

MEMORANDUM



To: Hans Smith and Chris Butler - Yakama Nation Fisheries

From: Mike Brunfelt, LG and Mike McAllister PE – Interfluve

Date: December 31, 2022

Re: Cub Creek 2 Fire: Chewuch River Watershed and Fish Habitat Impact Summary

Introduction

The Cub Creek 2 Fire started on July 16, 2021, and through the end of the summer, burned approximately 71,000-acres of the Chewuch River watershed. During that time the wildfire produced periods of high intensity burn in a large percentage of the Chewuch watershed (USFS, 2021). This memorandum provides:

1. a general description of fire impacts to watersheds, debris torrents and their post-fire risks over time;
2. specific fire impacts observed in the Chewuch River watershed and several restoration projects previously completed by the Yakama Nation;
3. a re-assessment of conceptual projects identified in 2021 for the Yakama Nation as it relates to longer term post-fire processes;
4. and new conceptual projects that could be applied to the Chewuch River burn area between RM 13 and 20 to help mitigate long term post-fire process risk to fish habitat. Supporting concept drawings are attached (Appendix A).

General Fire Impacts to Watersheds, Post Fire Debris Flows and River Processes

Studies that have created computer models of post-fire debris torrents to assess risk in burned landscapes have examined several factors that may influence their development. Through this research, the key variables that contribute to all debris torrents found in risk modeling are:

- Percentage of basin with high and moderate burn severity
- Soil properties (sorting, thickness, percent clay and permeability)
- Available water capacity
- Slope
- Precipitation intensity and duration
- Post-fire watershed recovery time

During extreme fire weather (low humidity, high winds), wildfires that reach and carry through forest tree crowns burn at extreme temperature often destroying soil organic matter and leaving behind a relatively hydrophobic residue of ash and mineral soil over the ground surface. These soil conditions are

highly susceptible to erosion and overland transport during rain fall. Crown fires that carry for long distances across a watershed can create expansive areas of water repellent soils that increase runoff, erosion, and volume of sediment delivered into downstream channel networks.

Burned watershed soils on steep terrain can produce large post-fire sediment runoff that can develop into debris torrents when concentrated in steep confined channels (Coe, 2019). Debris torrents are high-energy supersaturated water/sediment events that carry boulders, debris, and vegetation down steep channels at high rates of speed. These events greatly exceed normal background sediment loads that existed before the fire. Evidence of debris torrents exist in the form of debris cones or fans that have extended far onto valley floors (Riedel, 2020).

Rainfall conditions drive the development and size of debris flows by acting on the variety of post-fire conditions present within the watershed through time (Canon, 2015). Post-fire debris torrents are generally produced during intense runoff conditions under two mechanisms. The first is more likely to occur within the first 2 years following a fire when intense rainfall on hydrophobic soil conditions rapidly runs off, eroding and transporting ash and loose soil, and debris into channel networks (DeGraff, 2015). When sediment transport bulking created from large surface area runoff accumulates in steep confined channels, the high-density sediment load rapidly erodes the bed and banks, further increasing the energy and momentum. The debris torrent continues to accumulate mud, alluvium, colluvium, boulders and wood until a flatter runout zone or valley bottom is reached, where the energy is reduced and the debris torrent material deposits. The second mechanism generally occurs 2-10 years following a fire. During heavy rain, deeper water infiltration within steep hillsides or headwall areas reduces soil strength, and dead and decomposing roots of trees and shrubs killed by fires lose the ability to hold deep-seated soil and colluvium on the hillside. The weakened soils break loose and the slope failures initiate debris flows in steep terrain that run out to the valley bottom (Cannon 2015).

Watershed vegetative recovery reduces the frequency and magnitude of debris torrents. Ground cover re-growth improves soil infiltration rate, reduces runoff and begins to rebuild surface organic matter and water holding capacity that further slows runoff. As trees regrow and their roots penetrate deeper into the soil structure, the risk of deep-seated hillside failures diminish.

Observed Fire Impacts to the Chewuch River Watershed

In the Chewuch watershed, the soils are derived from post glacial till, glacial outwash, alluvium and colluvial bedrock sources within the basin. Many of the soils have within them a mantle of volcanic ash of varied thickness. Due to the parent soil material and climate, soil organic matter is generally thin and soil structure is generally poorly developed in a large percentage of the drainage area. Therefore, it is more easily disturbed and eroded in steep terrain. The United States Forest Service (USFS) post-burn report estimated 41% of the burned area within the Cub Creek 2 fire had high or moderate soil burn severity. Immediately after the fire they estimated water repellent soils may have developed due to the burn. Vegetation mortality in the moderate and high soil burn severity areas ranged from 80 – 100% (USFS, 2021) and would be consistent with severe burn and development of water repellent, easily eroded soils.

The USFS produced a Cub Creek 2 post-fire hydrologic model to estimate runoff over much of the burned area. The model indicated flows in smaller drainages resulting from the 5-yr 1-hour rainstorm (20% probability of occurrence in the first year following the fire, about 50% probability in years 1-3) are predicted to increase flows 50 to 200 times greater than pre-fire flow levels (Figure 1).

Due to the USFS post-fire survey of watershed soil conditions, hydrologic model results, steep tributary channels and clear evidence of past debris torrents, the USFS also estimated post-fire debris torrent risk using United States Geological Survey (USGS) debris flow risk models. The models estimated a moderate to high level of debris flow hazard in large segments of the watershed area burned in the fire. Sub watersheds in the center of the burn area were found to have high (60-80%) to very high (>80%) probability of debris flow occurrence if the modelled hydrologic precipitation event occurred in those areas (Figure 2). Doe Creek, Falls Creek, Eight Mile Creek, and the Chewuch River were areas where debris flow risk was the highest (USFS 2021).

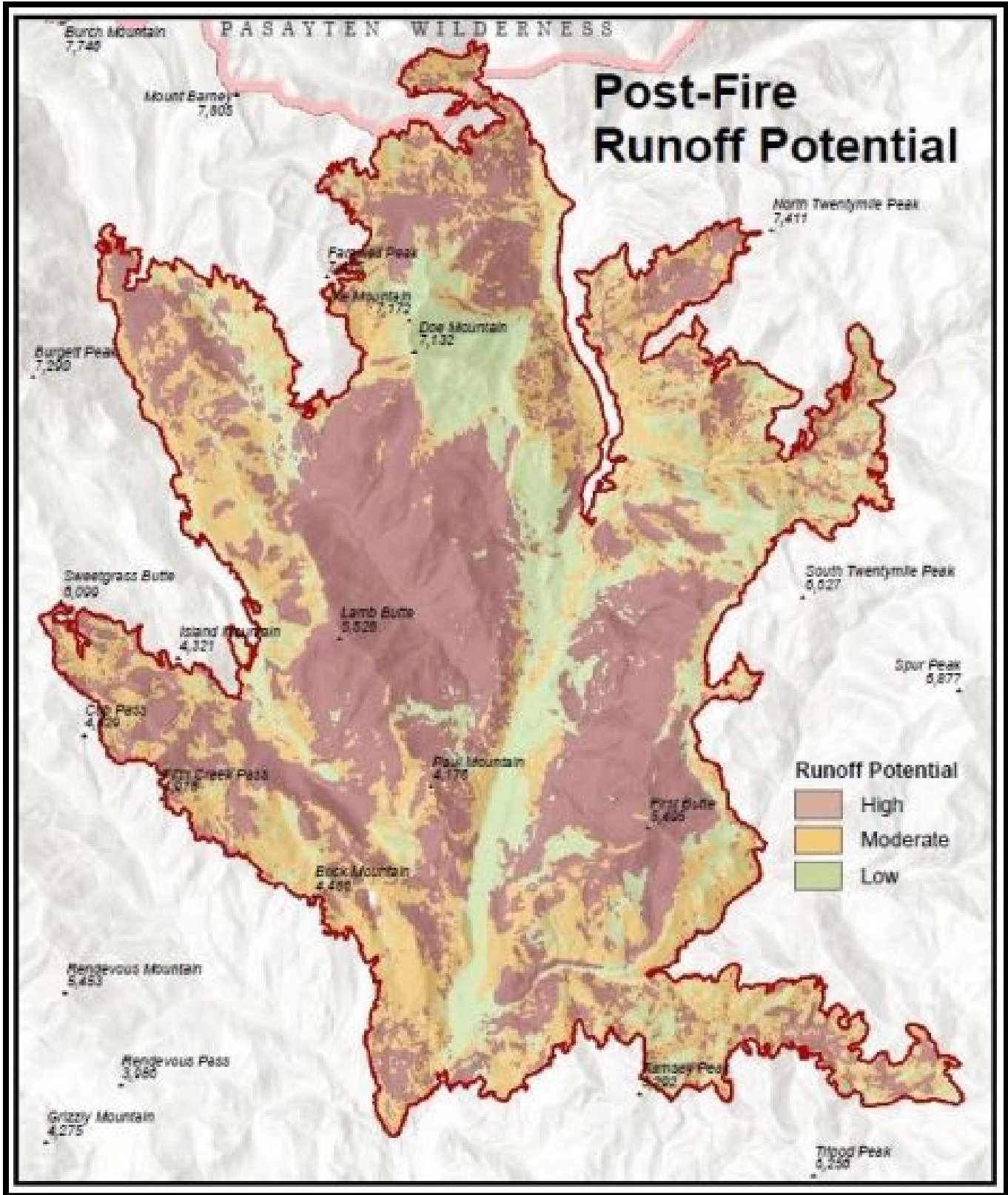


Figure 1. Map showing post fire runoff potential (USFS 2021).

