GEOLOGY AND GROUND WATER REPORT FOR THE EXPANSION OF THE MAINLINE FIVE MILE PROJECT SNOQUALMIE FOREST, KING COUNTY, WASHINGTON

June 21, 2021
Project No. 2021-608

1. INTRODUCTION

The Mainline Five Mile project is located about five air miles northeast of the City of Snoqualmie, in King County, Washington. The project lies along the southeast side of the Snoqualmie Forest Mainline Road at about Milepost 5. Access to the site is via SR 202 to Mill Pond Road to the Mainline Road and is located on 960-acres of land leased from the Weyerhaeuser Company in Sections 11 and 14, Township 24 North, Range 8 East, W.M. (Figures 1 &2). The current operation was started in 1998 and consists of an 80-acre permit area that was developed in four phases, each lasting about 5-years. Under the proposed expansion, the project will continue for another 30-years under a 6-phase mining plan developed on adjacent property east of the current operation. The surrounding area for many miles in all directions is commercial forest land controlled by Campbell Global, a Timber Investment Management Organization (TIMO).

The subject site lies within an upland plateau at an elevation of about 1,000 feet. The area surrounding the project is relatively flat forestland containing dense stands of second to third growth Douglas fir, Western hemlock, scattered hardwoods with an under story of low growing native vegetation. Onsite drainages include 10 Creek and Tate Creek. Ten Creek flows through the northern portion of the lease area, about 400 feet north of Mainline Road which is the north boundary of the proposed permit expansion. The headwaters of Tate Creek lies within southeastern portion of the lease area within an area referred to as Wetland "B." Along the south side of the current operation is Wetland "A" which has been monitored monthly since 2005. Monitoring reports are submitted to King County each February. Existing developments include a paved internal access road, temporary secondary gravel roads, a truck wheel wash, two office trailers and three storm water infiltration ponds. The proposed expansion area also contains secondary logging roads and crude tracked trails previously used by the King County Biosolids program.

The current operation is regulated by four government agencies: King County Department of Local Services Grading Permit No. L04C6431, Washington State Department of Natural Resources (DNR) Surface Mine Reclamation Permit No. 70-012894, Washington State Department of Ecology (DOE) Sand and Gravel General Permit No. WAG 503368, and Seattle-King County Public Health Inert Waste Landfill Permit No. PR0084509. The Inert Waste Landfill Permit was obtained at the request of the DOE at a time when the project was receiving backfill soil from tunnel boring projects in the Seattle area. Such soil did not fit the strict definition of "clean" as it included bentonite clay which had been added to facilitate drilling by the tunnel boring machine and to impede ground water migration. The landowner, the Weyerhaeuser Company allowed this soil to be imported under special circumstances, but not other materials typically associated with inert waste such as construction debris. The project no longer imports such soil.

2. GEOLOGY AND GROUND WATER CONDITIONS

The regional geology of the project site was mapped by Tabor et al (1993). In general, the underlying geology consists of pre-Tertiary metamorphic rocks (older than 65 million years) that are overlain by Pleistocene age glacial sediments (2.6 million to 10,000 years before present). The glacial sediments exposed in the project area consist of Vashon age (18,000 to 10,000 years ago) glacial drift consisting of lodgment till and recessional outwash that form the surface of a flat-lying upland plateau. The glacial sediments fill in pre-existing subsurface bedrock topography.

Pre-Tertiary Bedrock (pTm)
The bedrock units consist of highly metamorphosed marine sandstone and shale, locally cut by basaltic dikes. The bedrock underlying the site correlates with the basement rocks of the northern Cascade Range that pre-dates volcanic activity of the Cascade Range. In this area, these rocks form an impermeable aquitard.

The bedrock is exposed in the local vicinity in a number of resistant knobs that rise as isolated topographic highs above the surrounding glacial plateau. One such knob is located in the north-central portion of the expansion area, and it separates mine Phases 1 & 2 from Phases 4 & 5. Subsurface excavations within the project area indicate that bedrock knobs have also been buried in the glacial drift. On the north side of the project area bedrock has been exposed by Ten Creek, which forms a steep ravine 200 to 400 feet to the north of the Snoqualmie Mainline Road. Elsewhere, bedrock is exposed along the edges of the glacial plateau in Tokul Creek 2-1/2 miles to the west and by the North Fork Snoqualmie River 2-3 miles to the east and south of the site.

