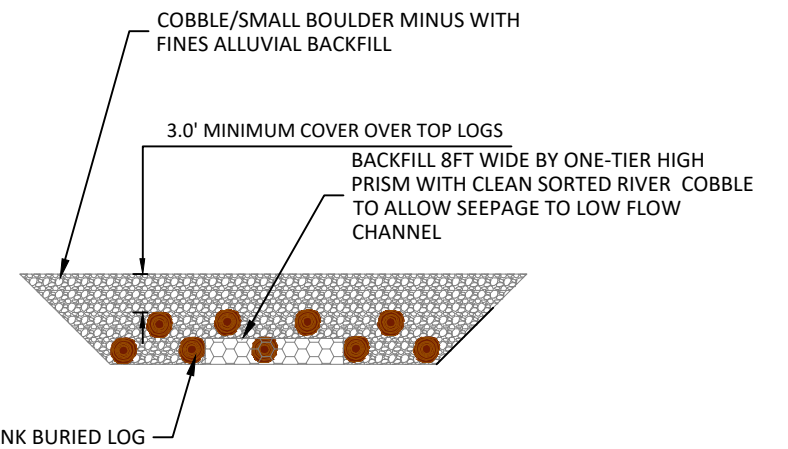
ROAD CROSS SECTIONS &
INLET SWALE PROFILE AND
SECTION

SHEET
20 OF 31

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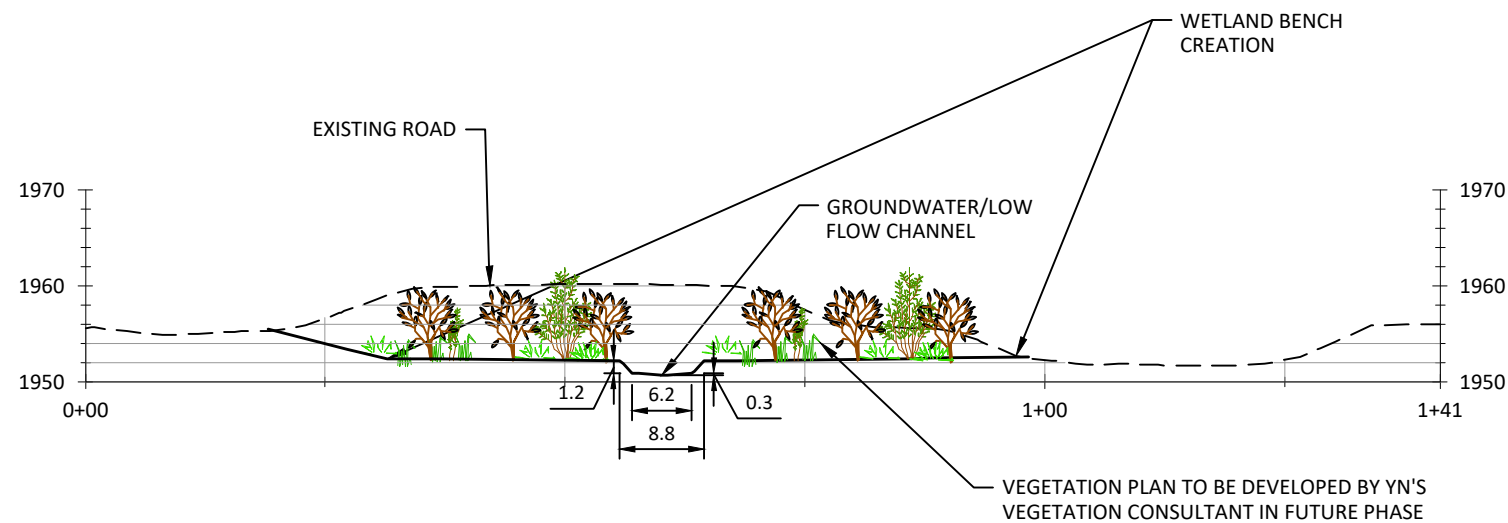


BANK BURIED JAM DETAILS FOR INLET TO GROUND WATER FED/WETLAND CHANNEL



BANK BURIED INFILTRATION LARGE WOOD STRUCTURE SECTION VIEW

1
21 GROUND WATER FED/WETLAND CHANNEL CONTROLLED INFLOW
1"=15'



2
21 TYPICAL SECTION - ROAD REMOVAL/WETLAND TERRACE
1"=20'

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PHASE 2 60% DESIGN

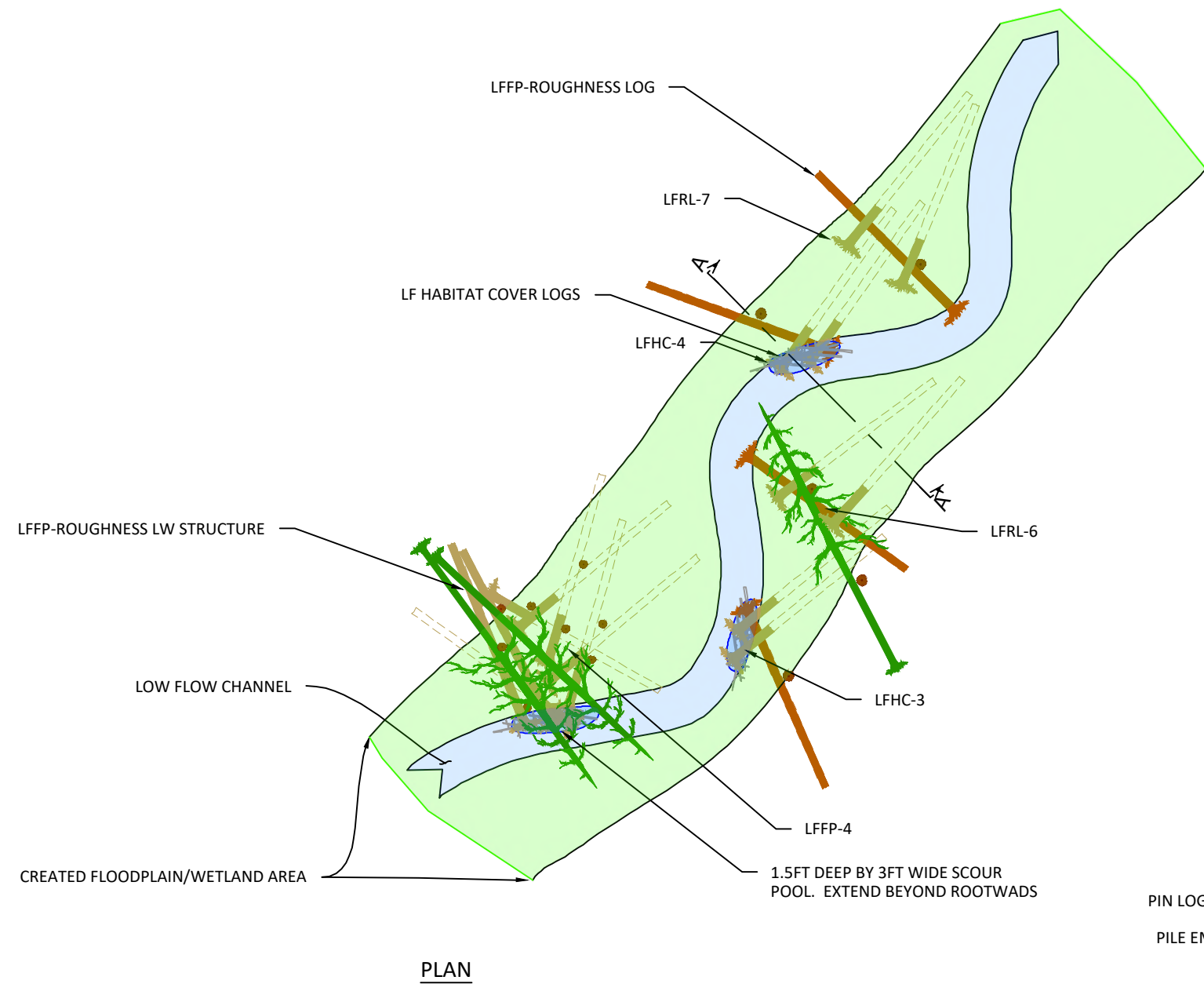
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Nation
Fisheries

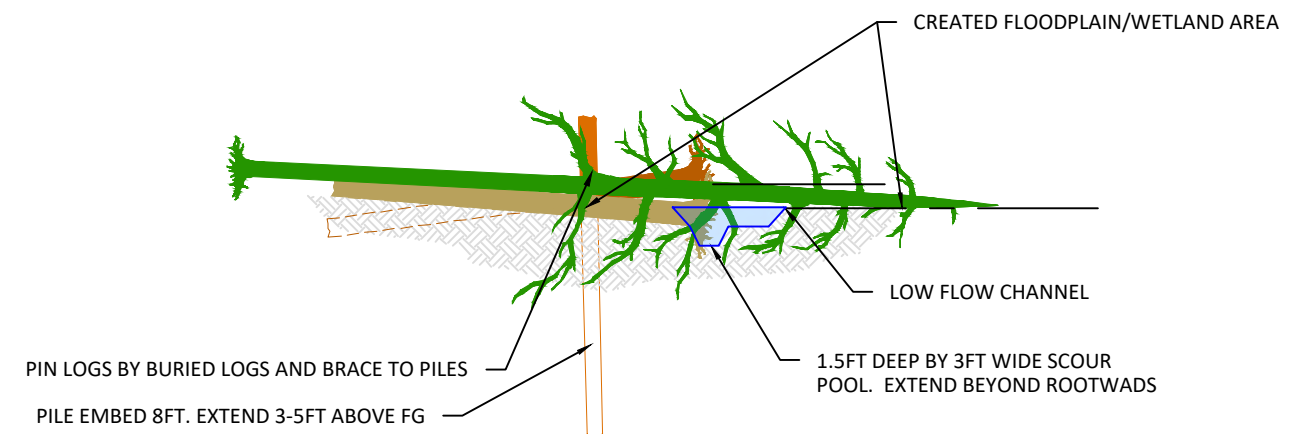
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CROSS SECTIONS

SHEET
21 OF 31



1 **LOW FLOW CHANNEL TYPICAL DETAIL**
22 NOT TO SCALE

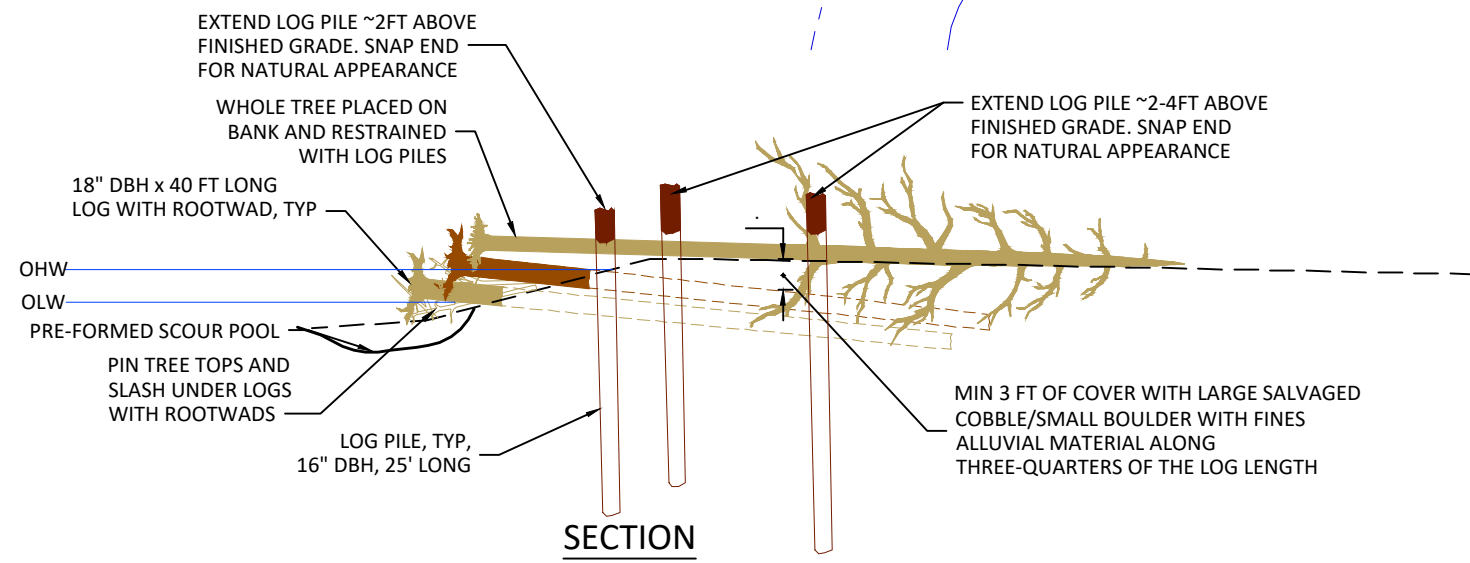
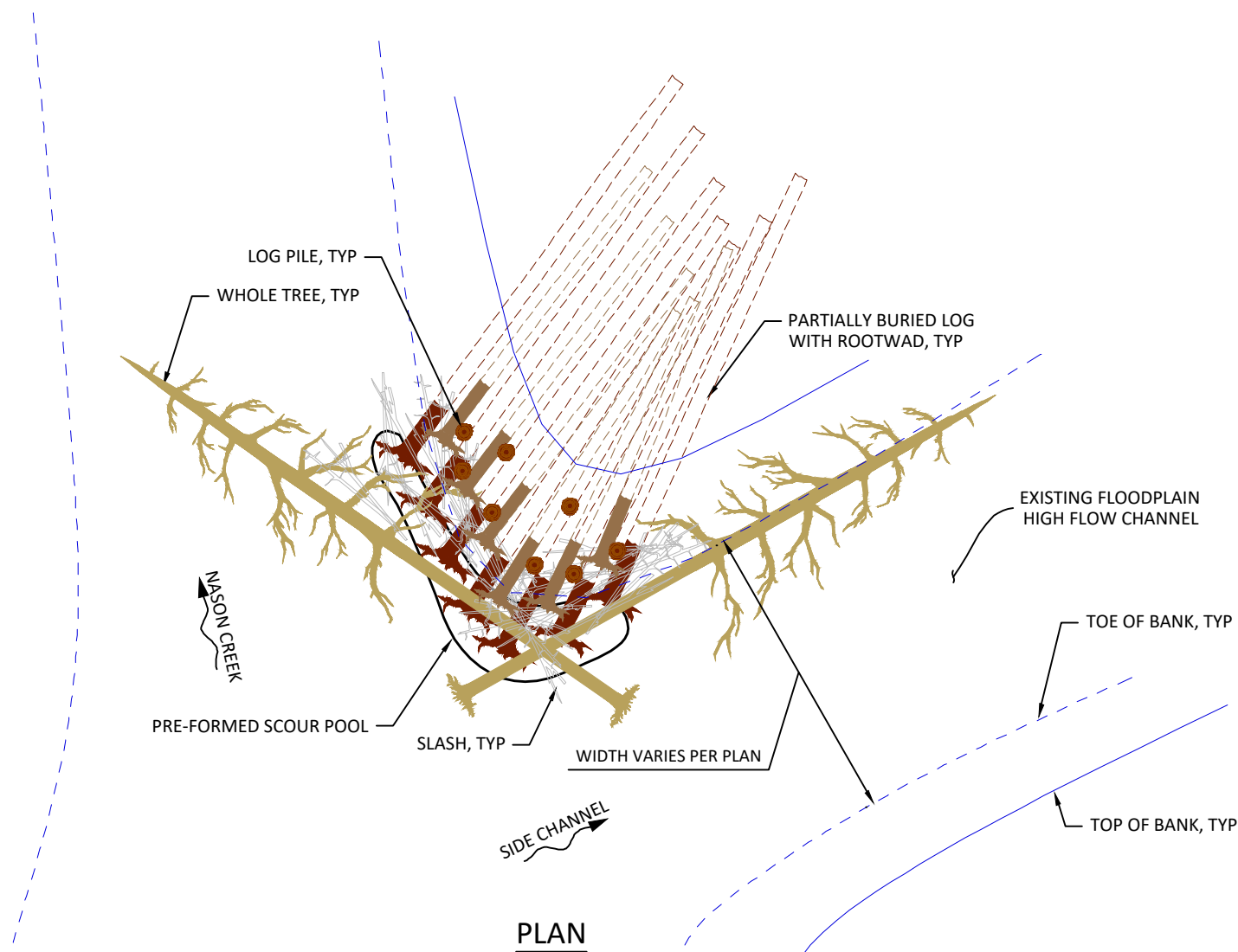


SECTION VIEW A-A'

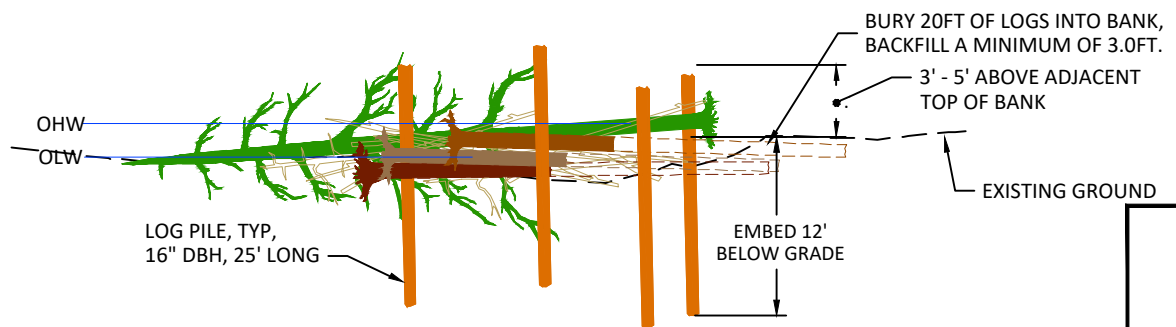
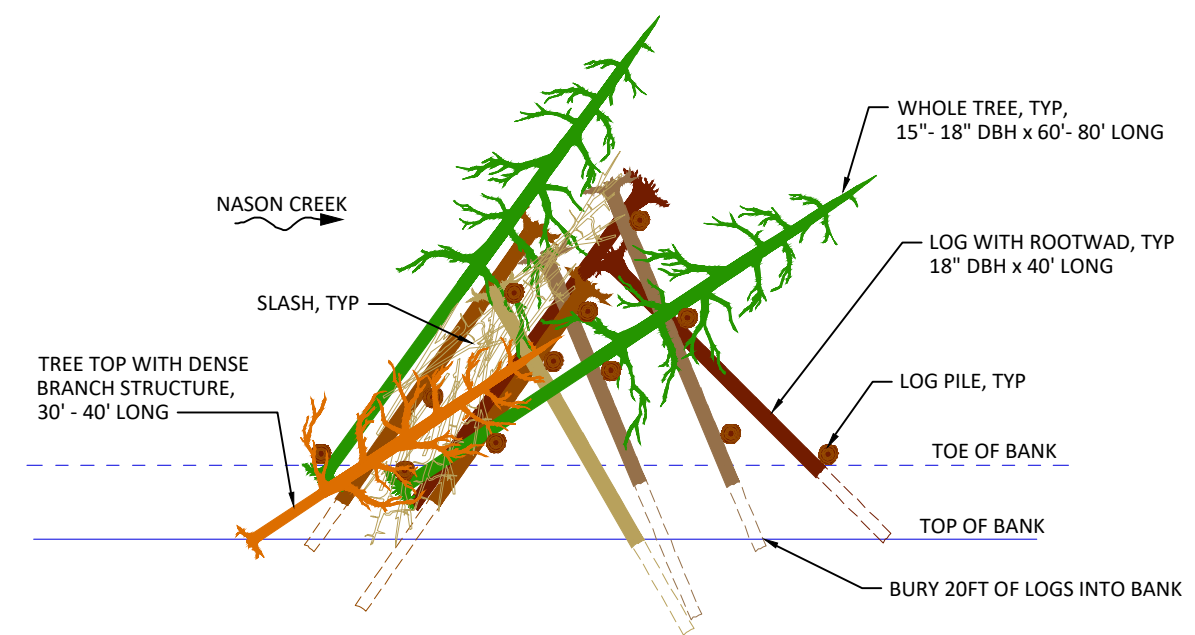


G.W.-P. Nason NO. BY DATE REVISION DESCRIPTION				CM	DM	DM	YAKAMA NATION FISHERIES NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT PHASE 2 60% DESIGN	 501 Portway Avenue, Suite 101 Hood River, OR 97031 541.386.9003 www.interfluve.com	 POST OFFICE BOX 151 FORT ROAD TOPPENISH, WA 98948 (509)865-5121	LOW FLOW CHANNEL TYPICAL DETAIL	SHEET
				DRAWN	DESIGNED	CHECKED					22 OF 31
				DM	01/13/2026	200237					
				APPROVED	DATE	PROJECT					

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1
23 TYPICAL DETAIL - INLET LARGE WOOD STRUCTURE (INLET)
NOT TO SCALE



2
23 TYPICAL DETAIL - MARGIN LARGE WOOD STRUCTURE (M)
NOT TO SCALE

Preliminary
Not for Construction

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YAKAMA NATION FISHERIES
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PHASE 2 60% DESIGN



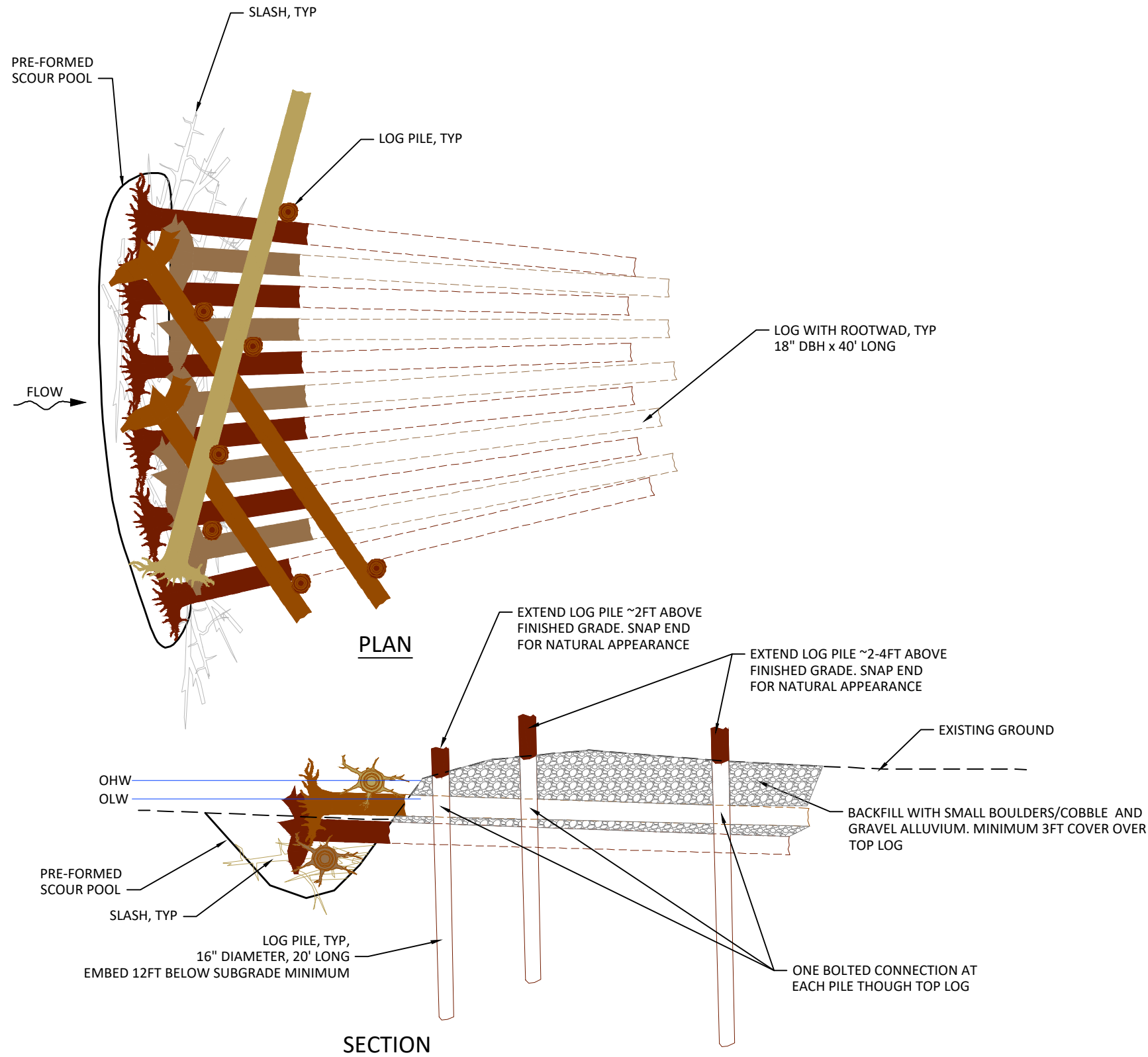
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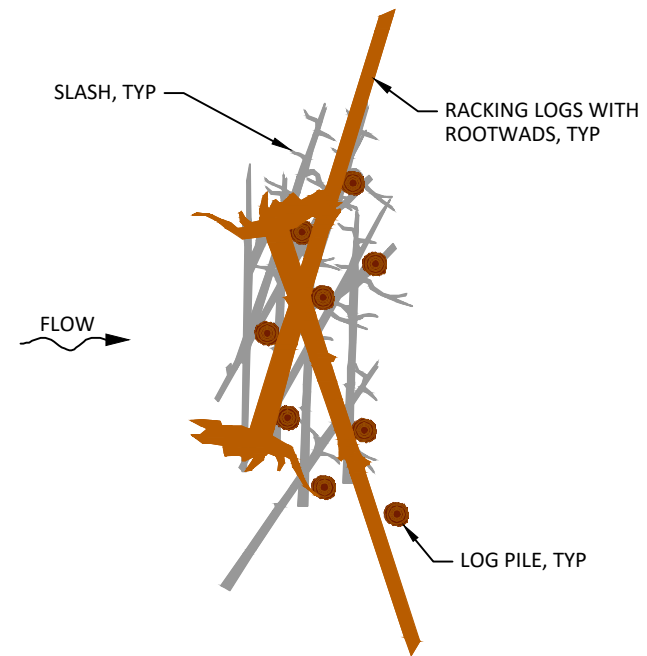
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LARGE WOOD TYPICAL DETAILS
(1 OF 5)

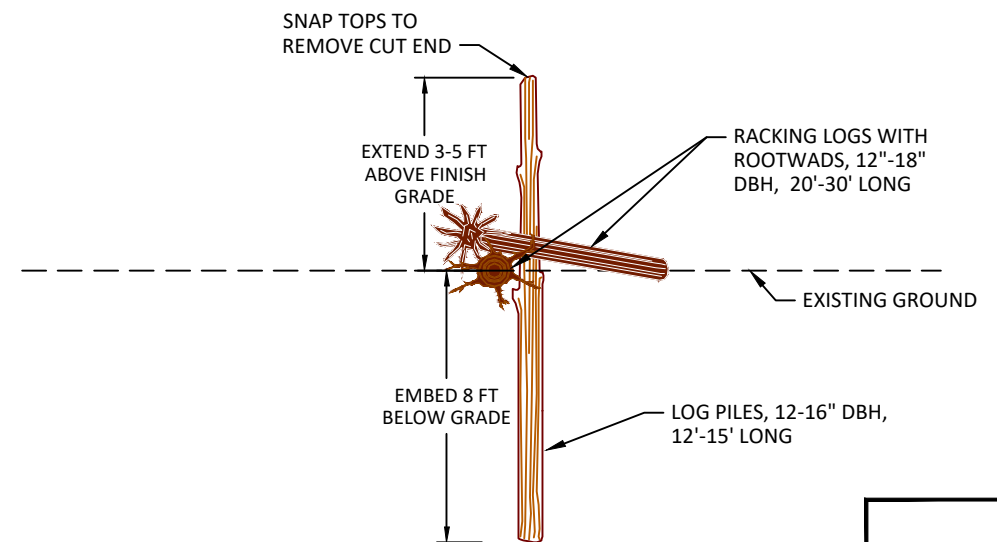
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1
24
TYPICAL DETAIL - APEX LARGE WOOD STRUCTURE (APEX)
NOT TO SCALE



PLAN



SECTION

2
24
TYPICAL DETAIL - DEFLECTOR STRUCTURE (DFL)
NOT TO SCALE

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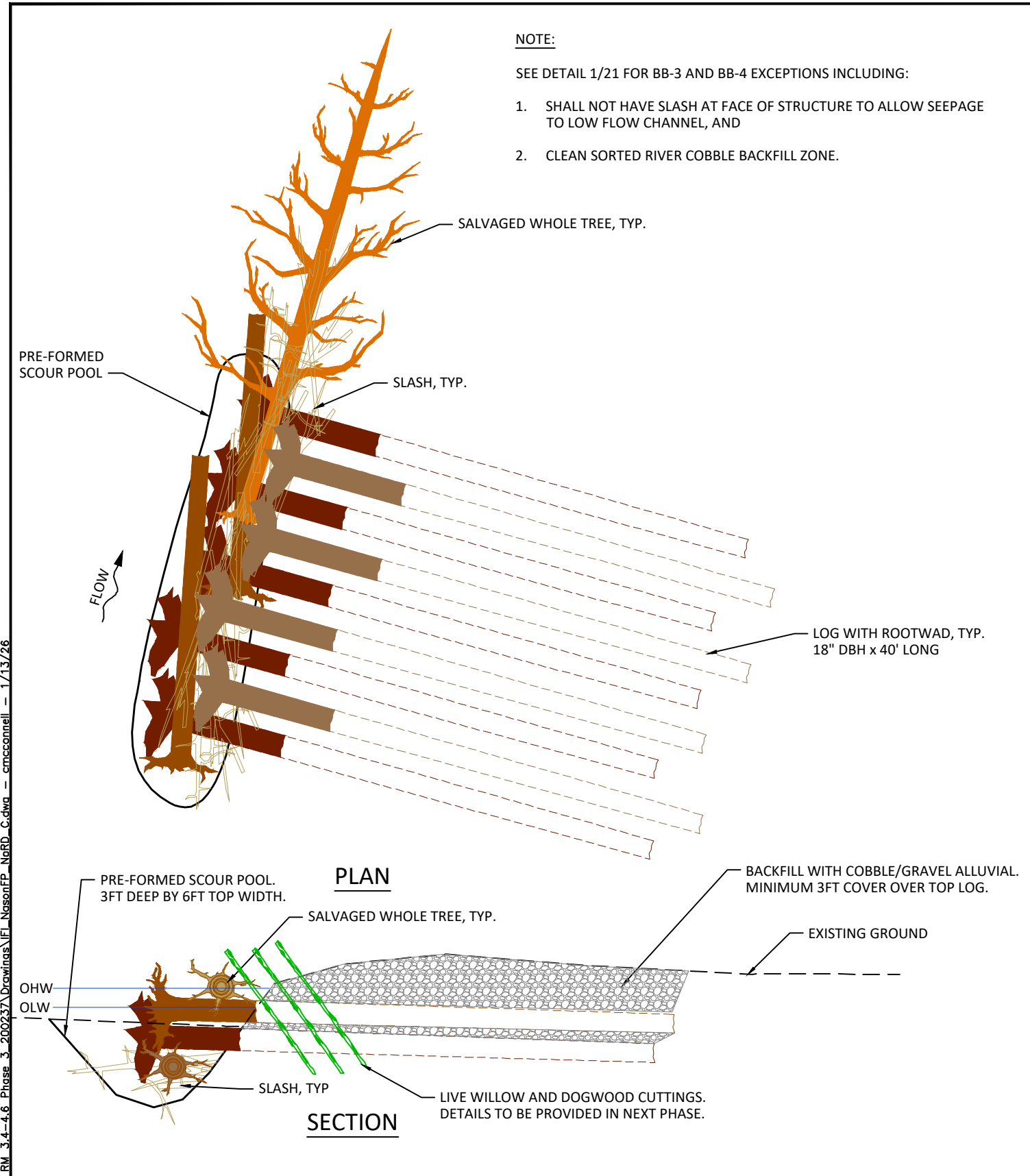


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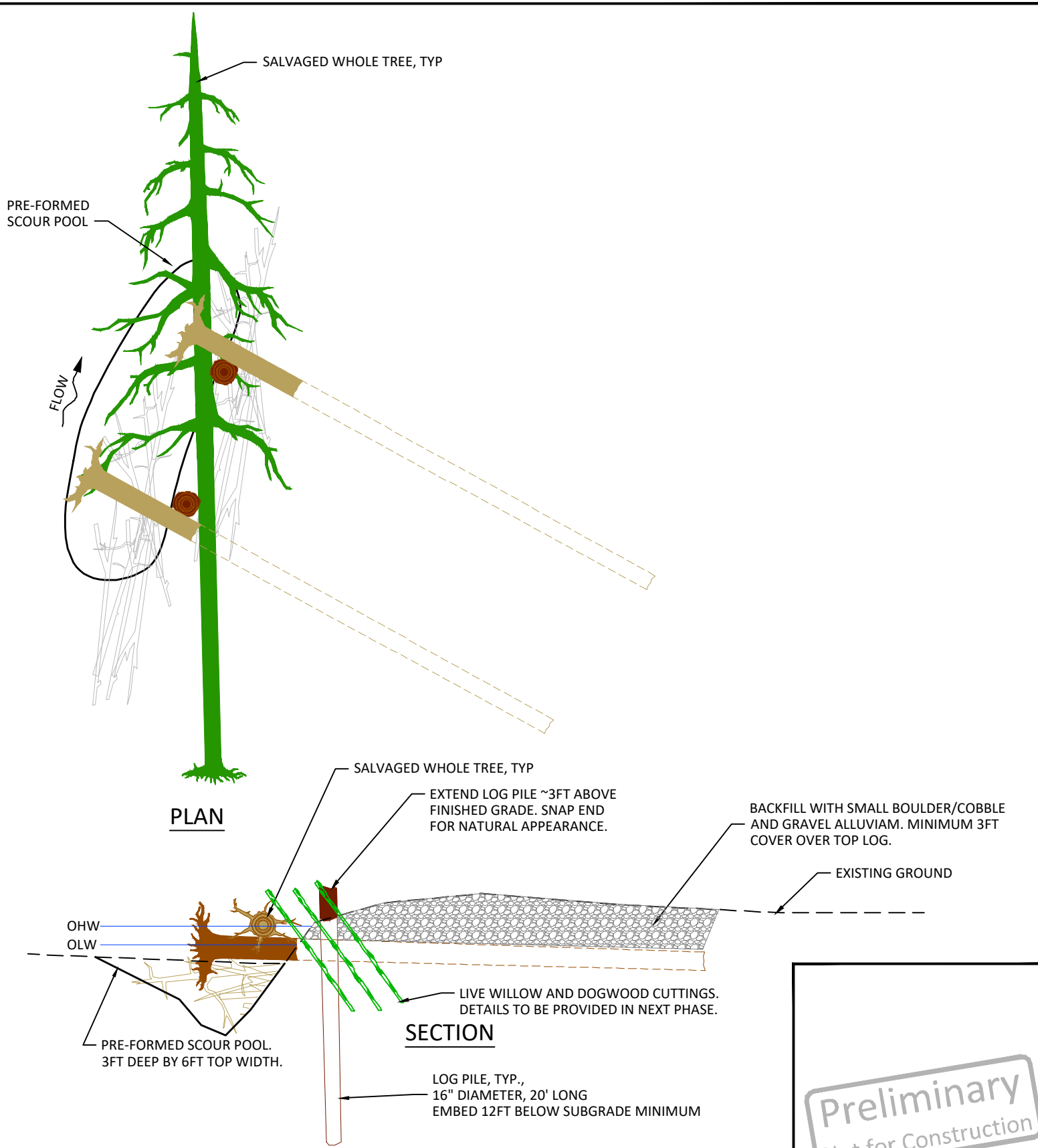
LARGE WOOD TYPICAL DETAILS
(2 OF 5)

