GEORESOURCES
earth science & geotechnical engineering
4809 Pacific Hwy. E. | Fife, Washington 98424 | 253.896.1011 | www. georesources.rocks

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JJC Resources, LLC
PO Box 428
Port Angeles, WA 98326
(360) 452-5388
jesse@bruchandbruch.com

Geological Report
Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001
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INTRODUCTION

This *Geological Report* summarizes our site observations, our review of subsurface explorations by others, our review of the *Preliminary Reclamation Grading Plan* provided by you, our engineering analyses, and provides geologic recommendations for the proposed surface mine expansion at the subject site. The general location of the site is shown on the attached Site Location Map, Figure 1.

Our understanding of the project is based on our telephone and email discussions with Lisa Mahr, NW Mining Solutions; our review of published geologic maps and aerial imagery for the site area; our understanding of Washington Department of Natural Resources mining regulations; our August 25, 2023 and March 1, 2024 site visits; and our experience in the project area and on similar projects.

We understand the current proposal includes an expansion of the existing permitted mining limits to the west, south, and east. Accordingly, characterization of the expected conditions and development of a geologic basis for the design of the proposed mining and reclamation plans is necessary.

PURPOSE & SCOPE

The purpose of our services was to evaluate the surface conditions across the site as a basis for a) developing an evaluation of the potential aggregate resource within the property boundaries and b) preparing geotechnical recommendations for its safe and efficient extraction within the limitations of the current surface mining act. Our scope was based on our initial review of the property and was limited to those areas that may be immediately feasible for aggregate extraction. Specifically, our scope of services for the project included the following:

1. ***File Review –*** We completed a review of our files, other studies performed by others in the project area, as available, and geotechnical and soils information and geologic mapping for the site area.
2. ***Site Reconnaissance –*** We walked the site to observe the current surface conditions.

3. ***Geologic and Engineering Analyses –*** We prepared analyses of potential geologic hazards at the site, including those associated with proposed temporary and permanent slope conditions.
4. ***Reporting –*** We prepared this report summarizing our site observations, conclusions, and our geotechnical recommendations and design criteria, along with the supporting data.

LITERATURE REVIEW

Our geotechnical engineering services included the review of the following documents as a basis for assessing potential geologic hazards at the site:

- *US 101 Unnamed Tributary to Hoh River – Remove Fish Barrier, XL-5352, US-101, MP 175.45* prepared by Monique A. Anderson, PE and Shannon & Wilson, Inc. dated July 16, 2019.

    - *Summary:* This report for the US 101 Unnamed Tributary to Hoh River project provides a characterization of the subsurface conditions at the proposed culvert site and a broad overview of geologic hazards relevant to the replacement of an existing culvert to improve fish passage. The site, located near milepost 175.45, is characterized by a dormant landslide feature adjacent to the project location and various soil types, including glacial outwash sands, gravels, and finer-grained glaciolacustrine silts and clays. Groundwater was encountered at elevations ranging from 170 to 190 feet. The report concludes that the proposed culvert replacement is feasible, provided design considerations for the site and potential geologic hazards are incorporated. The report provided the opinion that the landslide deposits did not extend to the highway and that the landslide appeared inactive.

- *XL-2669, US 101 Vicinity MP 175.25 to MP 176 Geotechnical Evaluation of Potential Landslides and Slope Instability,* Washington State Department of Transportation memorandum from Marc Fish/Eric Smith, Thru: Tony Allen, E&EP Geotechnical Division, 47365, dated December 14, 2006

    - *Summary:* This geotechnical report on the proposed US 101 realignment at mileposts 175.25 to 176.00 provides an evaluation of the landslide conditions in the area. The memo references previous work and includes excerpts of the reports prepared by Shannon & Wilson (2000) and M2 Environmental Services (2000) that evaluated the potential impacts of proposed timber harvests of the DNR property east of the highway and west of the St. Regis pit property. We did not receive copies of either of these reports in our public records request. Both reports acknowledge the presence of deep-seated landslide activity, although there was a lack of concurrence of the failure mode, the landslide deposits were generally evaluated as marginally stable and that there was a lack of activity along any apparent slip surfaces over the last several decades. The reports conclude that the most significant movements are confined to the upper, steeper portions of the slope, in the form of soil creep. Debris slides associated with oversteepening of a drainage ravine were also noted. Shannon & Wilson concluded that the proposed timber harvest, with minor revisions

to bound out timber from their cross sections C-C' and D-D' areas where creep was observed, could be completed without significantly increasing the potential for landsliding that could impact public resources.

- The Geotechnical Evaluation went on to conclude that a modest realignment of the highway to the east may be feasible, but if cuts were proposed into the toe of the slope, a detailed investigation and slope stability analyses should be performed.

SITE CONDITIONS

Surface Conditions

The St. Regis Gravel Pit is located at an unaddressed parcel near the intersection of Washington State Highway 101 and Hoh Mainline in the Forks area of Jefferson County, Washington. The site is comprised of two rectangular parcels of land connected at the northwest and southeast corners. Together, the northwest and southeast lots measure approximately 2,585 and 2,660 feet wide (east to west) by approximately 2,695 and 2,700 feet long (north to south), respectively, and encompass about 320 acres in total. The site is bounded by commercial forest land to the east and south, commercial forest land and the Hoh Mainline railroad to the north, and commercial forest land and Hwy 101 to the west.

The site is located on the western side of the Olympic Peninsula on an upland area adjacent to the Hoh River valley. Generally, the site ground surface slopes down at 5 to 10 percent from the southeast to the Hoh River in the northwest and the Winfield Creek drainage to the northeast. The top of the steep western slope of the Hoh River valley is located in the western portion of the parcel. The steep Hoh River valley slope drops down from the east to the west at approximately 20 to 35 percent with about 210 to 250 feet of vertical relief. Total vertical relief in the northwest and southeast portions of the parcel are on the order of 180 feet and 350 feet, respectively. Vertical relief across the entire site is on the order of 530 feet. A level topographic low exists in the northwest portion of the site, in the location of the former and on-going surface mining operations.

The topography at the site and surrounding area has been significantly shaped by geomorphic processes such as glaciation, river meandering, and landslides. High river terraces were created when the Hoh River eroded the older glacial deposits, often high in fines content. Landslides are common, usually occurring when the terraces become undercut by the river. The steep slope in the western portion of the site, which continues offsite to the west, is characterized by an arcuate crest of the slope with relatively steep uniform slopes below. Relatively level benches are located below the steepest slope segments and above somewhat hummocky terrain that continues to the toe of the slope. This geomorphology is indicative of mass wasting. The existing site conditions and topography are shown on the attached Site Map, Figure 2 and the Washington DNR LiDAR Imagery, Figure 3.

At the time of our August 25, 2023 site visit, vegetation had largely been removed from the active operation area, while the remaining portions of the site were well vegetated with a mature to sub mature forest of species typical for the area. During our March 1, 2024 site visit, we observed significant tree clearing in the area of the proposed mine expansion. Standing water was observed in the upper, flatter portion of the site in densely vegetated areas and groundwater seepage was observed at the time of our March 2024 site visit on the adjacent WA DNR parcel to the west at approximately elevation 363 feet. Rapidly flowing water was observed in channels at locations that aligned with the *US 101 Unnamed Tributary to Hoh River – Remove Fish Barrier* Watershed Map, Figure 4.

Site Soils

The USDA Natural Resource Conservation Service (NRCS) Web Soil Survey maps the surficial soils at the site as Klone gravelly silt loam (KGD) and Klone-Hoko association (KND). An excerpt of the NRCS soils map for the site area is included as Figure 5, and detailed descriptions of the soils are included below.

- *Klone gravelly silt loam (KGD)*: The Klone soils, mapped in the central portion of the parcel, are derived from glacial outwash and/or till and are included in hydrologic soil group B. They form on slopes of 0 to 30 percent, and are listed as a "moderate" erosion hazard when exposed.
- *Klone-Hoko association (KND)*: The Klone-Hoko soils, mapped in the eastern and western portions of the parcel, are derived from basal till and are included in hydrologic soil group B. They form on slopes of 15 to 30 percent and are listed as a "moderate" erosion hazard when exposed.

Site Geology

According to the *Geologic Map of the Forks 1:100,000 quadrangle, Washington* (Gerstel & Lingley, 2020), the site is in an area underlain by Alpine glacial till, Fraser-age (Qat(m)), Alpine glacial till, pre-Fraser morainal deposits (Qapt(m)), Alpine glacial outwash, Fraser-age (Qao), and Marine clastic rocks (MEml). The alpine glacial geologic units were generally deposited before and during the most recent Vashon Stade of the Fraser Glaciation, some 12,000 to 15,000 years ago. The Marine clastic rocks were deposited during the Miocene Epoch, approximately 5.3 to 23 million years ago. An excerpt of the above referenced geologic map is attached as Figure 6, and descriptions of the geologic units are included below.

- *Alpine Glacial Outwash, Fraser-age (Qao)*: Glacial outwash typically consists of poorly to well stratified sand and gravel with local deposits of silt and clay that were deposited during the advance of alpine glaciers originating from the Olympic Mountains during the Vashon Stade of the Fraser Glaciation. These soils are typically encountered in a dense to very dense condition, as they were generally overridden by the glacier during its advancement west. Thus, these deposits are considered overconsolidated and exhibit high strength and low compressibility characteristics where undisturbed. Infiltration characteristics are generally favorable.
- *Glacial Till (Qat(m) and Qapt(m))*: Lodgment till typically consists of a heterogeneous mixture of clay, silt, and sand, and gravel that was deposited at the base of the glacial ice mass and was subsequently over-ridden. As such, glacial till is considered over-consolidated and exhibits high strength and low compressibility characteristics where undisturbed. Infiltration characteristics are generally unfavorable due to the high fines content and overconsolidated condition.
- *Marine Clastic Rocks (MEml)*: The marine clastic rocks in this region typically consist of thick-bedded lithic sandstone. Lithic sandstone is relatively weak compared to other rock types and may contain structures adverse to stability. Because of the compact nature of thick-bedded lithic sandstone, the potential for stormwater infiltration is low.