Vashon Drift, Lodgment Till (Qvt) and Recessional Outwash (Qvr)
Following the volcanic activities and uplift that created the Cascade Range, glacial ice sheets repeatedly advanced across the Puget Sound Region during the past 2 million years. During the latest ice advance, from about 18,000 to 10,000 years ago (Vashon Stade of the Frazer Glaciation), an ice sheet in excess of 3,000 feet thick covered the site and extended across the Puget Lowland from the Cascade Front on the east to the Olympic Mountains on the west. Lodgment till was deposited at the sole of this advancing ice sheet and consists of an unsorted mixture of sand, silt, gravel, consolidated to a dense state by the weight of the overlying ice. Within the project area the till was deposited directly atop bedrock, however elsewhere in the region till overlies older glacial units. The till is considered an aquitard due to its high silt content and densely consolidated state.

About 10,000 years ago as the ice sheet receded, enormous meltwater channels formed along the edge of the continental glacier at its border with the mountain front. These channels contained ice-dammed lakes that filled with gravel and then repeatedly ruptured as the ice containment broke away. The meltwater streams deposited extensive sheets of sand and gravel, with occasional beds of boulders that probably represent outburst flood events. The previous mapping suggests that the project site lies along the western edge of an ice marginal outwash channel; deposits to the west of the site are characterized by lodgment till and to the east of the site by coarse gravel and boulders. Present day lakes and wetlands that lie along the paleo outwash channel typically represent glacial kettles, or areas where large blocks of stagnant ice became buried by outwash. When the ice finally melted the gravel collapsed upon itself leaving an enclosed topographic depression that frequently filled with water.

Typically, recessional outwash overlies lodgment till. However, within the project area the outwash commonly lies directly on bedrock. This indicates that the till was never deposited, or it was eroded away by the meltwater streams. The recessional outwash in this area is typically a sandy, cobbly gravel, with low silt content and is thus rather permeable to ground water flow.

Expansion Area Geology

A total of 24 exploration pits were completed within the expansion area as well as 5 ground water monitoring wells. Logs for these explorations are attached to this report and their locations are plotted on Figure 3. Cross sections are displayed on Figure 5. In general, the geology encountered in the expansion area was the same as within the current permit area, except that less ground water was encountered. The gravels in the expansion area are at a somewhat higher elevation than within the current permit area and thus are above the local water table. Coarse grained recessional outwash (Qvrg) was encountered at the surface in all of the explorations, and it typically consisted of sandy cobbly gravel with abundant boulders and a low silt content. Locally fine to medium sand was encountered in the Phase 4 northeastern portion of the expansion area (TP19-5 and TP19-7). The thickness of the recessional outwash varied from less than 5-feet thick in TP19-18, to more than 50-feet thick in EB-4. As discussed previously, the recessional outwash fills in and covers pre-existing topography, which accounts for the great variation in the thickness of this unit.

Underlying the recessional outwash, lodgment till was encountered at a depth of 5 feet in TP19-18, 11 feet in TP19-17,18 feet in TP19-5, and a depth of 55 feet in EB-4. The till consisted of dense, moist, gray, gravelly silty sand, and is interpreted to occur as discontinuous lenses deposited directly atop the bedrock. Till occurs at the surface across the broad level plain to the west of the site and also occurs along the base of bedrock knobs to the west and south of the project area (Tabor 1993).

Bedrock was also encountered beneath the recessional outwash at 10 feet in TP19-6 and TP19-10, and at a depth of 45 feet in monitor well EB-2. As discussed previously bedrock occurs at the surface within an elongate knob in the north central portion at the juncture of mine Phase 1 & 2 with Phases 3 & 4. It generally consisted of hard, brownish black, highly metamorphosed shale and sandstone.

Surface Drainages

As seen on the site map, Figure 3, the Ten Creek drainage passes within about 300 feet of the north side of the expansion area and Tate Creek originates as a perennial stream about 600 feet from Phase 3 in the southeastern portion of the lease area. Topographically the Mainline Road lies along the drainage divide between Ten Creek and Tate Creek. This divide is most likely due to a bedrock high which diverted the Ten Creek drainage from a north-to-south flow direction to an east-to-west direction. About ½ mile south of this bedrock high are the headwaters of Tate Creek, which flows in a southerly direction at the same longitude as Ten Creek before its westward diversion. (Figures 1-3).