SHEET
24 OF 31

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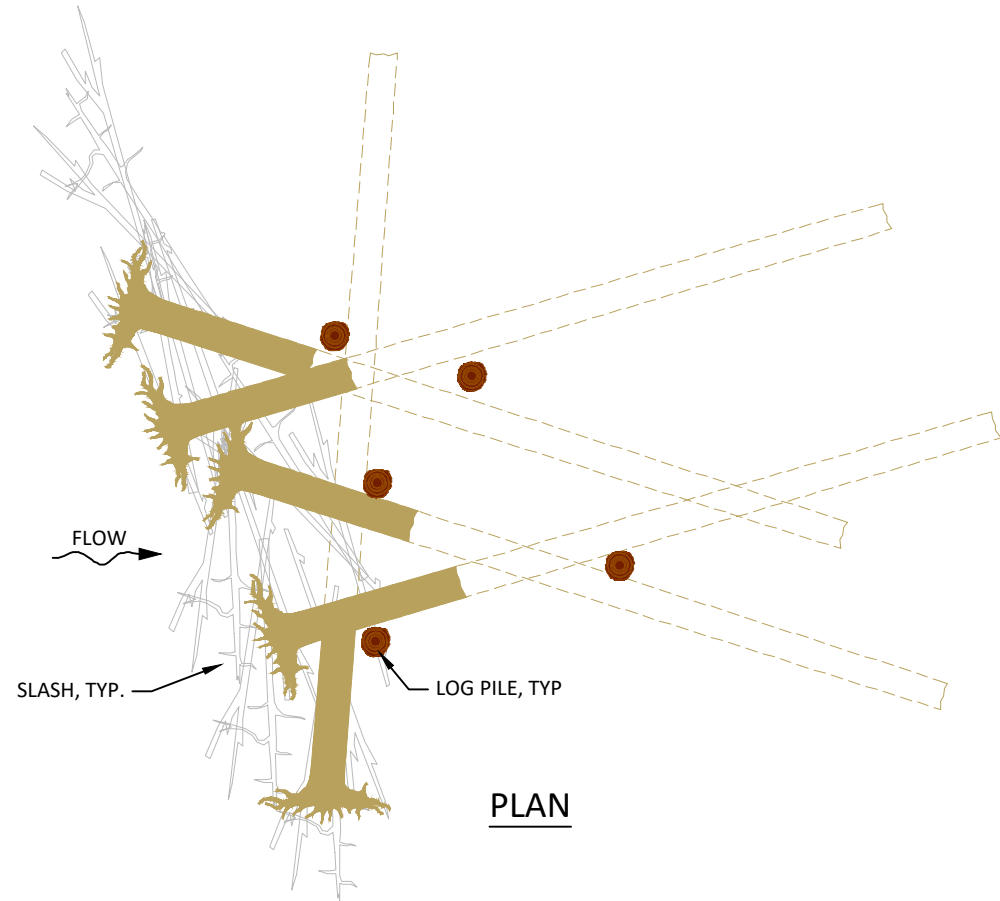
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25 TYPICAL DETAIL - BANK BURIED LARGE WOOD STRUCTURE (BB)
NOT TO SCALE



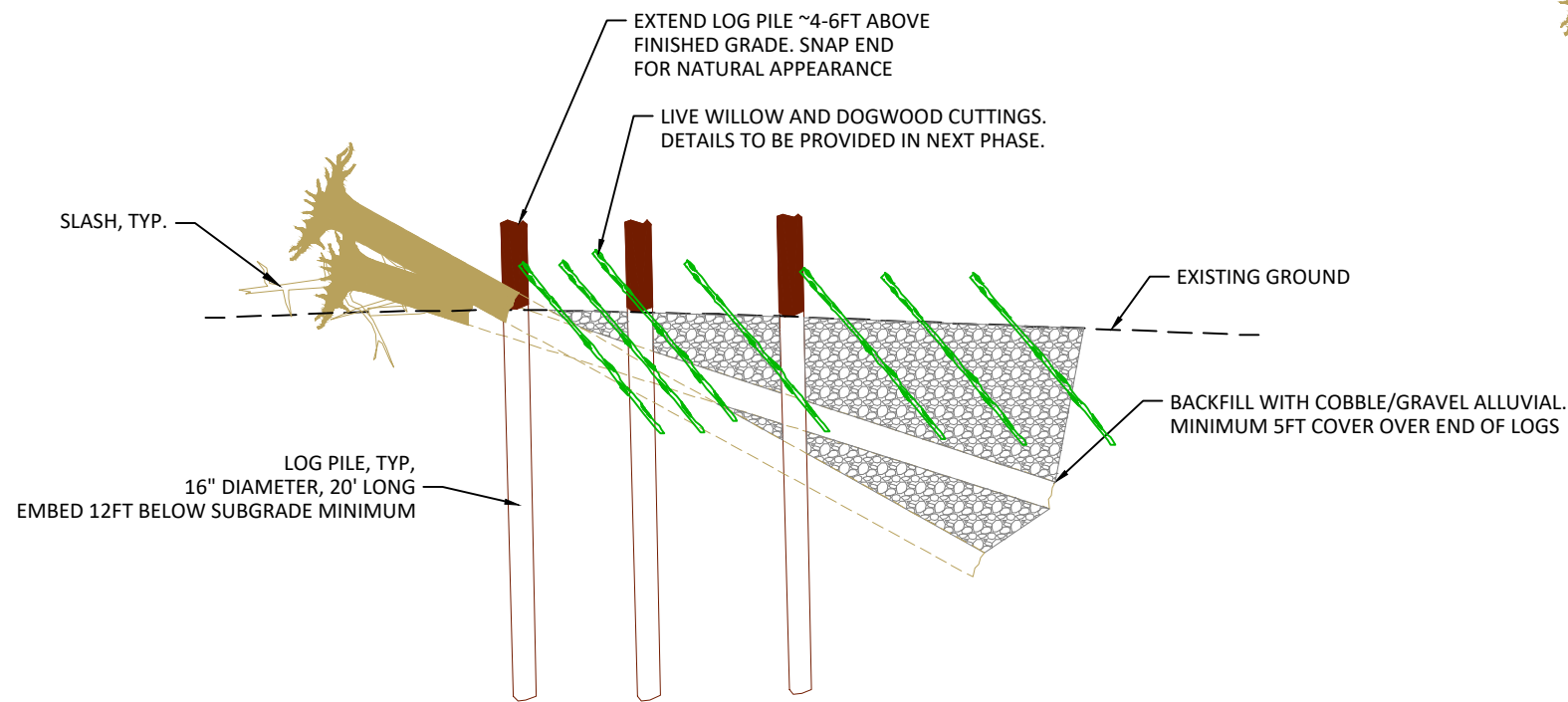
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25 TYPICAL DETAIL - SMALL BANK BURIED LARGE WOOD STRUCTURE (SM-BB)
NOT TO SCALE

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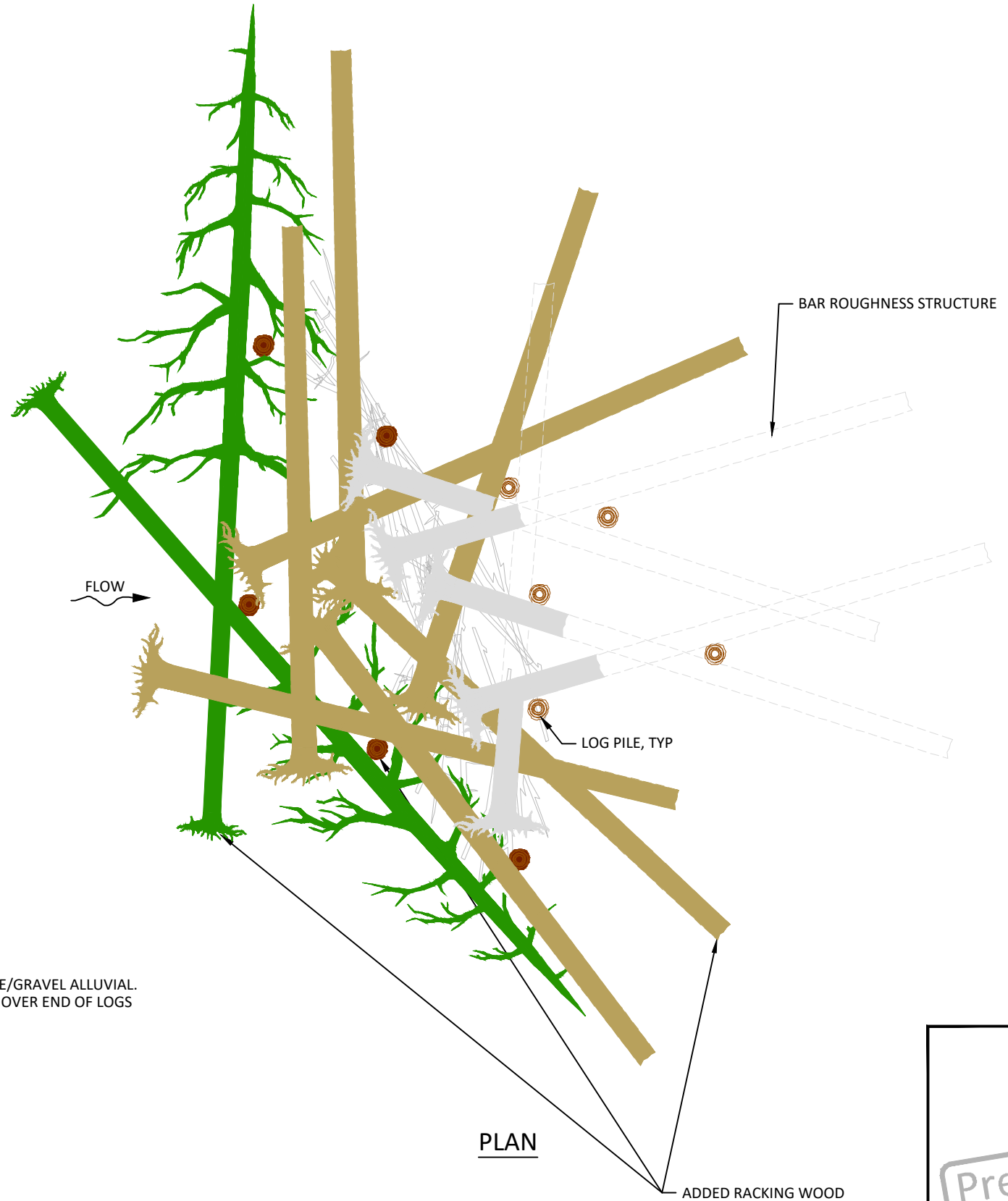


PLAN



SECTION

2
26 TYPICAL DETAIL - BAR ROUGHNESS LW STRUCTURE (BR)
NOT TO SCALE



PLAN

BAR ROUGHNESS WITH ADDED RACKING WOOD

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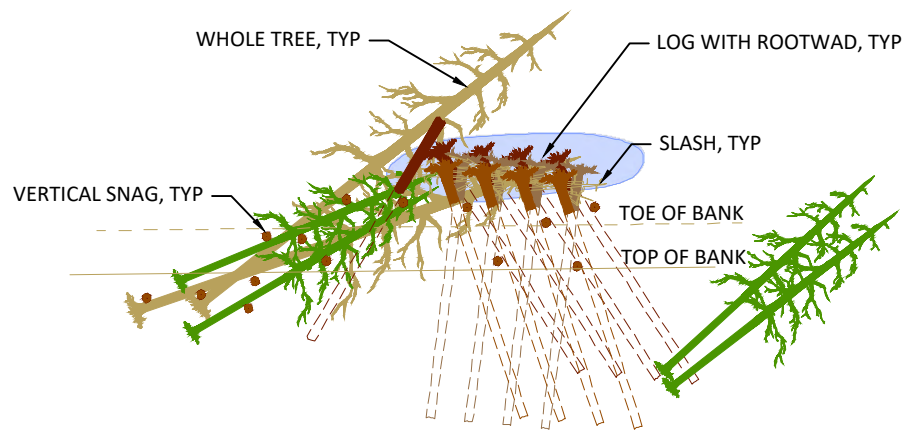


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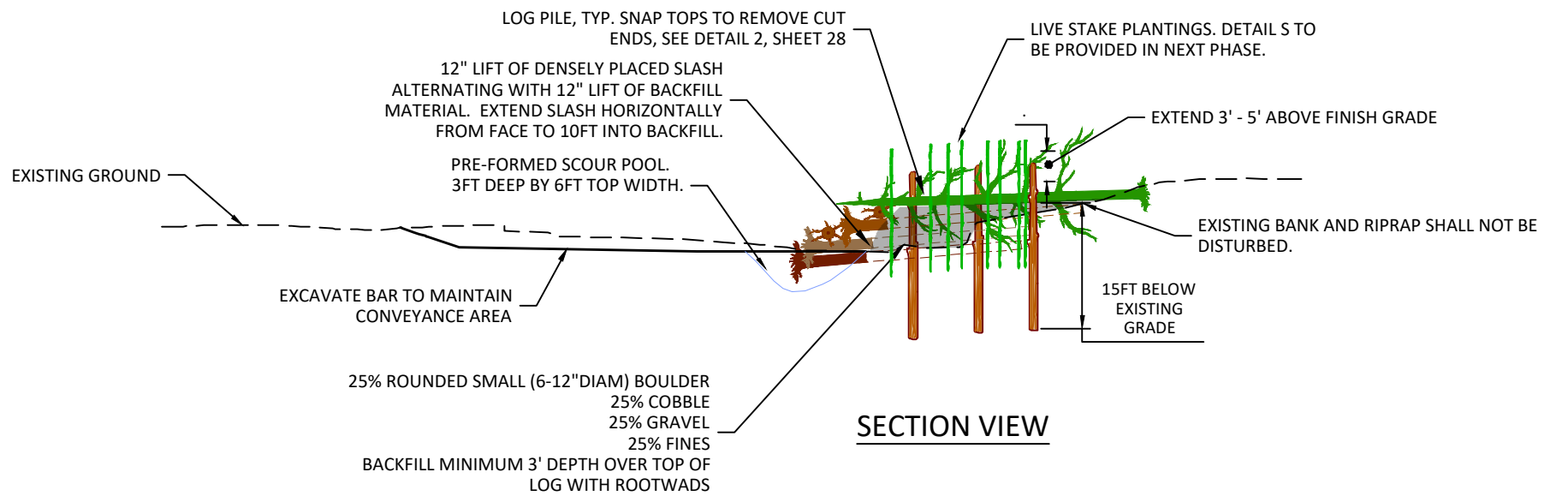
LARGE WOOD TYPICAL DETAILS
(4 OF 5)

SHEET
26 OF 31

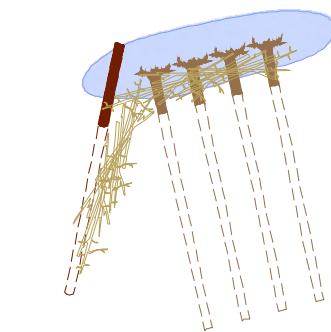
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PLAN VIEW

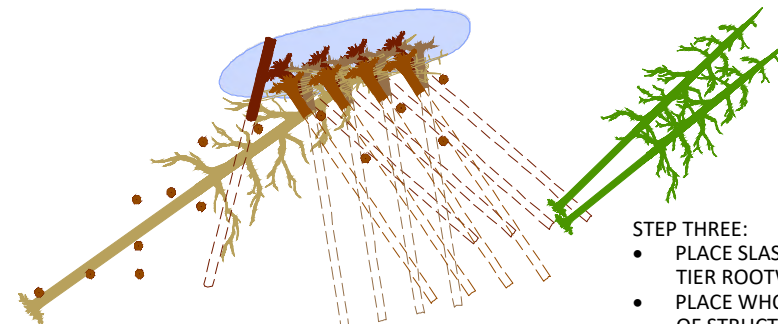


SECTION VIEW



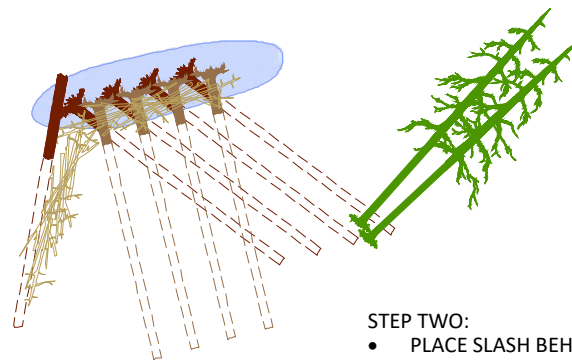
STEP 1

- STEP ONE:
- EXCAVATE SCOUR POOL
 - PLACE SLASH ALONG PERIMETER OF STRUCTURE
 - PLACE BOTTOM TIER OF LOGS WITH ROOTWADS AND BUMPER LOG ON STREAMBED, PINNING SLASH UNDER AND BEHIND ROOTWADS
 - BACKFILL TO TOPS OF LOGS



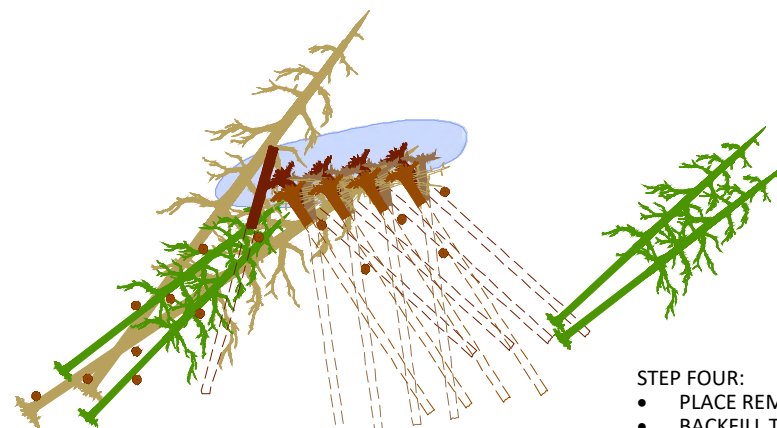
STEP 3

- STEP THREE:
- PLACE SLASH BEHIND ROOTWADS OF MIDDLE TIER ROOTWADS
 - PLACE WHOLE TREES ALONG UPSTREAM FACE OF STRUCTURE
 - PLACE THIRD TIER OF LOGS WITH ROOTWADS, PINNING SLASH UNDER AND BEHIND ROOTWADS
 - INSTALL LOG PILES
 - BACKFILL TO TOPS OF LOGS



STEP 2

- STEP TWO:
- PLACE SLASH BEHIND ROOTWADS OF BOTTOM TIER ROOTWADS
 - PLACE DOWNSTREAM WHOLE TREES SPANNING BETWEEN STRUCTURES
 - PLACE SECOND TIER OF LOGS WITH ROOTWADS, PINNING SLASH UNDER AND BEHIND ROOTWADS
 - BACKFILL TO TOPS OF LOGS



STEP 4

- STEP FOUR:
- PLACE REMAINING WHOLE TREES
 - BACKFILL TO FINISHED GRADE

SEQUENCING

1
27

TYPICAL DETAIL - RIPARIAN LARGE WOOD STRUCTURE

NOT TO SCALE

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NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT
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LARGE WOOD TYPICAL DETAILS
(5 OF 5)

SHEET

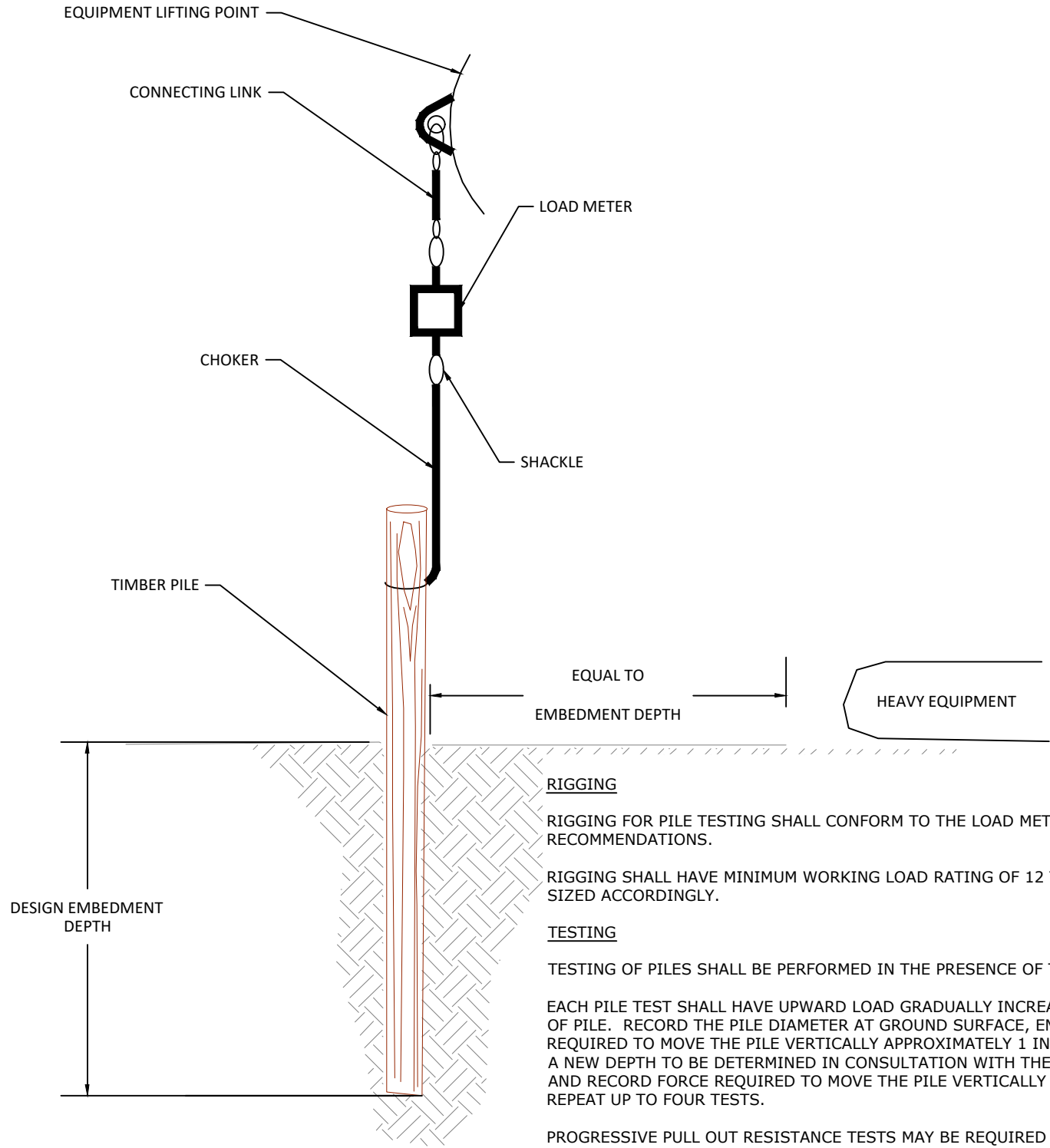
27 OF 31

Preliminary
Not for Construction

NO.	BY	DATE	REVISION DESCRIPTION

CM	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

G:\M-P\Nason Creek Floodplain RM 3.4-4.6 Phase 3 200237 Drawings\JFL NasonFP_NaRD_C.dwg -- emcconnell -- 1/13/26



RIGGING

RIGGING FOR PILE TESTING SHALL CONFORM TO THE LOAD METER MANUFACTURER'S RECOMMENDATIONS.

RIGGING SHALL HAVE MINIMUM WORKING LOAD RATING OF 12 TONS. FITTINGS SHALL BE SIZED ACCORDINGLY.

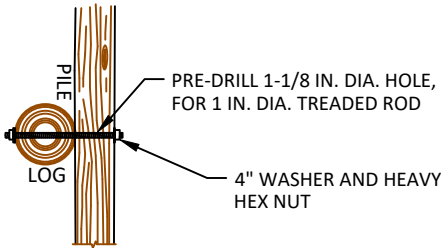
TESTING

TESTING OF PILES SHALL BE PERFORMED IN THE PRESENCE OF THE ENGINEER.

EACH PILE TEST SHALL HAVE UPWARD LOAD GRADUALLY INCREASED AND ALIGNED TO AXIS OF PILE. RECORD THE PILE DIAMETER AT GROUND SURFACE, EMBEDMENT DEPTH AND FORCE REQUIRED TO MOVE THE PILE VERTICALLY APPROXIMATELY 1 INCH. THEN DRIVE THE PILE TO A NEW DEPTH TO BE DETERMINED IN CONSULTATION WITH THE ENGINEER. APPLY NEW LOAD AND RECORD FORCE REQUIRED TO MOVE THE PILE VERTICALLY APPROXIMATELY 1 INCH. REPEAT UP TO FOUR TESTS.

PROGRESSIVE PULL OUT RESISTANCE TESTS MAY BE REQUIRED AT UP TO FOUR DEPTHS FOR EACH PILE PENDING RESULTS AND APPROVAL BY ENGINEER. DEPTHS SHALL BE DETERMINED IN THE FIELD. AS A GUIDELINE, TEST EMBEDMENT DEPTHS MAY INCLUDE 50%, 60%, 80% AND 100% OF THE DESIGN EMBEDMENT DEPTH. PULL OUT RESISTANCE TEST AT 80% AND 100% OF DESIGN EMBEDMENT DEPTH SHALL ONLY BE REQUIRED IF PULL OUT LOAD IS LESS THAN THE PROOF LOAD REQUIRED IN THE SPECIFICATIONS.

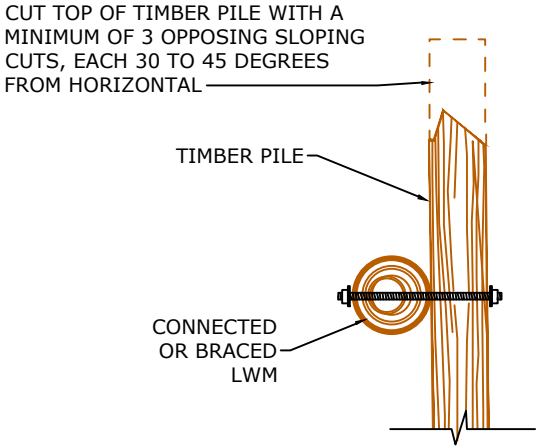
EQUIPMENT CONDUCTING PULL OUT LOADING SHALL BE POSITIONED NO CLOSER THAN EMBEDMENT DEPTH OF PILE, IF POSSIBLE. IF A CLOSER POSITIONING IS REQUIRED, EQUIPMENT SHALL BE NO CLOSER THAN THAT REQUIRED TO GENERATE REQUIRED LOADING WITH DISTANCE FROM PILE NOTED IN THE TEST RECORD. IF EQUIPMENT IS CLOSER THAN HALF THE EMBEDMENT DEPTH, DISTRIBUTE GROUND LOADING ON TIMBERS AND AWAY FROM THE PILE LOCATION. TIMBER DIMENSIONS AND LENGTHS SHALL BE NOTED IN THE TEST RECORD.



NOTES:

1. DRILL 1-1/8" DIA HOLE THROUGH LOGS.
2. INSERT 1" DIA TREADED ROD.
3. INSTALL 1/4" THICK BY 4" SQUARE OR ROUND STEEL WASHER AND HEAVY HEX NUTS. SECURE NUTS BY CHISELING THREADS OR MUSHROOMING EXPOSED ENDS OF ROD.
4. CUT BOLT TO EXTEND NO FURTHER THAN 2" PAST NUT.
5. FILE OR GRIND OFF SHARP EDGES

2
28 TYPICAL DETAIL - BOLTED CONNECTIONS
NOT TO SCALE



3
28 TYPICAL DETAIL - TIMBER PILE TOPS
NOT TO SCALE

Preliminary
Not for Construction

1
28 TYPICAL DETAIL - TIMBER PILE TESTING
NOT TO SCALE

NO.	BY	DATE	REVISION DESCRIPTION

CM	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

YAKAMA NATION FISHERIES
NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT
PHASE 2 60% DESIGN

	501 Portway Avenue, Suite 101 Hood River, OR 97031 541.386.9003 www.interfluve.com
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	POST OFFICE BOX 151 FORT ROAD TOPPENISH, WA 98948 (509)865-5121
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LOG PILE DETAILS
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SHEET
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INTRODUCTION
THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION'S STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION 2026 (WSDOT STANDARD SPECIFICATIONS) SHALL APPLY UNLESS OTHERWISE NOTED IN THE FOLLOWING PROVISIONS. IN CASE OF A CONFLICT BETWEEN THE REGULATORY STANDARDS OR SPECIFICATIONS, THE MORE STRINGENT WILL GOVERN. THE "CONTRACTING AGENCY" OR "OWNER" SHALL BE THE CONFEDERATED TRIBES AND BANDS OF THE YAKAMA NATION, UPPER COLUMBIA HABITAT RESTORATION PROJECT (UCHRP). ADDITIONAL SPECIFICATIONS IN THE FOLLOWING CONTRACT SECTIONS ARE INCLUDED FOR ITEMS NOT COVERED BY THE WSDOT STANDARD SPECIFICATIONS.

SECTIONS 1-02, 1-03, AND 1-08 (EXCEPT 1-08.6, 1-08.7, 1-08.8) OF THE STANDARD SPECIFICATIONS DO NOT APPLY.

THE IN-WATER WORK WINDOW FOR THIS PROJECT IS JULY 1 - AUGUST 15. WORK MAY OCCUR OUTSIDE OF WATER BEFORE OR AFTER THE IN-WATER WORK WINDOW.

FLOWES ARE RECORDED BY WASHINGTON DEPARTMENT OF ECOLOGY STREAM GAGE 45J070 NEAR MOUTH OF NASON CREEK

THIS PROJECT WAS DESIGNED IN ACCORDANCE WITH THE BPA HABITAT IMPROVEMENT PROGRAM (HIP). HIP GENERAL CONSERVATION MEASURES (CMS) ARE INCLUDED ON SHEETS 6-8 OF THE PLANS. SITE SPECIFIC DIRECTION IS ADDED TO THE FOLLOWING PROVISIONS. ANY VARIANCES FROM HIP CMS WILL BE REQUESTED BY OWNER. IN A CASE OF A CONFLICT BETWEEN THE REGULATORY STANDARDS OR SPECIFICATIONS, LOCAL REGULATIONS, OR OTHER CONTRACT DOCUMENTATION, THE MORE STRINGENT WILL GOVERN, UNLESS SPECIFIED IN WRITING BY THE OWNER.

ITEM 001 - MOBILIZATION

THIS ITEM SHALL CONSIST OF PREPARATION WORK AND OPERATIONS PERFORMED BY THE CONTRACTOR. THE PROVISIONS OF SECTION 2.01 OF THE WSDOT STANDARD SPECIFICATIONS, AND AS AMENDED BY THESE SPECIAL PROVISIONS.

- CONSTRUCTION REQUIREMENTS
- PRIOR TO ENTERING THE SITE, ALL EQUIPMENT SHALL BE POWER WASHED, BECOME FULLY DRY, AND INSPECTED TO MAKE SURE NO PLANTS, SOIL, OR OTHER ORGANIC MATERIAL ADHERES TO THE SURFACE. IF EQUIPMENT LEAVES THE SITE AND RETURNS, IT SHALL BE REWASHED AND INSPECTED PRIOR TO ACCESSING THE SITE.
 - TEMPORARY SITE ACCESS SHALL BE ALONG ACCESS ROUTES AND STAGING AREAS SHOWN IN THE PLANS. THESE ARE APPROXIMATE. ACTUAL DISTURBANCE LIMITS WILL BE STAKED AND FLAGGED IN THE FIELD BY THE OWNER. DESIGNATED DISTURBANCE LIMITS SHALL BE STRICTLY ADHERED TO AND NO LARGE TREES WILL BE IMPACTED WITHOUT PERMISSION FROM THE OWNER.
 - DESIGNATED RIVER CROSSINGS ARE SHOWN IN THE PLANS. A TEMPORARY BRIDGE AS SPECIFIED IN ITEM 0### TEMPORARY ACCESS BRIDGE SHALL BE USED TO CROSS FLOWING CHANNELS. TEMPORARY RIVER WET CROSSINGS ARE SHOWN ON THE PLANS. NO RIVER CROSSING SHALL BE MADE PRIOR TO APPROVAL BY OWNER.
 - PRIOR TO DEMOBILIZATION, RUTTING AND DISTURBED GROUND SHALL BE RIPPED TO 18INCHES DEEP TO DECOMPACT SOILS IF DIRECTED BY OWNER, AND GRADED SMOOTH TO BLEND WITH EXISTING TOPOGRAPHY. ACCESS ROUTES, AND STOCKPILE AND STAGING AREAS SHALL BE RETURNED TO ORIGINAL OR BETTER CONDITION. ANY REMOVED OR DAMAGED FENCES SHALL BE REPAIRED OR REPLACED TO PRE-PROJECT CONDITION OR BETTER.
 - EXISTING ROADS SHALL BE RESTORED TO PRE-PROJECT OR BETTER CONDITION AS DIRECTED BY OWNER.
 - BEFORE THE RELEASE OF FINAL RETAINAGE TO THE CONTRACTOR, THE CONTRACTOR WILL PARTICIPATE IN A WALK-THROUGH WITH THE OWNER AND USFS STAFF TO EVALUATE THE RESTORED AREAS.
 - ALL HEAVY EQUIPMENT OPERATING ON PAVEMENT SHALL USE RUBBER MATS OR SIMILAR TO AVOID IMPACTS TO PAVED SURFACE.
 - ROAD ASPHALT REPAIR/REPLACEMENT WORK SHALL CONFORM TO COUNTY, STATE OR USFS SPECIFICATIONS BASED ON JURISDICTION OF ROAD IF MORE STRINGENT THAN SPECIFICATIONS HEREIN.

- MATERIALS EXCAVATED FOR DISPOSAL SHALL BE HAULED AND PLACED OUTSIDE OF THE FEMA DELINEATED FLOODPLAIN IN A LEGAL DISPOSAL AREA AND IN COMPLIANCE WITH ANY APPLICABLE REGULATIONS WITH ANY NECESSARY PERMITS OBTAINED BY THE CONTRACTOR.
- CONTRACTOR SHALL REPAIR/REPLACE CRUSHED GRAVEL ROAD BASE PER WSDOT STANDARD SPECIFICATION 9-03.9(3) CRUSHED SURFACING BASE COURSE. FINISHED GRADE SHALL BE SLOPED PER ROAD JURISDICTIONAL CRITERIA TO PROVIDE POSITIVE DRAINAGE OFF ROAD SURFACE.

MEASUREMENT AND PAYMENT

MOBILIZATION SHALL BE MEASURED AND PAID FOR BY LUMP SUM. PARTIAL PAYMENTS WILL BE MADE IN ACCORDANCE WITH SECTION 2.01 OF THE STANDARD SPECIFICATIONS. WITHHOLDING OF PARTIAL PAYMENT WILL OCCUR IF LIMITS OF DISTURBANCE ARE NOT ADHERED TO. PAYMENT SHALL BE CONSIDERED FULL COMPENSATION FOR ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED.

ITEM 002- TRAFFIC CONTROL

TEMPORARY TRAFFIC CONTROL REQUIREMENTS SHALL INCLUDE BARRICADES AND CONSTRUCTION SIGNAGE AT THE ENTRANCE TO THE PROJECT SITE AND ANY OTHER MEASURES PER STANDARD SPECIFICATIONS SECTION 2-04.3 AND LOCAL REGULATIONS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO OBTAIN APPLICABLE COUNTY PERMITS.

MEASUREMENT AND PAYMENT

TRAFFIC CONTROL SHALL BE MEASURED AND PAID FOR BY LUMP SUM. PARTIAL PAYMENTS WILL BE MADE IN ACCORDANCE WITH SECTION 2.04 OF THE STANDARD SPECIFICATIONS. PAYMENT SHALL BE CONSIDERED FULL COMPENSATION ACQUIRING RIGHT-OF-WAY PERMIT, AS WELL AS ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED.