We reviewed the Washington Geological Survey (WGS) compiled landslide mapping groups for this site and surrounding area, shown on the Washington State Department of Natural Resources (WA DNR) Geologic Information Portal. This data source is referenced from published geologic maps and reports. The WA DNR compiled landslide mapping shows a low confidence shallow undifferentiated landslide in the southwest portion of the site and several low to moderate confidence shallow undifferentiated landslides along the Hoh River approximately 1 mile to the north of the site. An excerpt of the referenced Landslide Map is provided as Figure 7.

Site Reconnaissance

Site reconnaissance of the proposed mine expansion area and the adjacent WA DNR parcel were performed by a representative from our office on August 25, 2023 and March 1, 2024. During the August 25, 2023 site reconnaissance, we walked the area of the proposed mine expansion and portions of the slope below the expansion to observe geomorphic features and assess potential landslide hazard indicators. On March 1, 2024, the same representative from our office revisited the site and traversed key features identified on the topographic map and LiDAR imagery of the area. We developed a subsurface profile, included as Figure 8, along cross section A-A', shown on Figure 2, based on the reviewed literature and the observations made during our site reconnaissances.

Our March 1, 2024 site reconnaissance was focused on assessing hydrologic features of the local watershed in the proposed mine expansion area and the adjacent WA DNR parcel located downslope, as well as gathering specific geomorphic evidence related to relative activity and age constraints of the landslide. A site map showing locations of key features observed is included as Figure 9. Corresponding annotated site photos are included in Appendix A of this report. Photos 1 and 2 show the current operations of the mine.

Across the area of the proposed expansion, we generally observed field evidence consistent with typical conditions of a deep-seated rotational failure within a glacial upland area. Standing water was observed in the upland area behind and above the crown of the landslide, draining onto the head and body of the landslide deposit (Images 3 and 5). Second growth and old growth stumps were observed on the head of the landslide and throughout the body of the landslide deposit. These stumps were generally observed in an upright condition (Images 4 and 6). Within the steeper sections of the deposit, immature trees with pistol butted trunks were observed adjacent to upright second-growth stumps (Image 7). This may be indicative of ongoing shallow soil creep, but is not a typical indicator of ongoing global movement within a landslide deposit. Moderate seepage was observed issuing from the face of the landslide deposit. The seepage zones appear to merge into a single channel that eventually flows through a culvert under Highway 101 at the toe of the slope (Images 8 and 9). The roadcut across the landslide deposit for Highway 101 reveals a back rotated head within the main body of the landslide where glacial till is overlying advance outwash deposits (Image 10). The same geologic contact is exposed in the active extraction area, outside of the landslide deposit (Image 11).

Subsurface Conditions

We have not performed any site-specific subsurface explorations on the site as part of our current scope of work. Instead, we visited the site, reviewed published geologic literature as described above, and observed road cuts and the exposed temporary slopes within the current active portion of the extraction area.

The exposed soils of the roadcuts and the temporary slopes within the active extraction area generally confirmed the mapped stratigraphy. We observed a relatively thin layer of very dense glacial till soils mantling dense to very dense glacial advance outwash soils. Both units appeared to consist of gray silty sand with gravel to sandy gravel with silt. Additionally, Washington DNR and the surface mining operator have reported encountering a fine-grained soil layer at an elevation of approximately 405 feet along the western edge of the current working face within the advance outwash deposits. These fine-grained soils appear to be dipping to the east, but the lateral extent of these soils is unknown at the time of this report's preparation.

Groundwater Conditions

As stated, the surface mine is generally located in an upland area adjacent to the Hoh River valley. The nearest water well or resource protection well reports are located along the Hoh River at approximately the same elevation as Highway 101 west of the subject site. These reports indicate that groundwater is present at depths of 10 to 15 feet below the highway grade, approximately elevation 170 to 190 feet. Based on our site reconnaissance and literature review, we anticipate that a perched unconfined aquifer may be present at relatively shallow depths below the existing ground surface in the upland portion of the site. This expectation is based on the observed presence of glacial till coupled with areas of standing water in the upland area of the site. Additionally, a groundwater seepage zone daylighting on the face of the slope was observed at approximately elevation 360 feet on the WA DNR parcel at the time of our March 1, 2024 site reconnaissance. This approximate elevation would indicate that a confined or partially confined aquifer may be present within the advance outwash deposits that underlie the glacial till. However, the fine-grained soil layer identified by Washington DNR and the surface mine operator exists within the advance outwash deposits and dips away from the crest of the slope to the east.

For planning purposes, we recommend estimating that groundwater levels within the perched aquifer may be present within the first several feet from the existing ground surface, coincident with the wetland deposits on the northeast portion of the active mine. A deeper confined or partially confined aquifer is likely present at an elevation of 355 to 365 feet within the advance outwash deposits. These groundwater elevations are based on our interpretation of the geologic conditions made during our site reconnaissance. No subsurface explorations were completed as part of our scope of work.

Groundwater Recharge Areas

We developed a catchment model utilizing GIS tools and a digital elevation model (DEM) of the site and site vicinity derived from LiDAR data. Based on the catchment model, it appears the total potential groundwater recharge area (GWRA) for the glacial deep-seated landslide complex is relatively narrow in the north and widens to the south. The topography between the headscarp area and the subject site is somewhat undulating and has developed observed or predicted seasonal drainages. Accordingly, we identified a primary and secondary GWRA as shown on Figure 10. The primary GWRA is distinguished by terrain that appears to promote immediate delivery of stormwater and shallow subsurface flow downslope to the landslide feature. The secondary GWRA likely contributes groundwater recharge to the landslide feature, but given the undulating nature of the terrain and established drainages, operates on an extended timescale compared to the primary GWRA, i.e., precipitation would need to accumulate.

ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Based on our assessment, the proposed expansion of the surface mining operation appears feasible from a geological and geotechnical engineering standpoint. The following sections provide additional comments and recommendations for reclamation.

Geologically Hazardous Areas – per Jefferson County Code Chapter 18.22.510

Jefferson County Title 18.22.510 defines geologically hazardous areas (erosion, landslides, seismic, channel migration zones, wave, and tsunami hazards) and provides key indicators for their identification. Below, we provide the quoted text from Title 18.22.510 for erosion and landslide hazards, followed by our comments and site-specific evaluation.

(1) The following are geologically hazardous areas and subject to the standards of this article when mapped as high or moderate geologically hazardous areas:
   - A. Erosion hazard areas (as defined in JCC 18.10.050).
     - (i) "Erosion hazard areas" has the same meaning as in WAC 365-190-030(5).
   - B. Landslide hazard areas (as defined in JCC 18.10.120). Landslide hazard areas include any areas susceptible to landslide because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors, as follows:
     - (i) Areas of historic failures, such as:
       - (A) Areas delineated by United States Department of Agriculture, Natural Resources Conservation Service as having a significant limitation for building site development;
       - (B) Coastal areas mapped by the Washington Department of Ecology Coastal Atlas as unstable, unstable old slides, and unstable recent slides; or
       - (C) Areas designated and mapped as quaternary slumps, earthflows, mudflows, lahars, or landslide hazards by the Washington Department of Natural Resources or the United States Geological Survey.
     - (ii) Areas where all three of the following conditions occur:
       - (A) Slopes are steeper than 15 percent;
       - (B) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and
       - (C) Spring or groundwater seepage.
     - (iii) Areas that have shown movement during the Holocene epoch (from 10,000 years ago to present) or have been underlain or covered by mass wastage debris of this epoch.
     - (iv) Areas with slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials.
     - (v) Areas with slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking.
     - (vi) Areas that are potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones.
     - (vii) Areas that show evidence of, or are at risk from, snow avalanches.
     - (viii) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding.

(ix) Areas with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet, except areas composed of bedrock.

Erosion Hazard Areas

WAC 365-190-030(5) defines erosion hazard areas as those areas containing soils which, according to the United States Department of Agriculture Natural Resources Conservation Service Soil Survey Program, may experience significant erosion. Erosion hazard areas also include coastal erosion-prone areas and channel migration zones.

As stated above, the USDA NRCS maps the site soils as Klone gravelly silt loam (KGD) and Klone-Hoko association (KND), and lists these soils as "moderate" erosion hazard when exposed. The site is not located on the Pacific coast or other freshwater shoreline. The Hoh River is located below and west of the site on the other side of Highway 101. The distance between the river and the toe of the valley slope combined with the presence of and any protections put in place for the highway should be sufficient to protect the site from erosion hazards associated with future migration of the river. Based on the above, it is our opinion that the site does not contain an erosion hazard.

Landslide Hazard Areas

Data for the site was not available on the Jefferson County Landslide Hazard Map or the DOE Coastal Atlas map; consequently, these maps are not included in this report. The *Geologic Map of the Forks 1:100,000 quadrangle, Washington* (Gerstel & Lingley, 2000) does not map a landslide deposit or mass wasting deposit on or within the site vicinity. Slopes steeper than 15 percent are mapped and were observed at the site. We did not observe any adverse contacts during our site visit. The published mapping for the site area does not suggest the presence of, nor do we interpret the site to have, slopes that are parallel or subparallel to planes of weakness. Springs or groundwater seepage were not observed onsite at the time of our site visit; however, groundwater seepage was observed at about elevation 360 feet on the adjacent WA DNR parcel located downslope from the site. Tension cracks were not observed onsite. The site is located approximately 1,150 feet from the Hoh River, but the toe of the valley slope is generally protected by the US Highway 101 grade. We do not interpret the site to be at risk of snow avalanches. There are slopes steeper than 40 percent with 10 feet or more of vertical relief at several locations throughout the site, including the slope of the active mining face.

