Technical Memorandum

Date:	December 17, 2021
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR – Justin Williams, Verena Winter
Subject:	Quarry Operations (Draft)

1.0 Introduction and Purpose

The Draft Environmental Impact Statements (EISs) prepared by the Washington Department of Ecology (Ecology; pursuant to the State Environmental Policy Act) and the U.S. Army Corps of Engineers (USACE; pursuant to the National Environmental Policy Act) evaluate anticipated impacts associated with construction and operation of a proposed Flood Retention Only - Expandable (FRE) facility (i.e., the Chehalis River Basin Flood Damage Reduction Project [proposed project]) in the Chehalis Basin, Washington State. The Chehalis Basin Flood Control Zone District (District) is the project proponent. During development of the Final EISs, Ecology and USACE requested additional information to inform the assumptions for quarry operations requirements. The previous work completed by HDR and Shannon & Wilson is the basis for this memorandum which advances the technical quantities of the quarries.

The FRE facility would require development of about 900,000 cubic yards (CY) or 1.7 million tons of aggregate materials (based on a bulking factor of 1.25 resulting from laboratory testing of the basalt that shows a density of 162 pounds per cubic foot [pcf] and assuming in place bulk density of 130 pcf). The amount of material required for road base and riprap have not been defined in detail. However, a quarry capable of generating up to 2 times the aggregate required for the dam is expected to provide a sufficient margin of safety required to the combined aggregate, road base, and riprap with a suitable allowance for waste associated with unacceptable rock such as weathered basalt or interbedded siltstone materials. It is unlikely the quarry rock would be suitable for conventional concrete and material would need to be furnished from offsite. The 900,000 CY does not include road surfacing quantities that may be required related to future negotiated Weyerhauser access requirements which have not been evaluated in this study. It is anticipated that less than 50,000 tons of aggregate materials will be acquired offsite from existing commercial sources and not be provided by the quarries.

This memorandum describes the two quarries that were identified in the area as potentially suitable for construction of the FRE facility. Additional information about the quarry area, rough order magnitude (ROM) of material that will be disposed, estimated amount of rock needed from the quarry, and equipment requirements to inform effects on air quality are provided below.

At this stage in the project, the configuration and operation of the quarries can only be approximated based on a general understanding of construction processes and accompanying best management practices for environmental protection. Final design of the FRE facility will include more testing, geotechnical field work, and analysis that will inform the accompanying quarry selection and operations. The ROM estimates provided herein will change once the design is further refined. HDR has used professional judgement to provide the recommended value for the EIS; however, this value can only be used as a guideline at this point in time.

2.0 Quarry Descriptions

Potential quarry sites for obtaining construction materials for the proposed flood retention structure (aggregate for roller compacted concrete [RCC], road base, and riprap) were first identified through a regional geologic mapping and assessment process. Following identification of a candidate quarry site, a sequence of site investigations, laboratory testing, and engineering assessments were performed.

The following quarry descriptions provide the quarry locations and a summary of the field investigations that have been completed including geotechnical borings and seismic refraction survey lines. For site investigation methodology details and results refer to the Phase 2 Site Characterization Technical Memorandum (HDR 2017) and the Phase 3 Geotechnical Data Report (Shannon & Wilson, Inc. 2019).

North Quarry: The North Quarry is located about 1.2 miles directly southeast (2.14 miles by road) of the proposed FRE facility site within the limits of the detention pool. The site is accessed off the main Road 1000 by Road 1013 (Figure 1). One seismic refraction survey line and four borings (one in 2016 and three in 2018) have been completed at this potential quarry site (Figure 2).

South Quarry: The South Quarry is located about 2.5 miles directly south (4.3 miles by road) of the proposed FRE facility site also within the limits of the detention pool. The site is accessed off the main Road 1000 by Road 1020 southwest of the site as it rises to the northeast and exposes a basalt outcrop along the southeastern margin of the site (Figure 1). This quarry site was added following the Phase 2 investigation when a Weyerhaeuser contractor improved the grade of the Road 1020, west of the mainstem Chehalis River, exposing basalt not previously visible. A grab sample of the rock from that road cut was tested in early 2018 and indicated that the rock may be promising for use as aggregate. Consequently, a boring was included in the Phase 3 investigation (Figure 3), but no seismic refraction survey has been performed.