ITEM 003- TESC, SPCC PLAN AND IMPLEMENTATION

THIS WORK SHALL PROVIDE FOR PREPARATION, IMPLEMENTATION, AND REMOVAL OF A TEMPORARY EROSION SEDIMENT CONTROL (TESC) PLAN AND FOR THE PREPARATION AND IMPLEMENTATION OF A SPILL PREVENTION CONTROL AND COUNTERMEASURE (SPCC) PLAN IN ACCORDANCE WITH SECTION 1-07.15 OF THE STANDARD SPECIFICATIONS, AND AS AMENDED BY THESE SPECIAL PROVISIONS.

- THE CONTRACTOR SHALL SUBMIT A TESC FOR THE PROJECT TO THE OWNER FOR APPROVAL. THE TESC MUST SATISFY THE REQUIREMENTS OF THE WASHINGTON DEPARTMENT OF ECOLOGY NPDES STORMWATER GENERAL PERMIT FOR CONSTRUCTION ACTIVITY AND ALL OTHER APPLICABLE PERMITS. THE CONTRACTOR SHALL USE MEASURES OF THEIR OWN DESIGN TO ENSURE SATISFACTORY PERFORMANCE AND THAT THE EROSION CONTROL REQUIREMENTS OF ALL APPLICABLE PERMITS ARE MET. THE CONTRACTOR SHALL BE NAMED AS THE PERMIT HOLDER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING, INSPECTING AND FILING REPORTS, MAINTAINING, REPLACING, AND REMOVING TESC AND SPCC MEASURES. THE PLAN SHALL INCLUDE THE NAME, ADDRESS AND 24-HOUR CONTACT NUMBER OF THE PERSON RESPONSIBLE FOR EROSION PREVENTION AND SEDIMENT CONTROL MEASURES.
- A SPILL CONTAINMENT KIT SHALL BE ON SITE AND CREWS SHALL BE TRAINED IN ITS USE.
- BIODEGRADABLE HYDRAULIC FLUID SHALL BE INSTALLED INTO EACH PIECE OF HEAVY MACHINERY WORKING WITHIN 50 FEET OF THE RIVER AND SIDE CHANNELS.
- CONTRACTOR WILL BE REQUIRED TO APPLY FOR AN INDUSTRIAL FIRE PROTECTION LEVEL (IFPL) 3 WAIVER IN THE EVENT THAT DEPARTMENT OF NATURAL RESOURCES DECLARES THE IFPL LEVEL HAS BEEN INCREASED TO LEVEL 3. REGARDLESS OF IFPL LEVELS, A FIRE CONTAINMENT KIT INCLUDING SHOVELS AND FIRE EXTINGUISHERS WILL BE KEPT WHERE ANY CONSTRUCTION ACTIVITIES ARE TAKING PLACE AND AT THE REFUELING LOCATION.

INSPECTION AND MAINTENANCE

THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE AT OWN EXPENSE FOR PROVIDING AND MAINTAINING ALL NECESSARY EROSION CONTROL FACILITIES TO COMPLY WITH APPLICABLE EROSION CONTROL REGULATIONS AND TO MAINTAIN CLEAN ACCESS ROUTES.

ALL TESC FACILITIES SHALL BE INSPECTED, MAINTAINED, AND REPAIRED AS NEEDED TO ASSURE CONTINUED PERFORMANCE OF THEIR INTENDED FUNCTION. ALL TESC FACILITIES SHALL BE INSPECTED DAILY AND WITHIN 24 HOURS AFTER ANY STORM EVENT GREATER THAN 0.5 INCHES OF RAIN PER 24 HOUR PERIOD AND AFTER EVENTS EXCEEDING 2 HOURS DURATION.

CONTRACTOR'S MEETINGS AND TESC RECORDS

THE CONTRACTOR SHALL MEET WITH THE OWNER AND OWNER'S REPRESENTATIVE AT THE BEGINNING OF EACH WORK WEEK TO DISCUSS: WORK COMPLETED DURING THE PRIOR WEEK, WORK ANTICIPATED IN THE NEXT WEEK, CONSTRUCTION SCHEDULE, WORK SITE ORGANIZATION, ACCESS ROUTES, CONSTRUCTION TECHNIQUES, LANDOWNER CONSIDERATIONS, BIOLOGICAL OBJECTIVES, LOGISTICS AND OTHER TOPICS PERTINENT TO IMPLEMENTATION OF THE PROJECT.

THE CONTRACTOR SHALL SUBMIT WEEKLY REPORTS TO THE OWNER. REPORTS SHALL INCLUDE: SCOPE OF INSPECTIONS, THE PERSONNEL CONDUCTING THE INSPECTION, THE DATE(S) OF THE INSPECTION, MAJOR OBSERVATIONS RELATING TO THE IMPLEMENTATION OF THE CONTRACTOR'S EROSION AND SEDIMENT CONTROL PLAN, AND ACTIONS TAKEN AS A RESULT OF THE INSPECTIONS SHALL BE PREPARED AND RETAINED ON SITE BY THE CONTRACTOR. IN ADDITION, A RECORD OF THE FOLLOWING EVENTS SHALL BE INCLUDED IN THE REPORTS:

- WHEN MAJOR GRADING ACTIVITIES OCCUR,
- DATES OF RAINFALL EVENTS EITHER EXCEEDING 2 HOURS DURATION OR MORE THAN 0.5 INCHES/24 HOURS,
- WHEN CONSTRUCTION ACTIVITIES TEMPORARILY OR PERMANENTLY CEASE ON SITE, OR ON A PORTION OF THE SITE,
- WHEN STABILIZATION MEASURES ARE INITIATED FOR PORTIONS OF THE SITE.

TESC RECORDS SHALL BE MADE AVAILABLE TO THE OWNER AND THE OWNER'S REPRESENTATIVE ON THE REQUEST AND SHALL BE PROVIDED FOR REVIEW AND APPROVAL PRIOR TO APPLICATION FOR PAYMENT.

MEASUREMENT AND PAYMENT

"TESC, SPCC PLAN AND IMPLEMENTATION," INCLUDING THE ABOVE AMENDMENTS TO THE ITEM WILL BE MEASURED AND PAID FOR BY LUMP SUM. PAYMENT SHALL BE CONSIDERED FULL COMPENSATION FOR ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED.

ITEM 004 - CLEARING AND GRUBBING

THIS ITEM CONSISTS OF CLEARING AND GRUBBING FOR CONSTRUCTION AS SHOWN IN THE PLANS INCLUDING THOSE AREAS REQUIRED FOR TEMPORARY ACCESS ROUTES AND IN ACCORDANCE WITH SECTION 3-01 OF THE STANDARD SPECIFICATIONS, AND AS AMENDED BY THESE SPECIAL PROVISIONS.

- CLEARING AND GRUBBING SHALL BE LIMITED TO APPROVED ACCESS ROUTES, EXCAVATION/FILL AND LWM STRUCTURE CONSTRUCTION AREAS AS SHOWN IN THE PLANS. LIMITS OF DISTURBANCE EXTENTS MAY BE ADJUSTED BY THE OWNER TO REDUCE DAMAGE TO THE ENVIRONMENT. THE FINAL AREAS WILL BE FLAGGED IN THE FIELD BY THE OWNER PRIOR TO CLEARING AND GRUBBING WORK. CLEARING AND GRUBBING SHALL NOT OCCUR OUTSIDE OF THE DESIGNATED LIMITS.
- BRUSH, SHRUBS AND TREES SHALL BE CLEARED BY CUTTING AT GROUND LEVEL. GRUBBING SHALL ONLY OCCUR TO VEGETATION SPECIFIED BY OWNER.

- INCLUDED IN THIS ITEM ARE TREES VARYING IN SIZE IDENTIFIED BY THE OWNER FOR REMOVAL AND SALVAGE. TREE SPECIES INCLUDE CONIFEROUS AND DECIDUOUS. REMOVED TREES SHALL BE SALVAGED FOR INSTALLATION AS LARGE WOODY MATERIAL DURING CONSTRUCTION OF THE SIDE CHANNEL AND LOG STRUCTURES. FOR CONIFEROUS TREES, THE CONTRACTOR SHALL EXCAVATE TO LOOSEN SOIL AROUND EACH ROOTWAD AND THEN PUSH OVER TREES IN ORDER TO SALVAGE LOGS WITH INTACT ATTACHED ROOTS. DECIDUOUS TREES MAY BE CUT AT THE STUMP WITH ROOTS LEFT UNGRUBBED. SALVAGED TREES SHALL BE TEMPORARILY STOCKPILED WITHIN PROJECT LIMITS OF DISTURBANCE.
- TREES AND SHRUBS SMALLER THAN 12" DBH THAT ARE REMOVED DURING CLEARING AND GRUBBING SHALL BE SALVAGED AND USED AS SLASH DURING INSTALLATION OF LWM . UNUSED EXCESS SLASH MAY REMAIN ON SITE AND SHALL BE EVENLY DISTRIBUTED ON DISTURBED AREAS.
- VEGETATION PROTECTION AND RESTORATION PER SECTION 1-07.16(2) SHALL BE INCIDENTAL TO CLEARING AND GRUBBING.

MEASUREMENT AND PAYMENT

REMOVAL AND SALVAGE OF TREES AND SHRUBS SHALL BE CONSIDERED INCIDENTAL TO CLEARING AND GRUBBING.

INSTALLATION OF THE SALVAGED TREES INTO PROJECT FEATURES SHALL BE AS SHOWN ON THE PLANS AND SHALL BE INCIDENTAL TO THOSE ITEMS. NO ADDITIONAL COMPENSATION WILL BE ALLOWED.

MEASUREMENT AND PAYMENT FOR CLEARING AND GRUBBING SHALL BE BY THE LUMP SUM CONTRACT PRICE FOR "CLEARING AND GRUBBING". PAYMENT SHALL BE CONSIDERED FULL COMPENSATION FOR ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED.

Preliminary
Not for Construction

				CM	DM	DM	YAKAMA NATION FISHERIES NASON CR. R.M. 3.6-4.6 FLOODPLAIN ENHANCEMENT PHASE 2 60% DESIGN			501 Portway Avenue, Suite 101 Hood River, OR 97031 541.386.9003 www.interfluve.com		POST OFFICE BOX 151 FORT ROAD TOPPENISH, WA 98948 (509)865-5121	SPECIFICATIONS (1 OF 3)		SHEET
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				DM	01/13/2026	200237									
				APPROVED	DATE	PROJECT									
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ITEM 005 - COFFERDAM AND DIVERSION

THIS ITEM CONSISTS OF PROVIDING AND INSTALLING, MAINTAINING, AND REMOVING MEASURES TO BYPASS THE SURFACE WATERS OF THE STREAM AROUND IN-CHANNEL WORK AREAS, AND TO PREVENT TURBIDITY FROM ENTERING THE RIVER. COFFERDAM LOCATIONS ARE SHOWN ON THE PLANS.

COFFERDAM SHALL BE VIBRATORY DRIVEN SHEETPILE. DRIVING SHEET PILE BY IMPACT HAMMER IS NOT ACCEPTABLE. REVIEW AND APPROVAL OF THE COFFERDAM PLAN SHALL NOT RELIEVE THE CONTRACTOR FROM FULL RESPONSIBILITY FOR THE ADEQUACY OF COFFERDAM WORK IF THE PROPOSED PLAN IS NOT SUCCESSFUL AT PROPERLY ISOLATING THE WORK AREA. COFFERDAMS SHALL BE SUITABLY OFFSET FROM WORK AREA SO AS TO NOT INTERFERE WITH LOG PLACEMENT OR LIMIT POOL EXCAVATION.

THE WORK INCLUDES COORDINATING WITH THE OWNER FOR FISH SALVAGE AND RELOCATION ACTIVITIES. EXCAVATION, FILL OR LOG PLACEMENT SHALL NOT OCCUR UNTIL THE OWNER COMPLETES FISH SALVAGE. THE CONTRACTOR SHALL PROVIDE MINIMUM 2 DAYS ADVANCE NOTICE TO THE OWNER BEFORE EACH COFFERDAM INSTALLATION DATE. THE CONTRACTOR SHALL PROVIDE OWNER ACCESS TO COFFERDAMS AND SUPPORTING STAFF FOR OWNER'S DEFISHING. THE CONTRACTOR IS ADVISED THAT FISH RESCUE MAY TAKE APPROXIMATELY 4 HOURS PER COFFERDAM.

MATERIALS

THE CONTRACTOR SHALL PROVIDE ALL REQUIRED MATERIALS FOR THE PROJECT.

CONSTRUCTION REQUIREMENTS

THE CONTRACTOR SHALL ISOLATE THE WORK AREA FROM THE RIVER BY INSTALLING COFFERDAM PER THE PLANS. NO TURBIDITY FROM CONSTRUCTION ACTIVITIES SHALL ENTER THE RIVER.

MEASUREMENT AND PAYMENT

“COFFERDAM AND DIVERSION,” INCLUDING THE ABOVE AMENDMENTS TO THE ITEM, WILL BE MEASURED BY LUMP SUM. PAYMENT SHALL BE CONSIDERED FULL COMPENSATION FOR ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED FOR THE ENTIRETY OF THE PROJECT. PAYMENT WILL BE MADE IN ACCORDANCE WITH SECTION 1-04.1 FOR THE FOLLOWING BID ITEMS: “COFFERDAM” PER LUMP SUM.

ITEM 006 - PUMPING

THIS ITEM INCLUDES DEWATERING AND CONTROLLING TURBIDITY WITHIN CONSTRUCTION AREAS ISOLATED FROM THE RIVER BY COFFERDAMS. THE WORK CONSISTS OF FURNISHING, MONITORING, OPERATING, MAINTAINING, AND REMOVING PUMPS, COORDINATING WITH THE OWNER FOR FISH SALVAGE RELOCATION ACTIVITIES, AND INSTALLATION OF CONTROL OF WATER BMPS.

MATERIALS

CONTRACTOR SHALL PROVIDE SUFFICIENT SIZE AND NUMBERS OF PUMPS TO DEWATER COFFERDAMS AND CONTROL TURBIDITY FOR THE PROJECT AND ENCOUNTERED FLOWS AND GROUNDWATER CONDITIONS. CONTRACTOR SHALL PROVIDE A MINIMUM OF ONE 6” TRASH PUMP WITH PUMPING CAPACITY GREATER THAN 600 GPM, ASSUMING 12 FEET OF VERTICAL LIFT AND 300 FEET OF DISCHARGE HOSE AND 2" TRASH PUMPS. ADDITIONAL PUMPS SHALL BE PROVIDED BY CONTRACTOR AS NEEDED AT NO ADDITIONAL COST

1. EACH WATER INTAKE SHALL HAVE A FISH SCREEN INSTALLED, OPERATED AND MAINTAINED ACCORDING TO NMFS' FISH SCREEN CRITERIA (NMFS 1997; NMFS 2008). NO PUMPING CAN OCCUR UNTIL FISH SCREEN HAS BEEN APPROVED BY OWNER PRIOR TO INSTALLATION.
2. PUMPS SHALL BE PLACED WITHIN A CONTAINER TO CONTAIN FUEL OR OIL SPILLS. OIL ABSORBENT DIAPERS SHALL BE STORED AT EACH PUMP.
3. THE CONTRACTOR SHALL PROVIDE ENVIRONMENTAL PROTECTION MEASURES SUCH AS STRAW BALES, PERFORATED PIPE FOR DISCHARGE FLOW DISTRIBUTORS, GEOTEXTILES, FILTER BAGS, OR OTHER MEANS OF CONTROLLING DISCHARGE WATER AND TURBIDITY. NO TURBIDITY SHALL BE ALLOWED TO ENTER THE RIVER OR WETLANDS.
4. TO HELP PREVENT TURBIDITY FROM LEAKING THROUGH COFFERDAMS, THE CONTRACTOR SHALL OPERATE 6” TRASH PUMP TO LOWER THE

WATER SURFACE WITHIN THE ISOLATED AREA AND DISCHARGE TO AN INFILTRATION AREA.

ENVIRONMENTAL PROTECTION MEASURES

- a. IF OBSERVED OR MEASURED TURBIDITY DOWNSTREAM OF COFFERDAM OR PUMP DISCHARGE IS MORE THAN 10% ABOVE THE UPSTREAM BACKGROUND VISUAL OBSERVATION OR MEASUREMENT - OR EXCEEDS APPLICABLE PERMITS AND REGULATIONS - THE ACTIVITY MUST BE MODIFIED TO REDUCE TURBIDITY. CONTINUE TO MONITOR EVERY 2 HOURS AS LONG AS INSTREAM ACTIVITY CONTINUES.
- b. IF EXCEEDANCES OCCUR FOR MORE THAN TWO CONSECUTIVE MONITORING INTERVALS (AFTER 4 HOURS), THE ACTIVITY MUST STOP UNTIL THE TURBIDITY LEVEL RETURNS TO BACKGROUND, AND THE EC LEAD MUST BE NOTIFIED WITHIN 48 HOURS.
- c. IF AT ANY TIME, MONITORING, INSPECTIONS, OR OBSERVATIONS/SAMPLES SHOW THAT THE TURBIDITY CONTROLS ARE INEFFECTIVE, IMMEDIATELY STOP WORK AND MOBILIZE WORK CREWS TO REPAIR, REPLACE, OR REINFORCE CONTROLS AS NECESSARY. ADDITIONAL AND ALTERNATIVE METHODS, SUCH AS PUMPING INTO STILLING BASINS OR FILTRATION GEOTEXTILE FABRIC SHALL BE REQUIRED AT THE CONTRACTOR'S EXPENSE.

“PUMPING,” INCLUDING THE ABOVE AMENDMENTS TO THE ITEM WILL BE MEASURED BY LUMP SUM. PAYMENT SHALL BE CONSIDERED FULL COMPENSATION FOR ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED FOR THE ENTIRETY OF THE PROJECT. PAYMENT WILL BE MADE IN ACCORDANCE WITH SECTION 1-04.8 FOR THE FOLLOWING BID ITEMS: “PUMPING” PER LUMP SUM.

ITEM 007 - TEMPORARY ACCESS BRIDGE

A TEMPORARY BRIDGE SHALL BE REQUIRED TO CROSS FLOW CHANNEL AT LOCATION SHOWN IN THE PLANS. CONTRACTOR SHALL SUBMIT AN ACCESS PLAN INCLUDING DRAWINGS SHOWING DETAILS OF PROPOSED METHODS FOR PROVIDING ACCESS FOR EQUIPMENT, INCLUDING LOADED HAUL TRUCKS, TO THE SITES. REVIEW AND APPROVAL OF THE PLAN SHALL NOT RELIEVE THE CONTRACTOR FROM FULL RESPONSIBILITY FOR THE ADEQUACY AND SAFETY OF THE CROSSING.

TEMPORARY BRIDGE SHALL SPAN FLOWING WATER WITHOUT CREATING A BACKWATER CONDITION AND PROVIDE A MINIMUM OF 1.0-FT OF FREEBOARD FROM LOW CHORD TO MAXIMUM WATER SURFACE ELEVATION FOR DURATION OF BRIDGE INSTALLATION. ABUTMENTS SHALL BE PROVIDED AS NECESSARY FOR THE BRIDGE SYSTEM AND SHALL NOT ENCROACH ON STREAM FLOW. APPROACH RAMPS TO THE BRIDGE SHALL BE CLEAN ALLUVIAL MATERIAL. ABUTMENTS MAY REQUIRE COFFERDAMS. COFFERDAM AND BRIDGE SHALL BE REMOVED AT PROJECT COMPLETION.

THE TEMPORARY BRIDGE SHALL BE REMOVED BEFORE THE END OF THE IN-WATER WORK WINDOW.

MEASUREMENT AND PAYMENT

"TEMPORARY ACCESS BRIDGE" WILL BE MEASURED AND PAID FOR BY ONE LUMP SUM FOR ALL TEMPORARY BRIDGE INSTALLATIONS. INSTALLATION OF THE TEMPORARY BRIDGE, REMOVAL, MAINTENANCE, AND ASSOCIATED ITEMS SUCH AS ABUTMENTS, FOOTINGS, RAMPS, AND SEDIMENT AND WATER CONTROLS SHALL BE INCLUDED IN THIS ITEM.

ITEMS 008 EARTHWORKS

EARTHWORKS SHALL CONSIST OF EXCAVATING, SORTING, LOADING AND HAULING SPOILS AND SALVAGE RIPRAP TO SPECIFIED ON-SITE DISPOSAL AREA TO BE DESIGNATED BY OWNER AND LEGAL OFF-SITE DISPOSAL AREA AND GRADING TO BLEND TO EXISTING CONTOURS, AND PLACING ALLUVIAL FILL IN LOCATIONS DESIGNATED ON PLANS. ROAD MATERIALS INCLUDING ASPHALT SHALL BE HANDLED PER APPLICABLE REGULATIONS FOR HAULING OFF SITE AND DISPOSING OF IN A LEGAL FACILITY. SPECIFIC LOCATION AND GRADING SHALL BE AS INDICATED IN PLANS.

1. CONTRACTOR SHALL PROVIDE SURVEY EQUIPMENT AND CONDUCT STAKEOUT AND SURVEY TO DETERMINE ELEVATIONS. EXISTING ELEVATION CONTROL POINTS ARE LOCATED NEARBY.
2. PORTIONS OF WORK MAY BE IN WATER. THE CONTRACTOR IS ADVISED

THAT GROUNDWATER MAY BE ENCOUNTERED THROUGHOUT EXCAVATION AREAS. PUMPING AND TESC SHALL BE IMPLEMENTED AS NECESSARY.

3. THIS ITEM INCLUDES HAULING OF MATERIAL EXCAVATED TO DESIGNATED DISPOSAL AREAS. EXCAVATED MATERIAL MAY BE REQUIRED AS SALVAGED BACKFILL IN STRUCTURES. CONTRACTOR SHALL SELECTIVELY STOCKPILE MATERIALS INTO SEGRAGETED SIZES
4. THIS ITEM INCLUDES DETAIL EXCAVATION, FILL AND GRADING TO SHAPE THE CHANNEL AS SHOWN IN THE PLANS, SCOUR POOLS SHALL BE OVER-EXCAVATED INTO THE STREAM BED AS DESIGNATED IN THE PLANS AND DETAILS.
5. NO WORK SHALL OCCUR OUTSIDE OF THE LIMITS OF DISTURBANCE SHOWN IN THE PLANS UNLESS AUTHORIZED BY THE OWNER.

MEASUREMENT AND PAYMENT

EARTHWORKS WILL BE MEASURED BY CUBIC YARDS OF EXCAVATION AND PLACEMENT. MEASUREMENTS SHALL BE IN PLACE QUANTITY BY COMPARISON OF PRE-PROJECT (EXISTING) TOPOGRAPHY, DESIGN SUBGRADE AND DESIGN FINISHED GRADE TOPOGRAPHIC SURFACES.

QUANTITIES MEASUREMENT BY TRUCK WEIGHT OR TRUCK COUNT SHALL NOT BE ALLOWED.

MEASUREMENT AND PAYMENT.

EXCAVATION, SORTING, HAUL, DISPOSAL, GRADING OF DISPOSED SPOILS, FILL AND GRADING OF CHANNEL FEATURES; PLACEMENT OF SALVAGED SLASH; AND EXCAVATION OF SCOUR POOLS FOR LARGE WOOD STRUCTURES SHALL BE INCIDENTAL TO THIS ITEM. NO ADDITIONAL COMPENSATION WILL BE MADE FOR EXCAVATED MATERIAL THAT IS OVER EXCAVATED OR STOCKPILED, RE-EXCAVATED, AND MOVED AGAIN.

PAYMENT SHALL BE CONSIDERED FULL COMPENSATION FOR ALL EQUIPMENT, LABOR, TOOLS, MATERIALS, AND INCIDENTALS NECESSARY TO COMPLETE THIS WORK AS SPECIFIED.

ITEMS 009-021 - LOG STRUCTURES

“LOG STRUCTURES” INCLUDES ALL WORK ASSOCIATED WITH HAULING, HANDLING AND INSTALLATION OF LWM, SALVAGED TREES AND SLASH. THIS ITEM INCLUDES EXCAVATION AND BACKFILL TO PARTIALLY BURY LWM, AND HAUL AND DISPOSAL OF SURPLUS EXCAVATED MATERIAL. COFFERDAM AND PUMPING ARE REQUIRED AT DESIGNATED “LOG STRUCTURES” SHOWN IN THE PLANS. “LOG STRUCTURES” INCLUDES:

- ITEM 009 - APEX JAMS
- ITEM 010 - BANK BURIED JAM
- ITEM 011 - SMALL BANK BURIED JAM
- ITEM 012 - BANK MARGIN WOOD
- ITEM 013 - BAR ROUGHNESS WOOD
- ITEM 014 - SMALL BANK BURIED AND BAR ROUGHNESS RACKING WOOD
- ITEM 015 - CED3 BANK BARB STRUCTURE
- ITEM 016 - DEFLECTOR JAM
- ITEM 017 - INLET STRUCTURE
- ITEM 018 - LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LW
- ITEM 019 - LOW FLOW CHANNEL HABITAT COVER LOGS
- ITEM 020 - LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LOG
- ITEM 021 - TIPPED TREE

MATERIALS

LOG STRUCTURES SHALL BE CONSTRUCTED OF LARGE WOODY MATERIAL (LWM), EXCAVATION AND BACKFILL, SLASH, SALVAGED TREES AND TREE TOPS AND - IF DIRECTED BY OWNER, OPTIONAL ADDITIVE ITEMS: ITEM 022 JAM BALLAST BOULDERS AND/OR ITEM 023 IMPORTED BOULDER BACKFILL.

LWM INCLUDES: LOGS WITH ROOTWADS, LOGS WITHOUT ROOTWADS, AND PILES.

LWM IS SUPPLIED BY THE OWNER AND IS DECKED AT WINTON MILL.

THE CONTRACTOR SHALL LOAD AND HAUL LWM FROM THE OWNER'S STOCKPILE. QUANTITIES TO BE MOVED TO EACH SITE ARE SHOWN IN THE PLANS.

OWNER SUPPLIED LWM WILL HAVE THE FOLLOWING CHARACTERISTICS:

6. LOGS WITH ROOTWADS: 40' LONG AND 18" DBH.
7. LOGS WITHOUT ROOTWADS: 40' LONG AND 18" DBH.
8. PILES: 20' LONG AND 16” DIAMETER AT MIDDLE OF LOG

SLASH: INCLUDES SHRUBS, TREES <6" DBH AND TREE TOPS REMOVED FROM ACCESS ROUTES AND EXCAVATION AREAS. UNITS OF SLASH SHALL BE DENSELY PACKED 4FT DIAMETER BY 12FT LONG BUNDLES.

CONSTRUCTION REQUIREMENTS

LOCATIONS FOR PLACEMENT AND DETAILS OF CONSTRUCTION FOR EACH STRUCTURE TYPE ARE SHOWN IN THE PLANS. FINAL LOCATION AND INSTALLATION WILL DEPEND UPON THE SIZE, SHAPE AND QUANTITY OF MATERIAL DELIVERED OR SALVAGED. INSTALLATION OF LWM SHALL BE UNDERSTOOD TO REQUIRE A “FIT IN THE FIELD” APPROACH AS DIRECTED BY THE OWNER.

Preliminary
Not for Construction

NO.	BY	DATE	REVISION DESCRIPTION

CM	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

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PILES: CONSTRUCTION OF PILES SHALL INCLUDE ON-SITE MOVEMENT AND INSTALLATION OF PILES TO DESIGNATED SITES SHOWN IN THE PLANS. PILES SHALL BE PER THE APPROXIMATE NUMBERS AND QUANTITIES INDICATED ON THE PLANS. CONTRACTOR SHALL CUT TO LENGTH AT NO ADDITIONAL COST. SPECIFIC LOCATIONS SHALL BE DETERMINED IN THE FIELD AND DIRECTED BY THE OWNER. THE REQUIRED EMBEDMENT DEPTH IS INDICATED ON THE PLANS. EACH PILE SHALL HAVE A "BROKEN TOP" BY STUMP-GRINDING OR MAKING MULTIPLE PLUNGE CUTS WITH CHAIN SAW TO PROVIDE A ROUGHENED OR RAGGED END. ROUGHENING ENDS SHALL NOT COMPROMISE PILE STRUCTURAL INTEGRITY AT LOG CONNECTIONS. PILES SHALL BE OF VARYING HEIGHTS EXTENDING FROM 2 TO 5 FEET ABOVE FINISHED GRADE. ONE BOLT SHALL BE INSTALLED IN EACH PILE CONNECTING TO TOP LOG AS DETAILED IN THE PLANS.

PILES SHALL BE INSTALLED BY VIBRATORY PILE DRIVER MEETING OR EXCEEDING THE FOLLOWING CHARACTERISTICS:

- a. MINIMUM OF 800 KN (80 TONS) OF CENTRIFUGAL FORCE.
- b. SIDE GRIP WITH MINIMUM 16” SPACE BETWEEN ENDS OF JAWS SO THAT 16” DIAMETER LOG WILL FIT INTO THE JAWS WITHOUT NEEDING TO SLIDE THE GRIP OVER THE END AND DOWN THE LOG.
- c. PRE-APPROVED PILE DRIVERS INCLUDE: MOVAX SP-80, GRIZZLY MG90, OR EQUIVALENT.

TESTING: AT EACH LOG STRUCTURE SITE, A MINIMUM OF ONE PILE SHALL BE TESTED FOR PULLOUT RESISTANCE. EACH TEST WILL REQUIRE UP TO FOUR INDIVIDUAL PULLS, EACH AT A DEEPER DEPTH. SEE DETAILS IN PLANS. THE CONTRACTOR SHALL PROVIDE THE TENSION LINK, METER, AND ASSOCIATED HARDWARE (RATED 12 TON).

SLASH: SLASH SHALL BE INCORPORATED INTO LOG STRUCTURES AS SHOWN IN THE PLANS AND DIRECTED BY THE OWNER. INTERMINGLE, STACK, AND RACK SLASH MATERIAL TO THE INSTALLED LWM AND PILE TO EMULATE NATURAL ACCUMULATIONS OF WOOD MATERIAL. IF INSUFFICIENT SLASH IS SALVAGED ON SITE. CONTRACTOR SHALL IMPORT SLASH AT NO ADDITIONAL COST

WHOLE TREES: TREES CLEARED FOR ACCESS OR ALREADY DOWNED TREES IMMEDIATELY ADJACENT TO CONSTRUCTION SITE AND REQUIRING MOVEMENT FOR SITE ACCESS MAY BE INCORPORATED, AS DIRECTED BY THE OWNER. SALVAGED TREE TOPS MAY BE USED AS SLASH. IF SALVAGE DOES NOT GENERATE SPECIFIED NUMBER OF WHOLE TREES, IMPORT WHOLE TREES AT NO ADDITIONAL COST.

TIPPED TREES SHOWN ON THE PLANS SHALL BE TIPPED BY EXCAVATOR OR CABLE - NO FELLING OR CUTTING OF TREES IS ALLOWED. IF TREE TIPPING IS DESIGNATED BY OWNER TO BE BY OTHERS, CONTRACTOR SHALL COORDINATE WITH TREE TIPPING CONTRACTOR.

EARTHWORK: WHERE PARTIAL BURIAL OF LWM IS REQUIRED, EXCAVATE TO SUBGRADE AND STOCKPILE MATERIAL WITHIN THE DESIGNATED DISTURBANCE AREA. SORT MATERIALS BY GENERAL SIZES, SEPARATING PILES FOR COARSE AND FINE MATERIAL. BACKFILL THE LWM AS EACH LAYER IS INSTALLED. USE COARSE FILL COMPRISED OF GRAVEL/COBBLE ALLUVIUM WITH FINES ALONG EXTERIOR OF FILL ZONE AND ALONG WATERWARD EDGE, AND FINER GRAVEL MATERIALS WITHIN INTERIOR OF FILL ZONE. SILT AND SAND SHALL NOT BE USED FOR BACKFILL AND SHALL BE HAULED FROM THE SITE; CONTRACTOR SHALL SALVAGE OR IMPORT GRAVEL/COBBLE ALLUVIUM FOR BACKFILL AT NO ADDITIONAL COST. WHERE POOL EXCAVATION IS INCLUDED, EXCAVATED MATERIAL SHALL BE SALVAGED AND PLACED AS BACKFILL IN LWM STRUCTURE. BACKFILL ALONG WATERWARD EDGE SHALL BE LAYERED WITH SLASH WITH LIFTS NO THICKER THAN 18INCHES AND BUCKET COMPACTED. SLASH SHALL EXTEND 10FT MINIMUM INTO FILL. BACKFILL THE LOGS AS EACH LAYER IS INSTALLED.

LIVE WILLOW AND DOGWOOD PLANTINGS SHALL BE INSTALLED IN LARGE WOOD STRUCTURES AND AS SHOWN ON PLANS AND DETAILS.

MEASUREMENT AND PAYMENT

MEASUREMENT AND PAYMENT SHALL BE MADE PER EACH STRUCTURE

FOR:

- ITEM 009 - APEX JAMS
- ITEM 010 - BANK BURIED JAM
- ITEM 011 - SMALL BANK BURIED JAM
- ITEM 012 - BANK MARGIN WOOD
- ITEM 013 - BAR ROUGHNESS WOOD
- ITEM 014 - SMALL BANK BURIED AND BAR ROUGHNESS RACKING WOOD
- ITEM 015 - CED3 BANK BARB STRUCTURE
- ITEM 016 - DEFLECTOR JAM
- ITEM 017 - INLET STRUCTURE
- ITEM 018 - LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LW
- ITEM 019 - LOW FLOW CHANNEL HABITAT COVER LOGS
- ITEM 020 - LOW FLOW CHANNEL FLOODPLAIN ROUGHNESS LOG
- ITEM 021 - TIPPED TREE

THE CONTRACT PRICE SHALL BE FULL COMPENSATION FOR ALL COSTS INCURRED FOR EQUIPMENT, MATERIALS AND LABOR FOR HANDLING, LOADING AND HAULING LWM FROM STOCKPILE AREAS, EXCAVATING TO SUBGRADE, SELECTIVE HANDLING OF EXCAVATED MATERIALS AND BACKFILL, SALVAGE OR IMPORT OF SUITABLE BACKFILL MATERIAL, INSTALLING AND SECURING LWM, PILES, SLASH AND SALVAGED TREE TOPS AND WHOLE TREES AS OUTLINED IN THE PLANS. EARTHWORK, HAUL AND DISPOSAL OF SPOILS. INSTALLING SLASH AND SALVAGED TREES SHALL BE INCIDENTAL.

LIVE WILLOW AND DOGWOOD CUTTINGS INCLUDED IN LARGE WOOD STRUCTURES SHALL BE INCIDENTAL TO LARGE WOOD STRUCTURES. CUTTINGS STORAGE & WATERING, EXCAVATION, INSTALLATION AND BACKFILL AND ANY OTHER WORK NECESSARY TO INSTALL LIVE WILLOWS SHALL BE INCIDENTAL.

REVEGETATION TO BE DESIGNED BY OTHERS IN FUTURE DESIGN PHASES.

OPTIONAL ADDITIVE ALTERNATE ITEMS

FOLLOWING ARE OPTIONAL ADDITIVE ALTERNATE ITEMS. OWNER SHALL DETERMINE IF ITEMS ARE REQUIRED, QUANTITIES AND LOCATIONS FOR PLACEMENTS. OWNER SHALL PROVIDE WRITTEN AUTHORIZATION TO IMPLEMENT THESE ITEMS PRIOR TO PROCUREMENT, TRANSPORT, HANDLING OR INSTALLATION.

ITEM 022 - JAM BALLAST BOULDERS

OWNER SHALL DETERMINE IF ADDITIONAL JAM BALLAST BOULDERS (BOULDERS) ARE REQUIRED. CONTRACTOR SHALL PROCURE AND IMPORT, HAUL AND PLACE BOULDERS. UNLESS NOTED HEREIN, BOULDERS SHALL MEET WSDOT STANDARD SPECIFICATION 9-13.1. BOULDERS SHALL BE MINIMUM 4FT EQUIVALENT DIAMETER WITH SPECIFIC GRAVITY OF 2.65 OR GREATER AND SHALL WEIGH NO LESS THAN 5,500 POUNDS DRY WEIGHT PER EACH. BOULDERS SHALL BE ROUNDED TO SUBANGULAR.