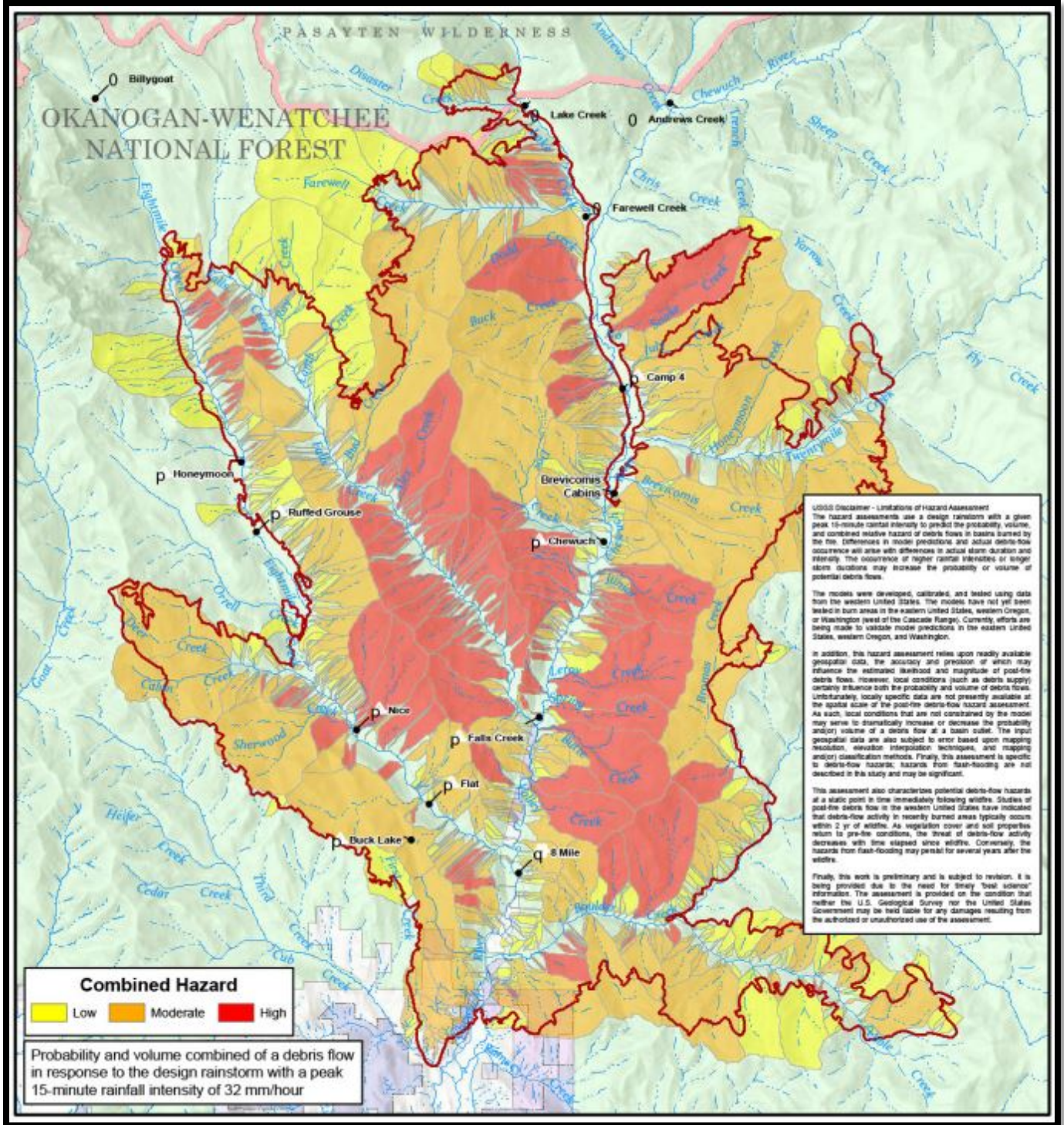


Figure 2. Map showing debris flow hazards based on USGS model run results (USFS 2021).

Following the fire and USFS post-fire analysis, debris torrent formation began to be observed in the watershed. Three debris torrents from steep tributary streams were observed in the summer of 2022. The timing and precipitation event that triggered them is unknown and their impacts to the Chewuch River were varied due to size and runout lengths. Two of the debris flows were relatively small. However, one debris torrent initiated in Leroy Creek was large enough to significantly impact the Chewuch River by depositing a large volume of fine sediment in the channel (Figures 3, 4 and 5). Indeed, the USFS post-burn analysis and USGS debris flow modeling predicted that Leroy Creek was high risk for debris flows, so 2022 debris flows events appear to be consistent with both general research on post-fire debris flow timing and USGS debris flow risk modeling.

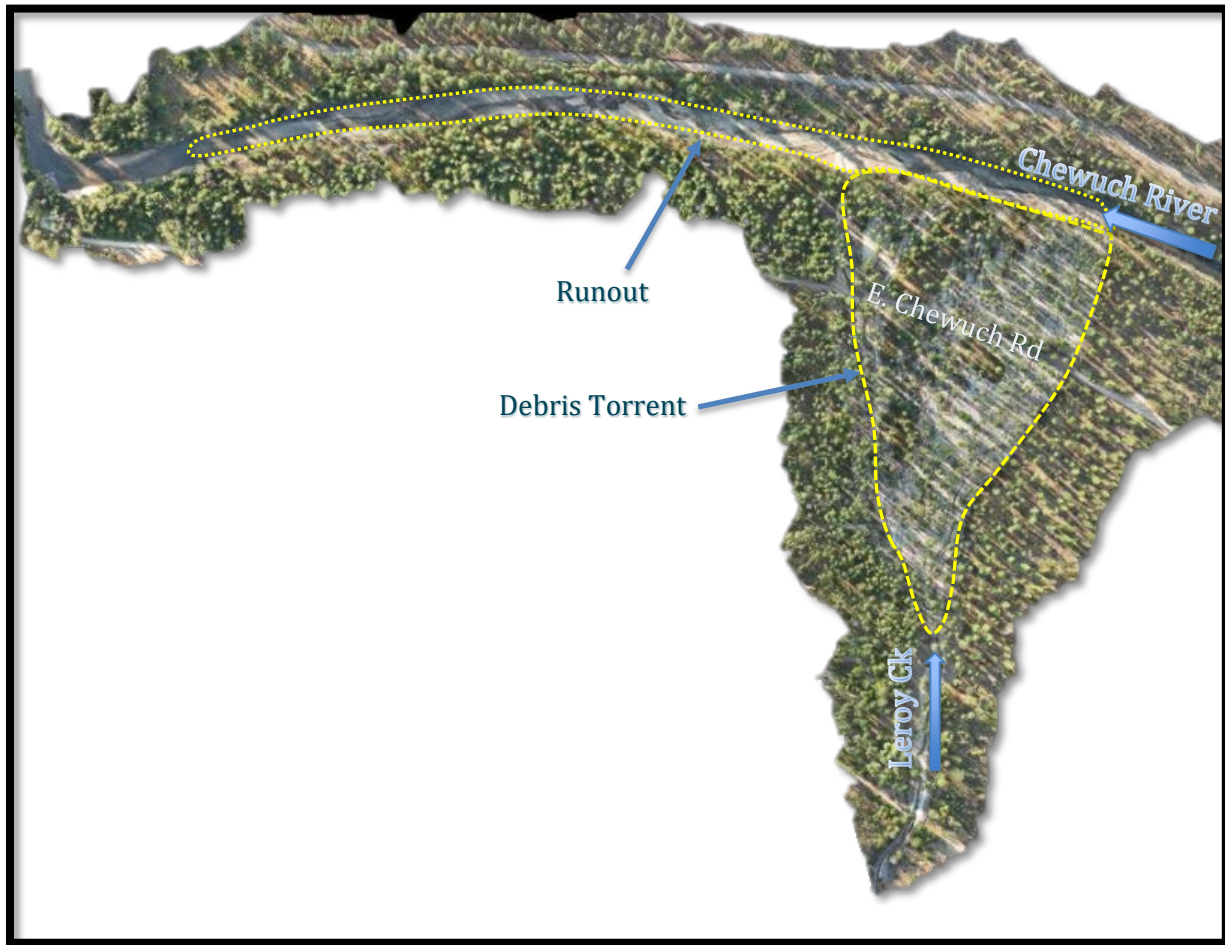


Figure 3. Orthomosaic aerial photo showing the Leroy Creek debris torrent runout and sediment impacts to the Chewuch River. Drone flight completed October 2022.



Figure 4. Leroy Creek debris flow runout taken along the East Chewuch Road.



Figure 5. Elevated sediment load and Leroy Creek debris flow runout (left bank).

Observed Fire Impacts to Chewuch River Habitat Projects

In the fall of 2021 and again in the summer of 2022, segments of the watershed were examined to assess direct burn damage to habitat projects and damage from secondary post-fire impacts as previously described.

Direct fire damage occurred on several large wood structures constructed to enhance salmonid habitat. Fire damage was concentrated between Chewuch River Miles (RM) 14 to 18 where the fire burned down to the river channel or fire brands ignited slash within a wood structure that spread and consumed larger components of the structure. Structures that were damaged by fire include:

- Chewuch River Mile 13-15 project site Q
- Chewuch River Mile 15.5-17 project sites B, E and J
- Chewuch River Mile 17-20 project sites M, N and P

None of the structures was entirely consumed by fire and several structures retain the original habitat functions. However, all burned structures now have reduced stability due to compromised vertical piles and reduction in wood diameters. Most structures, though damaged, will continue to collect wood and provide habitat, but individual or groups of logs may become loose or broken during large flooding.

Secondary impacts to projects have occurred from elevated sediment loads from debris torrent activity that has occurred in previously identified high risk areas. These impacts are likely to continue. Increased sediment loads may bury pools and portions of structures, and may reduce constructed side channel habitats in segments near the sediment transport threshold for sand and smaller size particles, which are abundant in the post-fire regime.

Although mainstem wood structures could be buried, it is likely that over time they will be naturally re-scoured as the burned areas recover and sediment loads return to pre-fire levels. Therefore, habitat loss due to mainstem channel filling and pool volume loss near large wood habitat may be temporary. To date, there has been only one example of a buried large wood structure near the Leroy debris torrent runout (Figure 6). However, other downstream project sites might experience similar impacts as sediment from existing and future debris torrents moves through the system.