The site appears to have two of the above listed indicators of a landslide hazard area as defined by Jefferson County Code 18.22.510 (slopes steeper than 40 percent with more than 10 feet of vertical relief, and landslide deposits on or near the site). Based on our site reconnaissance and literature review, it is our opinion that a landslide feature is present on the western portion of the site. This feature is readily identifiable on LiDAR imagery for the site, as shown on Figure 3. During our site reconnaissance, we observed areas of sparsely vegetated, over steepened soils along the observed head scarp, also visible in LiDAR imagery. Additionally, we observed a feature consistent with a back-rotated bench and hummocky terrain below. Hummocks were not pronounced and most of the anticipated runout appears to have been removed via erosion and sediment transport. Our interpretation of the approximate limits of the landslide feature and additional notes regarding the feature are included in Figure 2.

Based on our site reconnaissance, we would characterize the landslide feature as a dormant complex earth slide-earth flow. Our characterization as dormant is supported by findings in the

literature review that indicate low confidence in recent movement of the deposit along apparent slip planes. Specifically, previous investigations reported that portions of the landslide deposits are currently marginally stable, with some slow creep movement observed in the upper portions of the slope. However, no recent movement was noted on the lower portions, which supports the interpretation of dormancy. We do not consider soil creep as an indicator of landslide activity, as this phenomenon may also occur on slopes that have not previously failed. Furthermore, the landslide deposits identified by the DNR have a level of certainty of 4, where 1 is the highest level of certainty and 5 is the lowest, further supporting the low confidence in significant recent activity (Gerstel, 1999).

The presence of upright old growth stumps observed on the landslide deposit and a lack of other field evidence that would indicate more recent movement, as described above in the "**Site Reconnaissance**" section, further supports the characterization of the landslide as dormant. Based on our review of aerial photographs, timber was harvested from a significant portion of the landslide deposit between September 1952 and July 1955. The age of the harvest provides an age constraint on the most recent movement of the slide deposit. Accordingly, the most recent movement of the landslide deposit, based on available evidence, is likely in excess of 50 years ago.

Landslide Hazard Buffers

Given that we characterize the landslide feature as dormant, and the toe of the feature is relatively well protected by the US Highway 101 grade, it is our opinion that the likelihood of remobilization of the landslide feature is relatively low, provided our recommendations included below are appropriately incorporated into the design and operation of the mine. However, without additional analysis, a buffer should be included in the reclamation plans to provide protection against the potential for remobilization.

We recommend that no site disturbance is allowed within the primary GWRA, leaving a vegetated buffer in place. By avoiding disturbance of the primary GWRA, it is our opinion that the potential for increased groundwater recharge and associated pore water pressures within the slide deposit is negligible. In concurrence with the previous reports referenced in our literature review, maintaining or reducing pore water pressure levels within the landslide deposit is likely the most critical factor in promoting stability of the landslide deposit.

Mining and associated site disturbance should be allowed within the secondary GWRA, provided the following recommendations are appropriately adhered to during operation of the surface mine.

- Clearing and expansion of new phases within the secondary GWRA should be restricted to drier months of May to October to avoid temporary increases of runoff or groundwater recharge and to limit the potential for erosion.
- All ground surfaces within the secondary GWRA should be graded to promote a uniform surface that slopes to the east as soon as is reasonably practicable following clearing.
- The ground surface should remain sloped to the east throughout mining operations, ensuring all surface water runoff is conveyed to a stormwater facility and ultimately to an appropriate discharge point away from the landslide deposit.
- Reclamation grading should be designed and completed such that surface water runoff continues to be directed to the east.

- Regardless of the GWRA boundaries, a minimum 200 horizontal foot buffer should be maintained from the headscarp of the landslide deposit to account for topographic and soil variability.

Should additional expansion into this buffer be considered, detailed analyses based on subsurface explorations should be performed to determine the potential impacts to slope stability of the proposed mining expansion. This analysis should include a detailed characterization of the groundwater regime at the site, analysis of the impact of mining on groundwater recharge, static and pseudostatic numerical slope stability analyses, and recommended mitigation strategies.

Site Drainage

We recommend that the pit floor of the proposed mine be designed to generally slope down to the east and north, toward the wetland area, during all phases of extraction and reclamation. Additionally, all haul roads should be designed and constructed with conveyance systems that direct water to the east and north of the site. All surface water runoff should be collected and conveyed to a discharge location as far as possible from the landslide feature, preferably into the existing wetland areas. This should allow for extraction operations to proceed while maximizing lag time associated with groundwater recharge and thus minimizing potential impacts to the landslide feature. Additionally, we recommend a phased extraction and segmental reclamation approach is pursued to the extent practical. Each phase of extraction should be planned such that the total disturbed area is less than or equal to the historical maximum disturbed area of approximately 15 acres. This should reduce the pontial additional impact to the landslide feature above historic levels, which, based on our observations, do not appear to have prompted additional movement of the landslide deposit.

Temporary Slopes

Temporary cut slopes will be necessary during extraction and reclamation operations. Surface drainage should be directed away from all temporary and permanent slope faces, including active working faces.

As a general guide, temporary slopes of ¾H:1V (horizontal to vertical) or flatter may be used for temporary cuts in the dense glacial till soils. Where outwash soils are present, we recommend temporary slopes do not exceed 1H:1V. These guidelines assume that the temporary cut slopes will not exceed 50 feet in height, and that all surface loads are kept a minimum distance of at least one half the depth of the cut away from the top of the slope. In addition, where seepage occurs on the slope face, the slope inclination should be flattened and drainage should be provided to prevent erosion.

Given the significant volume of material to be extracted from the proposed expansion and our lack of site-specific subsurface explorations, the recommendations for temporary slopes should be periodically revisited. This can be achieved by allowing GeoResources personnel to observe the working face on a routine basis, or by the aggregate resource operator utilizing GeoResources personnel on an on-call basis as conditions change. The timing of routine observation should be determined based on extraction rate, but never less than a bi-annual basis.

Permanent Slopes

Permanent slopes in cut or fill soils should not exceed 2H:1V unless supported by site-specific analysis and design. Permanent slopes should blend with the surrounding topography to the extent

possible and should avoid rectilinear features. We recommend that permanent slopes not exceed vertical heights of 50 feet without providing a topographic break with a minimum width of 6 feet. All final grades should be capped with topsoil or amended soils and should be seeded as soon as practical to facilitate the development of a protective vegetative cover, or otherwise protected in accordance with the planned final use for the site. DNR reclamation guidelines should be followed with respect to replacing topsoil and subsoil at the site.

Reclamation Fill

Reclamation fill should consist of non-organic earth materials free of debris and deleterious material. The organic content of reclamation fill should be less than 3 percent by weight. Earth materials may be blended to reduce organic content to acceptable levels, provided appropriate laboratory analyses verify blending results. We anticipate that reclamation fill may consist of on-site materials and material imported from offsite. Material imported from offsite should adhere to a clean backfill policy established for the surface mining permit.

All earth fill material associated with reclamation grading should be placed in horizontal lifts of appropriate thickness to allow adequate and uniform compaction of each lift. For planning purposes, 12-inch loose lifts are typically appropriate for single- and double-drum vibratory roller compaction equipment. Track walking or compaction with conventional earth working equipment generally does not provide sufficient compaction on thicker lifts, and as such may require individual lifts be limited to 4- to 6-inch loose lifts. Lift thickness should be evaluated and adjusted as appropriate at the time of placement. Reclamation fill should be compacted to at least 90 percent of MDD (maximum dry density as determined in accordance with ASTM D1557).

The suitability of material for use as reclamation fill during wet weather will depend on the gradation and moisture content of the soil. As the amount of fines (material passing US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. It will be necessary to wait for dry weather conditions where these soils are present. In general, soils suitable for placement in wet conditions will have a fines content of 5 percent or less. If prolonged dry weather prevails during the earthwork activities, higher fines content (up to 10 to 12 percent) may be acceptable. Extended periods of dry weather may require the addition of moisture to achieve the desired compaction.

We expect the outwash soils will be extracted from the site, leaving only glacial till soils or backhauled import material for use as reclamation fill. The native glacial till soils on the site appear to contain a significant fraction of fines. Accordingly, these soils should be considered moisture sensitive and will be difficult or impossible to compact when wet. Blending of the soils should be completed prior to placement and compaction.

Quality Assurance

Quality assurance density testing by nuclear methods in general accordance with ASTM D6938 should be performed by an appropriately qualified professional and reviewed by the supervising geotechnical engineer during reclamation grading. We recommend that testing is completed at intervals of approximately 1 to 3 tests per acre of fill and a minimum of every 10 vertical feet.

Earth materials imported from offsite to be used as reclamation fill should be sampled to determine MDD at a minimum of one soil sample for every 1,000 cubic yards. On-site material used as reclamation fill may be sampled initially and that MDD value may be used until deviation is

observed. Blending of materials is inevitable during reclamation operations. Accordingly, additional sampling should be completed at the direction of the supervising geotechnical engineer.

The moisture content of reclamation fill should be monitored, and excessively moist soils should be placed aside and aerated until the moisture content is generally within 4 percent of optimum before placement is attempted. Moisture conditioning of soils over optimum moisture content should include aeration by the creation of wind rows.