MEASUREMENT AND PAYMENT

JAM BALLAST BOULDERS SHALL BE MEASURED AND PAID FOR PER EACH BOULDER. PAYMENT WILL BE FULL COMPENSATION FOR ALL COSTS INCURRED FOR SALVAGE OR IMPORT OF BOULDERS, HAULING, STOCKPILING AND PLACING.

ITEM 023 - IMPORTED BOULDER BACKFILL

OWNER SHALL DETERMINE IF IMPORTED BOULDER BACKFILL IS REQUIRED FOR BACKFILL ON BANK BURIED LARGE WOOD STRUCTURES. THIS MATERIAL IS COMPRISED OF COBBLE TO MEDIUM SIZED BOULDERS. SOURCE IS TO BE DETERMINED. CONTRACTOR SHALL PROCURE AND IMPORT, HAUL AND PLACE IMPORTED BOULDER BACKFILL IN LARGE WOOD STRUCTURES AS DIRECTED BY ENGINEER.

MEASUREMENT AND PAYMENT

IMPORTED BOULDER BACKFILL SHALL BE MEASURED AND PAID FOR PER CUBIC YARD PLACED. TRUCK COUNT OR WEIGHT MAY BE ALLOWED WITH WRITTEN PERMISSION. PAYMENT WILL BE FULL COMPENSATION FOR ALL COSTS INCURRED FOR IMPORTED BOULDER BACKFILL, PROCUREMENT, IMPORT, HAULING, STOCKPILING AND PLACING

Preliminary
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NO.	BY	DATE	REVISION DESCRIPTION

CM	DM	DM
DRAWN	DESIGNED	CHECKED
DM	01/13/2026	200237
APPROVED	DATE	PROJECT

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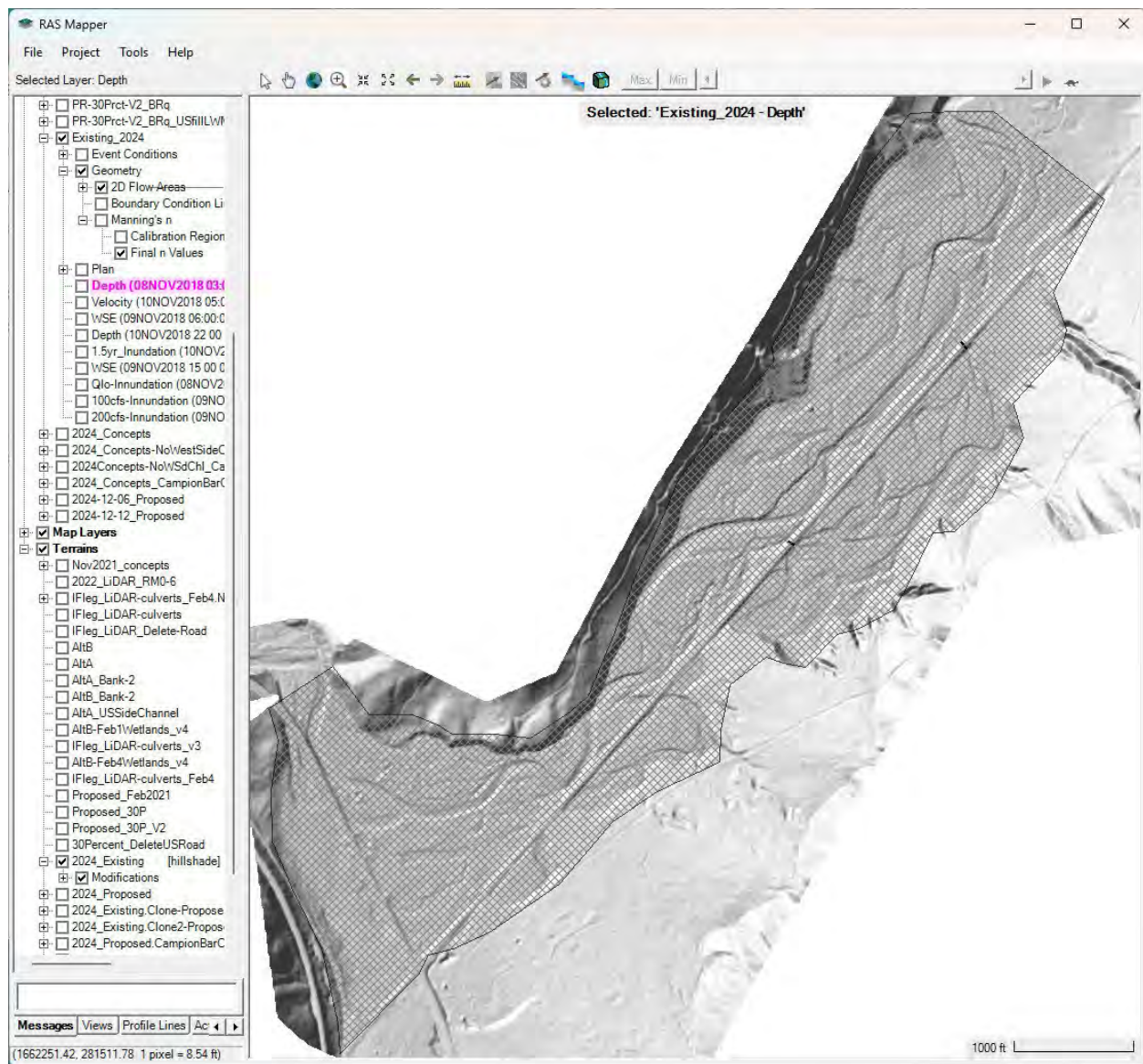
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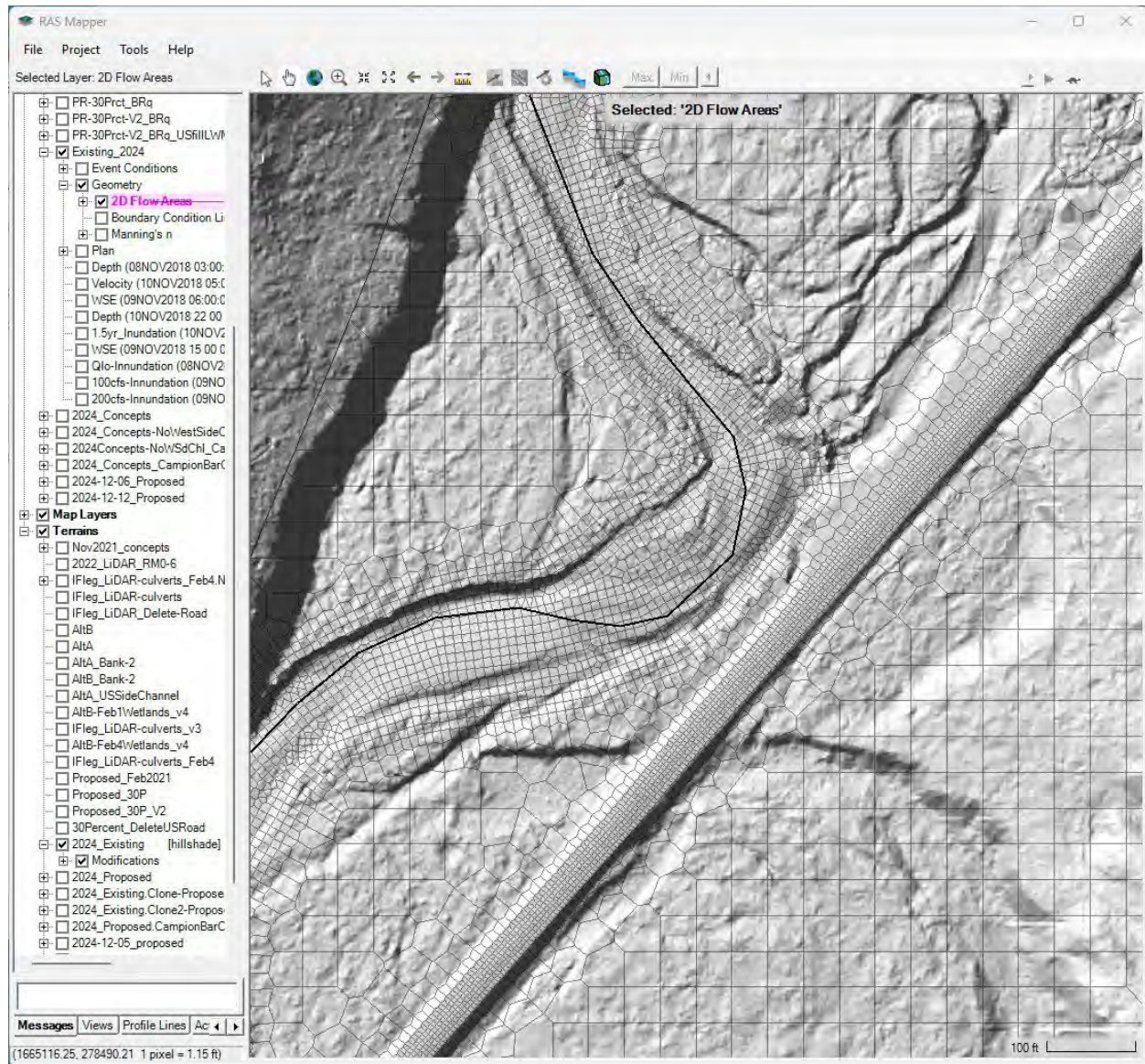
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Appendix C – Existing conditions HEC-RAS model

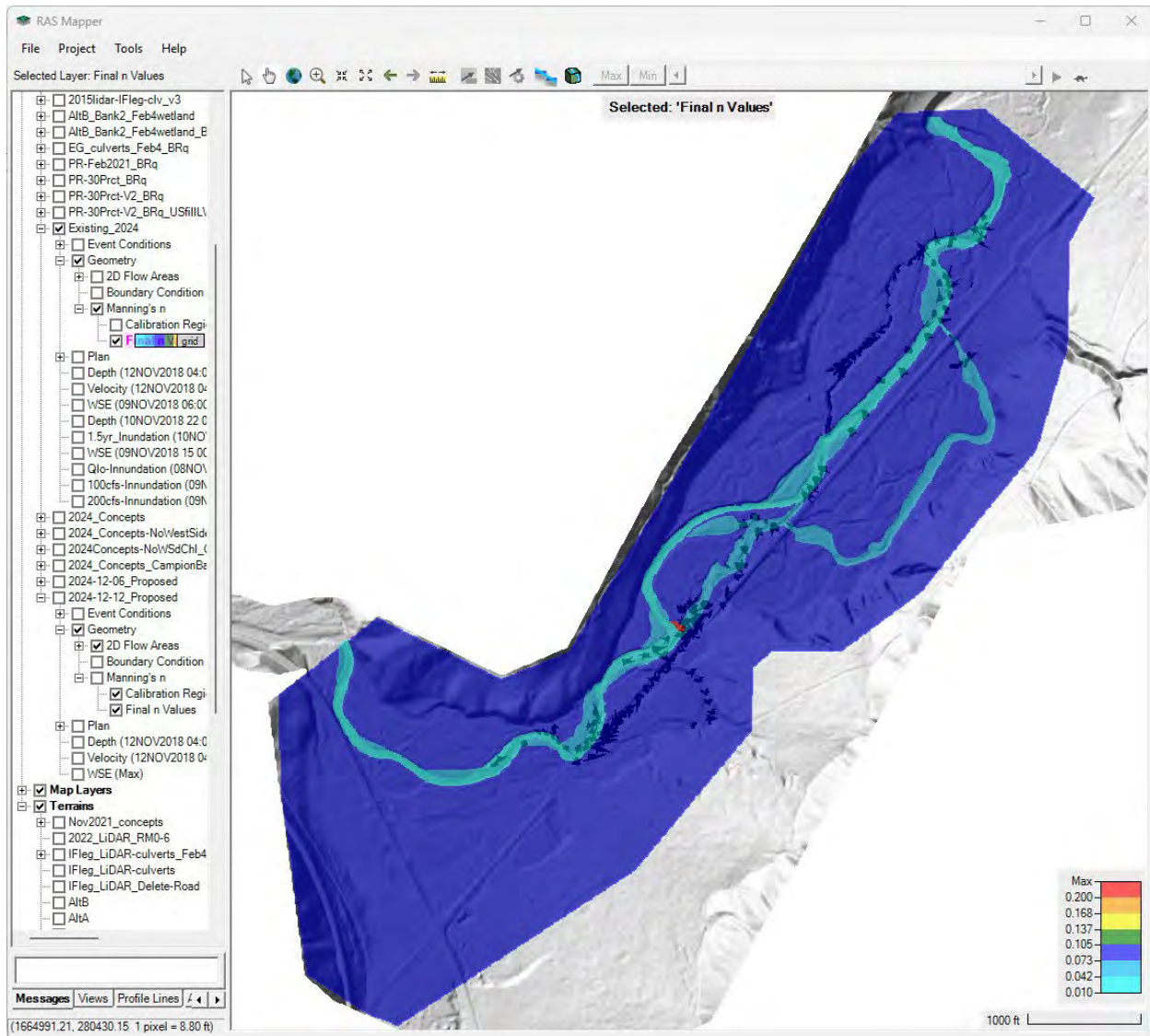
Existing condition model mesh



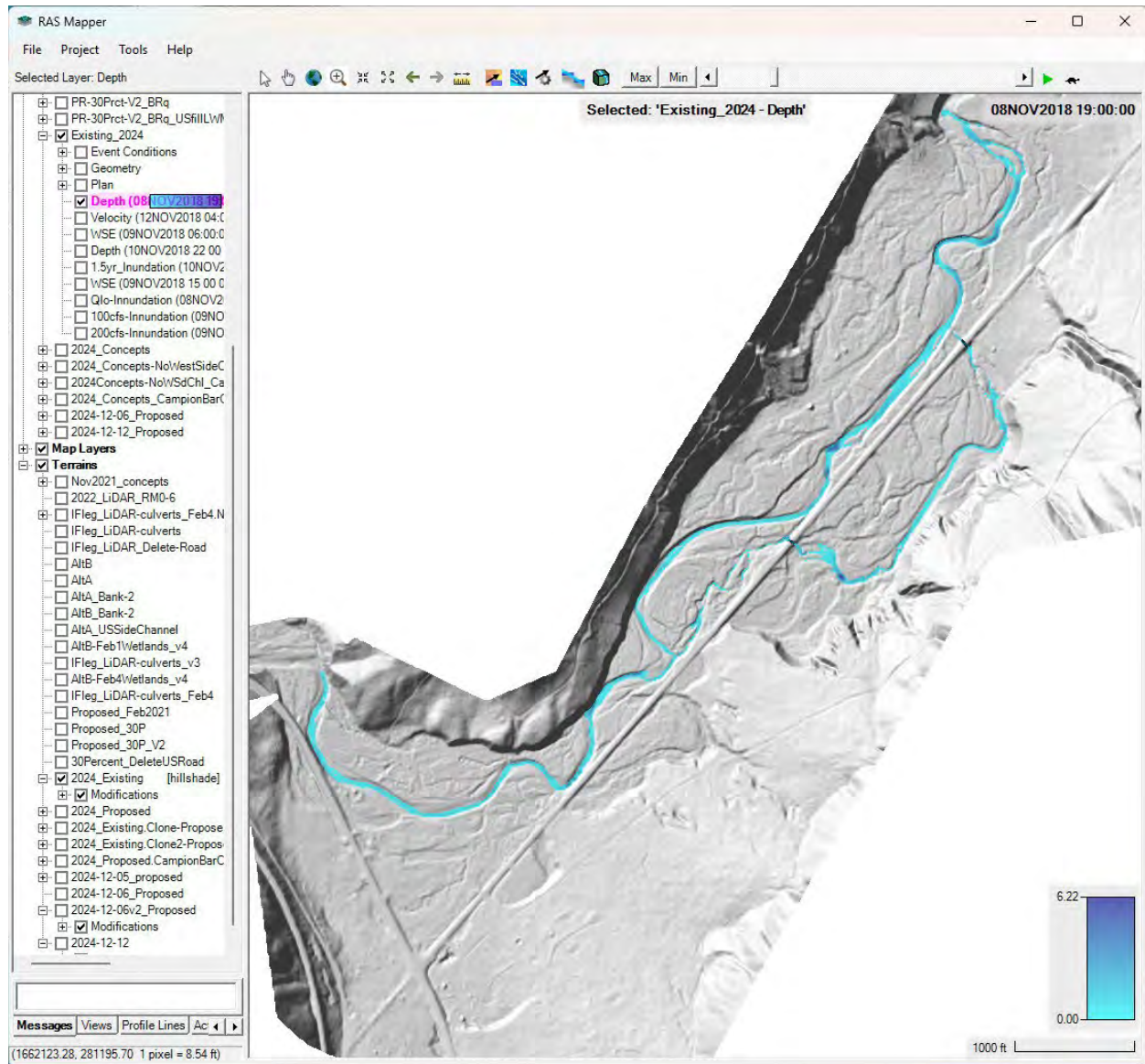
Existing condition model mesh example of detail



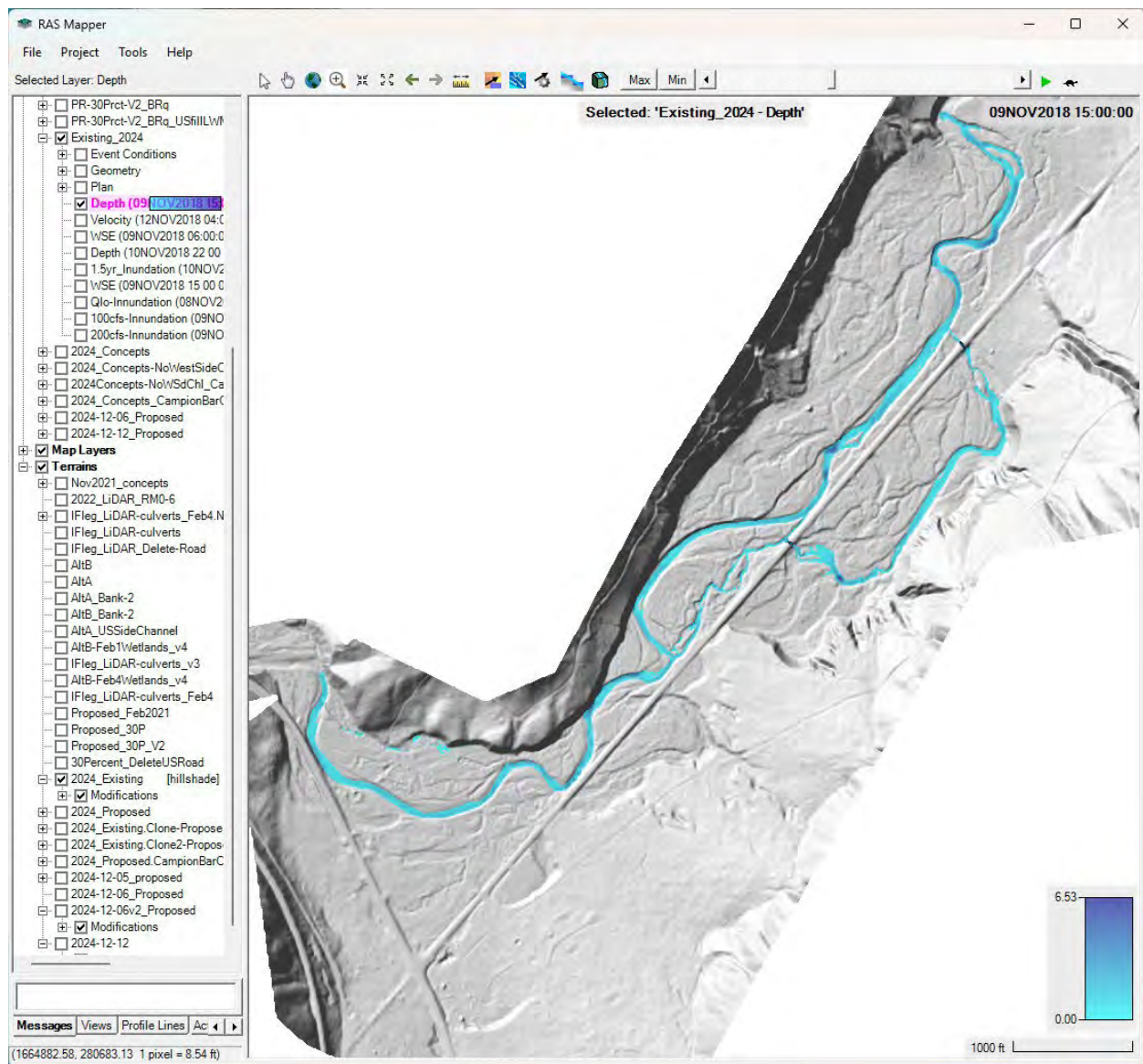
Existing condition Manning's n



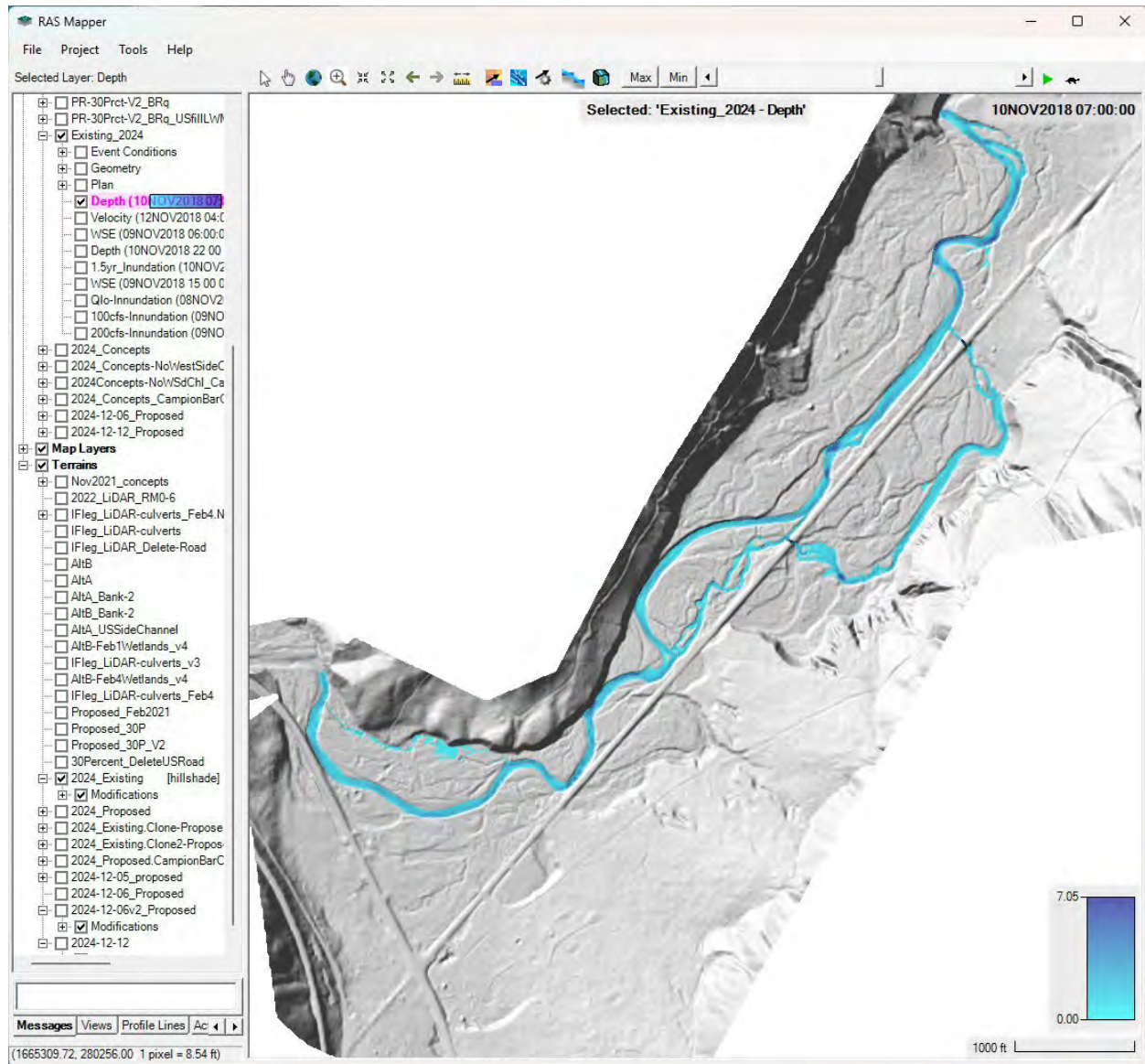
Existing condition: 50-cfs flow depth through project area



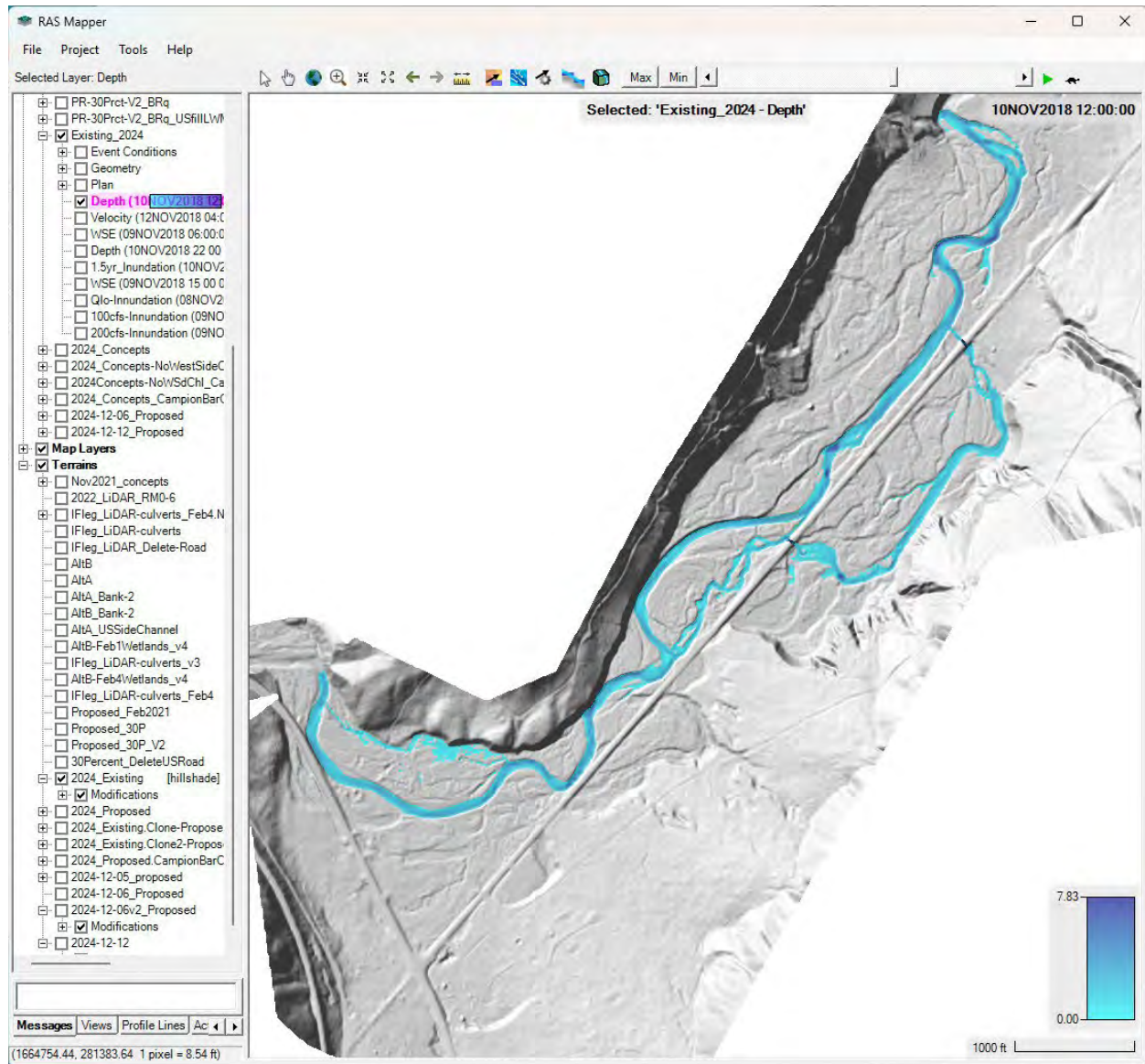
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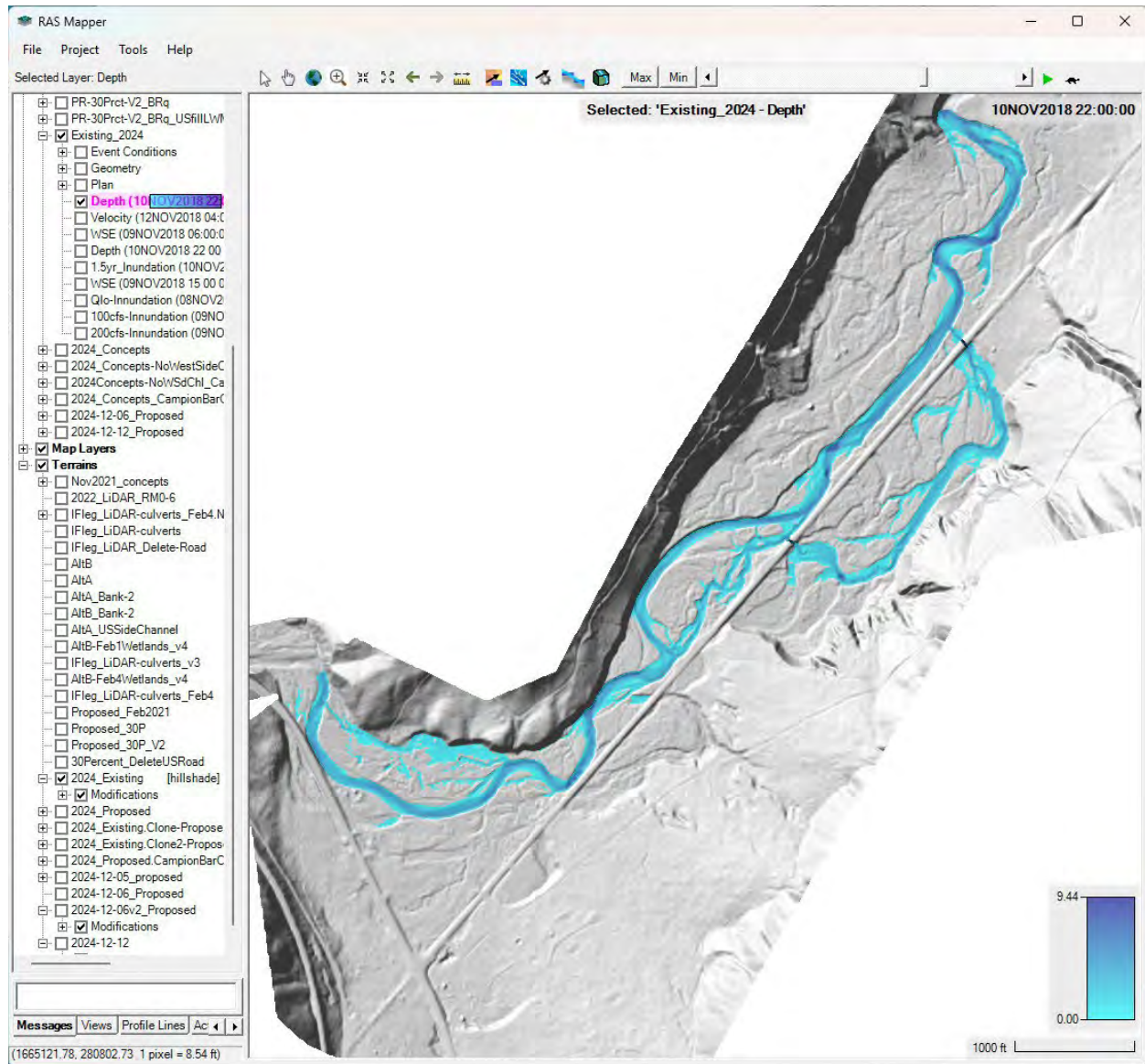
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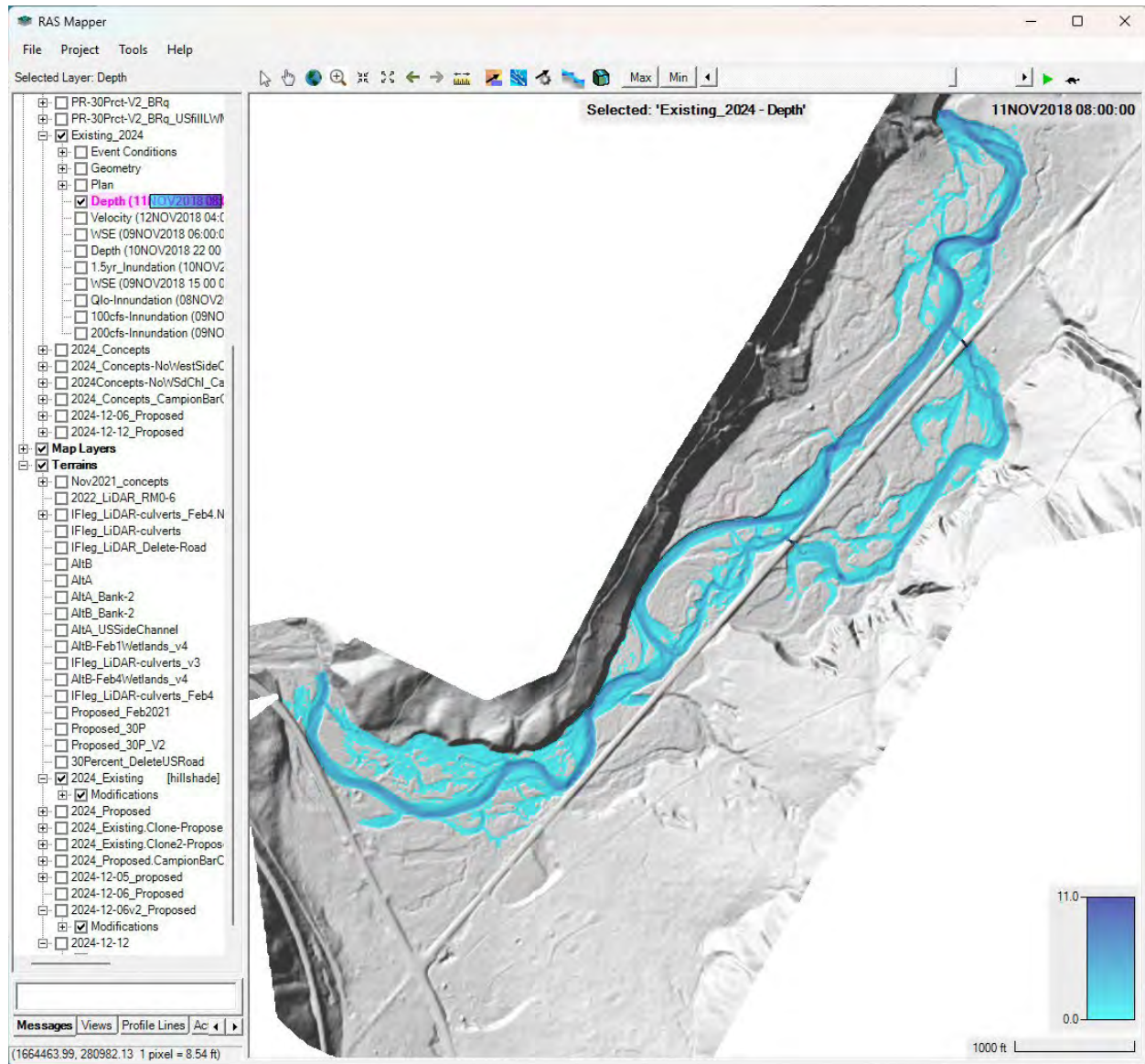
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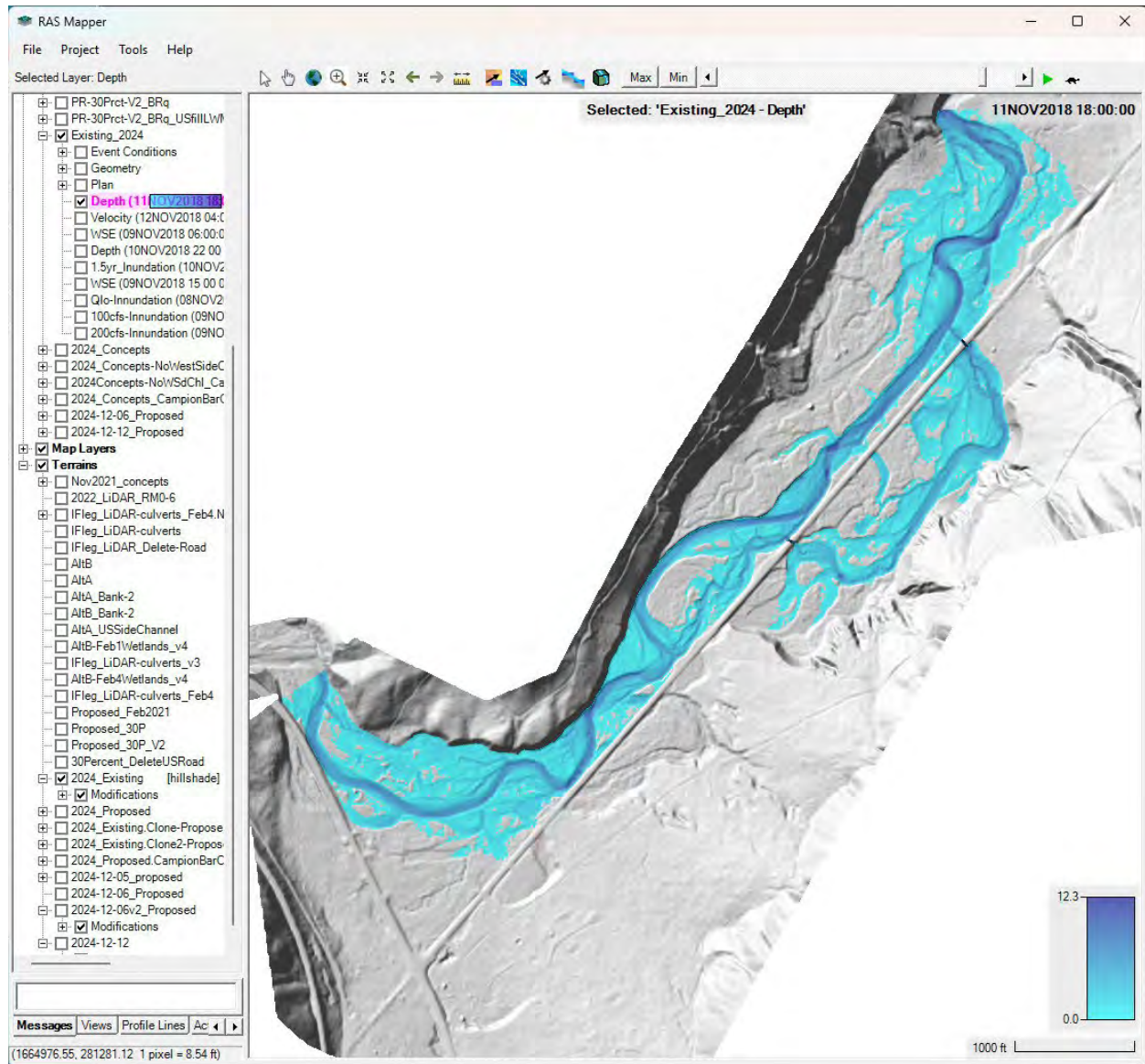
Existing condition: 1.5-year (2,200-cfs) flow depth, entire model domain