Figure 6. Photo showing typical mainstem large wood structure burn and post fire burial from 2022 Leroy Creek debris flow.

Side channel projects are at greater risk of permanent loss of intended habitat functions. Risk of side channel filling is elevated by several potential factors that include:

1. Debris accumulations at side channel inlets can reduce flows that enter the side channel to scour, mobilize, and clear sediments
2. Reduced flow energy can encourage beaver activity
3. Debris that moves into a side channel can cause blockages that induce deposition
4. Vegetation becoming established on deposited sediment

Elevated silt and sand volumes during years of post-fire conditions may deposit in constructed side channels reducing wetted areas and even loss of flow during the low flow periods on the mainstem. As continued sediment inputs become stored by debris and beaver dam blockages, and sediment becomes stabilized by colonizing vegetation, the ability of the side channel to flush these retained sediments during high flows weakens.

There has already been documented post-fire debris plugging a newly constructed side channel near RM 4.2 (Figure 7), which is far downstream of the burn area. In the future it is possible that debris and

sediment deposition will remain problematic until fine sediment load and debris returns to pre-fire levels.



Figure 7. Fire debris deposits within the 2021 Chewuch RM 4.2 project side channel inlet.

Chewuch RM 19-26 Conceptual Project Post Fire Re-assessment

In 2021, a conceptual project design was completed for the Chewuch River between RM 19-26 and segments of Boulder Creek, Lake Creek and Twenty Mile Creek. In 2022, the concepts were re-evaluated in the context of post-fire risks. Following that review, it has been concluded that all of the concepts provided are still viable and could be implemented in phases, depending on proximity to debris torrent risk areas, resulting sediment volumes, and watershed recovery time.

Research conclusions presented above indicated that debris torrents caused by rainstorm runoff of hydrophobic soil is most likely to occur 1-2 years after a fire. After two years, the risk rapidly reduces because soil recovery and infiltration rates improve enough to prevent runoff and erosion at a scale capable of generating debris torrents. However, debris torrents generated by hillside failures in steep terrain can occur up to ten years post fire until new tree growth and root structure replaces the stability once provided by trees and roots killed by fire. Research has found that most debris flows occur within two years following a fire and are caused by runoff over fire damaged soils versus deep seated hillside

failures. The USFS has mapped and identified debris flow risk in the watershed and these areas were compared to conceptual proposed areas provided in 2021.

Due to proximity to recent severe burns, conceptual project areas that should be delayed due to potential debris torrent risk and elevated sediment loads are Chewuch River RM 19 – 23.5 (Lake Creek Confluence), Lake Creek, Twenty Mile Creek, and Boulder Creek. Several of these conceptual project areas could be re-evaluated for viability and implementation after 2023.

Conceptual project areas on the Chewuch River between RM 23.5 to 26 have no risk because they were upstream of the Cub Creek 2 burn and were unaffected by the fire or its aftereffects. Projects in these areas could be implemented at any time with no post-fire risk of debris torrent and elevated sediment load.



Figure 8. Post fire debris flow risk within Chewuch RM 19-26 conceptual project designs.



Figure 9. Debris flow risk in Boulder Creek that is included in the Chewuch 10-26 conceptual project designs.

Chewuch Cub Creek 2 Fire Conceptual Mitigation Projects

Fire mitigation projects in the Chewuch River are those that directly repair fire impacted projects, import large wood to burned areas of the Chewuch channel and floodplain in order to compensate for fire consumed valley bottom forest, and additions to pre-existing projects that will maintain or enhance previous project work.

Direct repair is an option for some of the direct and indirect effects of the Cub Creek 2 fire. As it relates to burned mainstem jams, additional wood loading could be completed with a helicopter to increase vertical ballast, stability and complexity. In all cases, burned wood structures could be made to equal or exceed stability and habitat function of their pre-fire condition.

Side channel projects that become buried could be excavated using heavy equipment to maintain sediment transport in the side channels, until watershed sediment loads drop to pre-fire levels. Another way to meet the same objective would be to increase the large wood adjacent to created side channel projects at risk of filling. This method increases, mainstem roughness and complexity while also forcing more flows into side channels to increase sediment transport and habitat. This type of mitigation would lift habitat conditions to a level that is greater than the original projects by restoring large wood density in the mainstem while maintain side channel performance. On the Chewuch River there are two places where this could be done. The first is near RM 15 and the second is near RM 13. Both of these are pre-

fire created side channel projects that may become filled due to elevated post-fire sediment and debris. Mainstem wood structures in these zones would be ballasted to withstand large floods and be able to catch and retain wood and debris moving down the watershed.

To mitigate for long-term large wood losses in the decades following the Cub Creek 2 fire, a large-scale helicopter project similar to what was completed on the Twisp River in 2022 could be completed. Large wood jams would be constructed by a helicopter in natural depositional areas and zones where wood enhancement would benefit existing habitats. The structures could be non-restrained by ballast or piles, but stacked in layers to remain relatively stable, but expected to deform at a pre-determined flood flow. Similar to the large wood placed in the Twisp River in 2022, the material would be allowed to gradually adjust, move, and deposit to reassemble high functioning habitat as it migrates through the system over time. Ballasted wood near RM 13 and RM 15 would be designed and constructed to absorb and retain both imported large wood placed by a helicopter and natural wood transported downstream. The drawings in Appendix A illustrate the relative intensity and conceptual location of helicopter and pile ballasted structures in burned and fire impacted areas of the Chewuch River.

References

Cannon S., Gartner J., Rupert G., Michael J., Rea A., Parret C., 2010. Predicting the propagability and volume of post wildfire debris flows in the intermountain western United States. Geological Society of America; January/February 2010 v. 122 p127-144.

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APPENDIX: PROJECT CONCEPTS

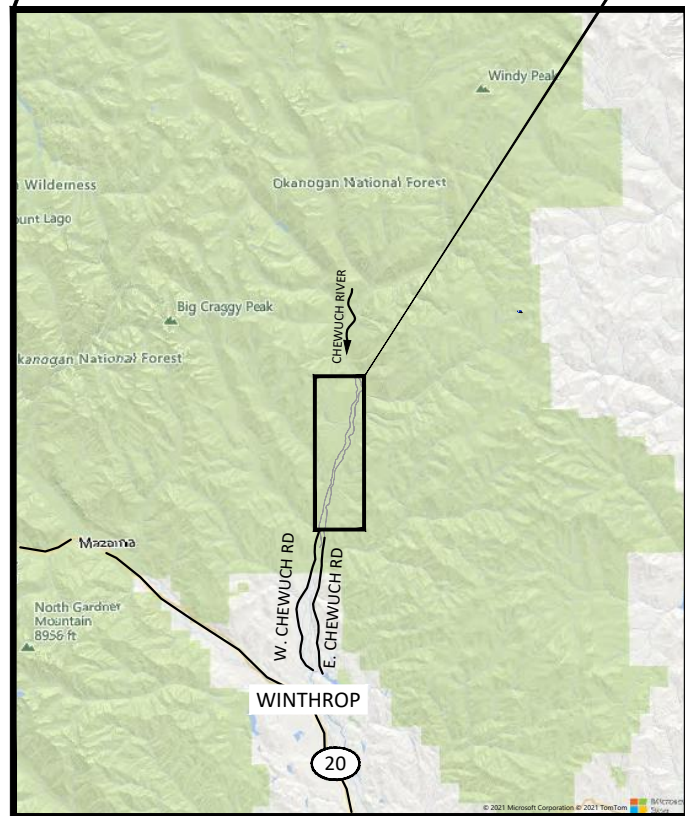
CHEWUCH RIVER LARGE WOOD RESTORATION

OKANOGAN COUNTY, WA

CONCEPTUAL DESIGNS



YAKAMA NATION FISHERIES
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WINTHROP WA, 98862

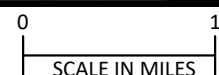


VICINITY MAP



PROJECT LOCATION
SEE SHEET 2

LOCATION MAP



COORDINATES:
LAT 47°36'20.22"N - 48°42'33.34"N
LON 120°9'45.45"W - 120°7'25.15"W

TOWNSHIP 36-37N, RANGE 21-22E
OKANOGAN COUNTY

WATERBODY: CHEWUCH RIVER
TRIBUTARY OF: METHOW RIVER > COLUMBIA RIVER

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CONCEPTUAL DESIGNS

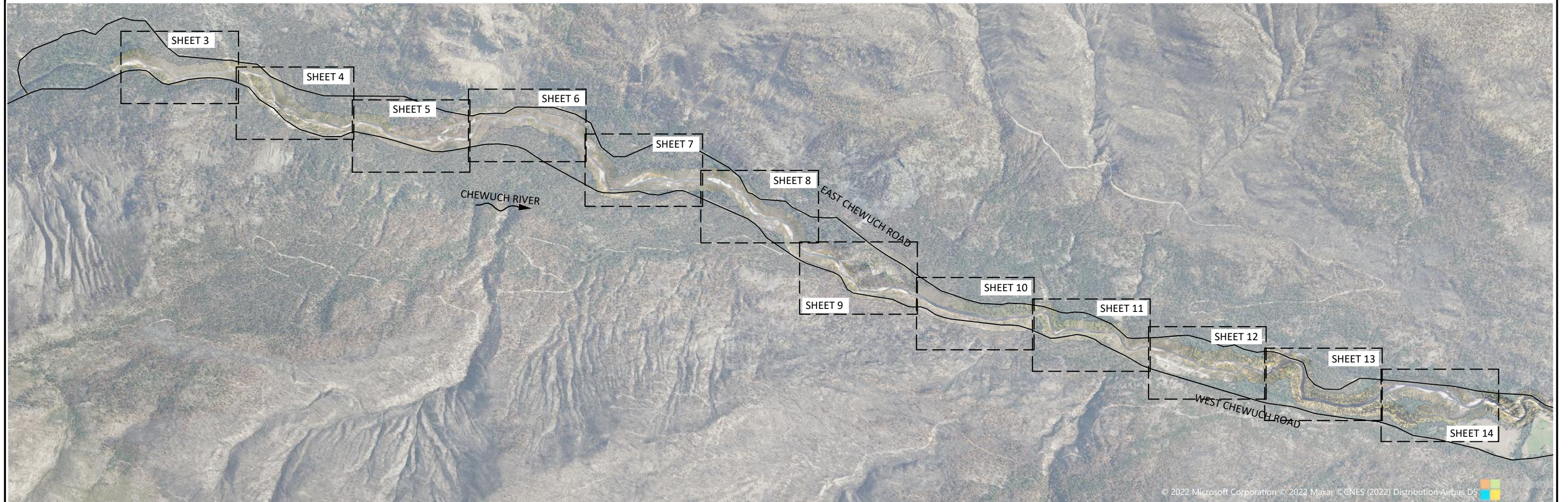


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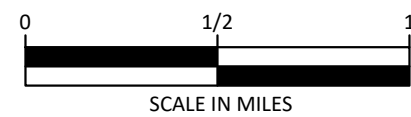
COVER, LOCATION MAPS & SHEET INDEX