A large wetland referred to as Wetland A of this report lies along the south side of the existing operation, and to southwest and west of Phases 3 and 6. A 300-foot, undisturbed, forested buffer has been left between this wetland and the existing operation and this buffer will also be extended on the ground adjacent to Phase 3. This wetland drains primarily through the subsurface, toward the southeast, where it eventually flows into a tributary of Tate Creek about 1000 feet southeast of the Phase 6.

As part of the permit conditions for the existing operation, monthly monitoring of hydrology and water chemistry is conducted at three wetland stations in Wetland A and four ground water monitoring wells within the current permit area. Semi-annual vegetation monitoring is also performed by a qualified wetland biologist. A report on wetland conditions is submitted annually to King County each February since 2007, with the latest report submitted in February 2021. As the existing operation reaches the end of its mine-life, the monitoring to date has found no measurable impacts to Wetland A as a result of the project.

The Tate Creek perennial initiation point (PIP) lies within a forested wetland referred to as Wetland B in this report. Wetland B has a lower rating than Wetland A and thus will be afforded a 215-foot undisturbed forested buffer. Two new wetland monitoring stations will be installed at Wetland B upon expansion approval to monitor hydrology and wetland chemistry. One station will be at the placed at the Tate Creek PIP and the other at a ground water seepage at the far western end of the wetland.

Wetlands A and B are not hydrologically connected as there is a bedrock/lodgment till subsurface high that separates the two wetlands (Figure 5). Wetland A has a large, hydrated surface at an elevation of about 948 feet above sea level that typically stays hydrated for 8-9 months of the year and drains mostly through the subsurface. Wetland B has a hydrated surface and an elevation of about 960 feet above sea level and drains mostly through ephemeral streams that were observed to be dry in late March 2021.

<u>Ground Water</u>

Within the existing permit area ground water was encountered in monitor wells MW-2, MW-3, and MW-4, and EP-23. Water elevations have been monitored in these and at staff gauges placed at the three wetland stations on a monthly basis since 2006. The monitoring has demonstrated that the ground water beneath the site is in close hydraulic continuity with surface water in Wetland A. The monitor wells and wetland staff gauges indicate that the water table is rather flat across the site and occurs at an elevation of about 948 feet above sea level. This is also the approximate elevation of surface water in Wetland A. Rainfall has been tracked on a monthly basis since 2006 and it shows that the elevation of ground water and wetland surface water is closely related to monthly precipitation. Graphs of the past 15 years of ground water, surface water, and precipitation are attached to this report. For information on water chemistry please refer to the latest annual report (Bennett and McGrath, 2021).

The flat water table associated with Wetland A is consistent with the coarse permeable nature of the underlying recessional outwash beneath the current project area and proposed expansion. The presence of bedrock highs to the west, north and east of Wetland A suggest that it lies in an isolated recharge basin. The explorations completed to date indicate that ground water flow within the existing project area and the western portion of proposed Phase 3 expansion is nearly entirely toward Wetland A (Figure 5, Section A-A'). Ground water was not encountered in any of the explorations completed within expansion phases 1 and 2. However, the elevation of till in this area suggests that onsite precipitation which does infiltrate into the surface gravels would likely migrate along the surface of the till toward Wetland A.

The recharge area of Wetland B is confined on its west and north sides by bedrock and till, which was encountered at shallow depths in expansion phases 2, 3, and 5. An unknown area of recharge does exist on offsite areas east of Wetland B. However, based on current observations, the limited hydroperiod and the presence of ephemeral streams suggest that Wetland B recharge is restricted to onsite precipitation within the wetland with minimal recharge by ground water. The proposed monitoring stations which will be installed as part of the expansion should provide more detail regarding hydroperiod and recharge area.

It should be noted that Wetland B is about 10-feet higher in elevation than Wetland A, as they are separated by a bedrock and lodgment till barrier, and they formed in separate ground water basins. While both wetlands provide recharge to Tate Creek, with Wetland B containing its headwaters, the actual recharge provided by Wetland B is relatively small compared to other sources. Other sources include the tributary draining Wetland A which empties into Tate Creek about 4,000 feet south of its headwaters in Wetland B. The most significant source of recharge however is provided by Lake McCleod, which has an outlet joining Tate Creek about 1-½ miles south of Wetland B. Upstream of this tributary, Tate Creek flows through a relatively deep canyon carved into bedrock, which appears to be too large for its current flow. This suggests that Tate Creek is an undersized drainage, and that its current pathway was carved out during glacial times when flow rates were significantly higher.