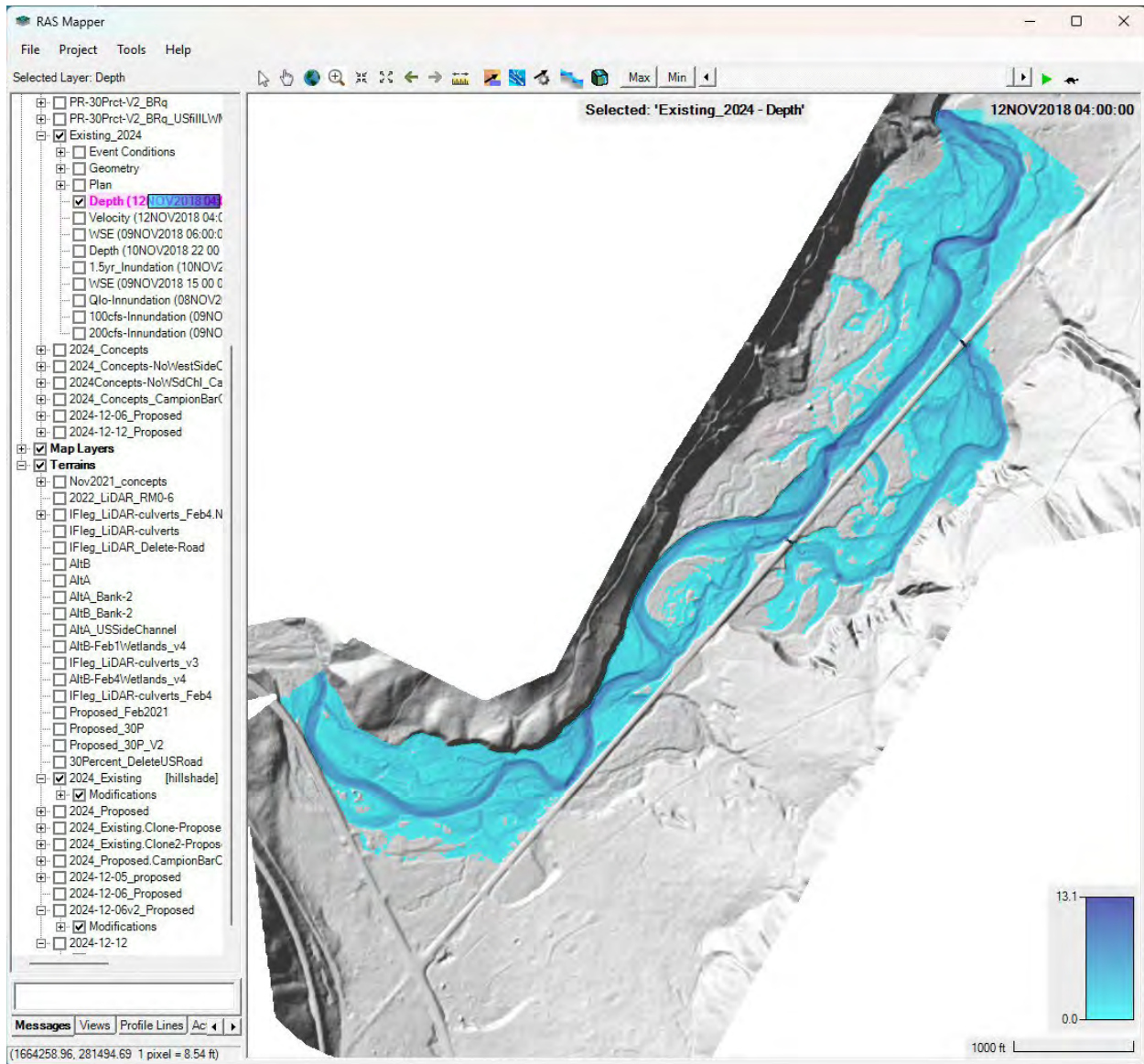
Existing condition: 5-year (3,900-cfs) flow depth, entire model domain



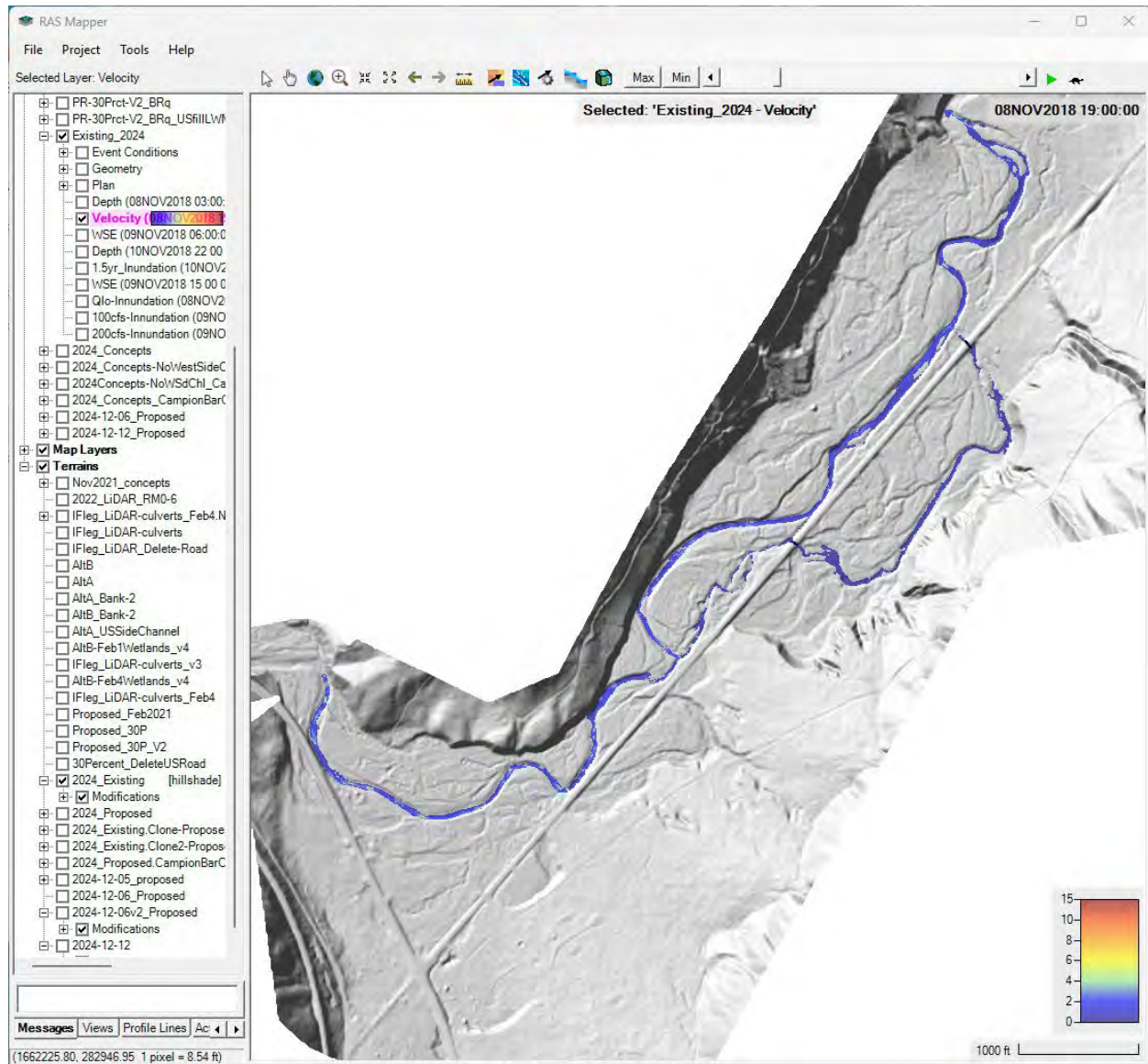
Existing condition: 25-year (6,500-cfs) flow depth, entire model domain



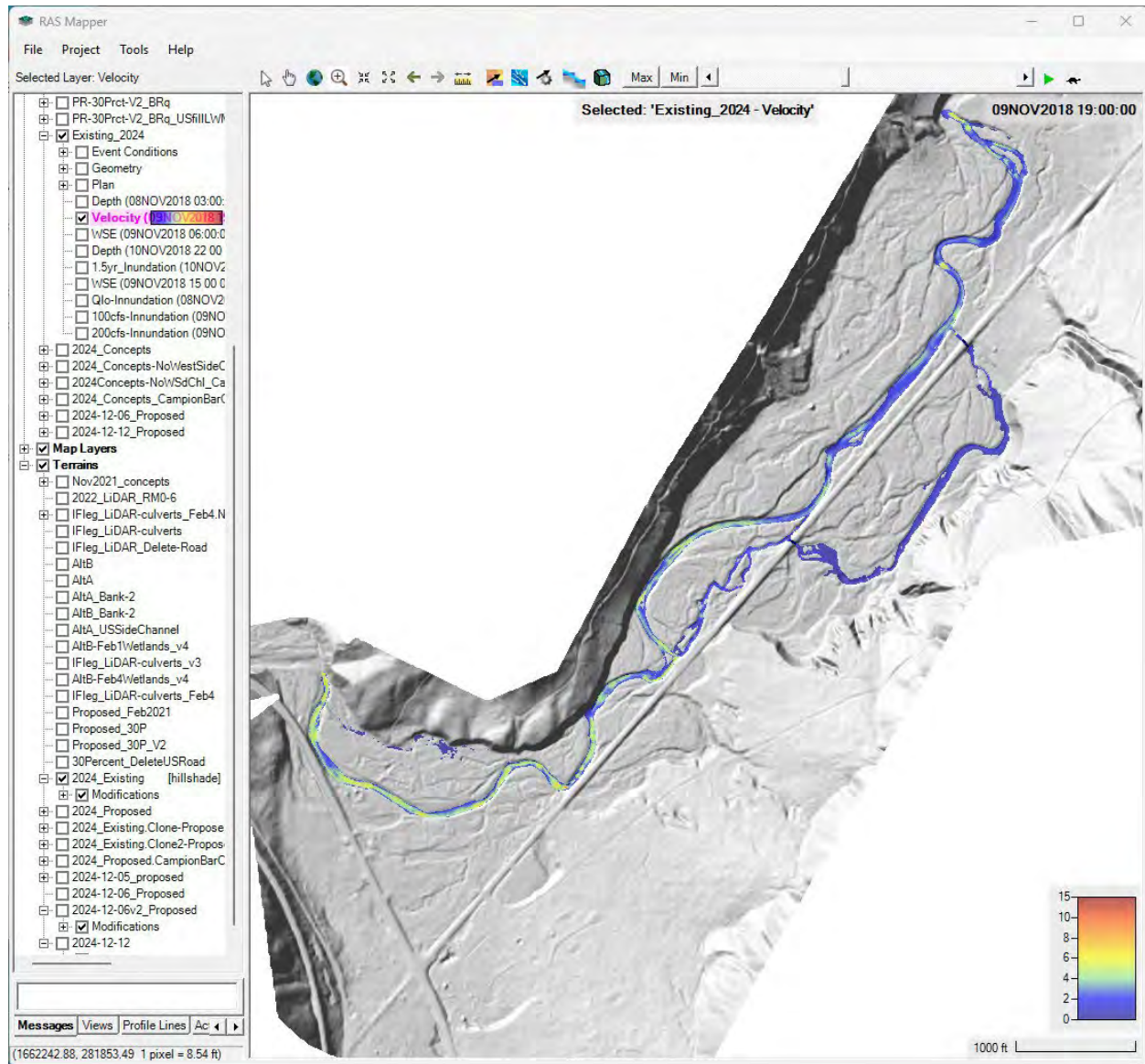
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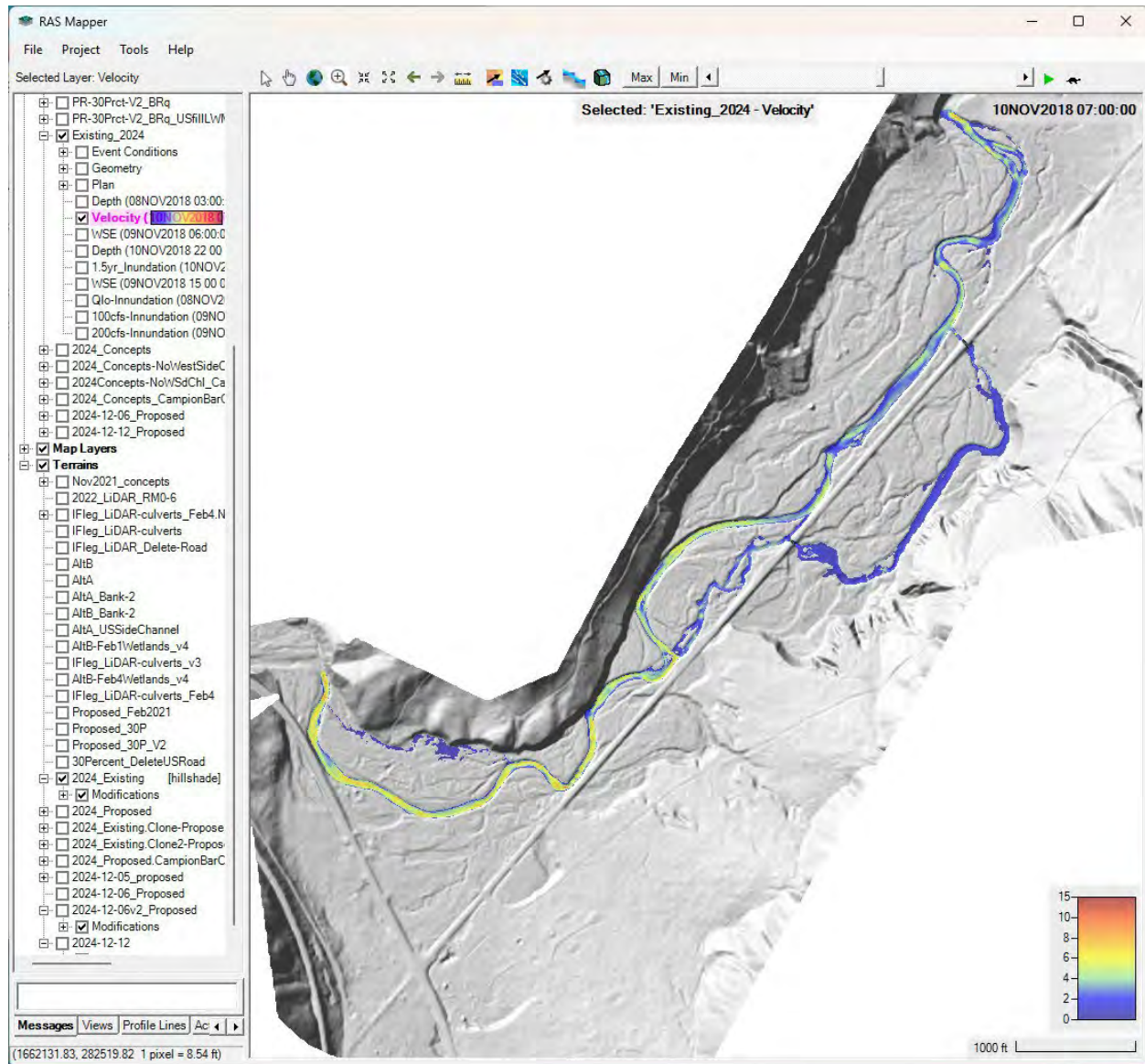
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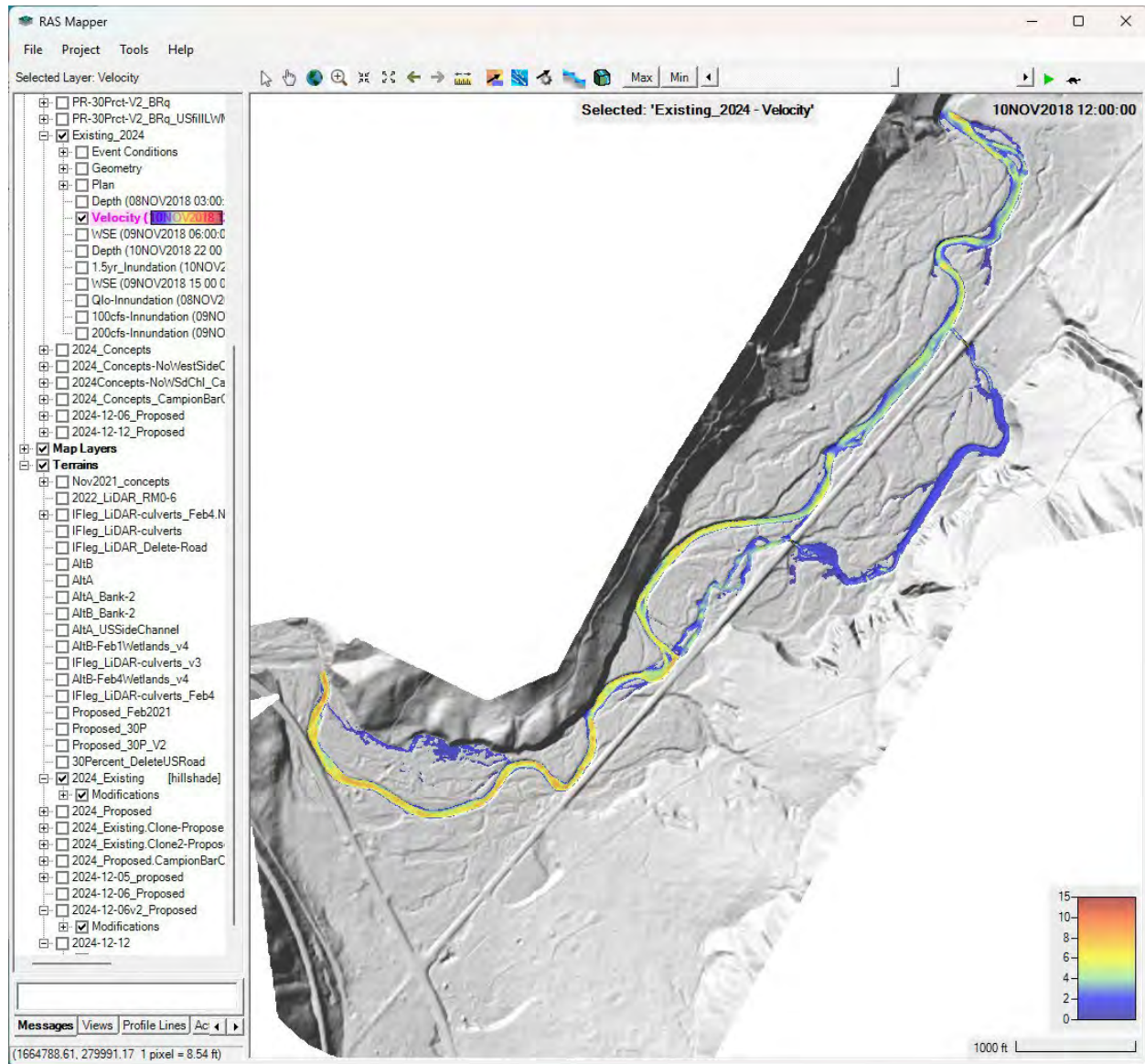
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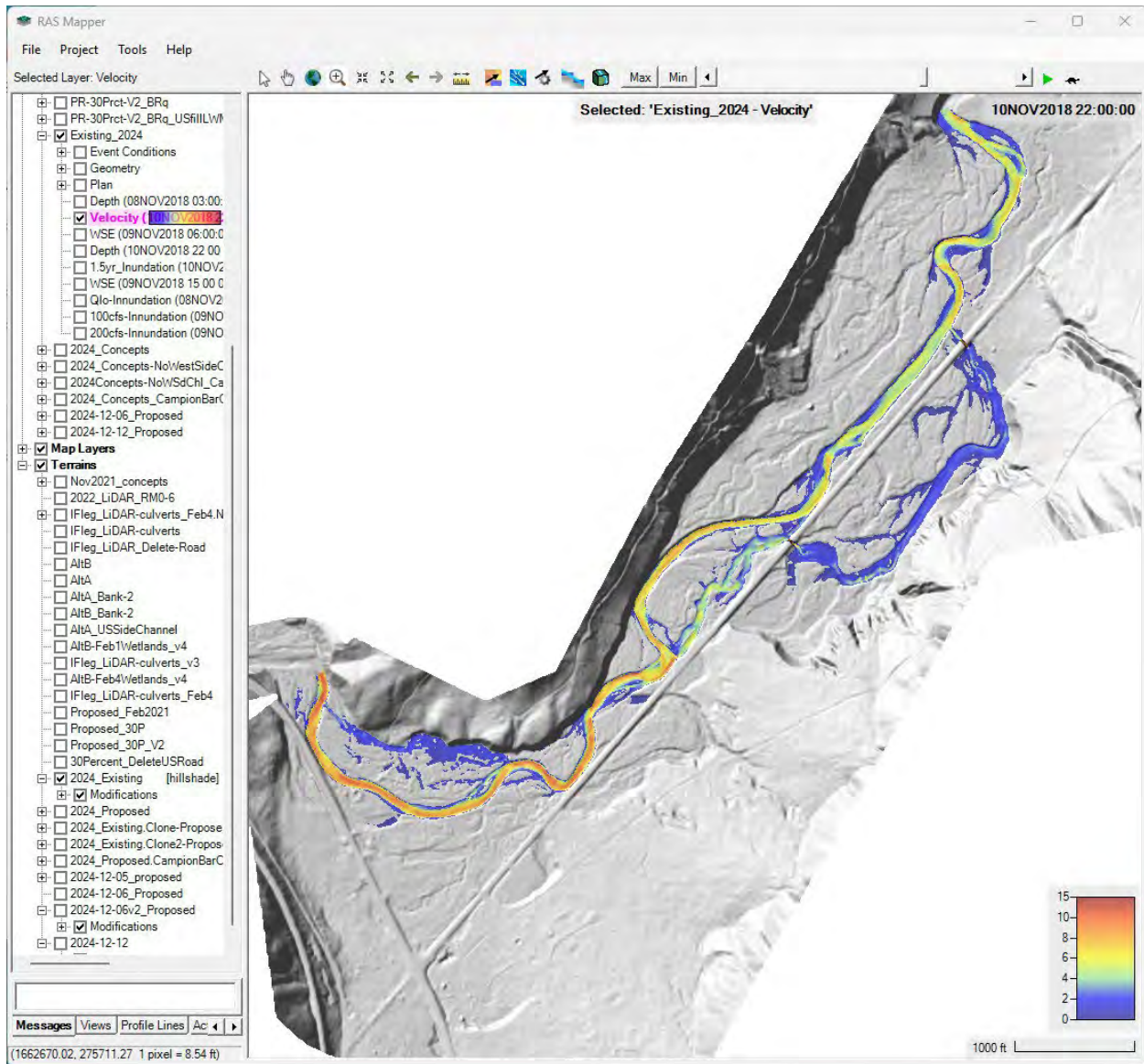
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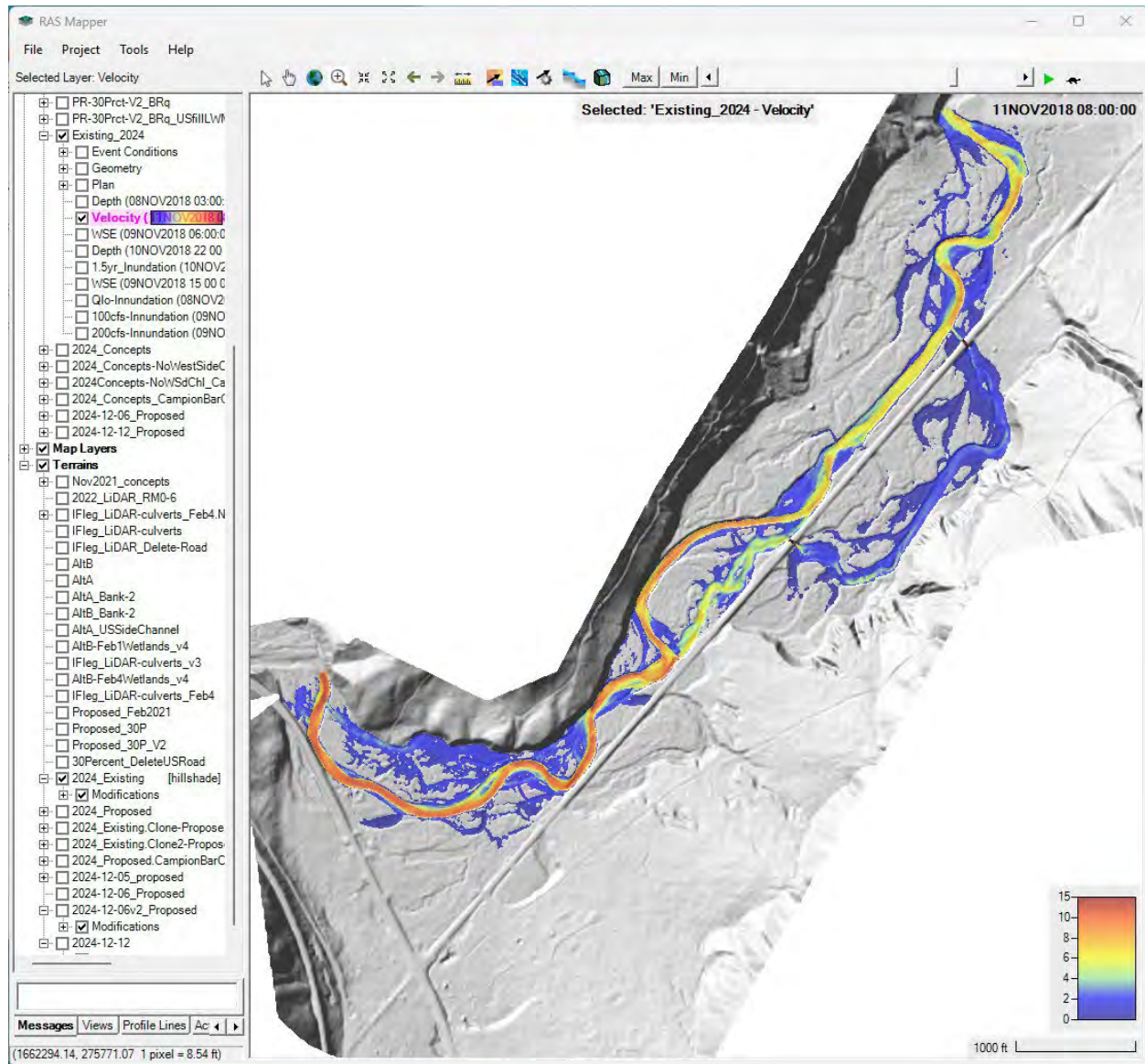
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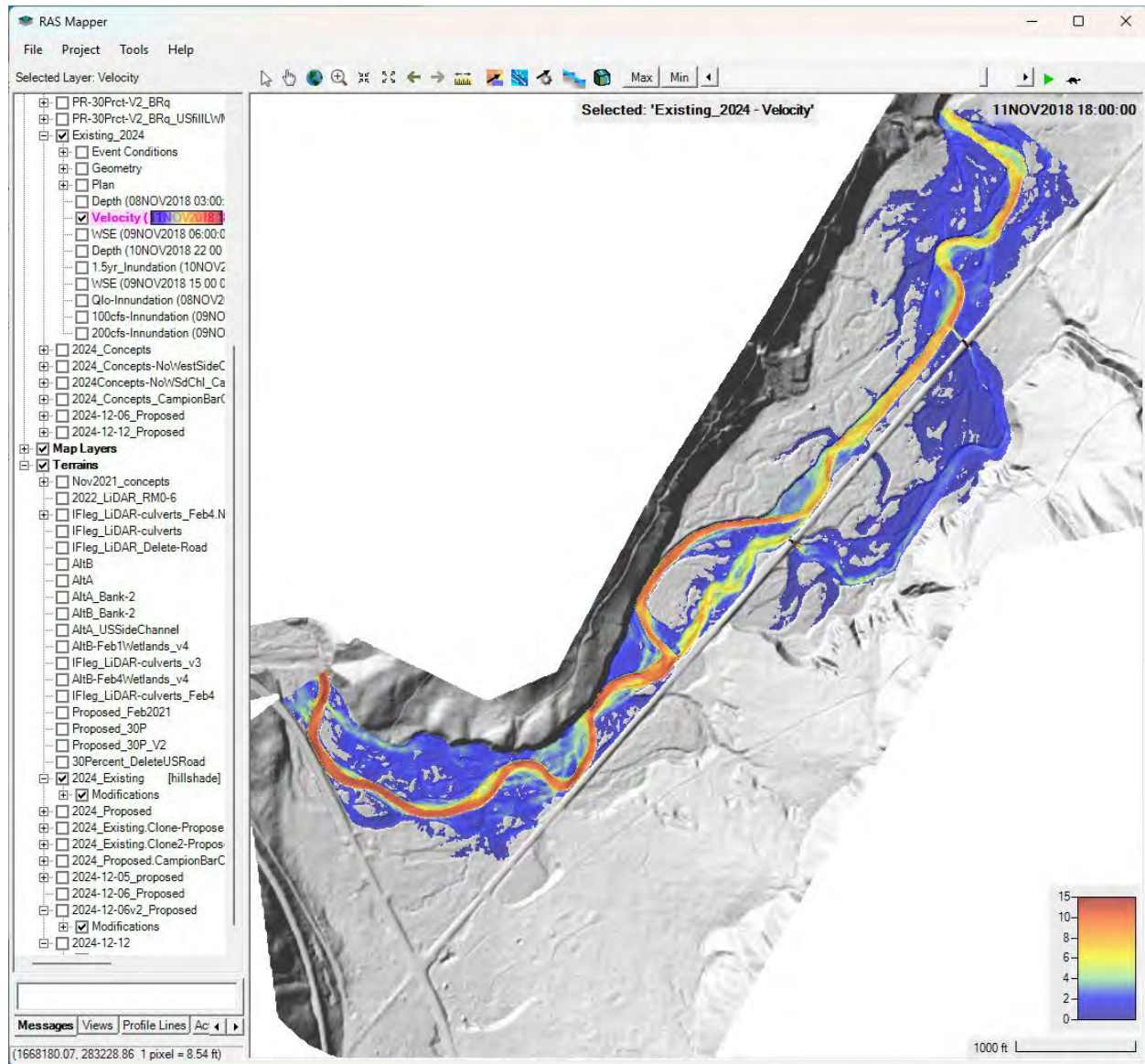
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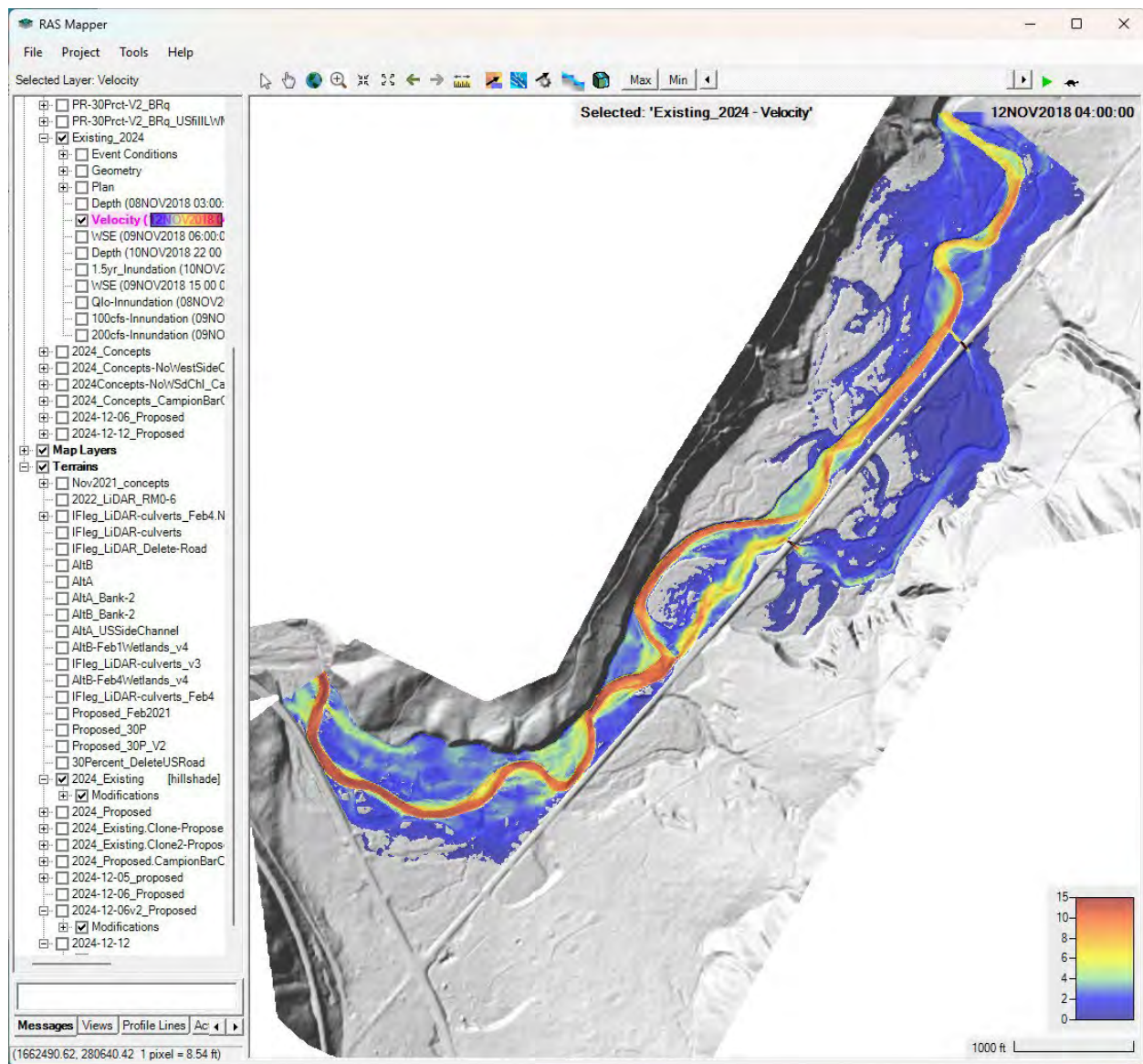
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Existing condition: 25-year (6,500-cfs) flow velocity through project area