Daily field reports should be provided that summarize the observations and testing of the supervising geotechnical engineering and their representatives. Upon completion of reclamation grading, a summary letter, prepared by the supervising geotechnical engineer, should be provided that describes the testing program and summarizes deviations from the above recommendations.

LIMITATIONS

We have prepared this report for use by JJC Resources and members of the permitting and reclamation design team. The data used in preparing this report and this report should be provided to prospective contractors for their bidding or estimating purposes only. Our report, conclusions and interpretations are based on subsurface and groundwater data from others, and our limited site reconnaissance, and should not be construed as a warranty of the subsurface conditions. No subsurface explorations were completed as part of this study.

Variations in subsurface conditions are possible between the explorations and may also occur with time. A contingency for unanticipated conditions should be included in the budget and schedule. Sufficient monitoring, testing and consultation should be provided by our firm during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and foundation installation activities comply with contract plans and specifications.

The scope of our services does not include services related to environmental remediation and construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

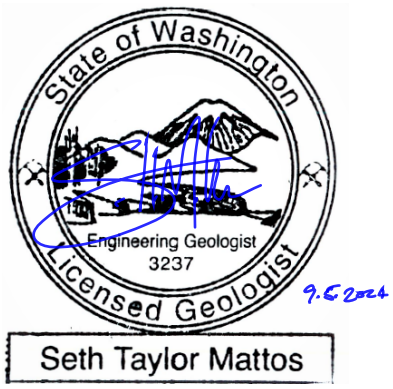
If there are any changes in the loads, grades, locations, configurations or type of facilities to be constructed, the conclusions and recommendations presented in this report may not be fully applicable. If such changes are made, we should be given the opportunity to review our recommendations and provide written modifications or verifications, as appropriate.

◆ ◆ ◆

We appreciate the opportunity to be of continued service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

Respectfully submitted,
GeoResources, LLC

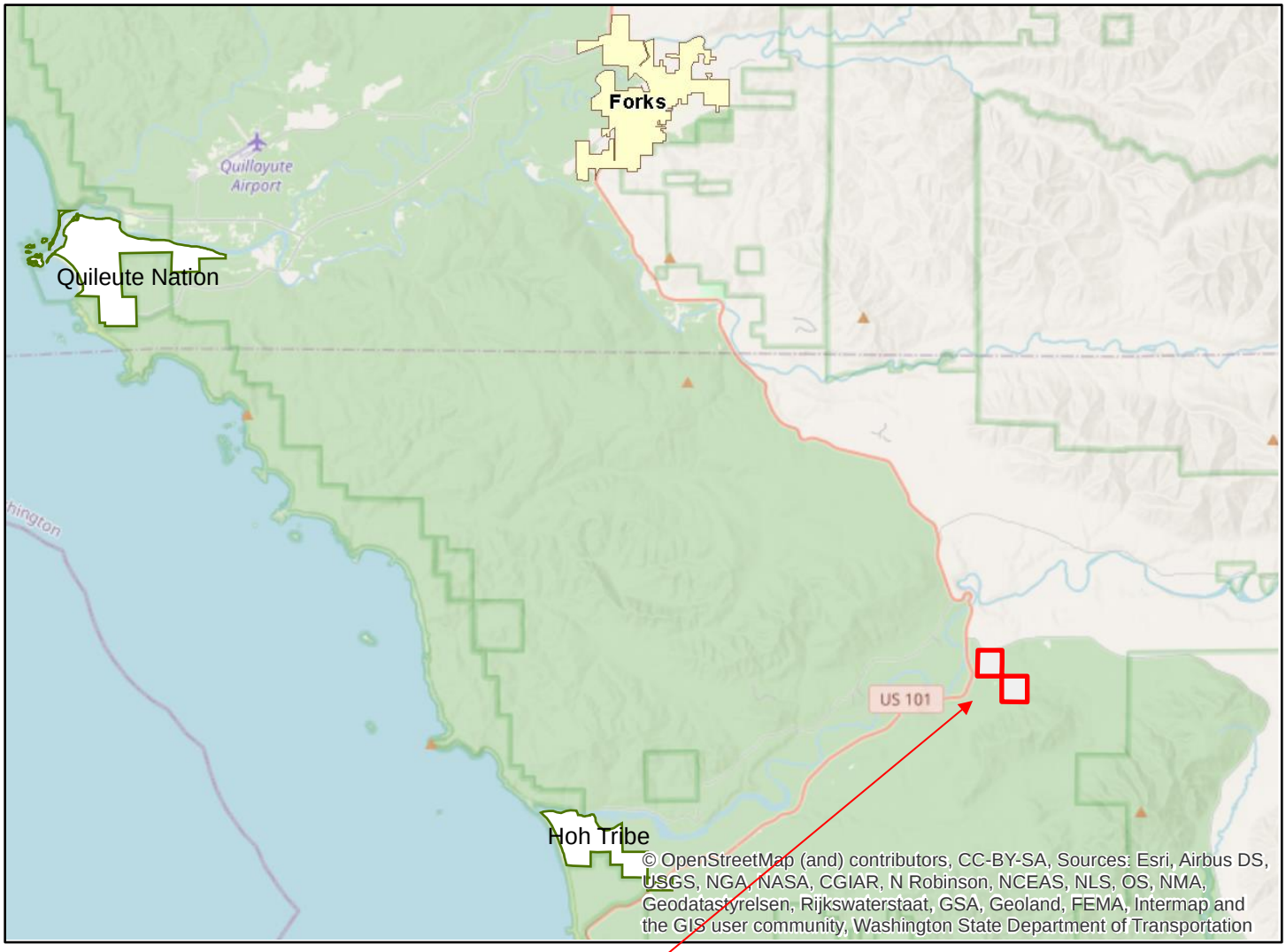
Darby McDaniel, GIT
Staff Geologist



Seth Mattos, LEG
Associate

Eric W. Heller, PE, LG
Senior Geotechnical Engineer

DEM:STM:EWH/dem
Doc ID: JJCResources.StRegisPit.RG
Attachments:
Figure 1: Site Location Map
Figure 2: Site Map & Phasing Plan
Figure 3: WA DNR LIDAR Imagery
Figure 4: Watershed Map
Figure 5: NRCS Soils Map
Figure 6: Geologic Map
Figure 7: WGS Landslide Hazard Map
Figure 8: Geologic Cross Section
Figure 9: Site Reconnaissance Map
Figure 10: Catchment Map
Appendix A: Annotated Site Photos



Approximate Site Location

Figure created in Esri ArcMap

N W E S

1 inch = 5 miles

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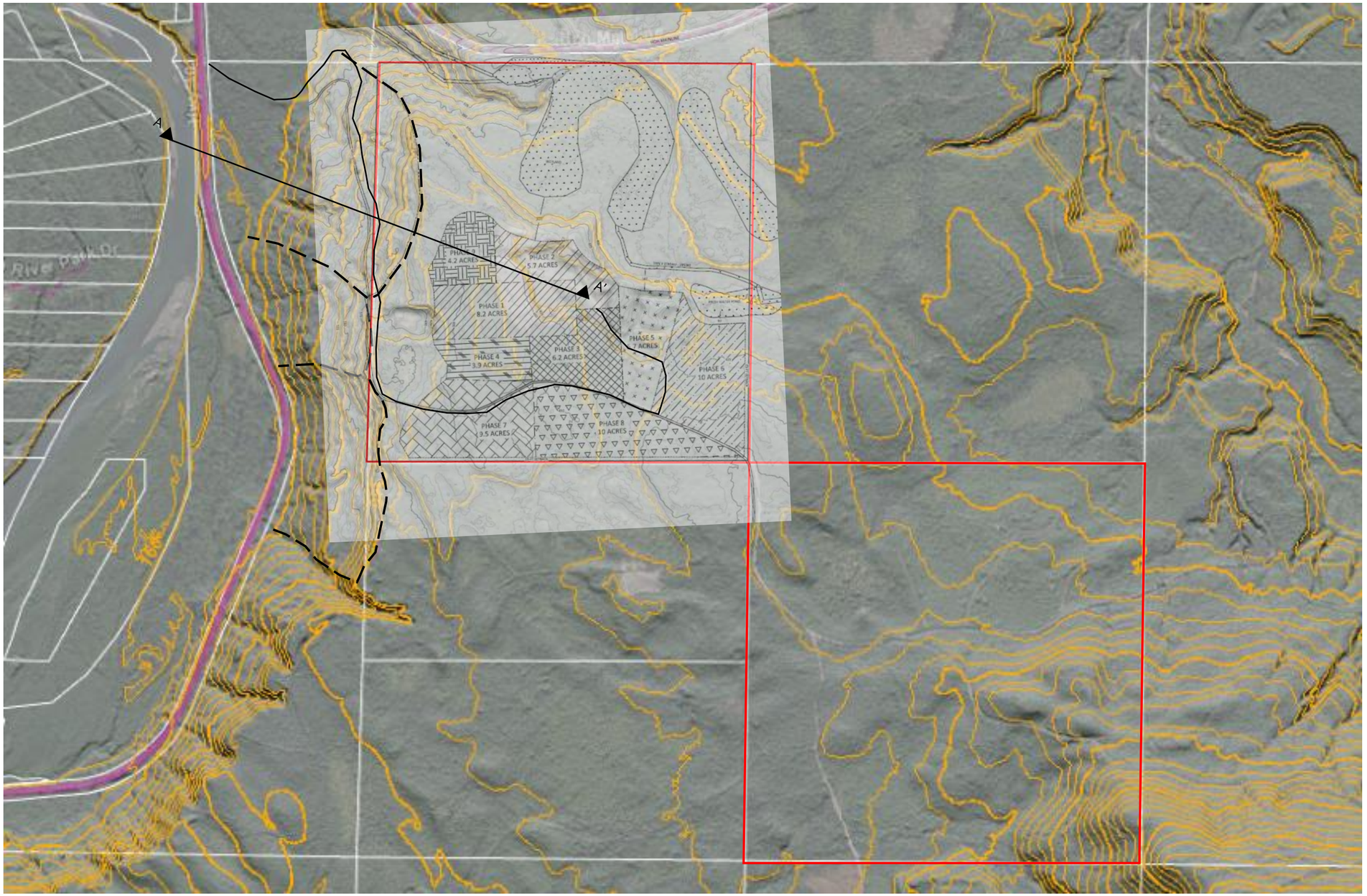
Site Location Map

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure 1



Notes: Basemap accessed from Jefferson County GIS (https://gisweb.jeffcowa.us/LandRecords)
Excerpt from the *Mining & Reclamation Sequence Map Phasing Plan* by NW Mining Solutions dated November 10, 2023

Approximate cross section location (Arrows indicate direction)

Landslide Deposits (Approx. limits)

Existing Access Road (Approx.)