Repeated dam-breach floods have raced down Tate Creek and in the past have compromised the access road and residential properties in the downstream Ernie's Grove settlement. These floods were attributed to the failures of beaver dams along the outlet of Lake McCleod (Mike March, Campbell Global Area Manager, personal communication). These occurrences start a mile downstream of the project area and have no relevance to Wetland B. As discussed above, Wetland B has a limited hydroperiod, and is judged unlikely to host beaver habitat.

It is also considered extremely unlikely that any activities within the project area would have an impact on domestic water wells as the closest wells are located nearly 3-miles southwest of the site. While the source of the water supply for these wells is unknown, the large distance and discontinuous geologic units underlying the site indicate that the chance of a hydraulic connection between the site and these wells is remote. Thus, the only ground water impacts would be related to Wetlands A & B and the headwaters of Tate Creek.

3. <u>PHASED DEVELOPMENT OF THE EXPANSION AREA</u>

The proposed expansion area comprises 175 acres and has been divided into six phases as shown of Figures 3 & 4. Each phase makes up approximately 30 acres and will be developed over a period of about five years. Typically, each phase will contain about 500,000 cubic yards of gravel and will be backfilled with about 2,000,000 cubic yards of imported soil. The thickness of the gravel within each phase varies from about 20 feet thick to more than 50 feet thick, so exact volumes will be determined at the time of development. The gravel will be mined down to a depth of where glacial till or bedrock is encountered and then backfilled. Where the gravel is especially thick ground water will be encountered before till or bedrock is reached. In such areas the excavation will stop 3-feet above the seasonal high-water table per King County guidelines. Based on 15 years of monitoring, the seasonal high-water table is at an elevation of 950 feet in the winter months which falls to below 947 feet in summer.

Gravel mining and soil backfilling procedures will be the same in the expansion area as it has been for the existing project. A given mine segment will be first cleared, followed by the construction of an access road and perimeter berm, with infiltration trenches with check dams that drain into an infiltration pond. Gravel will be mined down to an elevation of approximately 960 feet above sea level, unless till or bedrock is encountered at a higher elevation. As the excavation is completed it will be backfilled with fine grained native soil, defined as “clean” and free of contaminants per existing State and County permit conditions. As one segment is completed the process will be repeated for the next segments, as has taken place with the existing operation.

Typically, clean fill soil is imported from excavation projects in the local region by 25-yard tandem truck and trailer rigs that enter the site via the existing access and transport their loads to the active excavation/fill area. Depending on the job, the trucks may then backhaul excavated gravel from the site using the existing exit road and wheel wash. At times of peak production, up to 150 truckloads, or 3,000 yards of fill may be placed daily.

During excavation, temporary mine slopes are cut to a maximum 1H:1V gradient using a conventional track-mounted excavator prior to backfilling. The backfill material is inspected, monitored, and tabulated per the existing Clean Fill Acceptance Agreement prior to onsite transport. The fill soil is generally transported to the lowest portion of a depleted mine area and pushed into place in loose lifts with a bulldozer. The fill is then dozer-walked to achieve preliminary compaction. Once the soil is consolidated enough to accommodate heavy equipment travel, a layer of crushed rock is placed along the top of the fill soil to provide a driving surface. Final compaction is achieved by driving loaded dump trucks across the imported fill. Once a given lift of fill has been placed and compacted the process will be repeated, layer upon layer until the desired elevation of about 1040-feet above sea level has been achieved against the pre-constructed containment berms (Plates 1&2). Per DNR requirements final slopes must be at a 2H:1V or gentler gradient. Once the desired elevation and slope gradient have been achieved, the exposed slopes are hydroseeded with a deep rooting grass/forb mixture (Plates 2& 3). Eventually the entire site will be planted with trees and revert to commercial forestland.

4. STORM WATER MANAGEMENT

During the phased development, storm water management will be conducted in the same manner that has been done for the past 20-plus years. Because this is a gravel pit underlain by coarse, clean aggregate, surface water runoff is a non-issue within the open excavations of the active mine areas. Once backfilling with fine-grained soil starts, runoff will occur when the backfill reaches the elevation of the top of the pit. This runoff has and will be controlled through the construction of perimeter infiltration trenches that drain toward an infiltration pond. To date, the perimeter trenches alone have proven sufficient to infiltrate runoff. Only the initial pond, located at the western end of the current operation, accumulated silt. This occurred during the early years of backfilling. Even before pond cleanup occurred a few years ago, the water level never came close to overtopping its bank, as infiltration readily occurred along the sides of the pond.