SHEET

1 OF 16



AERIAL VIEW OF PROJECT REACH



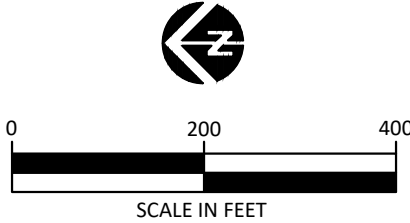
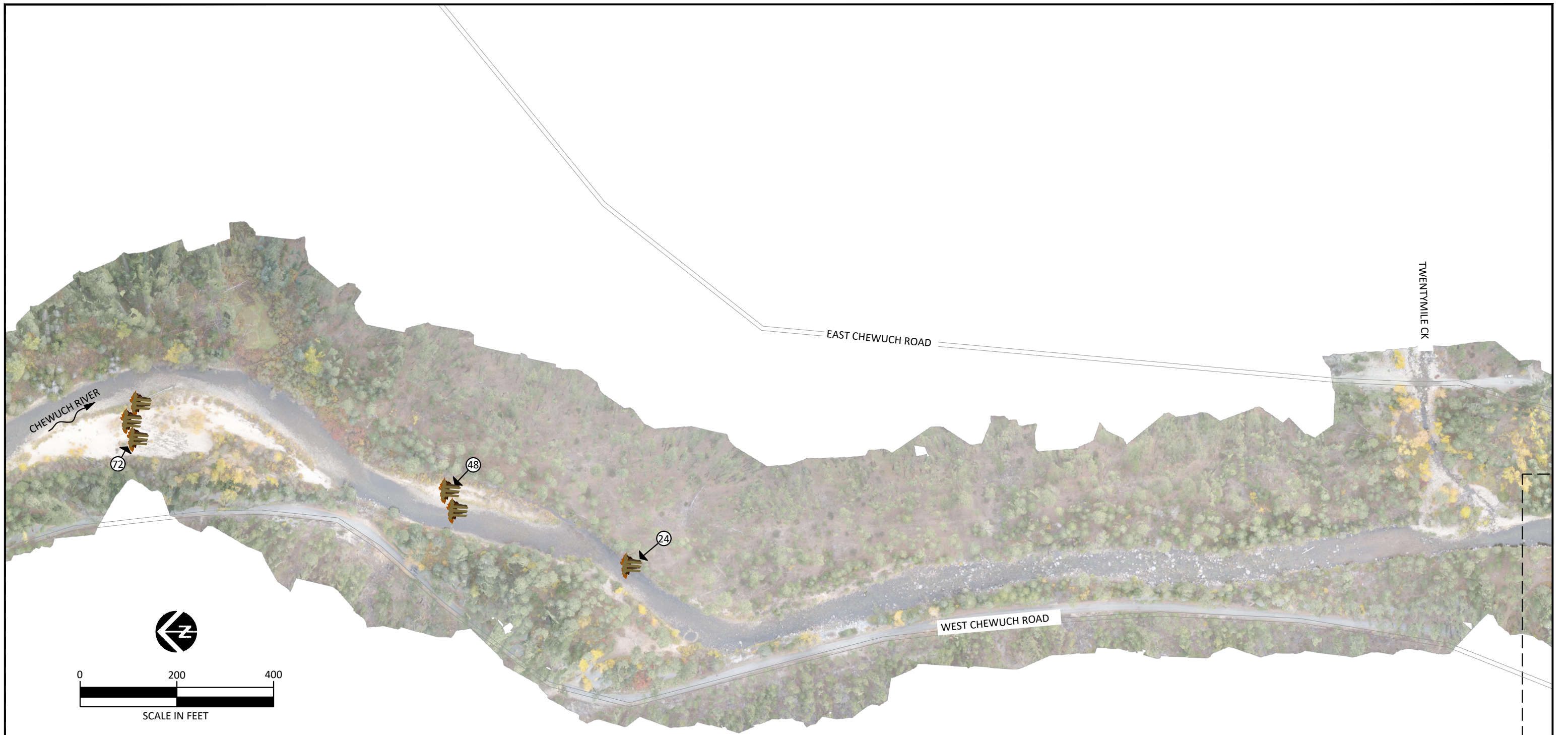
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CONCEPTUAL DESIGNS**





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PROJECT AREA & VIEW LAYOUTS MAP



LEGEND

-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  # QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

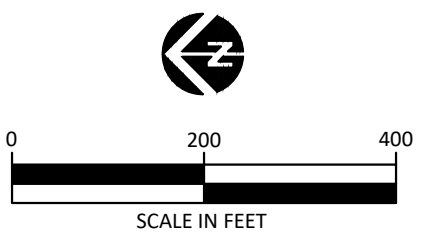
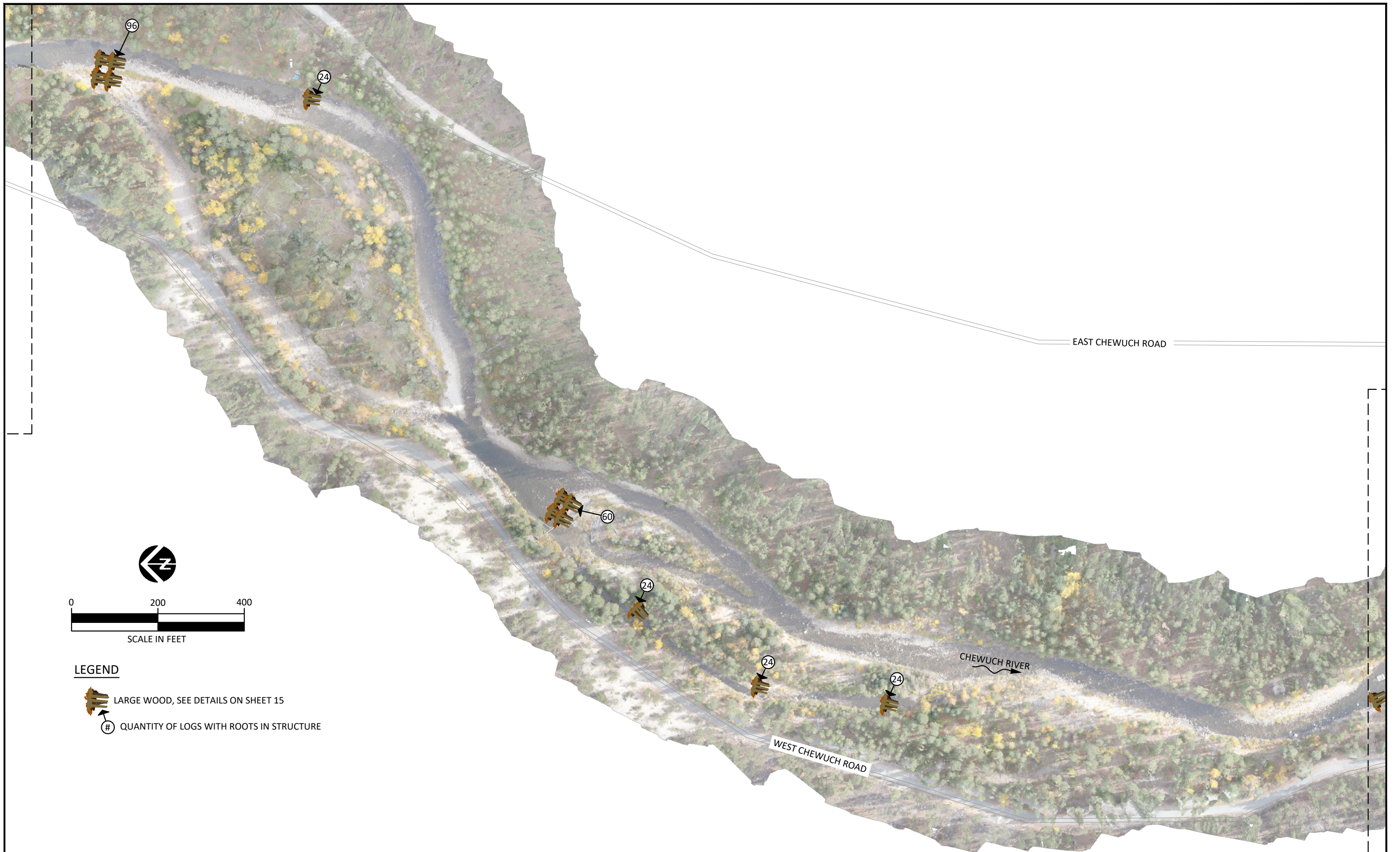
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CONCEPTUAL DESIGNS**