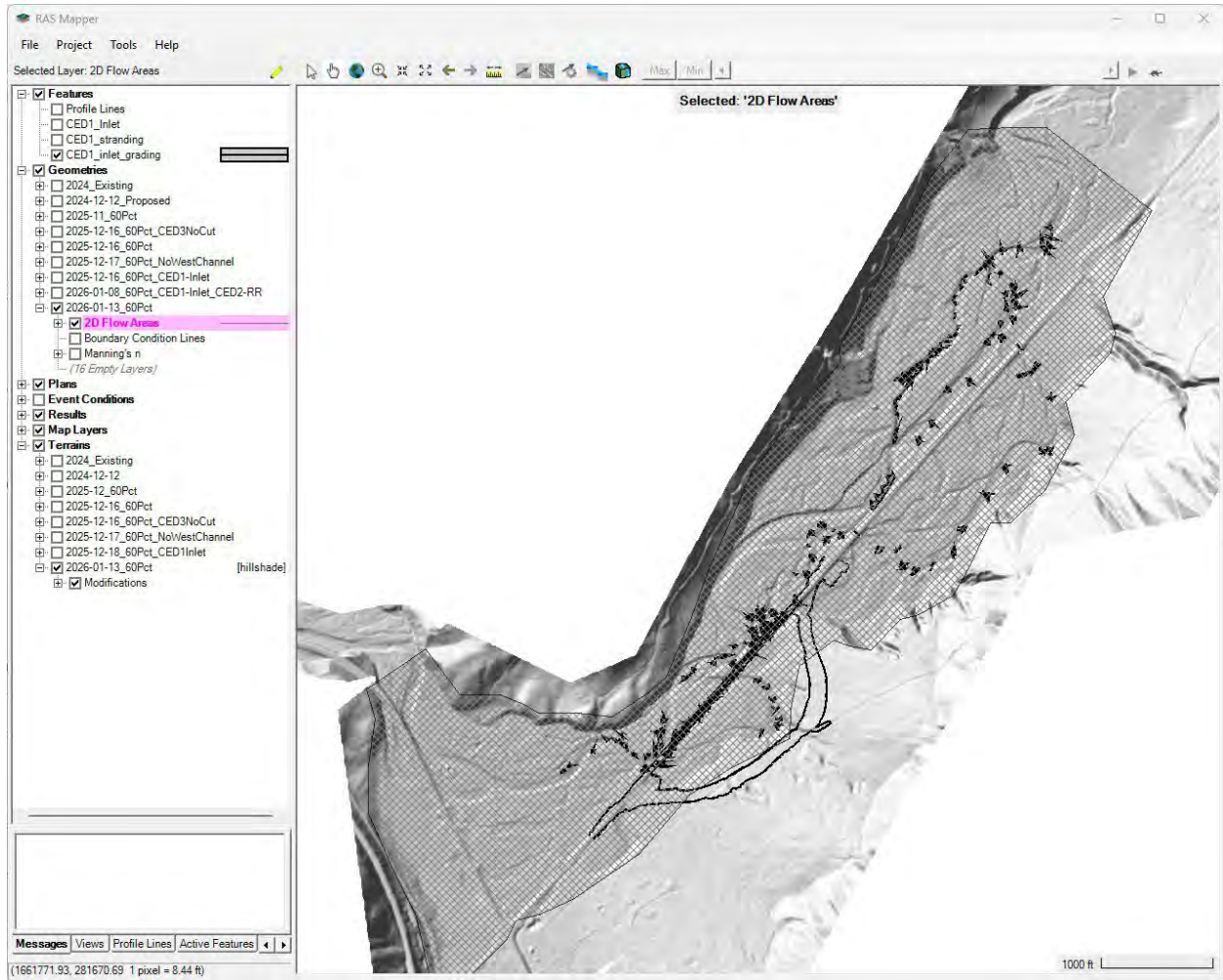


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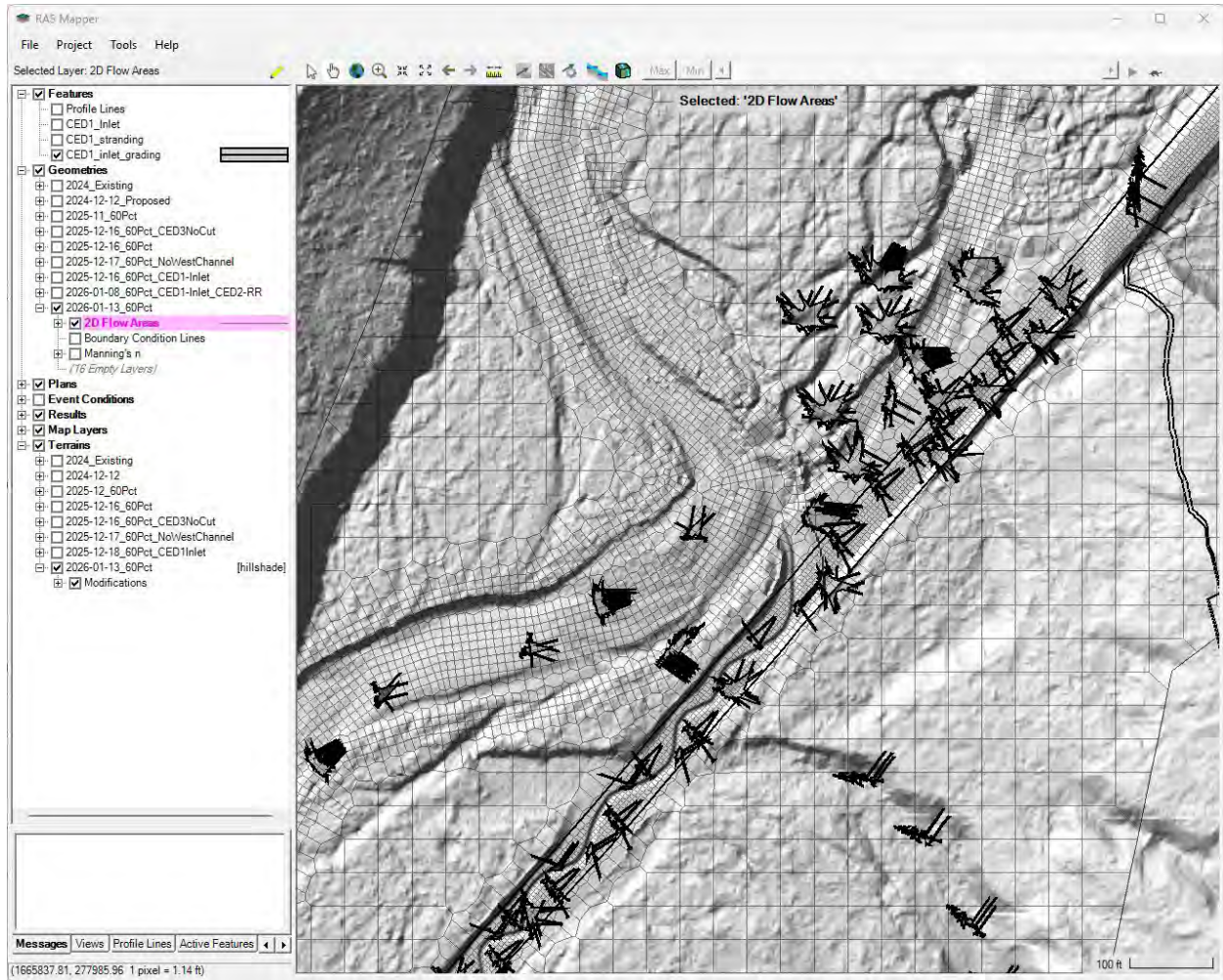


Appendix D – Proposed conditions HEC-RAS model

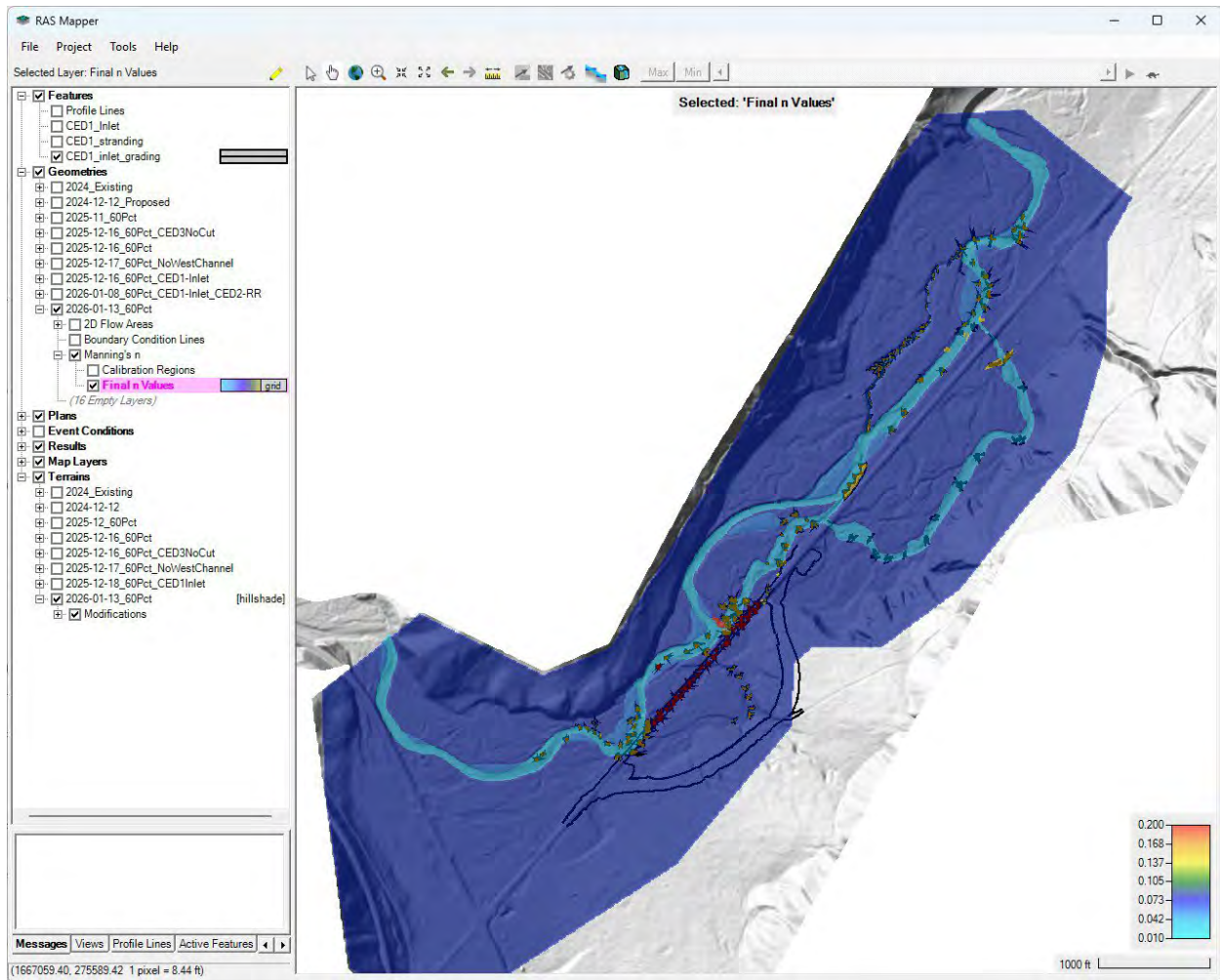
Proposed condition model mesh



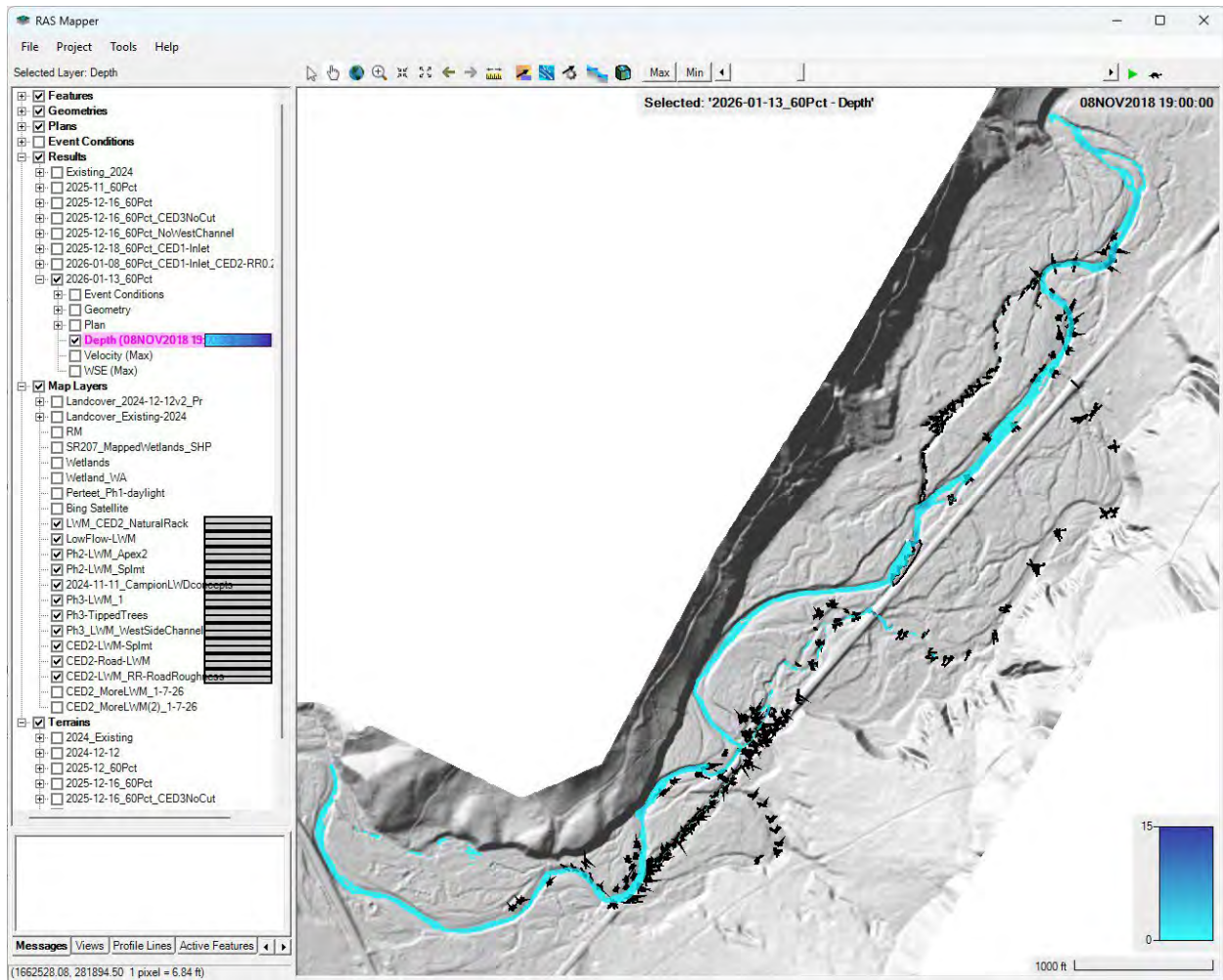
Proposed condition model mesh – example of mesh detail



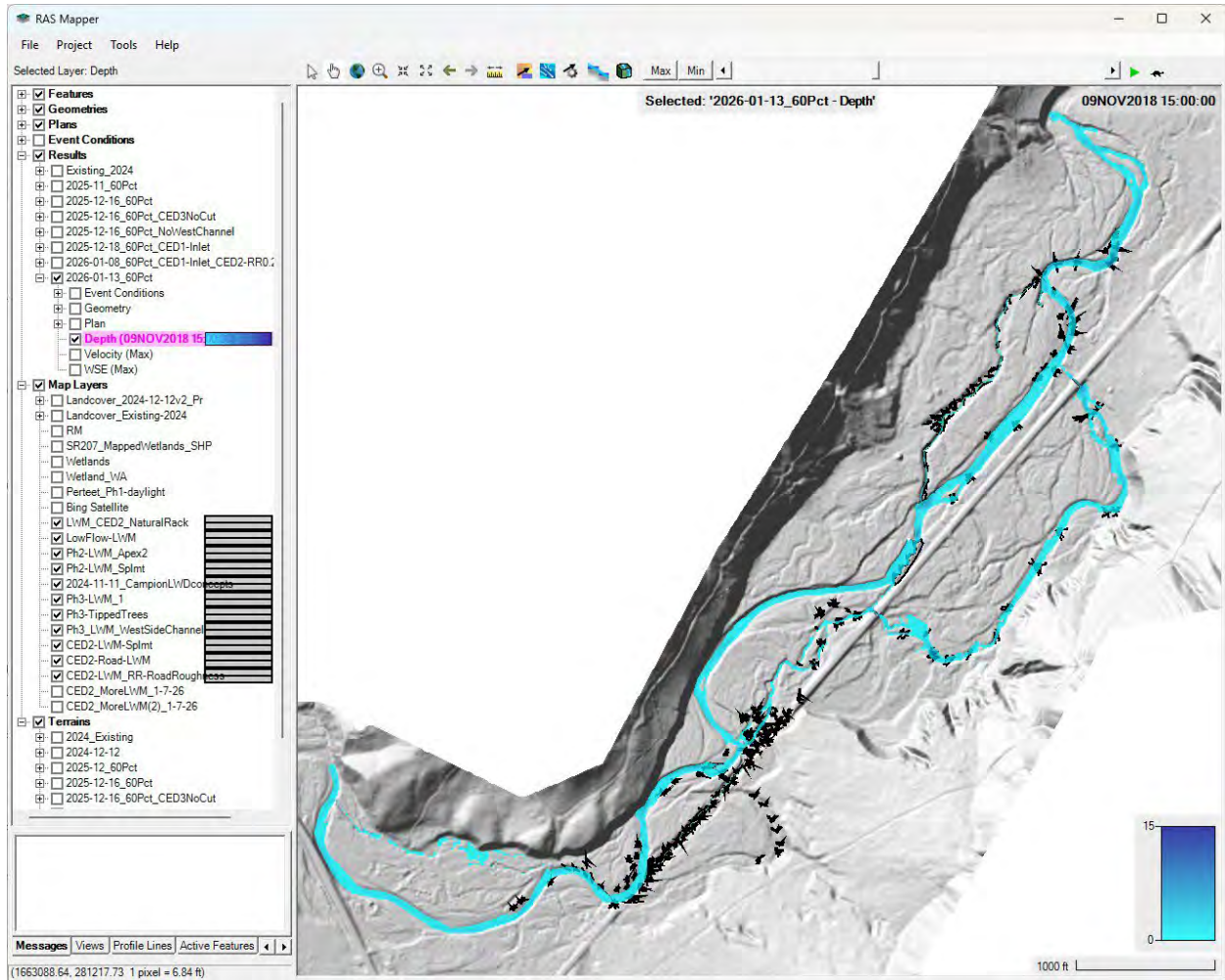
Proposed condition Manning's n



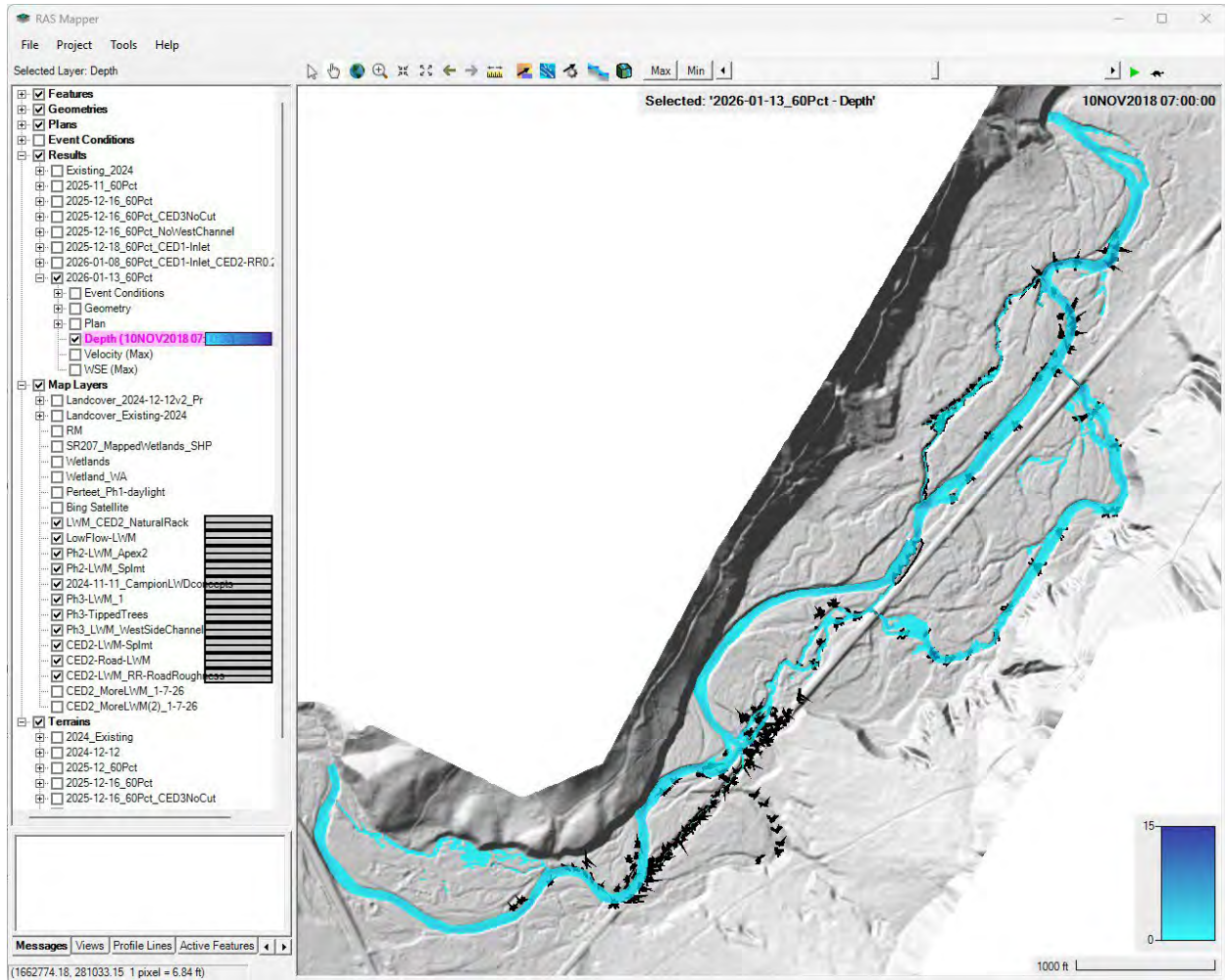
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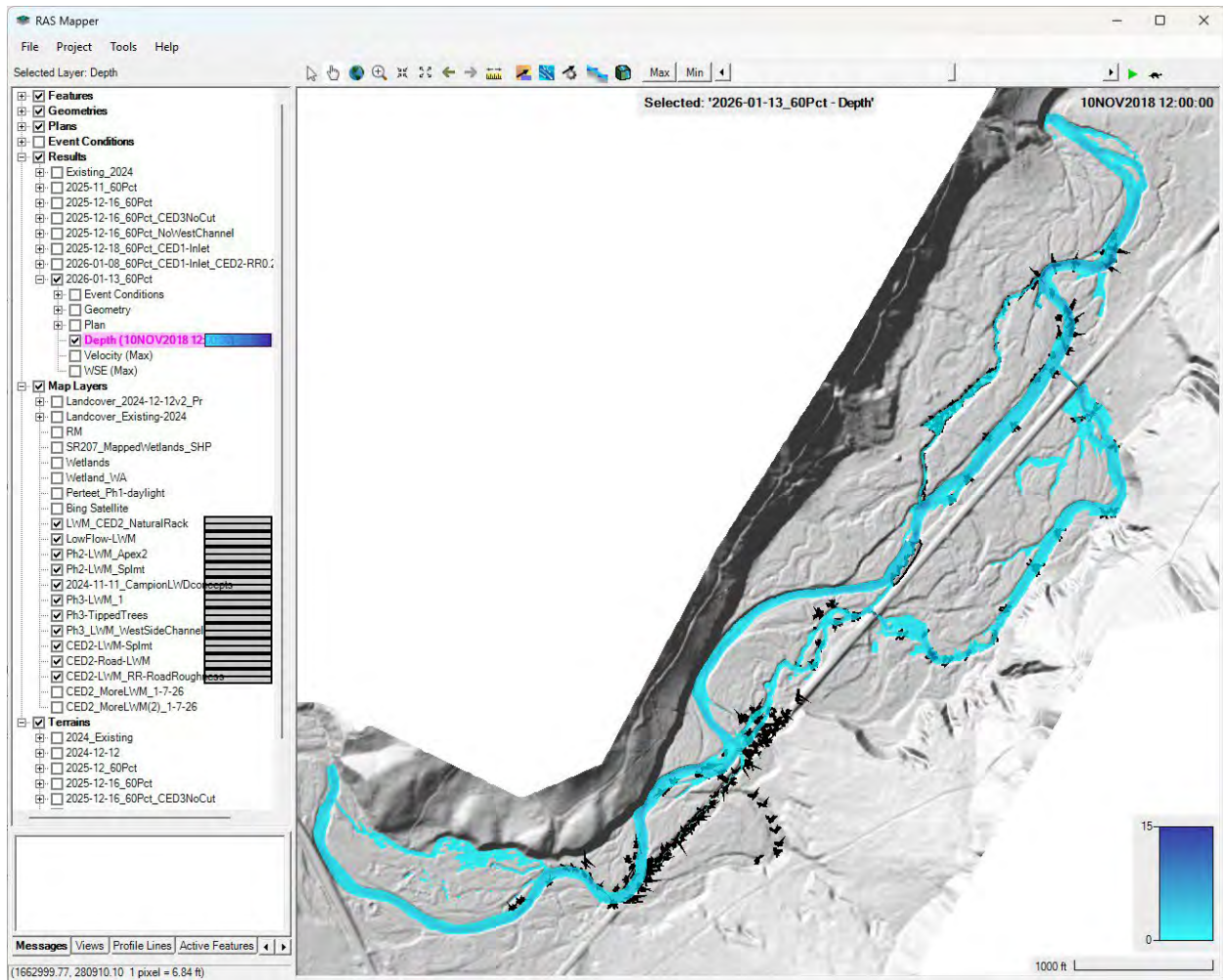
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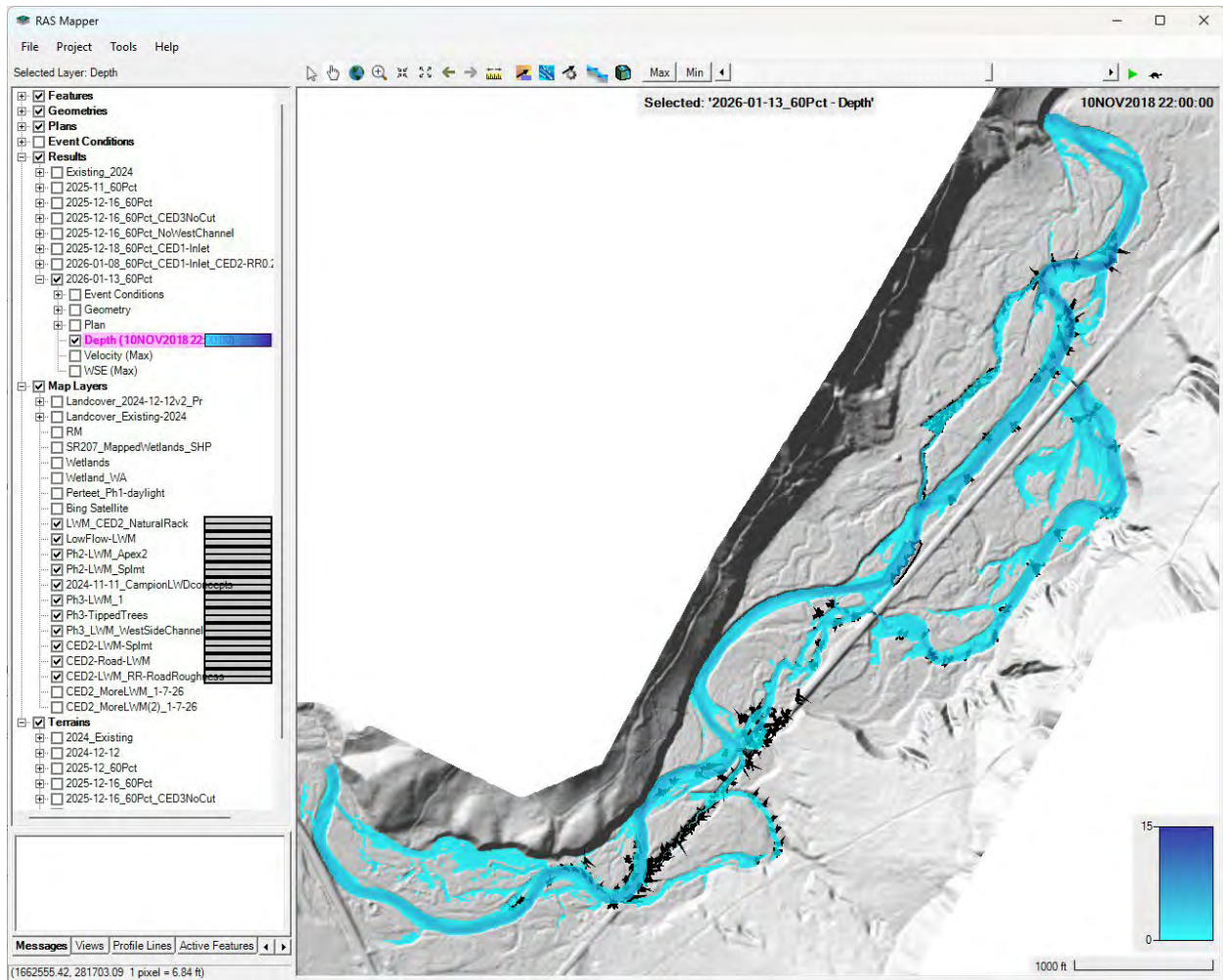
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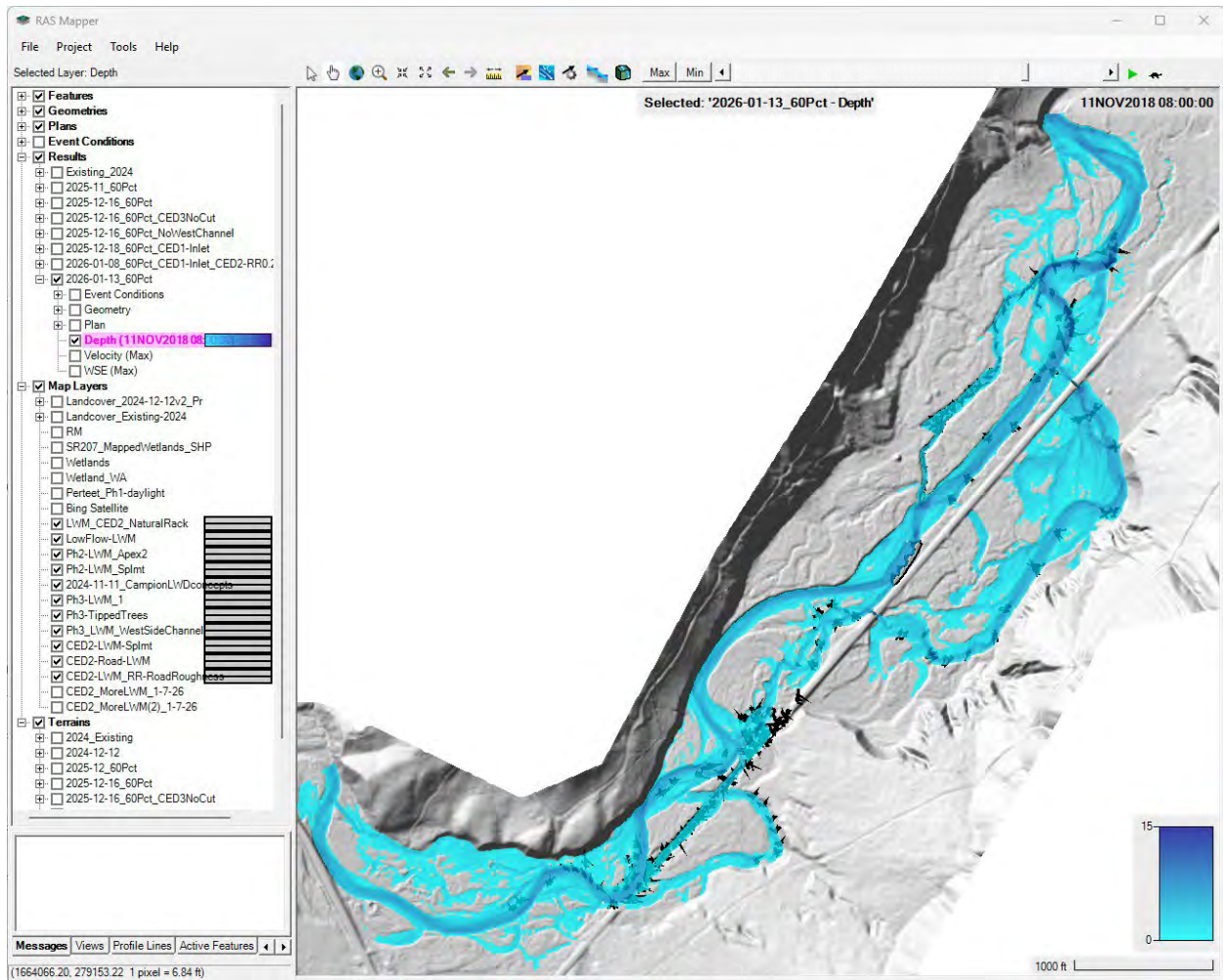
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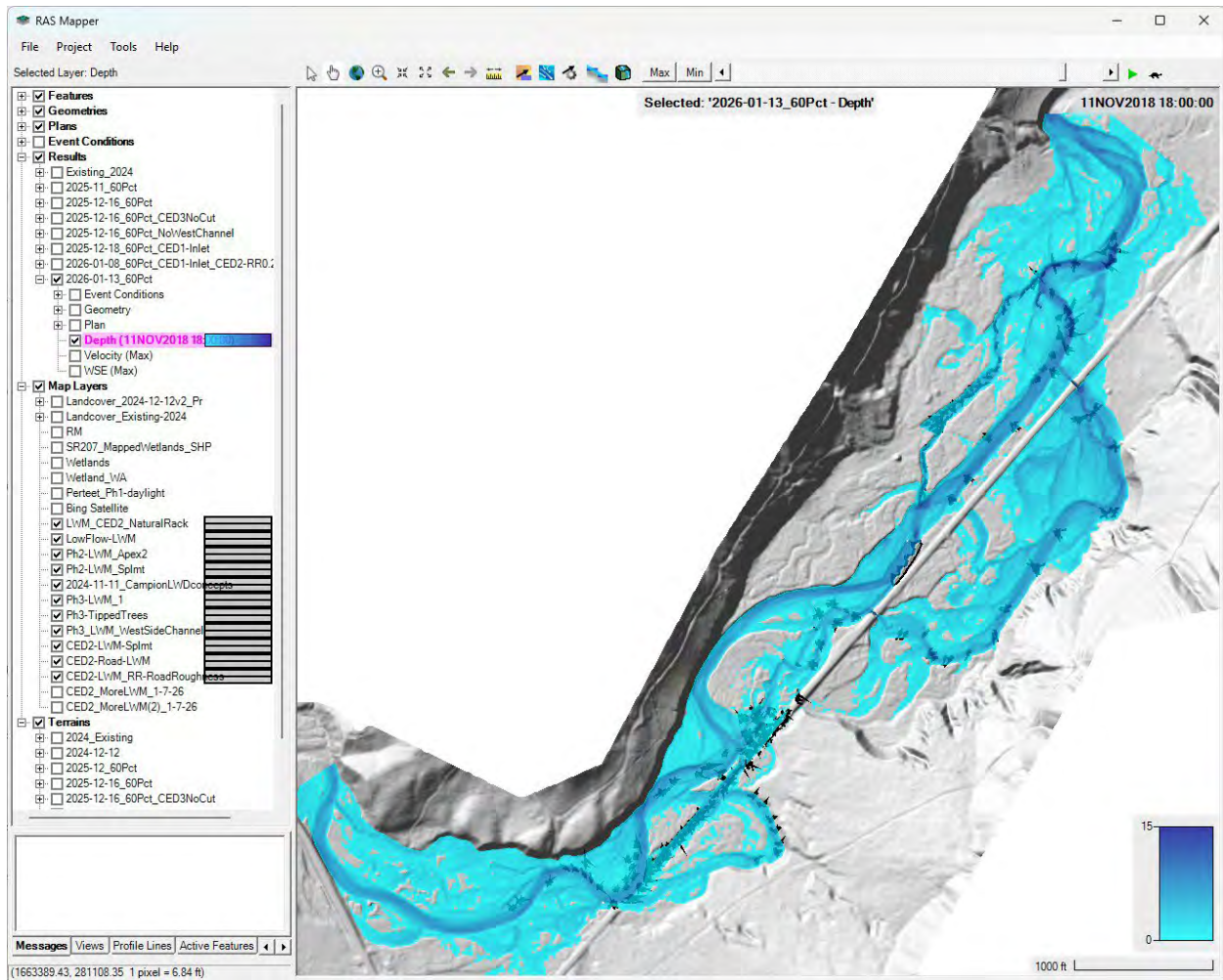
Proposed condition: 1.5-year (2,200-cfs) flow depth, entire model domain