North
(Not to Scale)

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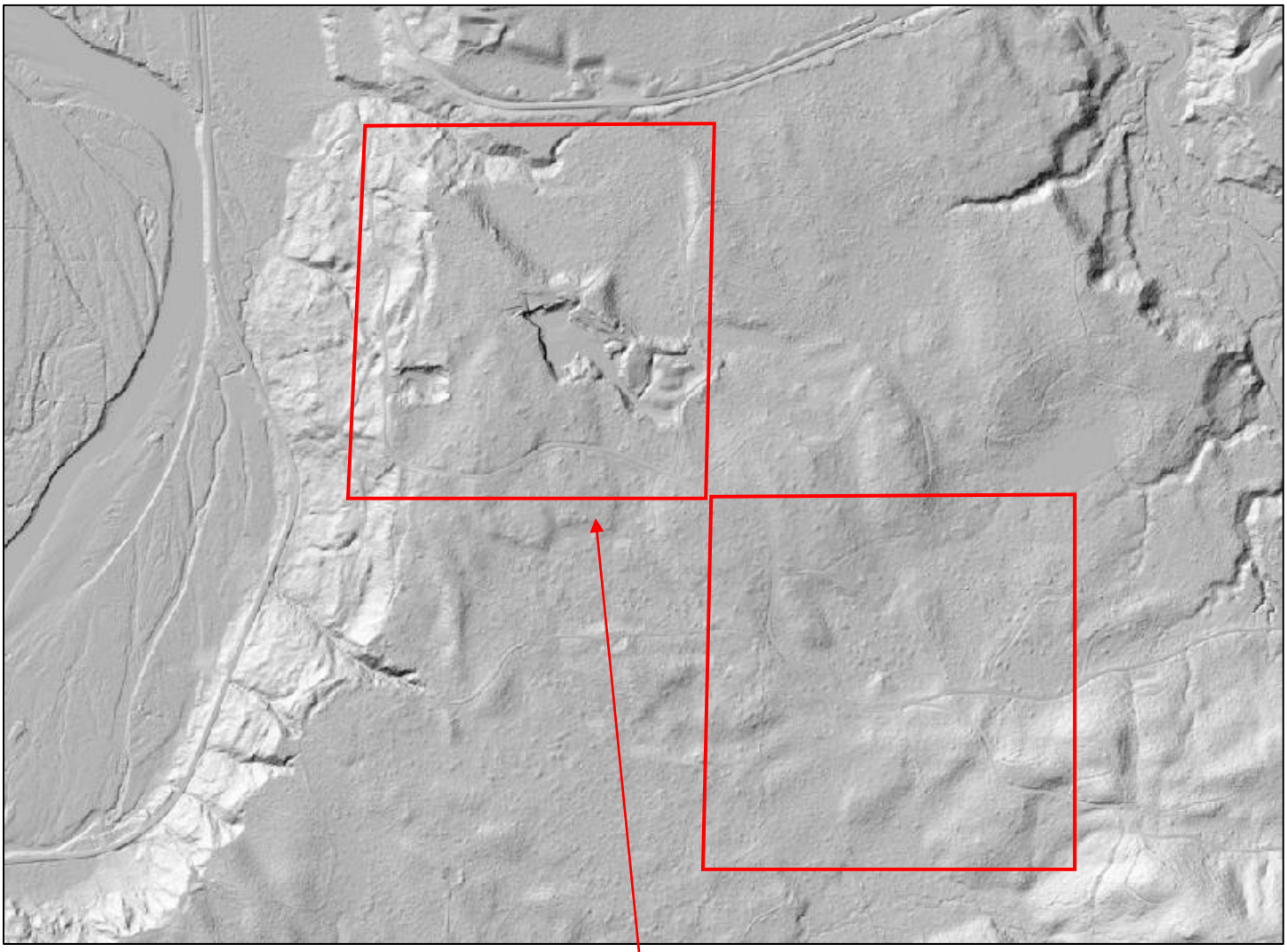
Site Map & Phasing Plan

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

DocID: JJCResources.StRegisPit.F2	Sept 2024	Figure 2



Approximate Site Location

An excerpt from the Washington State Department of Natural Resources Geologic Information Portal (https://geologyportal.dnr.wa.gov/)

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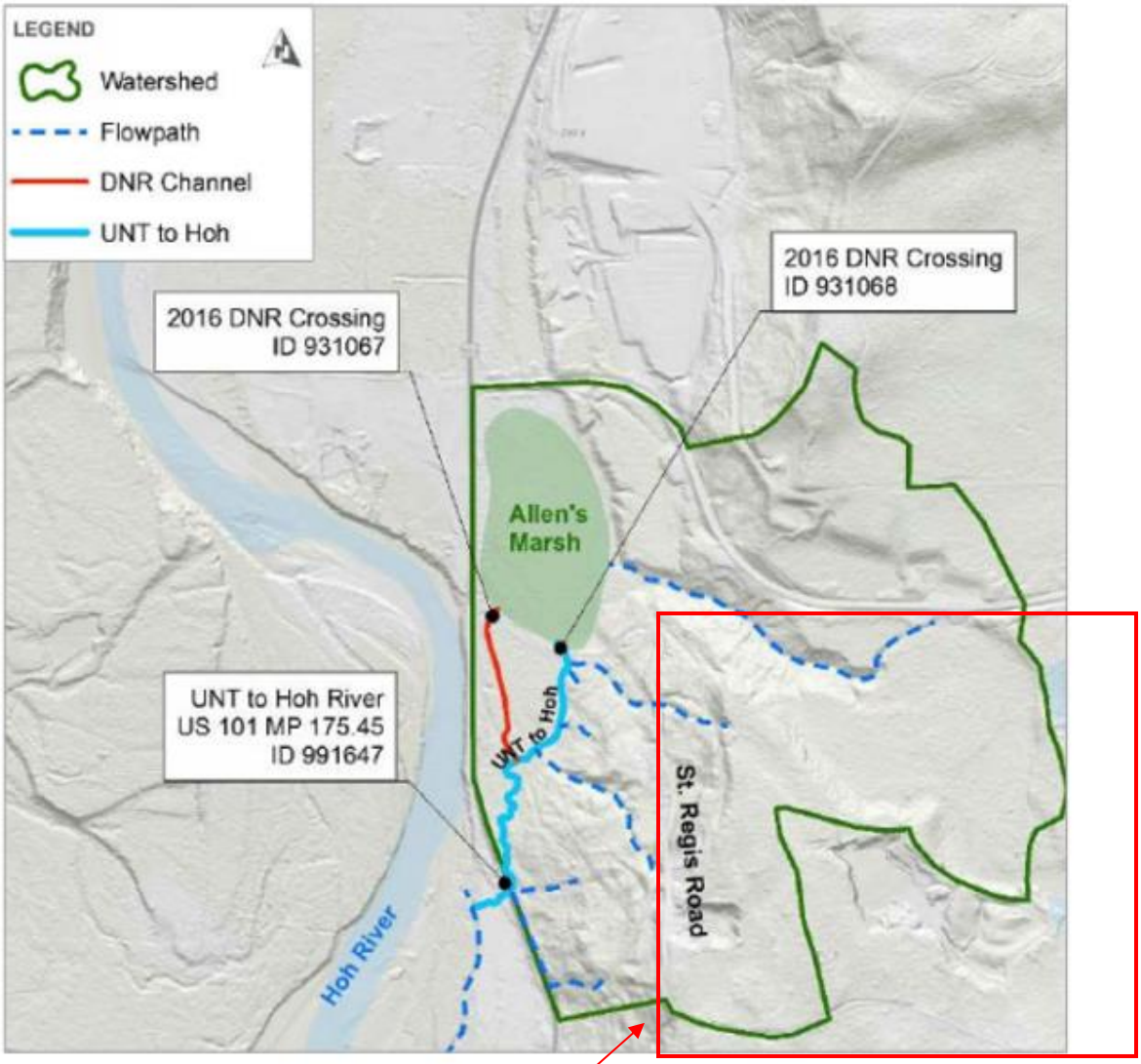
WA DNR LIDAR Imagery

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure 3



Approximate Site Location

Excerpt from *US 101 Unnamed Tributary to Hoh River – Remove Fish Barrier* prepared by Monique Anderson, PE and Shannon & Wilson, Inc. (July 16, 2019)