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AERIAL VIEW 1



LEGEND

 LARGE WOOD, SEE DETAILS ON SHEET 15

 QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

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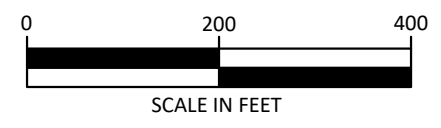
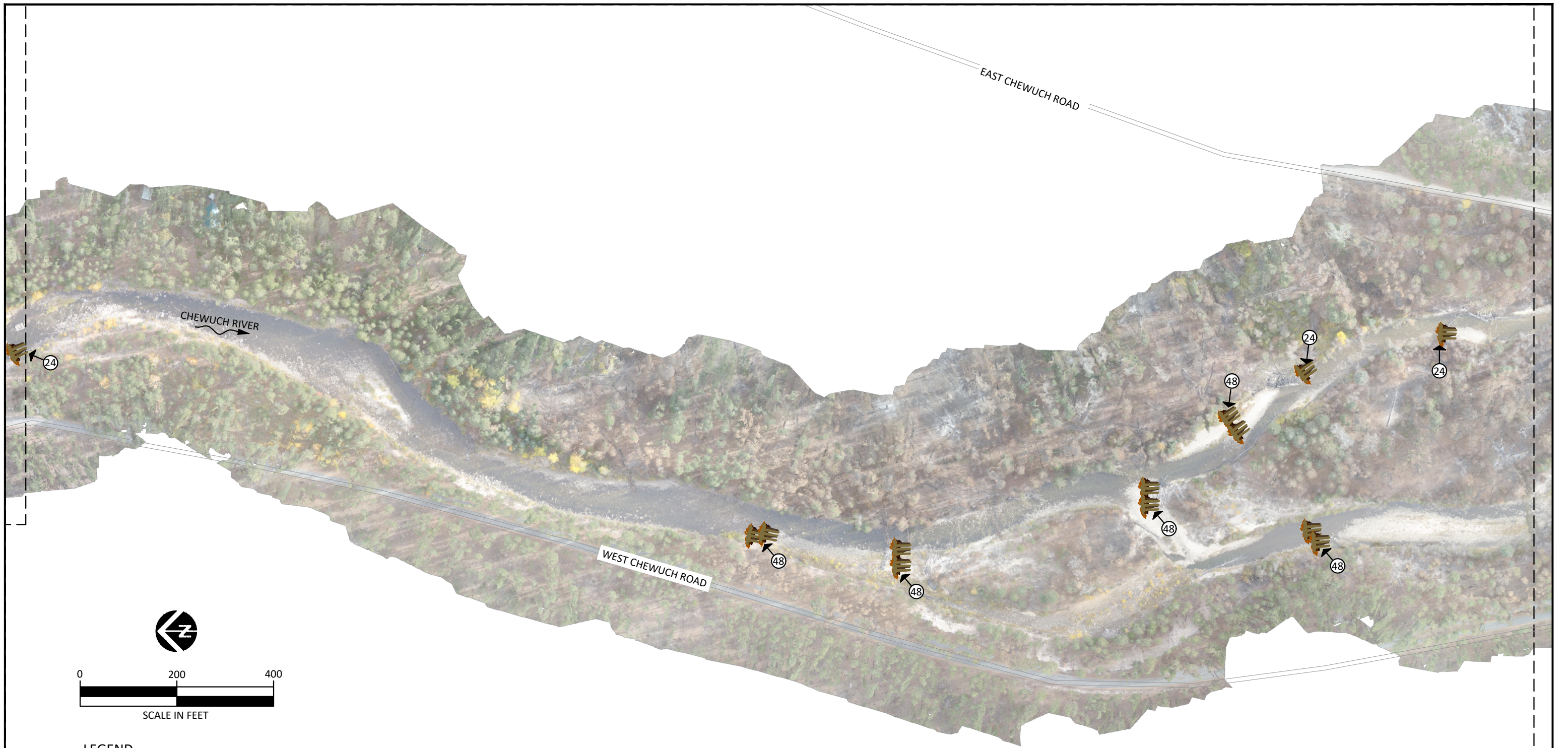
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AERIAL VIEW 2



LEGEND

-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  # QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

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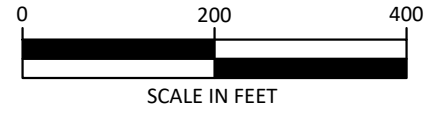
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AERIAL VIEW 3



LEGEND

-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  # QUANTITY OF LOGS WITH ROOTS IN STRUCTURE



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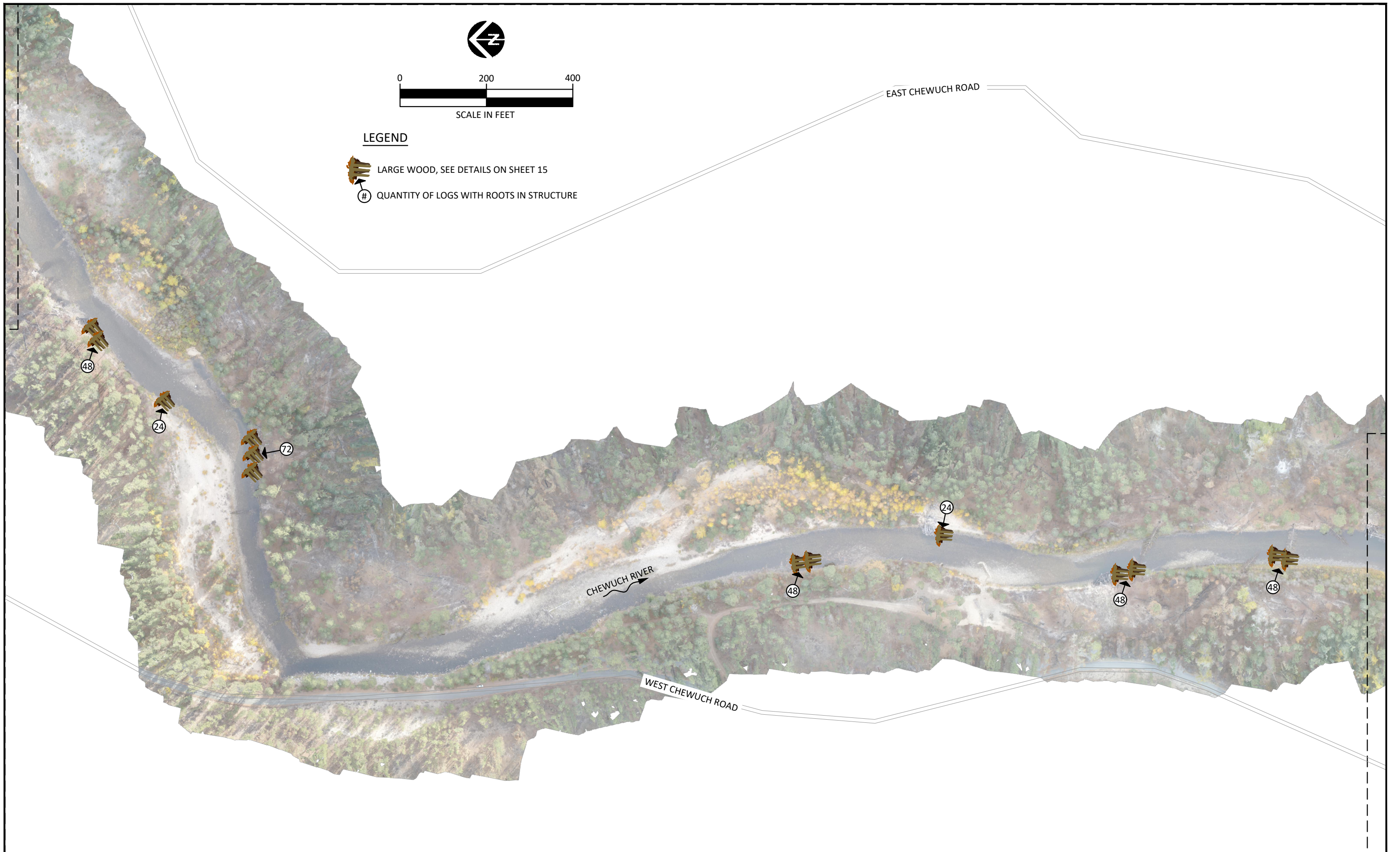
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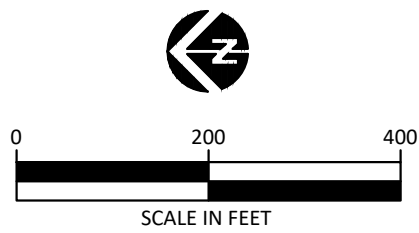
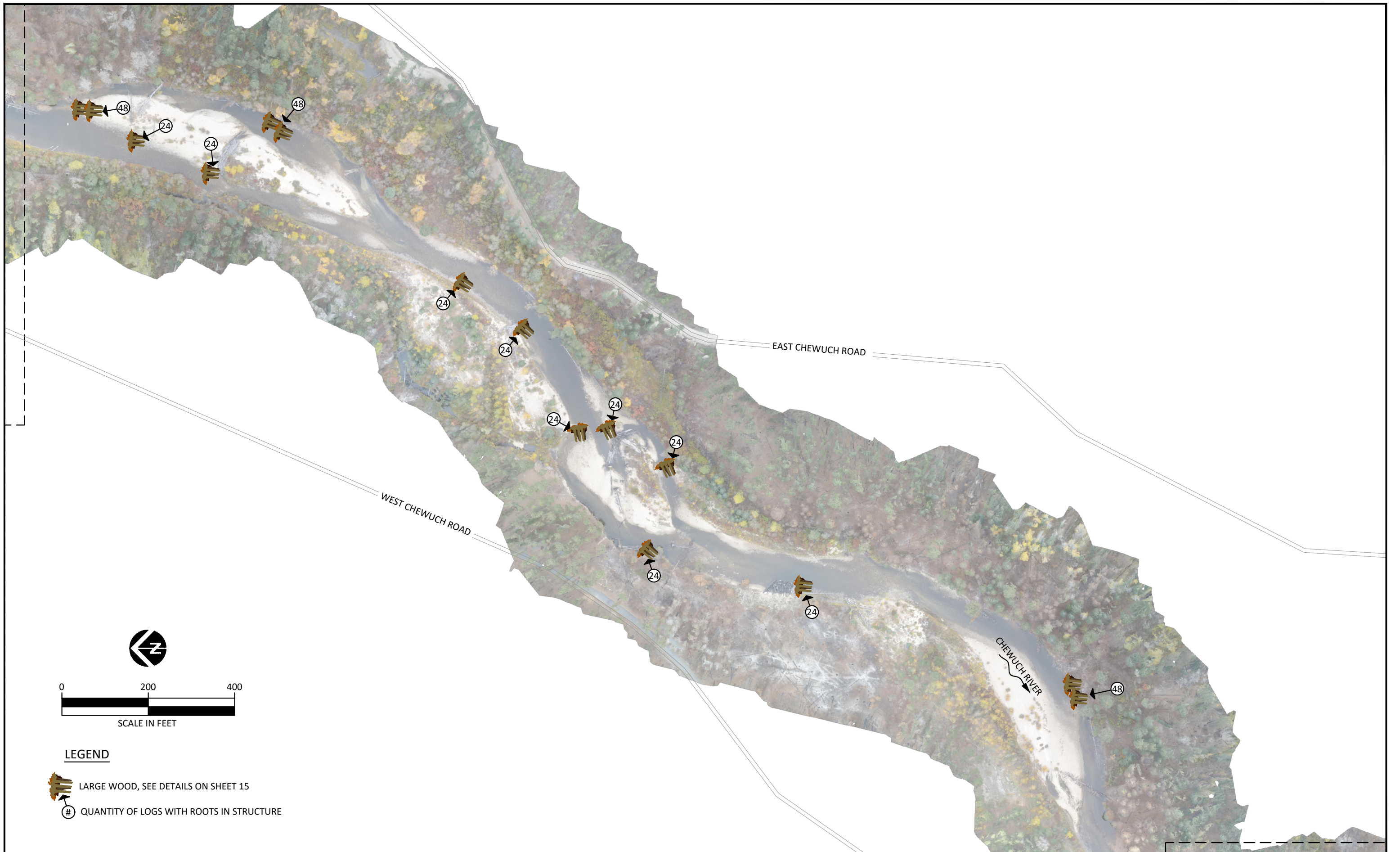
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AERIAL VIEW 5