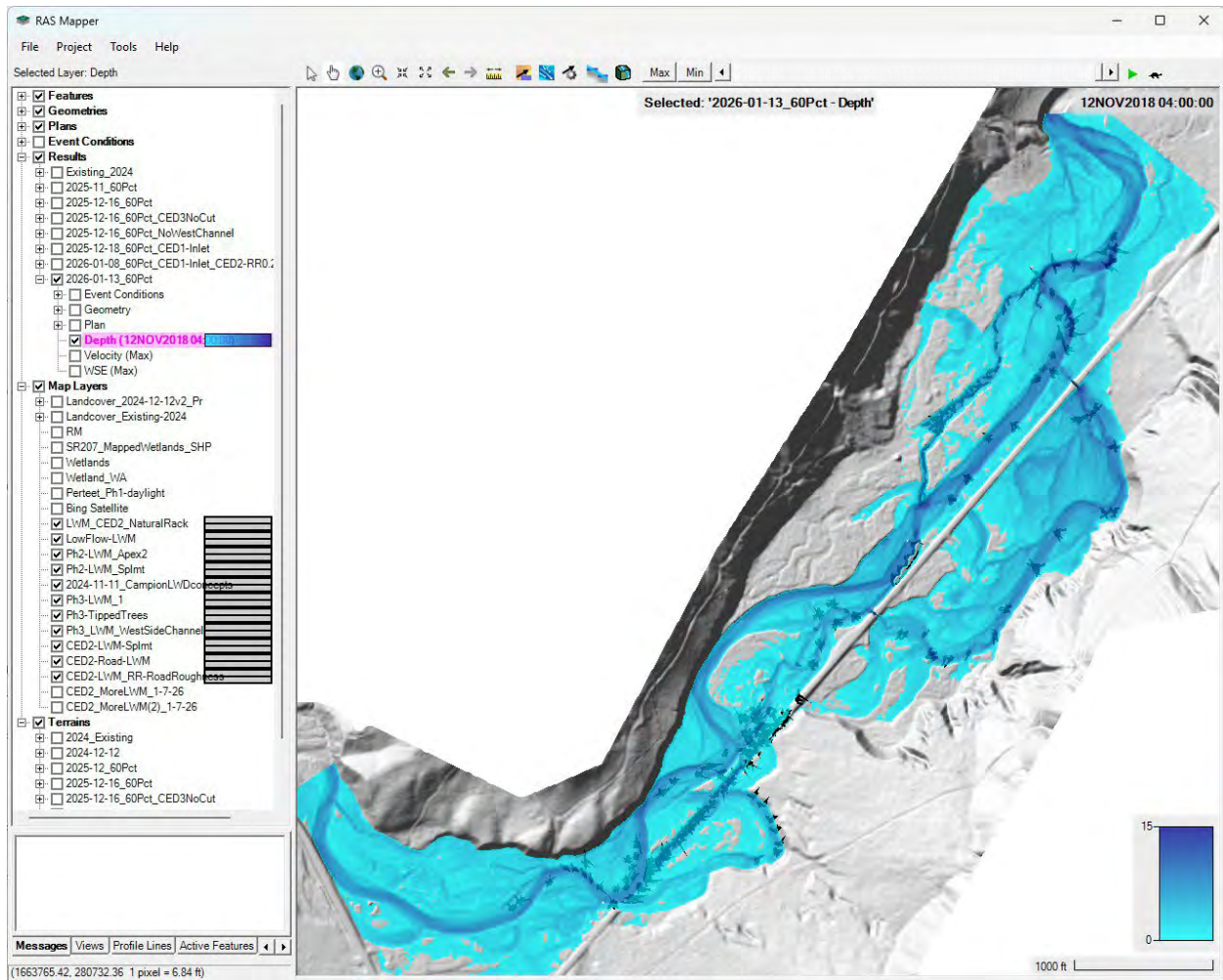
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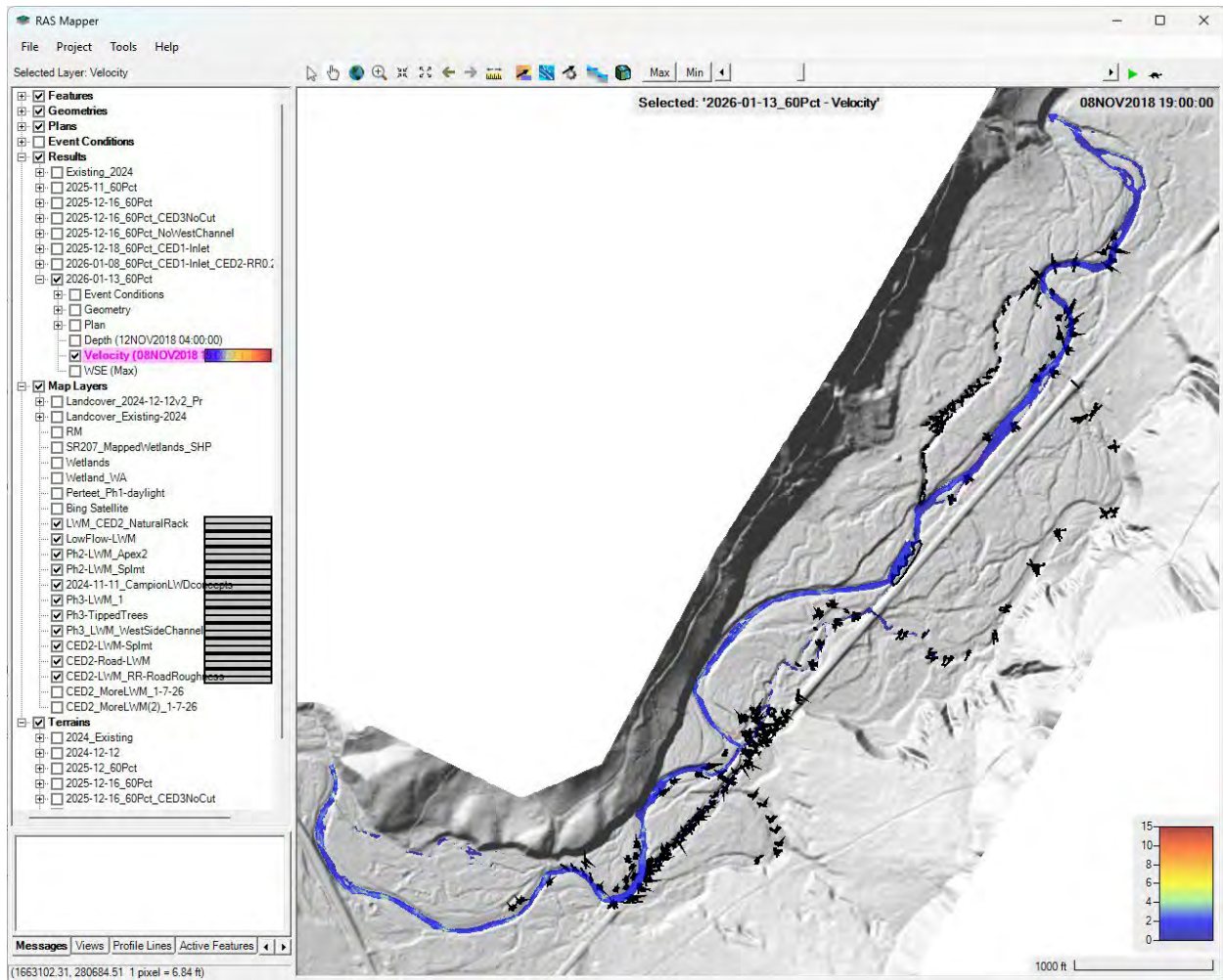
Proposed condition: 25-year (6,500-cfs) flow depth, entire model domain



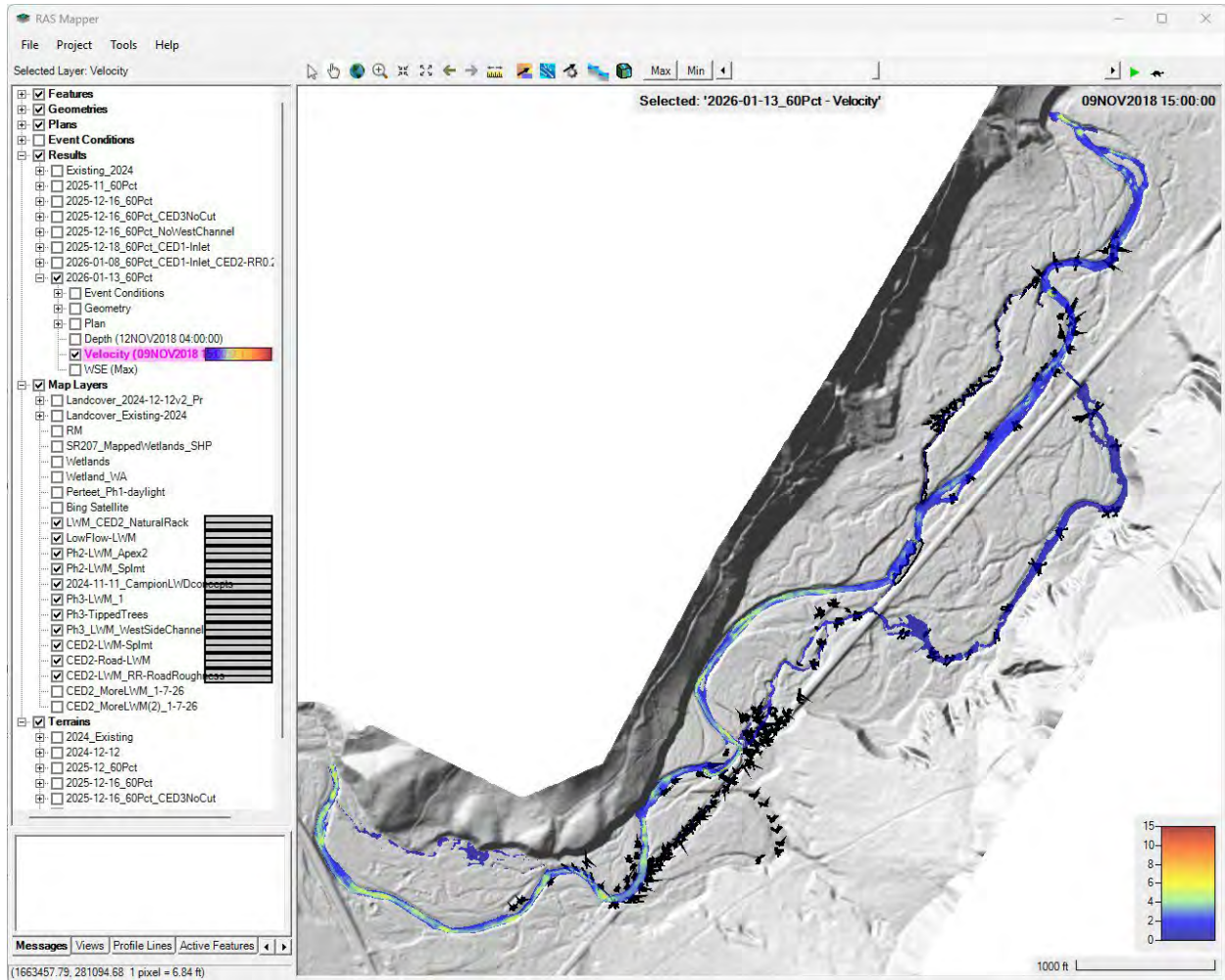
Proposed condition: 100-year (9,400-cfs) flow depth, entire model domain



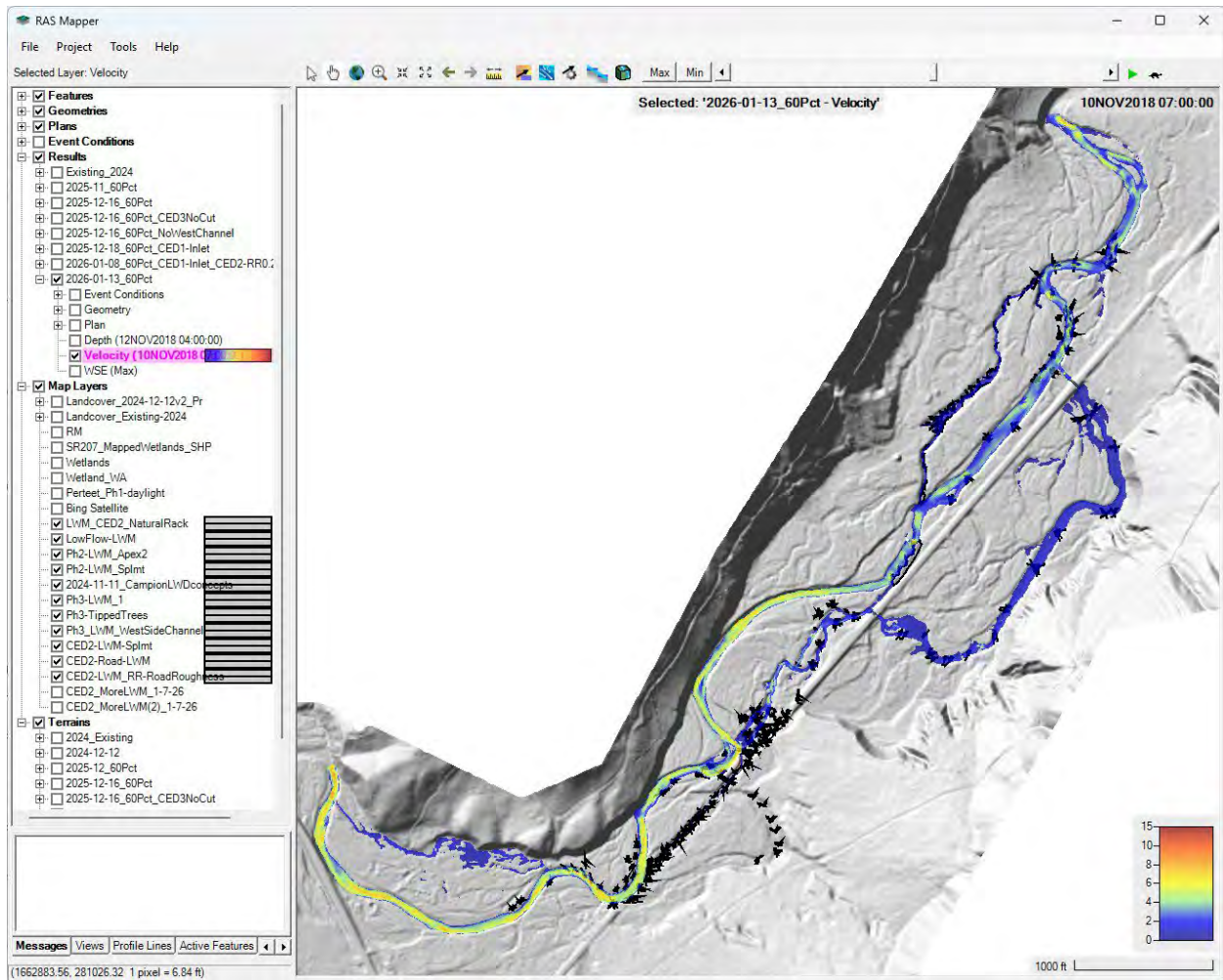
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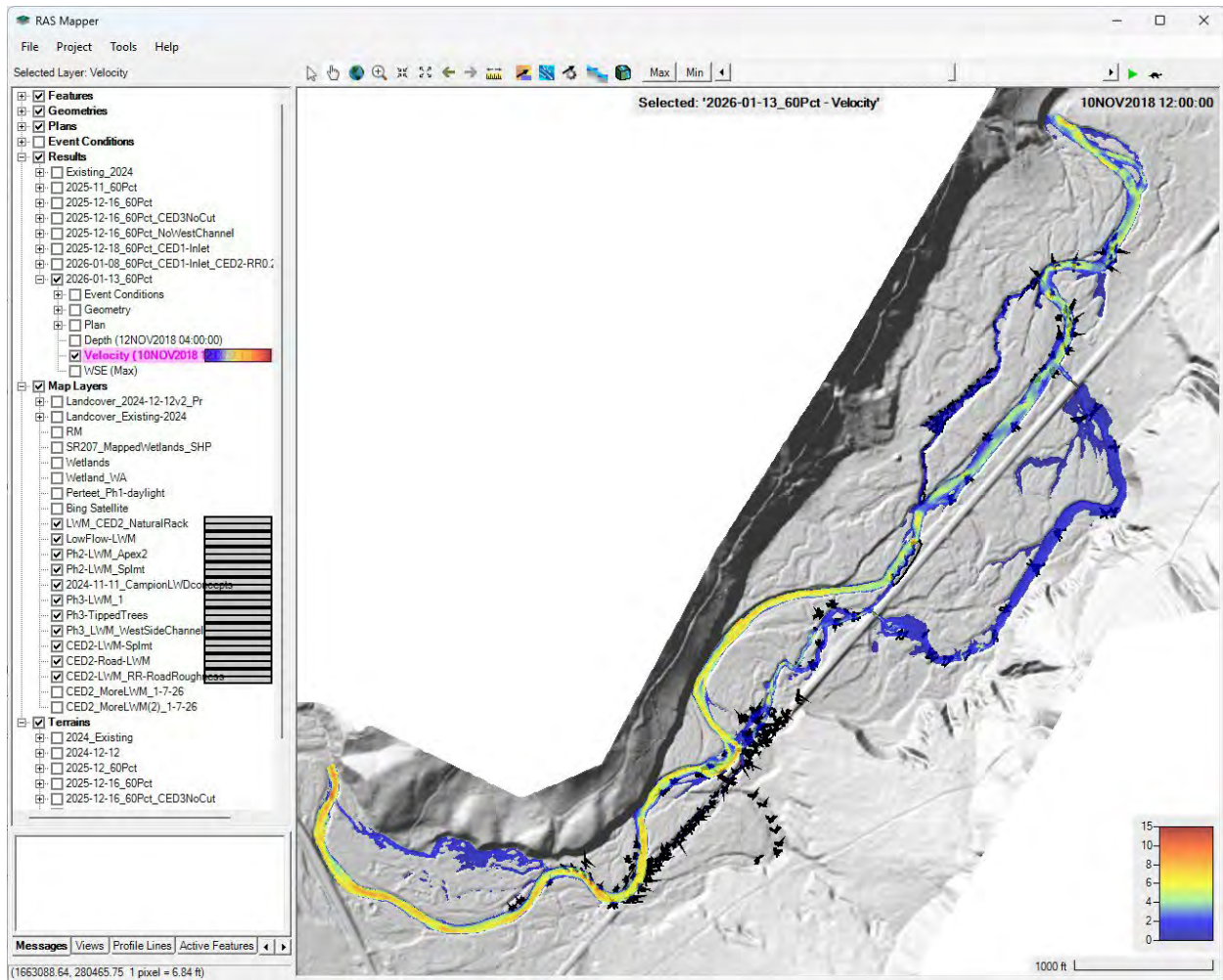
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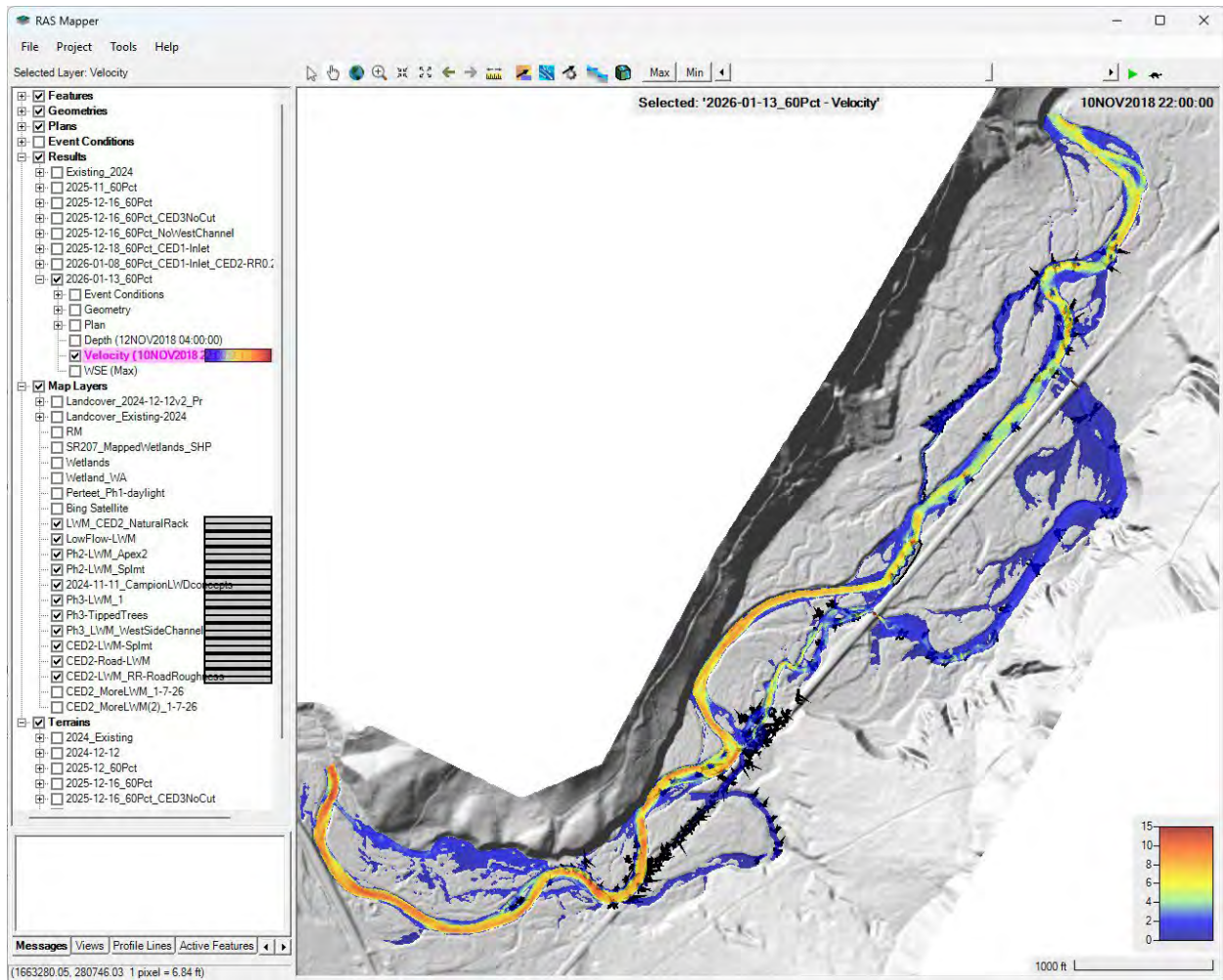
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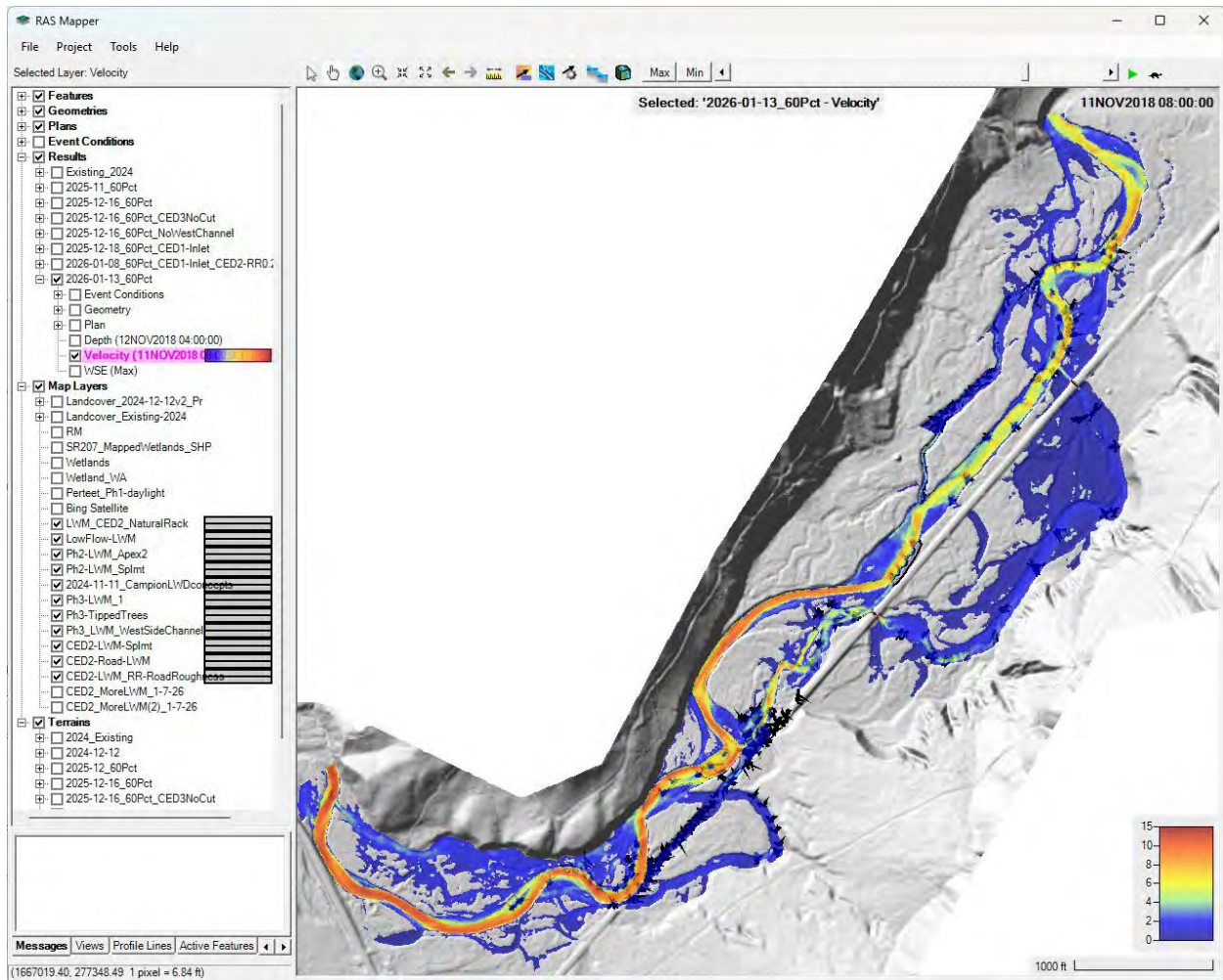
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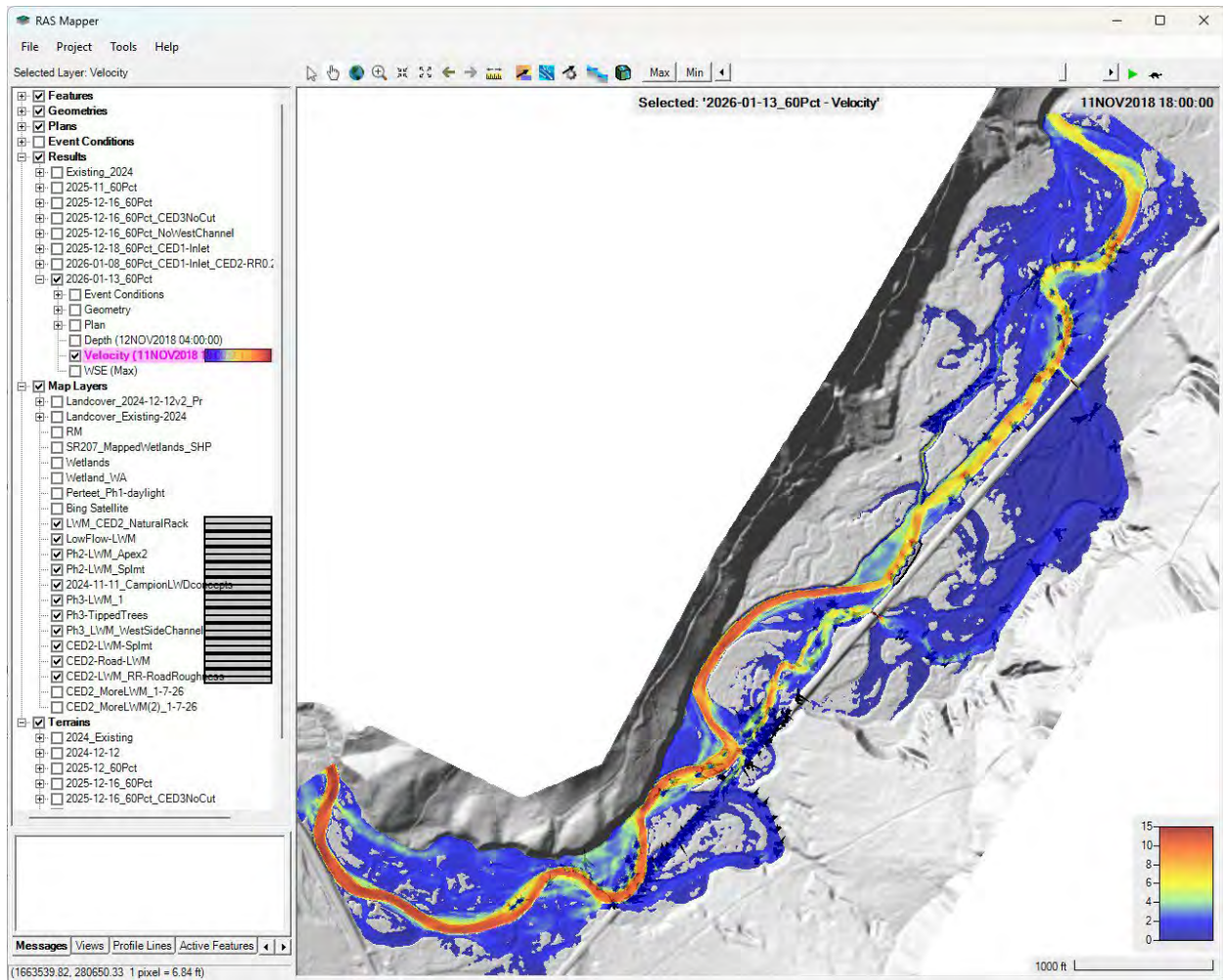
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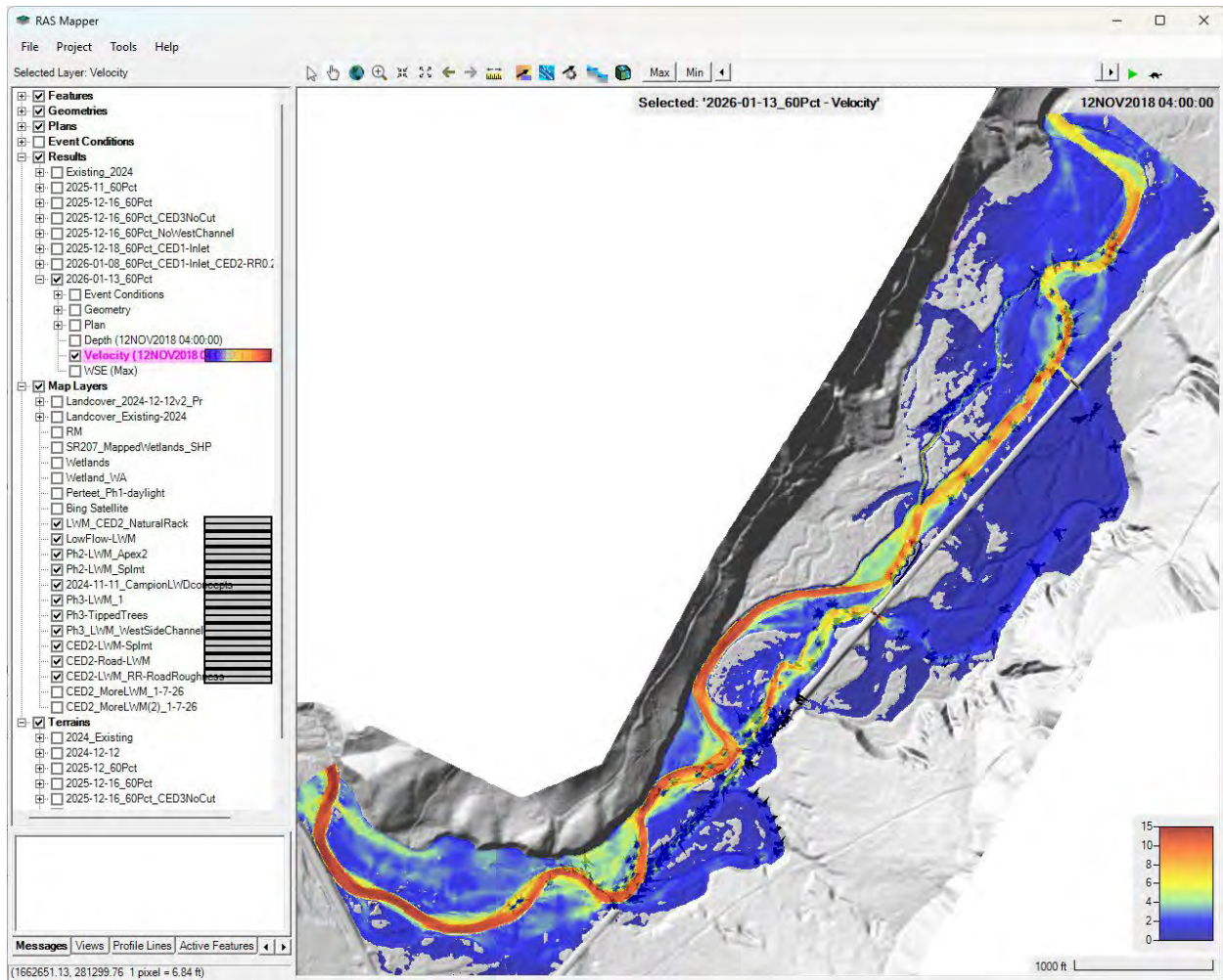
Proposed condition: 5-year (3,900-cfs) flow velocity through project area