Based on the past history of this site, it was recommended to CPH Engineers that the design of infiltration facilities in the expansion area should use the highest rate available in the King County Surface Water Design Manual (KCSWDM). To confirm this recommendation, King County personnel requested that a Pilot Pond Infiltration Test be conducted in the area of the proposed expansion. It was not possible to follow the exact procedures provided in the King County manual as the nearest hydrant was 5-miles away. Instead, a 4,000-gallon water truck was commissioned to provide the water supply. However, because the proposed expansion area is underlain by 25-feet of unsaturated cobbly gravel it was not possible to achieve saturated conditions with the available water supply. Even if a high-volume hydrant had been available, it is judged extremely unlikely that saturated conditions could ever have been achieved, regardless of the water supply. The results of the test conducted are, as follows:

> A 10-foot by 10-foot excavation was dug down to a depth of 5-feet below the surface and a staff gauge was installed with graduations in feet and inches. Water was pumped via a fire hose into the pond at a rate of 37 gallons per minute for 27 minutes, which failed to fully fill the bottom of the pond with water. To increase flow, the nozzle was removed from the fire hose and a flow rate of 86 gallons per minute was achieved. For 35 minutes, from 27 minutes to 62 minutes into the test, a water level of 1-inch was achieved across the bottom of the pond until the 4,000 gallons in the water truck was gone. Within less than one minutes from the time of flow stoppage the pond was empty again. Further testing was not attempted due to the long lead time in obtaining another load of water.

The results of this test, the long history of infiltration at this site, the flat water table, along with the coarse, cobbly gravels encountered in test pits, strongly suggest that a high infiltration rate is suitable for this project when conducting storm water calculations.

5. ANTICIPATED PROJECT IMPACTS AND MONITORING PROGRAM

Under existing conditions onsite precipitation readily infiltrates into the ground. This maintains the local ground water regime and ultimately contributes recharge to Wetlands A and B. Published reports for the North Bend / Snoqualmie area provide estimates of recharge between 31 and 45 inches per year (USGS, 1995). Within depleted mine phases where backfilling is complete, the rate of recharge will be reduced due to the finer grained nature of the backfill soil. However, the reclaimed site will be returned to forest cover and will still be relatively flat. The forest cover and flat topography should effectively contain onsite precipitation. Thus, the annual amount of recharge should remain the same as with predeveloped conditions, as there will be no surface water flowing offsite. Therefore, the overall water balance between precipitation and recharge to shallow ground water should not change between existing and reclaimed conditions.

Within the current operation, the data gathered since 2006 show that the use of interceptor trenches, infiltration ponds, and effective wetland buffers, have maintained the existing water balance between shallow ground water and wetlands. As discussed above, the attached Plates 4-13 show that the existing operation has had no measurable impact on the hydrology of Wetland A. As part of the proposed expansion, the use of interceptor trenches, infiltration ponds, and wetland buffers will continue. Because Wetland B receives less percentage of its recharge from ground water than does Wetland A, we expect no measurable impacts on Wetland B as a result of the project.

To document ground water and wetland conditions across the expansion area the newly established monitor wells will be monitored on a monthly basis along with the existing wells and wetland gauges. When the two new wetland gauges are established, one on the west side of Wetland B and the other at the Tate Creek PIP, they will be rolled into the existing monthly monitoring program with the annual report of groundwater, wetlands, and vegetation conditions submitted each February. In the unlikely event that a measurable change in ground water or wetland conditions is recognized, the configuration and/or size of the infiltration ponds or the excavation areas would be adjusted. However, we consider the possibility of a project related impact to the wetlands or Tate Creek as remote, given the past history of this project.

As discussed above, there are no water wells within nearly three miles of this project. Thus there is little possibility of any impacts to domestic water supplies.

We trust that the information contained in this report satisfy your current needs. If you have questions or need further information, please contact us.

Sincerely,
Bennett Consulting, PLLC

George H Bennett LHG
Licensed Hydrogeologist

List of Attachments.

Figure 1	Regional Map
Figure 2	Vicinity Map
Figure 3	Aerial Site Plan
Figure 4	Mine Phasing Plan
Figure 5	Cross Sections
Plates 1-3	Operation Photographs
Plates 4-10	Groundwater, Wetland and Rainfall Graphs
Plates 11-15	Monitor Well Logs
Plates 16-39	Test Pit Logs

SELECTED REFERENCES

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