LEGEND

-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

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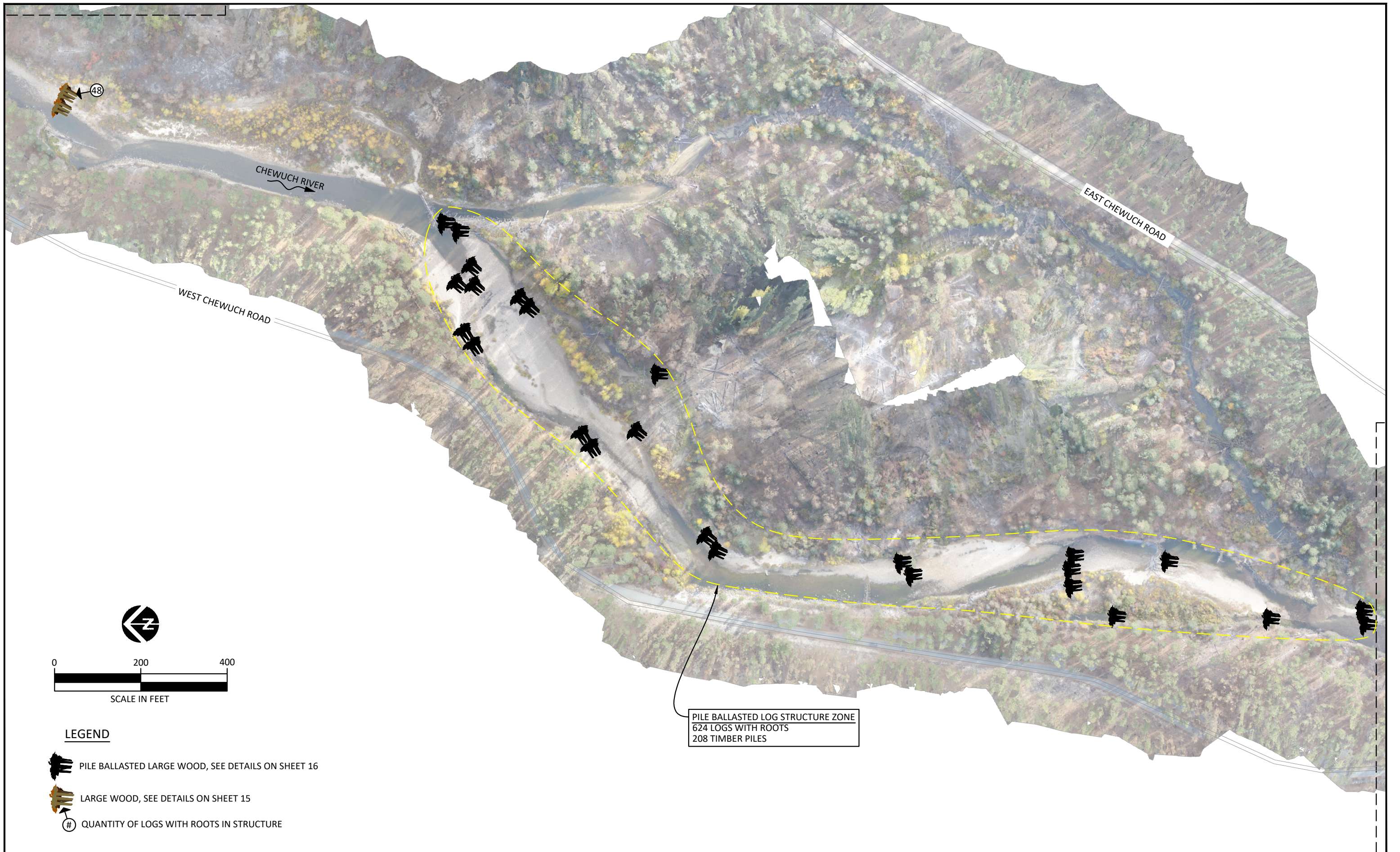
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AERIAL VIEW 6



PILE BALLASTED LOG STRUCTURE ZONE
 624 LOGS WITH ROOTS
 208 TIMBER PILES

LEGEND

-  PILE BALLASTED LARGE WOOD, SEE DETAILS ON SHEET 16
-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

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AERIAL VIEW 7



LEGEND

-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

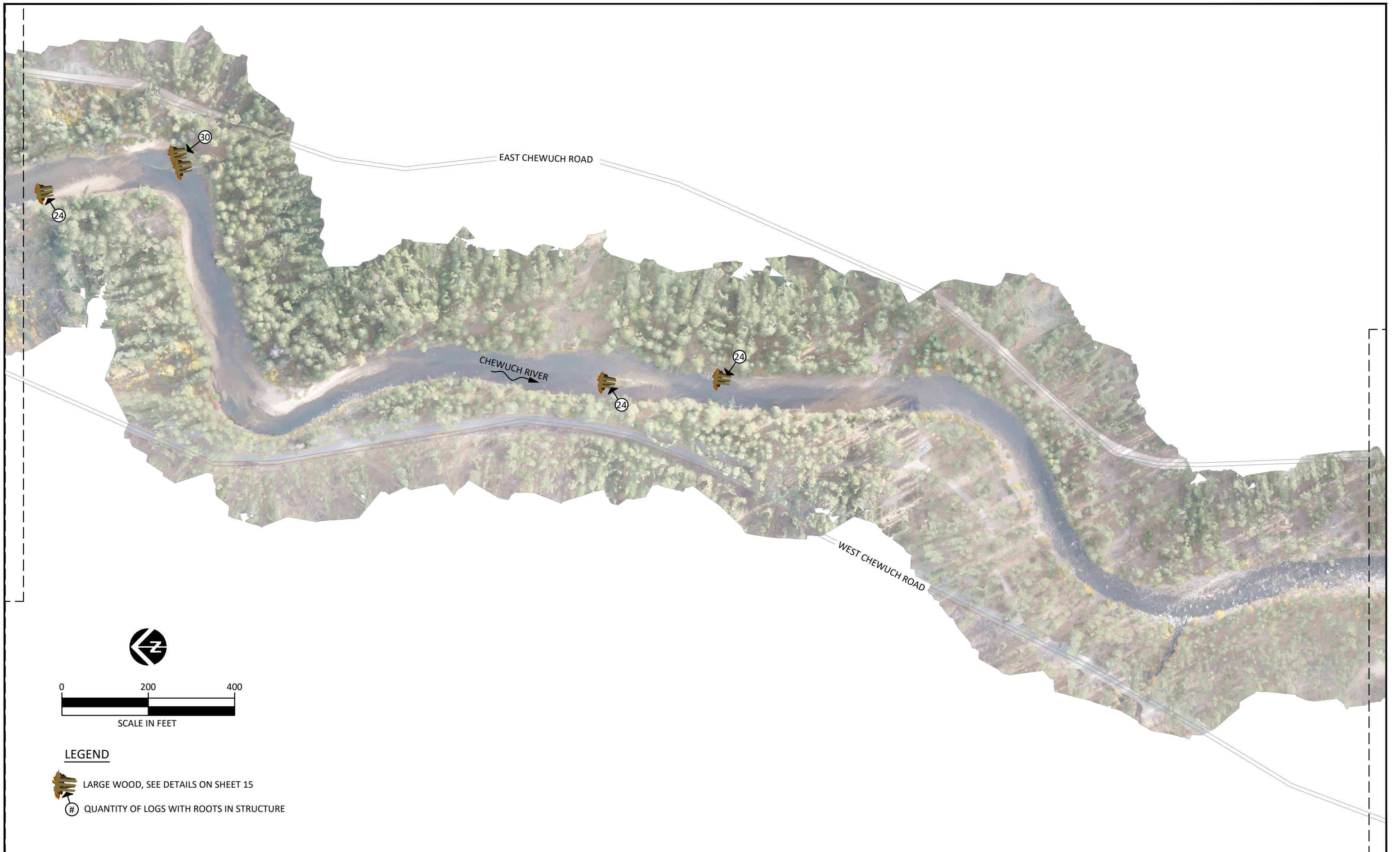
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-  QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