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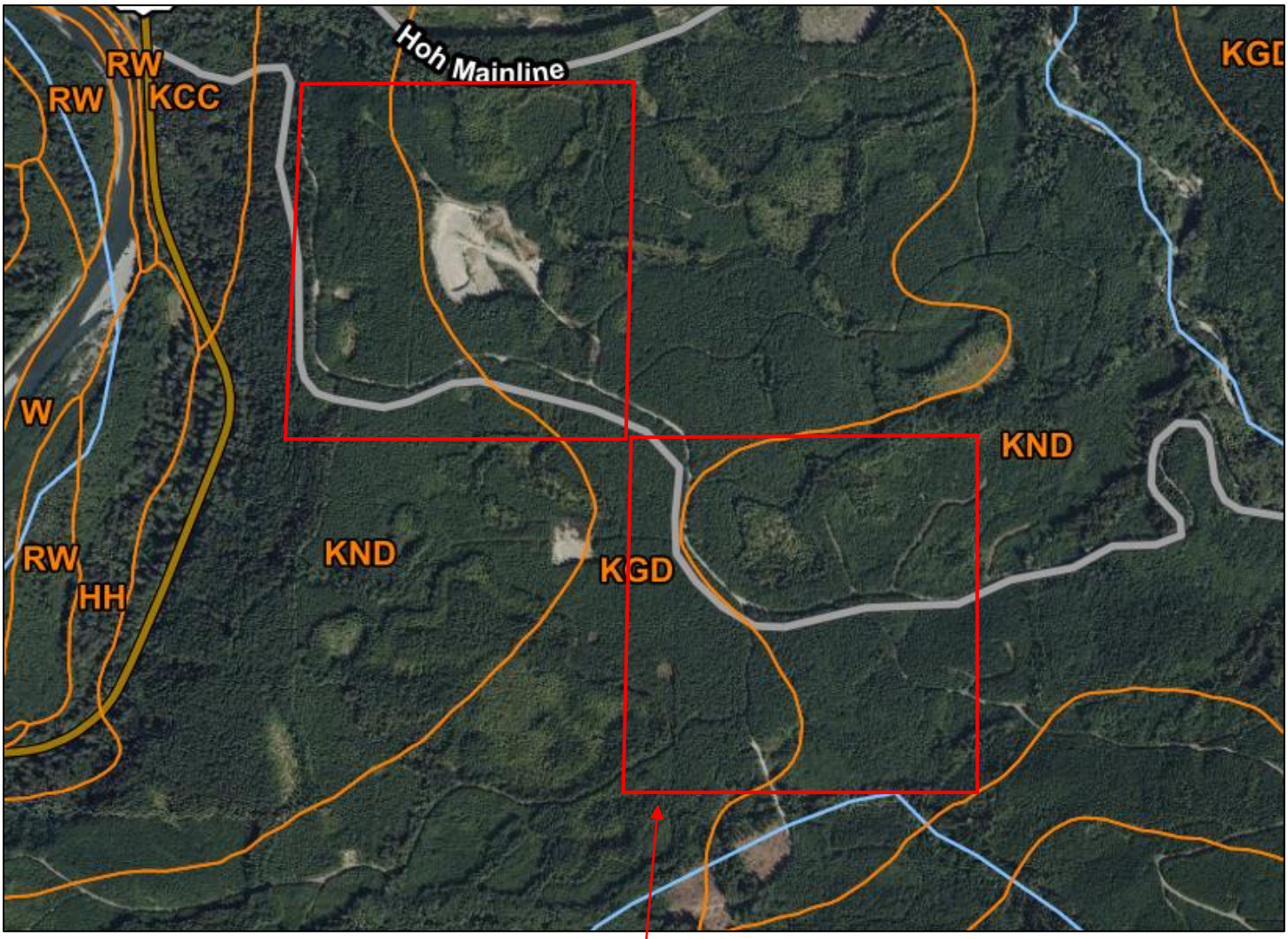
Watershed Map

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure 4



Approximate Site Location

Figure created from Web Soil Survey
(http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx)

Soil Type	Soil Name	Parent Material	Slopes	Erosion Hazard	Hydrologic Soils Group
KGD	Klone gravelly silt loam	Glacial outwash and/or till	0 to 30	Moderate	B
KND	Klone-Hoko association	Basal till	15 to 30		

Not to Scale

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NRCS Soils Map

Proposed Surface Mine Expansion
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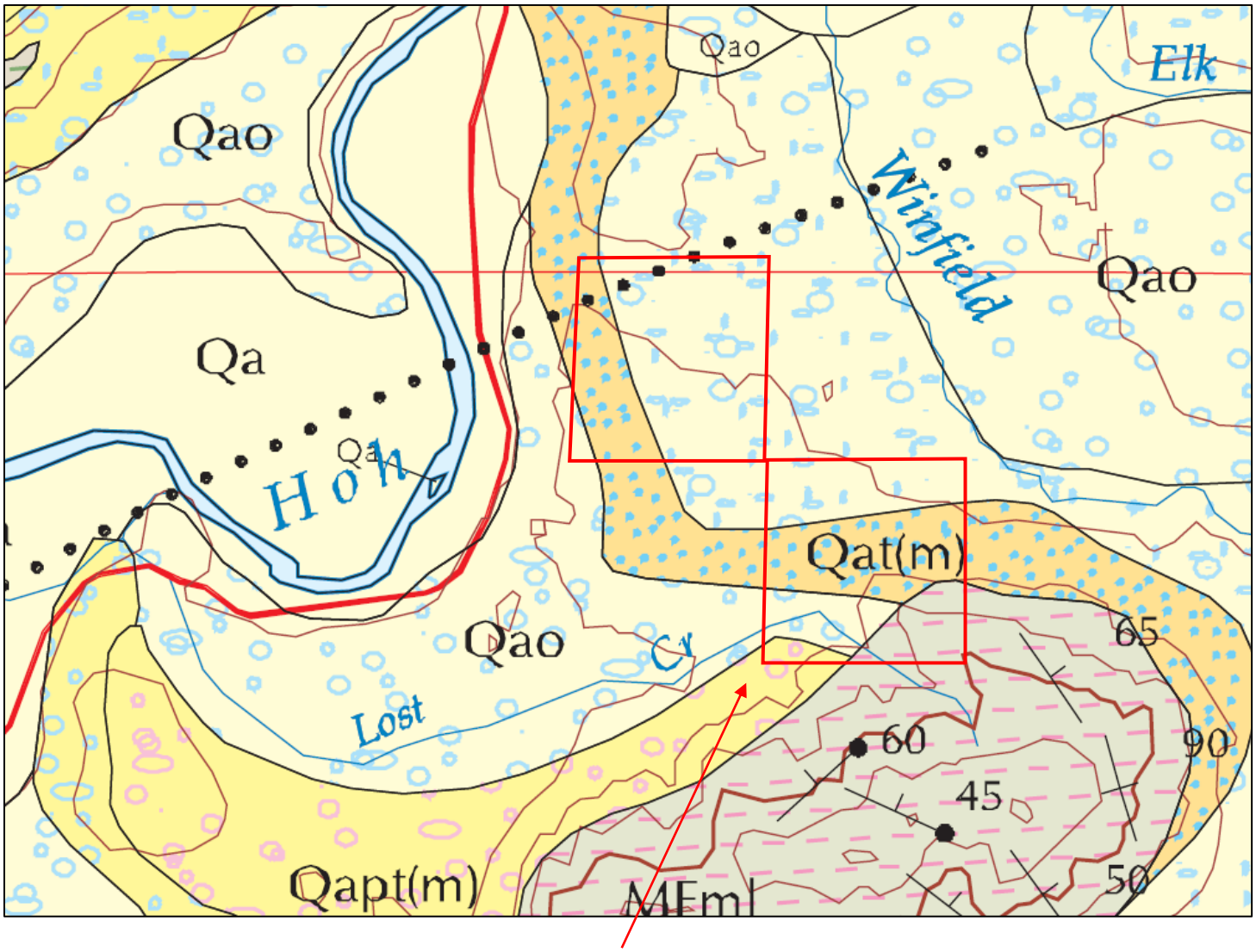
Jefferson County, Washington
PN: 612032001



Approximate Site Location

An excerpt from the *Geologic map of the Forks 1:100,000 quadrangle, Washington* by W. J. Gerstel, W. S. Lingley, Jr. (2000)

Symbol	Geologic Unit
Qat(m)	Alpine glacial till, Fraser-age
Qapt(m)	Alpine glacial till, pre-Fraser morainal deposits
Qao	Alpine glacial outwash, Fraser Age
MEml	Marine clastic rocks (thick-bedded lithic sandstone)