Proposed condition: 25-year (6,500-cfs) flow velocity through project area



Proposed condition: 100-year (9,400-cfs) flow velocity through project area



Appendix E – Large Wood Stability Calculations

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	1129 ft ³

F_{LWMS} (lb) 27,542	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
C_L = lift coefficient		0.2 typ. LWM value
A_{LWM} = area of large woody material perpendicular to flow		A_{LWM} = See Design Plan
U_u = upstream channel velocity at design event		A_{LWM} (ft ²) 152 For pre-racking condition
g = acceleration due to gravity		7 ft/s
		32.2 ft/s ²
F_L (lb)		N/A

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{bouldersub} = N_{bouldersub} \times \pi/6 \times d_{bouldersub}^3 \times (\gamma_{boulder} - \gamma_w)$$

	Design Value	Units / Notes
$N_{bouldersub}$ = number of submerged boulders		0 number
$d_{bouldersub}$ = effective diameter of submerged boulders		0 ft
$\gamma_{boulder}$ = unit weight of boulders		165 lb/ft ³
$F_{bouldersub}$ (lb)		N/A

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{backfillsub} = V_{backfillsub} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{backfillsub}$ = volume of backfill over LWM members		3,150 ft ³ See design plans
γ_s = unit weight of backfill material		110 lb/ft ³
$F_{backfillsub}$ (lb)		-149,940

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

5.25 number

L_{piles} = length of pile embedded below potential scour depth

15 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

357 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-51,121

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 1.9

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 5.4

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 7.3

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	152
$U_c = \text{velocity adjacent to the LWM structure}$	7	ft/s Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \text{ 7,217}$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	5.5
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	152
		Post racking area	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	5.5
		$A_d \text{ (ft}^2\text{)}$	152
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		Plan downstream area	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{W_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

W_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	7
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 184

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMS} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -95,628

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

5.25 number

N_{pile} = number of piles

L_{pile} = length of pile embedded below potential scour depth

15 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -61,455

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

FOS_{sliding} 21.2

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200 psi 172,800 psf
d_{pile} = diameter of the pile		1.30 ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24 ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216 ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971 --
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	3,524 ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	16,338 psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166 psi 167,835 psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		
	FOS_{pile strength} 10.3	

References

- Large Woody Material - Risk Based Design Guidelines
M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>
- ASTM D25. Allowable Stress Values for Treated Round Timber Piles.
- Timber Pile Design and Construction Manual, Timber Piling Council, 2015.
- American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	800 ft ³

F_{LWMS} (lb) 19,513	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
C_L = lift coefficient		0.2 typ. LWM value
A_{LWM} = area of large woody material perpendicular to flow		A_{LWM} = See Design Plan
U_u = upstream channel velocity at design event		A_{LWM} (ft ²) 40
		For pre-racking condition
		10 ft/s
g = acceleration due to gravity		32.2 ft/s ²
F_L (lb)		N/A

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{bouldersub} = N_{bouldersub} \times \pi/6 \times d_{bouldersub}^3 \times (\gamma_{boulder} - \gamma_w)$$

	Design Value	Units / Notes
$N_{bouldersub}$ = number of submerged boulders		0 number
$d_{bouldersub}$ = effective diameter of submerged boulders		0 ft
$\gamma_{boulder}$ = unit weight of boulders		165 lb/ft ³
$F_{bouldersub}$ (lb)		N/A

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{backfillsub} = V_{backfillsub} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{backfillsub}$ = volume of backfill over LWM members		3,150 ft ³
		See design plans
γ_s = unit weight of backfill material		110 lb/ft ³
$F_{backfillsub}$ (lb)		-149,940

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

0 number

L_{piles} = length of pile embedded below potential scour depth

12 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

285.6 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

0 Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 0.0

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 7.7

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 7.7

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$$

Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1 Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$
$U_c = \text{velocity adjacent to the LWM structure}$	10 ft/s
$g = \text{acceleration due to gravity}$	32.2 ft/s ²
F_d (lb) 3,876	

40

Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u \quad F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$$

F_{hu} , F_{hd} = hydrostatic force on upstream and downstream side of the wood structure

Y_u , Y_d = water depth upstream and downstream of the structure

A_u , A_d = area projected to flow direction on the upstream and downstream of the structure

Variable Design Value

Y_u (ft)	7
A_u (ft ²)	40
Post racking area	
Y_d (ft)	7
A_d (ft ²)	40
Plan downstream area	

$F_{hu} + F_{hd} = F_h$ (lb)	N/A
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Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value

W_{debris} (lb) 3,774

$V_{channel}$ (ft/s) 10

Δx (ft) 5

C_i 0.5

C_o 0.8

C_d 1.0

C_b 1.0

R_{max} 0.8

F_i (lb) 375

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMs} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -101,901

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

N_{pile} = number of piles

0 number

L_{pile} = length of pile embedded below potential scour depth

12 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) 0

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{24.0}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values	Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200	psi
		172,800	psf
d_{pile} = diameter of the pile		1.30	ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24	ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216	ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971	--
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	#DIV/0!	ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	#DIV/0!	psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166 167,835	psi psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength}$ #DIV/0!	

References

Large Woody Material - Risk Based Design Guidelines
M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	275 ft ³

F_{LWMS} (lb) 6,700	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
$C_L = \text{lift coefficient}$	0.2	typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$	4	ft/s
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
F_L (lb)	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{\text{bouldersub}} = N_{\text{bouldersub}} \times \pi/6 \times d_{\text{bouldersub}}^3 \times (\gamma_{\text{boulder}} - \gamma_w)$$

	Design Value	Units / Notes
$N_{\text{bouldersub}} = \text{number of submerged boulders}$	0	number
$d_{\text{bouldersub}} = \text{effective diameter of submerged boulders}$	0	ft
$\gamma_{\text{boulder}} = \text{unit weight of boulders}$	165	lb/ft ³
$F_{\text{bouldersub}}$ (lb)	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{\text{backfillsub}} = V_{\text{backfillsub}} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{\text{backfillsub}} = \text{volume of backfill over LWM members}$	630	ft ³
$\gamma_s = \text{unit weight of backfill material}$	110	lb/ft ³
$F_{\text{backfillsub}}$ (lb)	-29,988	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

1.5 number

L_{piles} = length of pile embedded below potential scour depth

12 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

285.6 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-9,348

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 1.4

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 4.5

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 5.9

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$$

Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1 Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$
$U_c = \text{velocity adjacent to the LWM structure}$	4 ft/s
$g = \text{acceleration due to gravity}$	32.2 ft/s ²
F_d (lb) 465	

30

Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u \quad F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$$

F_{hu} , F_{hd} = hydrostatic force on upstream and downstream side of the wood structure

Y_u , Y_d = water depth upstream and downstream of the structure

A_u , A_d = area projected to flow direction on the upstream and downstream of the structure

Variable	Design Value
Y_u (ft)	5
A_u (ft ²)	30
Post racking area	
Y_d (ft)	5
A_d (ft ²)	30
Plan downstream area	

$F_{hu} + F_{hd} = F_h$ (lb)	N/A
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Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value

W_{debris} (lb) 3,774

$V_{channel}$ (ft/s) 4

Δx (ft) 5

C_i 0.5

C_o 0.8

C_d 1.0

C_b 1.0

R_{max} 0.8

F_i (lb) 60

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMs} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -18,194

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

N_{pile} = number of piles

1.5 number

L_{pile} = length of pile embedded below potential scour depth

12 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -11,238

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{56.1}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values	Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200	psi
		172,800	psf
d_{pile} = diameter of the pile		1.30	ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24	ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216	ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971	--
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	875	ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	4,058	psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166	psi
		167,835	psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \quad \mathbf{41.4}$	

References

- Large Woody Material - Risk Based Design Guidelines
M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>
- ASTM D25. Allowable Stress Values for Treated Round Timber Piles.
- Timber Pile Design and Construction Manual, Timber Piling Council, 2015.
- American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	1005 ft ³

F_{LWMS} (lb) 24,527	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
C_L = lift coefficient		0.2 typ. LWM value
A_{LWM} = area of large woody material perpendicular to flow		A_{LWM} = See Design Plan
U_u = upstream channel velocity at design event		A_{LWM} (ft ²) 80 For pre-racking condition
g = acceleration due to gravity		5 ft/s
		32.2 ft/s ²
F_L (lb)		N/A

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{bouldersub} = N_{bouldersub} \times \pi/6 \times d_{bouldersub}^3 \times (\gamma_{boulder} - \gamma_w)$$

	Design Value	Units / Notes
$N_{bouldersub}$ = number of submerged boulders		0 number
$d_{bouldersub}$ = effective diameter of submerged boulders		0 ft
$\gamma_{boulder}$ = unit weight of boulders		165 lb/ft ³
$F_{bouldersub}$ (lb)		N/A

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{backfillsub} = V_{backfillsub} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{backfillsub}$ = volume of backfill over LWM members		3,150 ft ³
γ_s = unit weight of backfill material		See design plans 110 lb/ft ³
$F_{backfillsub}$ (lb)		-149,940

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3}\theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

9 number

L_{piles} = length of pile embedded below potential scour depth

12 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

285.6 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-56,086

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 2.3

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 6.1

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 8.4

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	80
$U_c = \text{velocity adjacent to the LWM structure}$	5	ft/s Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \text{ 1,938}$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	6.5
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	80
		<i>Post racking area</i>	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	6.5
		$A_d \text{ (ft}^2\text{)}$	80
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	5
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 94

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMS} + F_L + F_{bouldersub} + F_{backfillsub})$$

	Design Value Units / Source
μ_{bed} = coefficient of bed friction = $\tan(\theta)$	0.78 unit less
θ = internal friction angle (degrees)	38 Table 5, (Knutson et. al. 2014)

F_f (lb) -97,983

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

	Design Values Units
N_{pile} = number of piles	9 number
L_{pile} = length of pile embedded below potential scour depth	12 ft
d_{pile} = diameter of the pile	1.30 ft
h_{load} = applied load height above the potential scour depth	2.5 ft
$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$	4.2 unit less

$F_{piles-h}$ (lb) -67,425

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \text{ 81.4}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200 psi 172,800 psf
d_{pile} = diameter of the pile		1.30 ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24 ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216 ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971 --
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	564 ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	2,616 psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166 psi 167,835 psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \text{ 64.1}$

References

Large Woody Material - Risk Based Design Guidelines

M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	458 ft ³

F_{LWMS} (lb) 11,165	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
$C_L = \text{lift coefficient}$		0.2 typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$		$A_{LWM} \text{ (ft}^2\text{) } 70$ For pre-racking condition
	5 ft/s	
$g = \text{acceleration due to gravity}$	32.2 ft/s ²	
$F_L \text{ (lb)}$	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{\text{bouldersub}} = N_{\text{bouldersub}} \times \pi/6 \times d_{\text{bouldersub}}^3 \times (\gamma_{\text{boulder}} - \gamma_w)$$

	Design Value	Units / Notes
$N_{\text{bouldersub}} = \text{number of submerged boulders}$		0 number
$d_{\text{bouldersub}} = \text{effective diameter of submerged boulders}$		0 ft
$\gamma_{\text{boulder}} = \text{unit weight of boulders}$		165 lb/ft ³
$F_{\text{bouldersub}} \text{ (lb)}$	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{\text{backfillsub}} = V_{\text{backfillsub}} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{\text{backfillsub}} = \text{volume of backfill over LWM members}$		1,125 ft ³
		See design plans
$\gamma_s = \text{unit weight of backfill material}$		110 lb/ft ³
$F_{\text{backfillsub}} \text{ (lb)}$	-53,550	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

3.75 number

L_{piles} = length of pile embedded below potential scour depth

12 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

285.6 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-23,369

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 2.1

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 4.8

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 6.9

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$$

	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	70
$U_c = \text{velocity adjacent to the LWM structure}$	5	ft/s Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)}$ 1,696		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u \quad F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$$

F_{hu} , F_{hd} = hydrostatic force on upstream and downstream side of the wood structure

Y_u , Y_d = water depth upstream and downstream of the structure

A_u , A_d = area projected to flow direction on the upstream and downstream of the structure

Variable	Design Value
$Y_u \text{ (ft)}$	4
$A_u \text{ (ft}^2\text{)}$	70
Post racking area	
$Y_d \text{ (ft)}$	4
$A_d \text{ (ft}^2\text{)}$	70
Plan downstream area	

$F_{hu} + F_{hd} = F_h \text{ (lb)}$	N/A
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Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	5
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 94

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMS} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -33,115

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

N_{pile} = number of piles

3.75 number

L_{pile} = length of pile embedded below potential scour depth

12 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -28,094

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{34.2}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200 psi 172,800 psf
d_{pile} = diameter of the pile		1.30 ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24 ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216 ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971 --
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	1,193 ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	5,531 psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166 psi 167,835 psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		
	$FOS_{pile\ strength} \quad \mathbf{30.3}$	

References

- Large Woody Material - Risk Based Design Guidelines
M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>
- ASTM D25. Allowable Stress Values for Treated Round Timber Piles.
- Timber Pile Design and Construction Manual, Timber Piling Council, 2015.
- American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	1525 ft ³

F_{LWMS} (lb) 37,215	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
$C_L = \text{lift coefficient}$		0.2 typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$		$A_{LWM} \text{ (ft}^2\text{) } 75$ For pre-racking condition
	6 ft/s	
$g = \text{acceleration due to gravity}$	32.2 ft/s ²	
$F_L \text{ (lb)}$	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{\text{bouldersub}} = N_{\text{bouldersub}} \times \pi/6 \times d_{\text{bouldersub}}^3 \times (\gamma_{\text{boulder}} - \gamma_w)$$

	Design Value	Units / Notes
$N_{\text{bouldersub}} = \text{number of submerged boulders}$		0 number
$d_{\text{bouldersub}} = \text{effective diameter of submerged boulders}$		0 ft
$\gamma_{\text{boulder}} = \text{unit weight of boulders}$		165 lb/ft ³
$F_{\text{bouldersub}} \text{ (lb)}$	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{\text{backfillsub}} = V_{\text{backfillsub}} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{\text{backfillsub}} = \text{volume of backfill over LWM members}$	6,939 ft ³	
		See design plans
$\gamma_s = \text{unit weight of backfill material}$		110 lb/ft ³
$F_{\text{backfillsub}} \text{ (lb)}$	-330,296	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

10.5 number

L_{piles} = length of pile embedded below potential scour depth

15 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

357 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-102,241

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 2.7

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 8.9

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 11.6

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	75
$U_c = \text{velocity adjacent to the LWM structure}$	6	ft/s <i>Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.</i>
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \text{ 2,616}$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable Design Value
		$Y_u \text{ (ft)} \text{ 9}$
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)} \text{ 75}$
		<i>Post racking area</i>
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)} \text{ 9}$
		$A_d \text{ (ft}^2\text{)} \text{ 75}$
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	6
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

$$F_i \text{ (lb)} \quad 135$$

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMs} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

$$F_f \text{ (lb)} \quad -228,981$$

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

10.5 number

N_{pile} = number of piles

L_{pile} = length of pile embedded below potential scour depth

15 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$$F_{piles-h} \text{ (lb)} \quad -122,910$$

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{127.9}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values	Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200	psi
		172,800	psf
d_{pile} = diameter of the pile		1.30	ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24	ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216	ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971	--
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	655	ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	3,037	psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166	psi
		167,835	psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \quad \mathbf{55.3}$	

References

Large Woody Material - Risk Based Design Guidelines

M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	348 ft ³

F_{LWMS} (lb) 8,482	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
$C_L = \text{lift coefficient}$	0.2	typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$	5	ft/s
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
F_L (lb)	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{\text{bouldersub}} = N_{\text{bouldersub}} \times \pi/6 \times d_{\text{bouldersub}}^3 \times (\gamma_{\text{boulder}} - \gamma_w)$$

	Design Value	Units / Notes
$N_{\text{bouldersub}} = \text{number of submerged boulders}$	0	number
$d_{\text{bouldersub}} = \text{effective diameter of submerged boulders}$	0	ft
$\gamma_{\text{boulder}} = \text{unit weight of boulders}$	165	lb/ft ³
$F_{\text{bouldersub}}$ (lb)	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{\text{backfillsub}} = V_{\text{backfillsub}} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{\text{backfillsub}} = \text{volume of backfill over LWM members}$	1,125	ft ³
$\gamma_s = \text{unit weight of backfill material}$	110	lb/ft ³
$F_{\text{backfillsub}}$ (lb)	-53,550	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

6.75 number

L_{piles} = length of pile embedded below potential scour depth

12 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

285.6 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-42,065

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 5.0

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 6.3

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 11.3

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	70
$U_c = \text{velocity adjacent to the LWM structure}$	5	ft/s Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \quad 1,696$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	4
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	70
		<i>Post racking area</i>	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	4
		$A_d \text{ (ft}^2\text{)}$	70
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	5
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 94

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMs} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -35,211

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

6.75 number

N_{pile} = number of piles

L_{pile} = length of pile embedded below potential scour depth

12 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -50,569

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{47.9}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values	Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200	psi
		172,800	psf
d_{pile} = diameter of the pile		1.30	ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24	ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216	ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971	--
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	663	ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	3,073	psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166	psi
		167,835	psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \quad \mathbf{54.6}$	

References

Large Woody Material - Risk Based Design Guidelines

M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	1115 ft ³

F_{LWMS} (lb) 27,206	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
$C_L = \text{lift coefficient}$		0.2 typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$		$A_{LWM} \text{ (ft}^2\text{)} \text{ } 120$ For pre-racking condition
	8 ft/s	
$g = \text{acceleration due to gravity}$	32.2 ft/s ²	
$F_L \text{ (lb)}$	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{\text{bouldersub}} = N_{\text{bouldersub}} \times \pi/6 \times d_{\text{bouldersub}}^3 \times (\gamma_{\text{boulder}} - \gamma_w)$$

	Design Value	Units / Notes
$N_{\text{bouldersub}} = \text{number of submerged boulders}$		0 number
$d_{\text{bouldersub}} = \text{effective diameter of submerged boulders}$		0 ft
$\gamma_{\text{boulder}} = \text{unit weight of boulders}$		165 lb/ft ³
$F_{\text{bouldersub}} \text{ (lb)}$	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{\text{backfillsub}} = V_{\text{backfillsub}} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{\text{backfillsub}} = \text{volume of backfill over LWM members}$	5,910 ft ³	
		See design plans
$\gamma_s = \text{unit weight of backfill material}$		110 lb/ft ³
$F_{\text{backfillsub}} \text{ (lb)}$	-281,316	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

4.5 number

L_{piles} = length of pile embedded below potential scour depth

12 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

285.6 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-28,043

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 1.0

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 10.3

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 11.4

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	120
$U_c = \text{velocity adjacent to the LWM structure}$	8	ft/s <i>Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.</i>
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \text{ 7,441}$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	7
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	120
		<i>Post racking area</i>	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	7
		$A_d \text{ (ft}^2\text{)}$	120
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{W_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

W_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	8
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 240

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMS} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -198,533

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

4.5 number

N_{pile} = number of piles

L_{pile} = length of pile embedded below potential scour depth

12 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -33,713

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{30.2}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values	Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200	psi
		172,800	psf
d_{pile} = diameter of the pile		1.30	ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24	ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216	ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971	--
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	4,268	ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	19,785	psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166	psi
		167,835	psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \quad \mathbf{8.5}$	

References

Large Woody Material - Risk Based Design Guidelines

M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	831 ft ³

F_{LWMS} (lb) 20,265	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
C_L = lift coefficient	0.2	typ. LWM value
A_{LWM} = area of large woody material perpendicular to flow		A_{LWM} = See Design Plan
U_u = upstream channel velocity at design event	3	ft/s
g = acceleration due to gravity	32.2	ft/s ²
F_L (lb)	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{bouldersub} = N_{bouldersub} \times \pi/6 \times d_{bouldersub}^3 \times (\gamma_{boulder} - \gamma_w)$$

	Design Value	Units / Notes
$N_{bouldersub}$ = number of submerged boulders	0	number
$d_{bouldersub}$ = effective diameter of submerged boulders	0	ft
$\gamma_{boulder}$ = unit weight of boulders	165	lb/ft ³
$F_{bouldersub}$ (lb)	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{backfillsub} = V_{backfillsub} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{backfillsub}$ = volume of backfill over LWM members	1,125	ft ³
γ_s = unit weight of backfill material	See design plans	110 lb/ft ³
$F_{backfillsub}$ (lb)	-53,550	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

6 number

L_{piles} = length of pile embedded below potential scour depth

8 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

190.4 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-16,618

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 0.8

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 2.6

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 3.5

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	140
$U_c = \text{velocity adjacent to the LWM structure}$	3	ft/s <i>Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.</i>
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \text{ 1,221}$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	4.5
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	140
		<i>Post racking area</i>	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	4.5
		$A_d \text{ (ft}^2\text{)}$	140
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	3
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 34

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMs} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -26,005

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

6 number

N_{pile} = number of piles

L_{pile} = length of pile embedded below potential scour depth

8 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -19,978

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{36.7}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values	Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200	psi
		172,800	psf
d_{pile} = diameter of the pile		1.30	ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24	ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216	ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971	--
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	523	ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	2,424	psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166	psi
		167,835	psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \quad \mathbf{69.2}$	

References

Large Woody Material - Risk Based Design Guidelines

M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	231 ft ³

F_{LWMS} (lb) 5,642	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$	Design Value	Units / Notes
$C_L = \text{lift coefficient}$	0.2	typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$	3 ft/s	$A_{LWM} \text{ (ft}^2\text{)} = 20$ For pre-racking condition
$g = \text{acceleration due to gravity}$	32.2 ft/s ²	
$F_L \text{ (lb)}$	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$F_{bouldersub} = N_{bouldersub} \times \pi/6 \times d_{bouldersub}^3 \times (\gamma_{boulder} - \gamma_w)$	Design Value	Units / Notes
$N_{bouldersub} = \text{number of submerged boulders}$	0	number
$d_{bouldersub} = \text{effective diameter of submerged boulders}$	0	ft
$\gamma_{boulder} = \text{unit weight of boulders}$	165 lb/ft ³	
$F_{bouldersub} \text{ (lb)}$	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$F_{backfillsub} = V_{backfillsub} \times (\gamma_s - \gamma_w)$	Design Value	Units / Notes
$V_{backfillsub} = \text{volume of backfill over LWM members}$	450 ft ³	
$\gamma_s = \text{unit weight of backfill material}$	110 lb/ft ³	See design plans
$F_{backfillsub} \text{ (lb)}$	-21,420	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

0.75 number

L_{piles} = length of pile embedded below potential scour depth

8 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

190.4 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-2,077

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 0.4

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 3.8

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 4.2

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	20
$U_c = \text{velocity adjacent to the LWM structure}$	3	ft/s Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \quad 174$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	4.5
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	20
		<i>Post racking area</i>	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	4.5
		$A_d \text{ (ft}^2\text{)}$	20
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	3
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 34

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMS} + F_L + F_{bouldersub} + F_{backfillsub})$$

μ_{bed} = coefficient of bed friction = $\tan(\theta)$

Design Value Units / Source

0.78 unit less

θ = internal friction angle (degrees)

38 Table 5, (Knutson et. al. 2014)

F_f (lb) -12,327

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

assume three-quarters of piles are effective

Design Values Units

0.75 number

N_{pile} = number of piles

L_{pile} = length of pile embedded below potential scour depth

8 ft

d_{pile} = diameter of the pile

1.30 ft

h_{load} = applied load height above the potential scour depth

2.5 ft

$$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$$

4.2 unit less

$F_{piles-h}$ (lb) -2,497

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{71.2}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200 psi 172,800 psf
d_{pile} = diameter of the pile		1.30 ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24 ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216 ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971 --
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	694 ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	3,217 psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166 psi 167,835 psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		
	$FOS_{pile\ strength} \quad \mathbf{52.2}$	

References

- Large Woody Material - Risk Based Design Guidelines
M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>
- ASTM D25. Allowable Stress Values for Treated Round Timber Piles.
- Timber Pile Design and Construction Manual, Timber Piling Council, 2015.
- American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.

Nason Floodplain - Large Woody Structure Stability Evaluation

Structural Stability | 6.4

Structural stability of large woody material placements is evaluated herein using the procedures, formulas, and recommendations provided in the Reclamation's *Large Woody Material - Risk Based Design Guidelines* (Knutson et. al. 2014) along with insight gained from professional experience and general engineering judgment.

Factors of Safety | 6.4.1

Safety factors for structural stability were selected from *Table 4. Minimum recommended factors of safety* given the site specific public safety and property damage risk levels.

	Criteria:
Public Safety Risk Moderate	FOS _{sliding} 1.5
Property Damage Risk Moderate	FOS _{buoyancy} 1.75
Stability Design Flow Criteria 50-year	FOS _{rotation} 1.5

Resistance to Flotation | 6.4.2

Flotation is typically caused by the buoyant force and the lift force acting on the wood material from water passing over its surface.

Large Wood Material Force

Accounts for the vertical buoyant force of submerged large wood and the vertical weight force of unsubmerged large wood.

$$F_{LWMS} = V_{LWMS} \times (\gamma_{wood} - \gamma_w)$$

$$V_{LWMS} = \text{total volume of submerged large wood material}$$

$$V_{LWMS} = \sum N_{LWMi} \times V_{LWMi}$$

Variable	Design Value Units
γ_{wood} = unit weight of wood	38 lb/ft ³
γ_w = unit weight of water	62.4 lb/ft ³
V_{LWMS}	249 ft ³

F_{LWMS} (lb) 6,085	Positive values are upward forces.
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Lift Force

Accounts for the lift force of large wood in flowing water. Not applicable to LWS where the bed will deform around the leading edges.

$$F_L = \frac{C_L \times A_{LWM} \times \gamma_w \times U_o^2}{2 \times g}$$

	Design Value	Units / Notes
$C_L = \text{lift coefficient}$	0.2	typ. LWM value
$A_{LWM} = \text{area of large woody material perpendicular to flow}$		$A_{LWM} = \text{See Design Plan}$
$U_u = \text{upstream channel velocity at design event}$	3	ft/s
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
F_L (lb)	N/A	

Boulder Ballast Force

Accounts for the ballasting force of large boulders directly attached to or placed over LWM.

$$F_{\text{bouldersub}} = N_{\text{bouldersub}} \times \pi/6 \times d_{\text{bouldersub}}^3 \times (\gamma_{\text{boulder}} - \gamma_w)$$

	Design Value	Units / Notes
$N_{\text{bouldersub}} = \text{number of submerged boulders}$	0	number
$d_{\text{bouldersub}} = \text{effective diameter of submerged boulders}$	0	ft
$\gamma_{\text{boulder}} = \text{unit weight of boulders}$	165	lb/ft ³
$F_{\text{bouldersub}}$ (lb)	N/A	

Backfill Ballast Force

Accounts for the ballasting force of backfill placed directly over LWM members. Volume is based on the fill area over the log(s) and a the effective cover depth shown on the Drawings.

$$F_{\text{backfillsub}} = V_{\text{backfillsub}} \times (\gamma_s - \gamma_w)$$

	Design Value	Units / Notes
$V_{\text{backfillsub}} = \text{volume of backfill over LWM members}$	450	ft ³
$\gamma_s = \text{unit weight of backfill material}$	110	lb/ft ³
$F_{\text{backfillsub}}$ (lb)	-21,420	

Pile Skin Friction

Accounts for the vertical resistance provided by piles within the LWM structure. USBR document equation modified by Inter-Fluve to match industry pile design standard formulations.

$$F_{piles-v} = N_{piles} \times \pi \times d_{piles} \times L_{piles} \times (k_s \times \tan \frac{2}{3} \theta \times \sigma')$$

N_{piles} = number of piles

Assume three-quarters of piles are effective

Design Values Units

1.5 number

L_{piles} = length of pile embedded below potential scour depth

8 ft

d_{piles} = nominal diameter of the piles

1.30 ft

$$\sigma' = (L_{piles} \times (\gamma_{sat} - \gamma_w)) / 2$$

190.4 lb/ft²

K_s = coefficient of lateral earth pressure (0.5 to 1.0)

1.0 unit less

θ = internal friction angle of soils

36 deg.

$F_{piles-v}$ (lb)

-4,155

Negative values resist upward displacement.

Piles Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bPiles} = \frac{F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 0.7

Note this value does not include the backfill assuming it's all lost but the piles are holding.

Backfill Only Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bBackfill} = \frac{F_{backfillsub}}{F_{LWMS} + F_L}$$

FOS_b 3.5

Note this value does not include the piles.

Net Buoyancy Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{bNet} = \frac{F_{backfillsub} + F_{piles-v}}{F_{LWMS} + F_L}$$

FOS_b 4.2

Note this value includes the piles and backfill.

Resistance to Sliding | 6.4.3

LWM structures are also susceptible to failure through sliding.

Drag Force

LWM structures are pushed downstream by the fluid drag forces acting upon the wood by the flowing water.

$F_d = \frac{C_D \times A_{LWM} \times \gamma_w \times U_c^2}{2 \times g}$	Design Value	Units / Notes
$C_D = \text{drag coefficient}$	1	Per Equations 23 and 24
$A_{LWM} = \text{area of wetted wood normal to the flow direction}$	$A_{LWM} = \text{See Design Plan}$	
	$A_{LWM} \text{ (ft}^2\text{)}$	70
$U_c = \text{velocity adjacent to the LWM structure}$	3	ft/s Velocity value is conservative for all LWS locations. Value from 100-yr event 2D model results for main channel.
$g = \text{acceleration due to gravity}$	32.2	ft/s ²
$F_d \text{ (lb)} \text{ 610}$		

Hydrostatic Force

Hydrostatic forces act on the upstream and downstream faces of a LWM structure. They account for differences in the upstream and downstream water depths against the structure.

$F_{hu} = \frac{1}{2} \times \gamma_w \times Y_u \times A_u$	$F_{hd} = \frac{1}{2} \times \gamma_w \times Y_d \times A_d$	Variable	Design Value
		$Y_u \text{ (ft)}$	4.5
$F_{hu}, F_{hd} = \text{hydrostatic force on upstream and downstream side of the wood structure}$		$A_u \text{ (ft}^2\text{)}$	70
		<i>Post racking area</i>	
$Y_u, Y_d = \text{water depth upstream and downstream of the structure}$		$Y_d \text{ (ft)}$	4.5
		$A_d \text{ (ft}^2\text{)}$	70
$A_u, A_d = \text{area projected to flow direction on the upstream and downstream of the structure}$		<i>Plan downstream area</i>	
$F_{hu} + F_{hd} = F_h \text{ (lb)}$		N/A	

Impact Force

The impact force associated with debris impacting a large wood structure can be estimated by the impact force equation.

$$F_i = \frac{w_{debris}}{g} \times \frac{V_{channel}^2}{2 \times \Delta x} \times C_i \times C_o \times C_d \times C_b \times R_{max}$$

w_{debris} = weight of debris

$V_{channel}$ = channel approach velocity

Δx = deceleration distance

Coefficients (see Table 6 and Figures 11, 12 for values)

C_i = importance, C_o = orientation = 0.8, C_d = depth, C_b = blockage, R_{max} = impulse response ratio

Variable Design Value	
W_{debris} (lb)	3,774
$V_{channel}$ (ft/s)	3
Δx (ft)	5
C_i	0.5
C_o	0.8
C_d	1.0
C_b	1.0
R_{max}	0.8

F_i (lb) 34

Friction Force

Accounts for the friction force between the LWM and the channel bed. Restraint force from piles is not included as it does not exert a pressure on the LWS / bed interface.

$$F_f = -\mu_{bed} \times (F_{LWMS} + F_L + F_{bouldersub} + F_{backfillsub})$$

	Design Value Units / Source
μ_{bed} = coefficient of bed friction = $\tan(\theta)$	0.78 unit less
θ = internal friction angle (degrees)	38 Table 5, (Knutson et. al. 2014)

F_f (lb) -11,981

Negative values resist downstream displacement.

Lateral Resistance From Piles

Accounts for the lateral resistance provided by piles within the LWM structure. Assumes soil resistance is limiting, i.e. the pile pushes over before it breaks.

$$F_{piles-h} = N_{piles} \times \frac{L_{pile}^3 \times \frac{1}{2} \times (\gamma_s - \gamma_w) \times d_{pile} \times K_p}{h_{load} \times L_{pile}}$$

N_{pile} = number of piles	assume three-quarters of piles are effective	Design Values Units 1.5 number
L_{pile} = length of pile embedded below potential scour depth		8 ft
d_{pile} = diameter of the pile		1.30 ft
h_{load} = applied load height above the potential scour depth		2.5 ft
$K_p = \frac{1 + \sin \theta}{1 - \sin \theta}$		4.2 unit less

$F_{piles-h}$ (lb) -4,994

Negative values resist downstream displacement.

Sliding Factor of Safety

The factor of safety is the absolute value of the sum of resisting forces divided by the sum of driving forces.

$$FOS_{sliding} = \frac{F_f + F_{piles-h}}{F_d + F_{hu} + F_{hd} + F_i}$$

$$FOS_{sliding} \quad \mathbf{26.4}$$

Pile Strength Factor of Safety

The factor of safety for the timber bending stress capacity of the pile. This evaluates the potential for the pile(s) to break under load prior to the pile pushing over in the ground.

		Design Values Units
F_b = Timber Bending Stress Capacity per Timber Pile Manual Table 3-1 or AWC NDS Supplement Table 4D		1,200 psi 172,800 psf
d_{pile} = diameter of the pile		1.30 ft
I = circular cross – sectional moment of inertia	$I = \frac{\pi B^4}{4}$	2.24 ft ⁴
S = circular section modulus	$S = \frac{\pi B^3}{32}$	0.216 ft ³
C_F = strength reduction size factor for diameters greater than 12"	$C_F = \frac{1}{B}^{(1/9)}$	0.971 --
M_p = applied moment per pile	$M_p = \frac{(F_d + F_i + F_h) \times h_{load}}{N_{piles}}$	1,074 ft-lb
f_b = applied pile bending stress	$f_b = \frac{M_p}{S}$	4,978 psf
F_{bx} = Pile bending stress capacity	$F_{bx} = F_b \times C_F$	1,166 psi 167,835 psf
$FOS_{pile\ strength} = \frac{F_{bx}}{f_b}$		$FOS_{pile\ strength} \quad \mathbf{33.7}$

References

Large Woody Material - Risk Based Design Guidelines

M. Knutson, J. Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online at: <http://www.usbr.gov/pn/fcrps/documents/lwm.pdf>

ASTM D25. Allowable Stress Values for Treated Round Timber Piles.

Timber Pile Design and Construction Manual, Timber Piling Council, 2015.

American Wood Council (2018) National Design Specifications for Wood Construction, Design Supplement.