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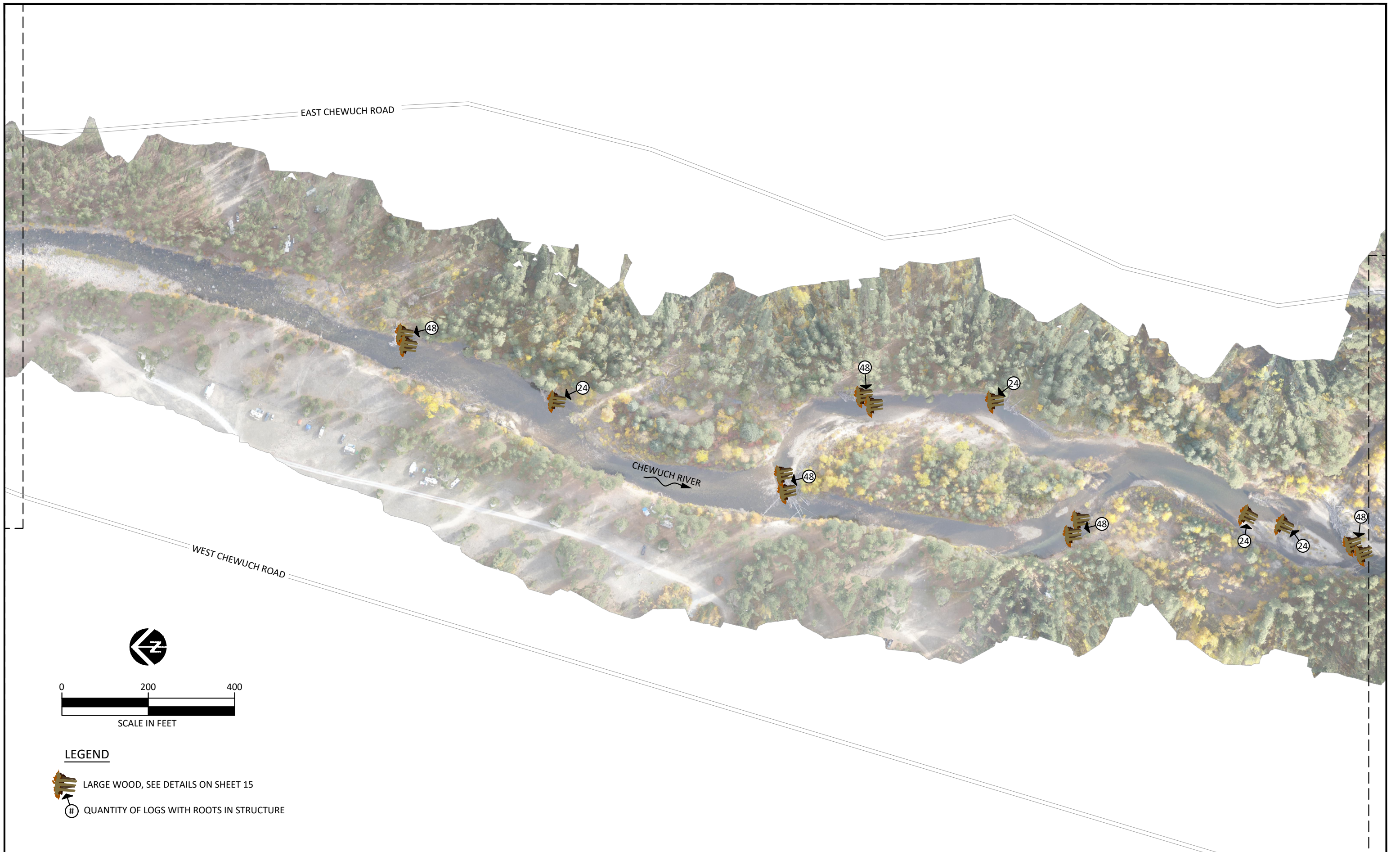
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


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AERIAL VIEW 10



LEGEND

-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

NO.	DATE	REVISION DESCRIPTION

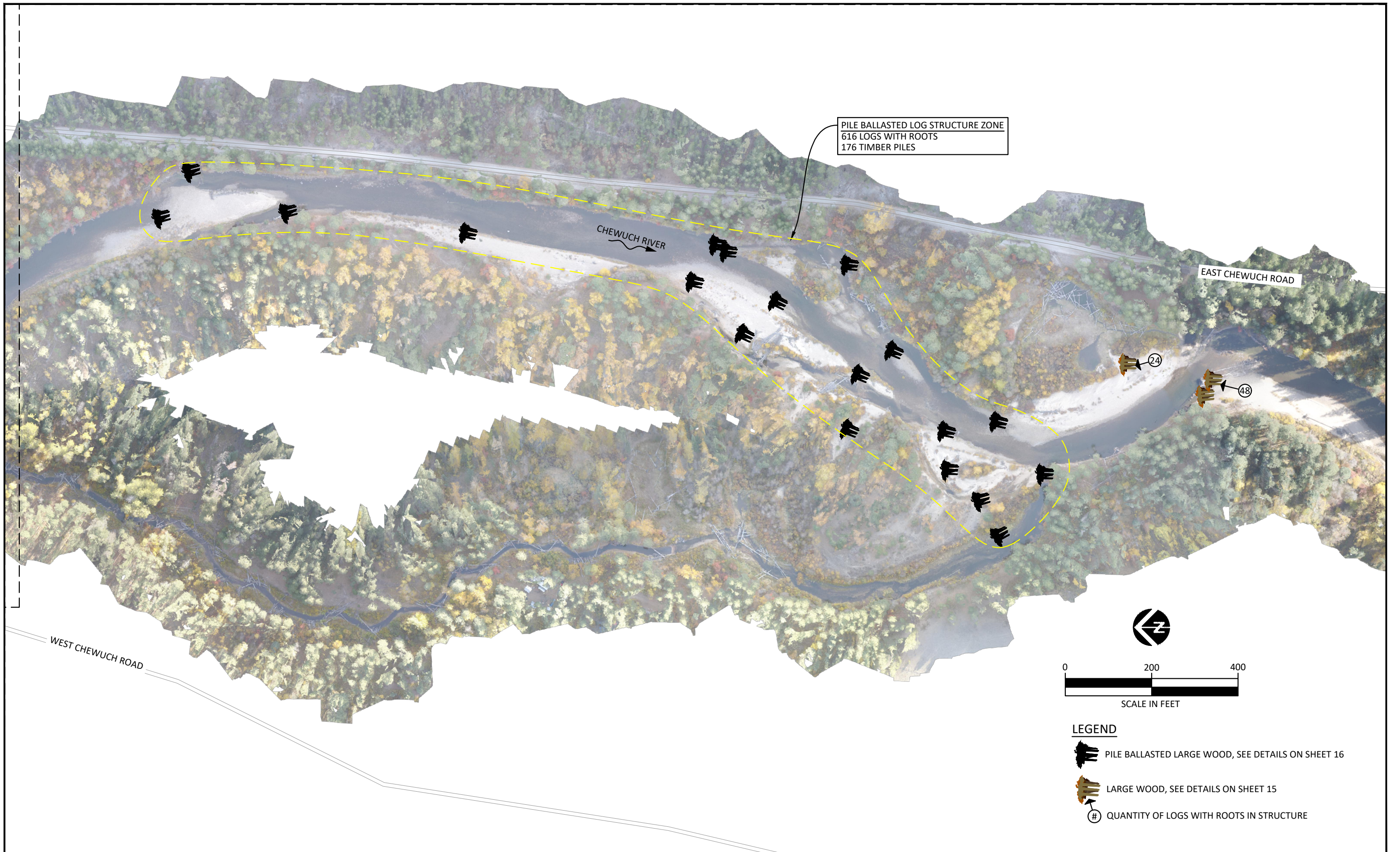
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DRAWN	DESIGNED	CHECKED
-	12/31/22	00-00-00
APPROVED	DATE	PROJECT

**YAKAMA NATION FISHERIES
CHEWUCH RIVER LARGE WOOD RESTORATION
CONCEPTUAL DESIGNS**



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AERIAL VIEW 11



PILE BALLASTED LOG STRUCTURE ZONE
 616 LOGS WITH ROOTS
 176 TIMBER PILES

EAST CHEWUCH ROAD




CHEWUCH RIVER

WEST CHEWUCH ROAD



SCALE IN FEET

LEGEND

-  PILE BALLASTED LARGE WOOD, SEE DETAILS ON SHEET 16
-  LARGE WOOD, SEE DETAILS ON SHEET 15
-  QUANTITY OF LOGS WITH ROOTS IN STRUCTURE