Not to Scale

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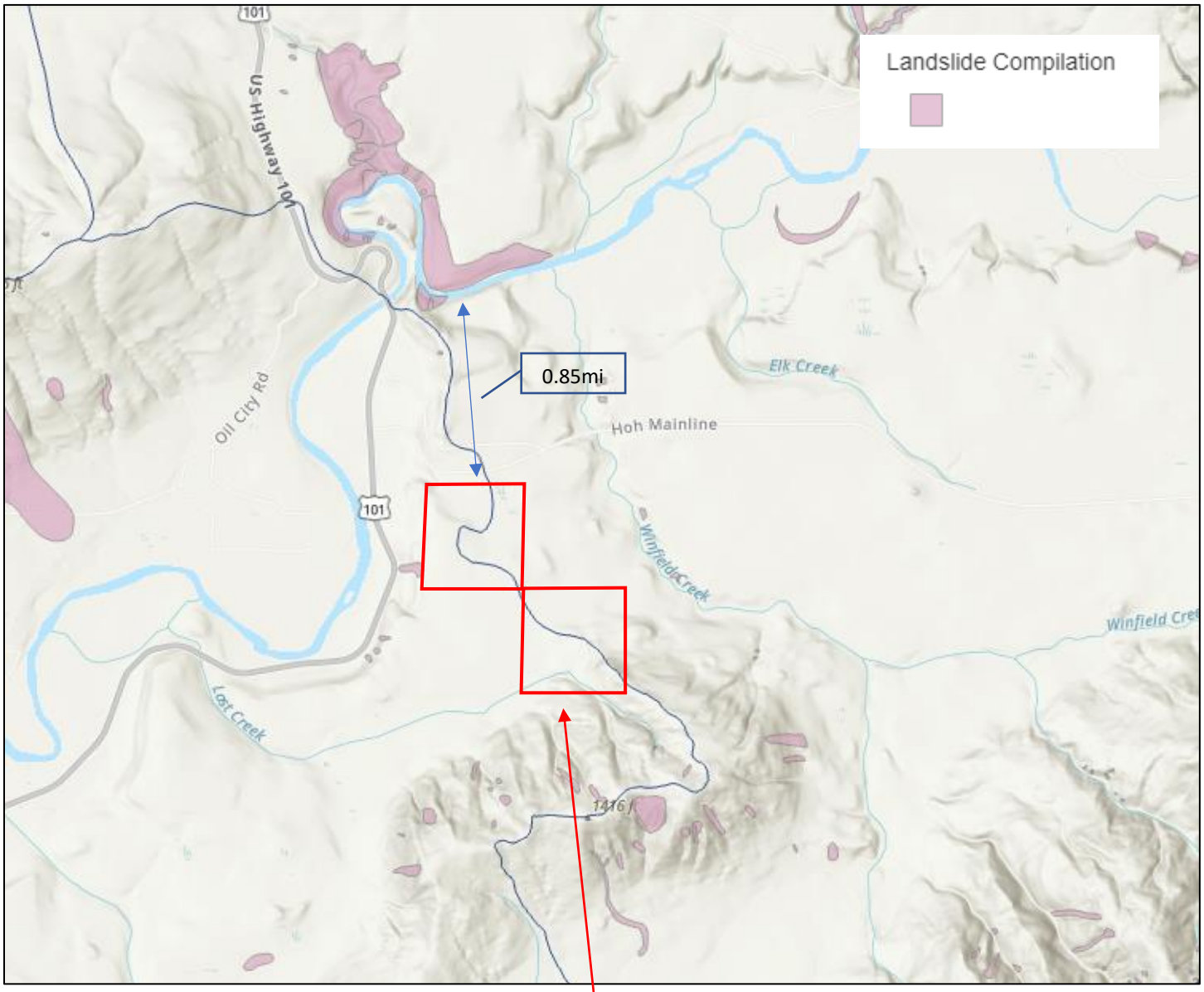
Geologic Map

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure 6



Approximate Site Location

An excerpt from the Washington State Department of Natural Resources Geologic Information Portal (https://geologyportal.dnr.wa.gov/)

N W E S

Not to Scale

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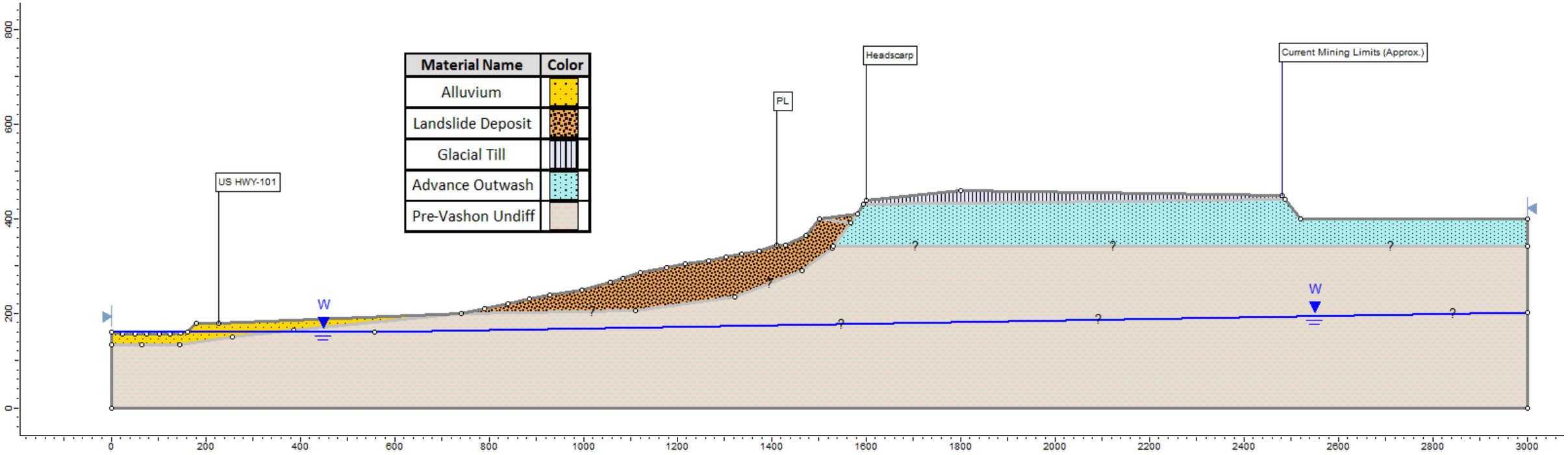
WGS Landslide Hazard Map

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure 7



Notes: All dimensions in feet
PL = Property Line

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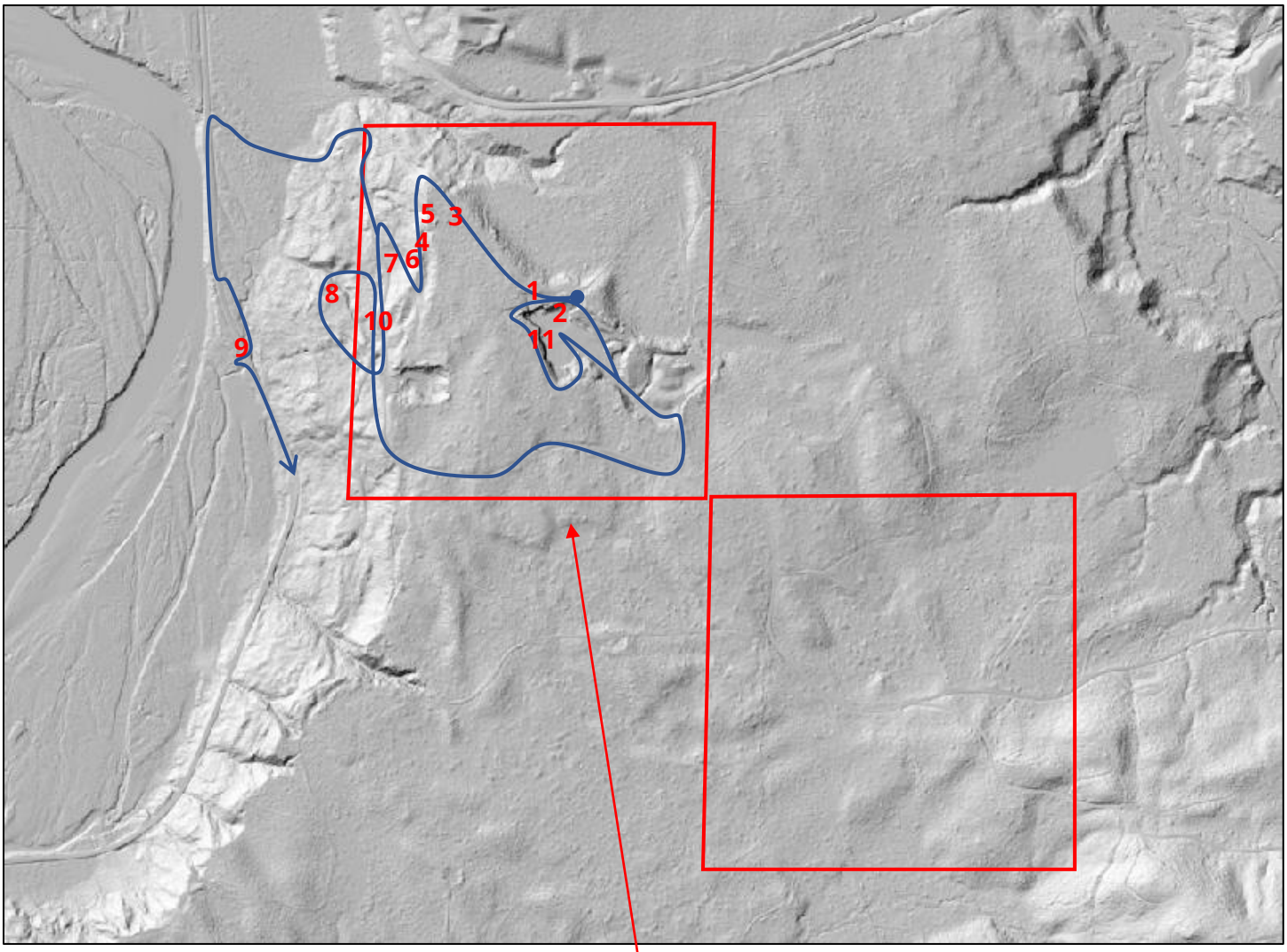
Geologic Cross Section A-A'
Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

DocID: JJCResources.StRegisPit.F2.	September 2024	Figure 8



Approximate Site Location

An excerpt from the Washington State Department of Natural Resources Geologic Information Portal (https://geologyportal.dnr.wa.gov/)