NO.	DATE	REVISION DESCRIPTION	MM	MB	MM
			DRAWN	DESIGNED	CHECKED
			-	12/31/22	00-00-00
			APPROVED	DATE	PROJECT

**YAKAMA NATION FISHERIES
 CHEWUCH RIVER LARGE WOOD RESTORATION
 CONCEPTUAL DESIGNS**

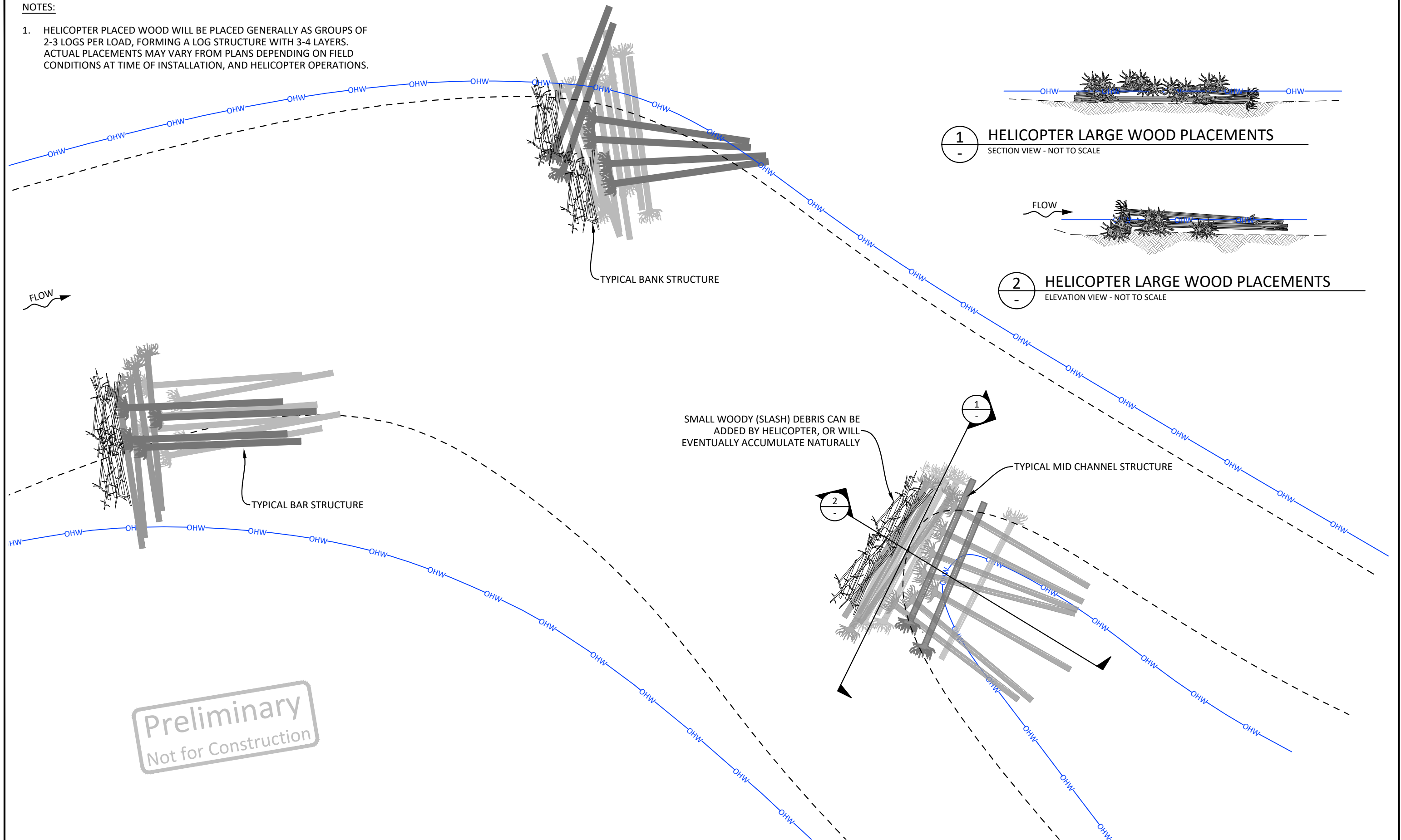


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AERIAL VIEW 12

NOTES:

- HELICOPTER PLACED WOOD WILL BE PLACED GENERALLY AS GROUPS OF 2-3 LOGS PER LOAD, FORMING A LOG STRUCTURE WITH 3-4 LAYERS. ACTUAL PLACEMENTS MAY VARY FROM PLANS DEPENDING ON FIELD CONDITIONS AT TIME OF INSTALLATION, AND HELICOPTER OPERATIONS.



Preliminary
 Not for Construction

NO.	DATE	REVISION DESCRIPTION

MM	MB	MM
DRAWN	DESIGNED	CHECKED
-	12/31/22	00-00-00
APPROVED	DATE	PROJECT

YAKAMA NATION FISHERIES
CHEWUCH RIVER LARGE WOOD RESTORATION
CONCEPTUAL DESIGNS

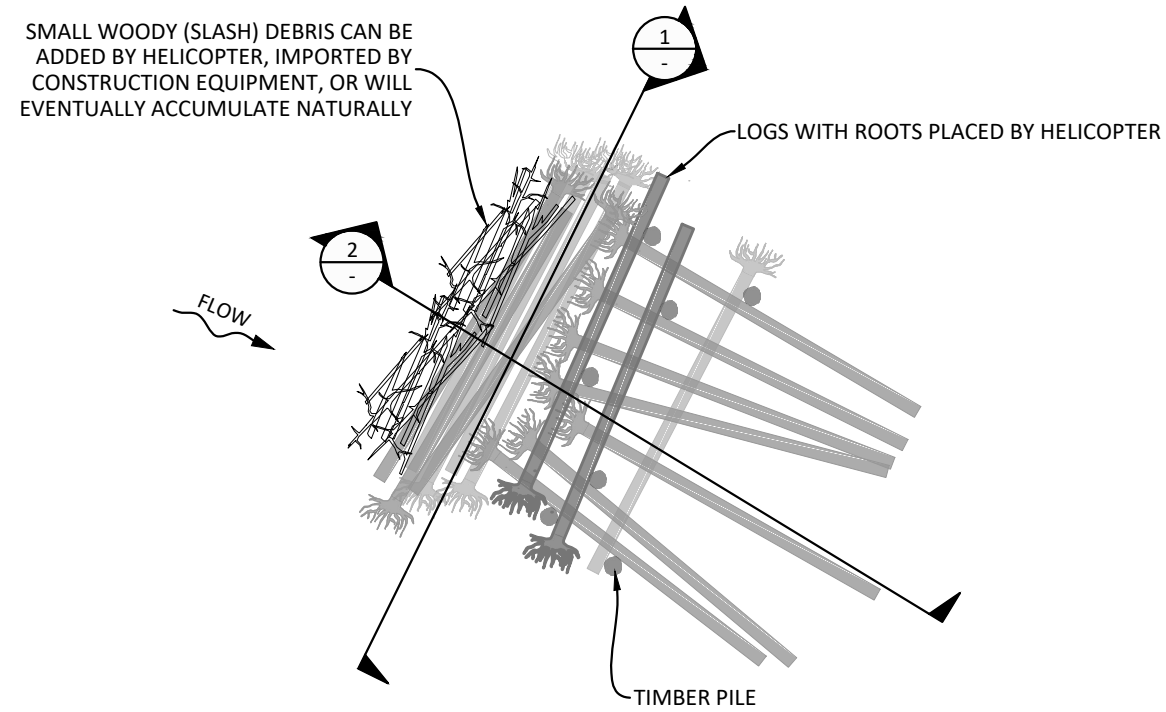


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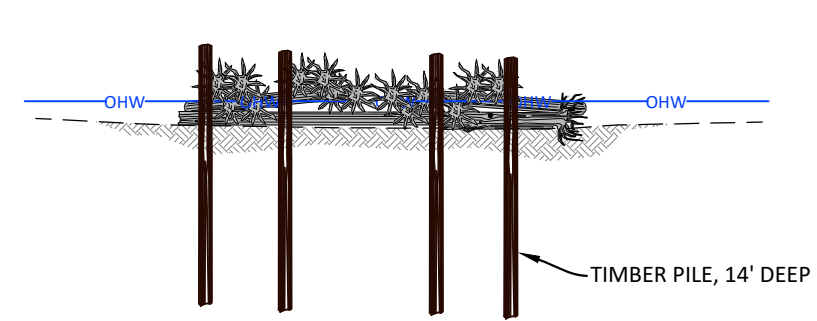
DETAILS - TYPICAL HELICOPTER PLACED STRUCTURES

NOTES:

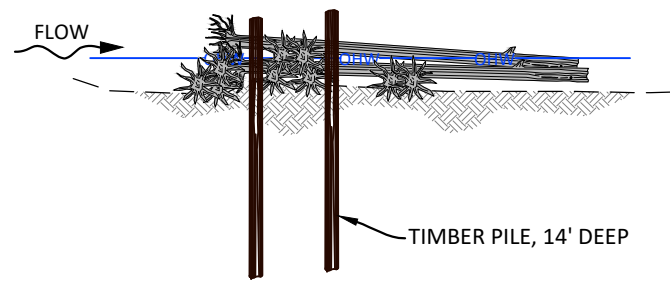
1. HELICOPTER PLACED WOOD WILL BE PLACED GENERALLY AS GROUPS OF 2-3 LOGS PER LOAD, FORMING A LOG STRUCTURE WITH 3-4 LAYERS.
2. TIMBER PILES WILL BE DELIVERED TO EACH SITE.
3. GROUND BASED EQUIPMENT WILL INSTALL TIMBER PILES.
4. ACTUAL PLACEMENTS MAY VARY FROM PLANS DEPENDING ON FIELD CONDITIONS AT TIME OF INSTALLATION, AND HELICOPTER OPERATIONS.



1
-
PILE BALLASTED LOG STRUCTURE
PLAN VIEW - NOT TO SCALE



2
-
PILE BALLASTED LOG STRUCTURE
SECTION VIEW - NOT TO SCALE



3
-
PILE BALASTED LOG STRUCTURE
SIDE ELEVATION VIEW - NOT TO SCALE

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NO.	DATE	REVISION DESCRIPTION	MM	MB	MM
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DETAILS - PILE BALLASTED STRUCTURE