Approximate site reconnaissance path

\# Key features*****

***Corresponding annotated site photos are included in Appendix A of this report.**

Not to Scale

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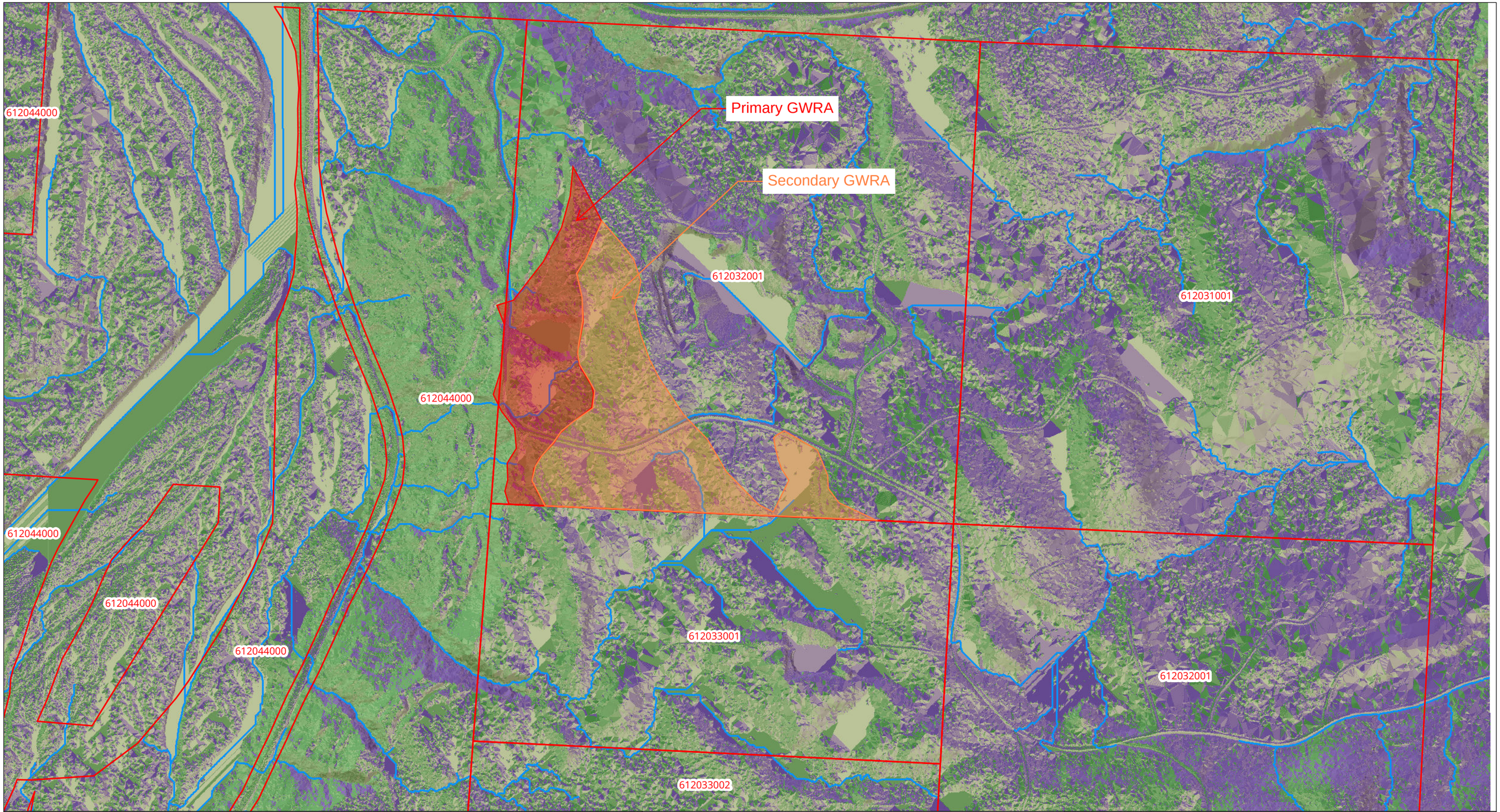
Site Reconnaissance Map

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure 9



Legend

Parcels
Channels
North
Northeast
East
Southeast
South
Southwest
West
Northwest

0 280 560 1,120 1,680 Feet

1 in = 500 ft

N W E S

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Catchment Model

Proposed Surface Mine Expansion
Hoh Mainline
Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	September 2024	Figure 10

Appendix A

Annotated Site Photos

Image 1. Tree clearing in area of proposed mine expansion.

Image 2. Active mine operation area.

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Annotated Site Photos

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Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure A-1

Image 3. Standing water in upland area, perched on glacial till

Image 4. Upright second growth stump on head of slide

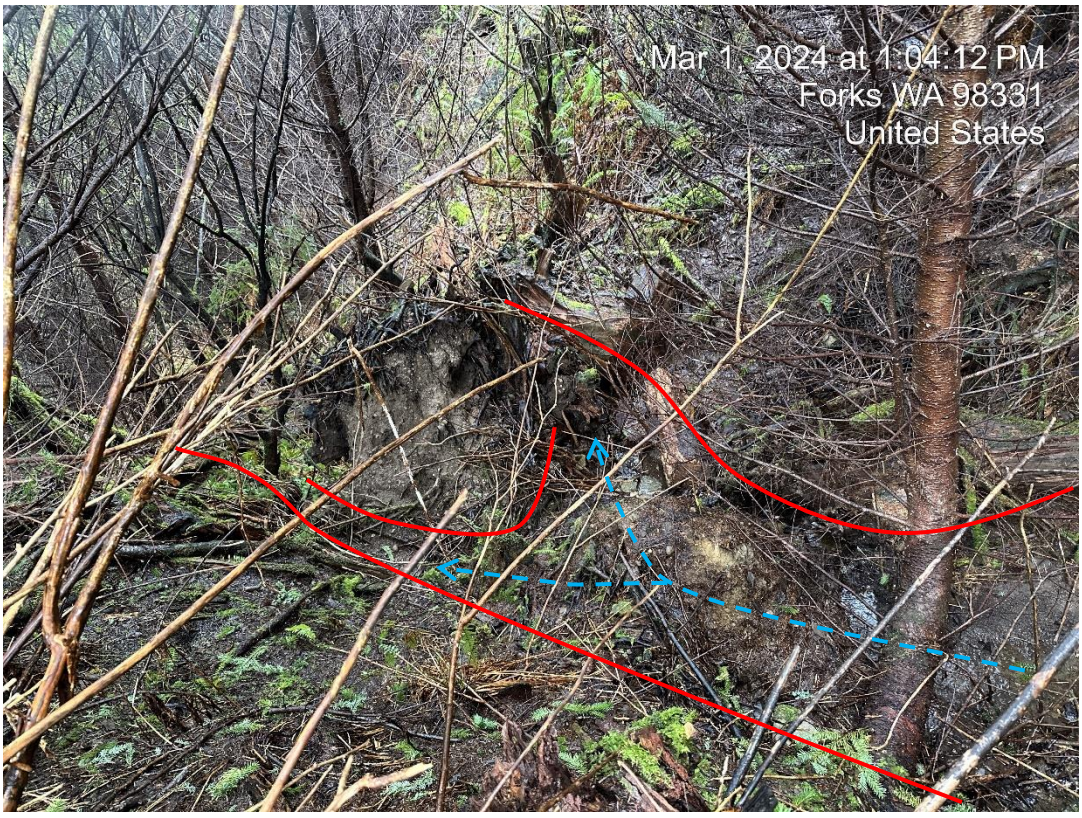

Image 5. Channel and flow path draining from upland over crown of slide

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Annotated Site Photos

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Jefferson County, Washington
PN: 612032001

Doc ID: JJCResources.StRegisPit.F	Sep 2024	Figure A-2

Image 6. Upright second growth stumps on landslide deposit

Image 7. Pistol butted immature trees on landslide deposit

Image 8. Channel and flow path on DNR parcel, downstream from seep zone at approx. el. 360 feet

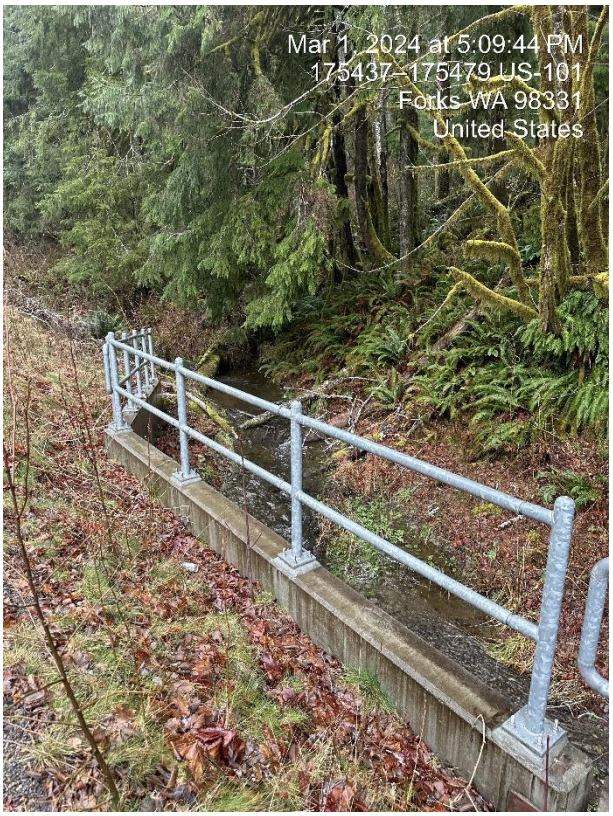

Image 9. Culvert at toe of slope near HWY 101

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Annotated Site Photos

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Image 10. Roadcut showing backrotated contact in the head of the landslide

Image 11. Active mine wall

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Annotated Site Photos

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