3.0 Available Material Quantity Estimates at Quarries

Limited investigations have been performed at both quarry sites. Hence, significant uncertainties remain regarding depth of overburden, thickness of quality rock, and the lateral extents that would be required. Further drilling investigations would be required to develop a final quarry plan. Therefore, the quantity estimates described in the following sections should only be considered a ROM subject to future verification.

3.1 North Quarry

Figure 2 shows the proposed extents of the North Quarry and the locations of the four borings and one seismic refraction survey line conducted to assess the quality and quantity of basalt for use as aggregate, road base, and riprap. The area of the potential quarry is estimated at 820,000 square feet (sf) or 18.8 acres (ac). Table 1 shows the estimated overburden and basalt bedrock thicknesses from each of the four borings and the potential total volume of overburden waste and processed rock that could be produced using the estimated quarry area.

Table 1. North Quarry Boring Result Summary

Boring ID	Thickness (ft)	
	Overburden	Basalt
RNQ-16-301 (QB1)	38	76
RNQ-18-301	75	45
RNQ-18-302	48	30
RNQ-18-303	45	55
Volume (CY):	**1,564,074**	**1,564,074**
Average:	**51.5**	**51.5**

By averaging the thickness for both overburden and basalt between the four borings, the volume of each is about 1.5 million CY. The boring logs indicate only a few siltstone interbeds on the order of 6 inches thick. This would result in a minimal amount of waste material (expected to be less than 10%) within the basalt resulting in about 1.4 million CY or about 3.1 million tons of usable rock. The necessary volume of aggregate is about 900,000 CY for the RCC dam (HDR 2018), or about 1.7 million tons resulting in a calculated factor of safety of 1.8. Some of this excess material would be used for road base and riprap but quantities for these are not well defined and can be assumed to be included in the factor of safety.

It should be noted that the seismic refraction survey was not consistent with the boring data and displayed an overburden thickness ranging from 70 to 90 feet. Also, below the basalt is a layer of siltstone that is the lower boundary of useable bedrock. If the overburden thickness is greater than what is shown in the boring logs, as indicated by the seismic refraction survey, then the lateral extents of the quarry area may need to be increased to mine sufficient quantities of basalt for all the aggregate, road base, and riprap that may be required for the project.

3.2 South Quarry

The proposed extents of the South Quarry are shown on Figure 3 as well as the location of the boring conducted to assess the quality and quantity of basalt for use as aggregate, road base, and riprap. The potential quarry area is estimated at 750,000 sf or 17.2 ac. Table 2 summarizes the boring log stratigraphy.

Table 2. South Quarry Boring Result Summary

Depth (ft)		Thickness (ft)	Description
From	To		
0	35	35	Overburden
35	133	98	Basalt
133	146	13	Breccia/siltstone
146	180	34	Basalt

Notes:
Total basalt thickness: 132 feet
The boring ended at 180 feet within basalt which may extend beyond the depth of the boring

The single boring in the potential quarry indicates an overburden thickness of 35 feet which results in an estimated useable rock volume of about 980,000 CY. Within the potentially usable basalt bedrock, there is a layer of basalt breccia and siltstone that would be wasted resulting in a total thickness of usable basalt of 132 feet. The boring log indicates several zones of weak and highly weathered rock within the usable basalt, which is more variability than seen in the basalt at the North Quarry. A 30 percent waste factor was applied to be conservative. When a thickness of 132 feet is multiplied by the quarry area (750,000 sf) and reduced by the 30 percent waste factor, the resulting volume is about 2.6 million CY or about 6 million tons. This provides a factor of safety of 3.4, using the required tonnage (1.7 million tons). With only a single boring, there is significant uncertainty to the calculated quantities and thus a much higher factor of safety is appropriate for the South Quarry.

3.3 Existing Quarry Quantity Summary

The quantities for each quarry are summarized based on the limited amount of existing data in Table 3. Further investigation and analysis is required to verify these values.

Table 3. Summary of Quarry Quantities

Item	Unit	North Quarry	South Quarry
Area	sf	820,000	750,000
Overburden Volume[1]	CY	1,500,000	980,000
Overburden Weight[2]	ton	2,600,000	1,640,000
Initial Basalt Volume	CY	1,500,000	3,700,000
Waste Factor	%	10%	30%
Expected Waste Volume[1]	CY	156,407	1,110,000
Useable Basalt Volume	CY	1,400,000	2,600,000

Item	Unit	North Quarry	South Quarry
Useable Basalt Weight[3]	tons	3,100,000	5,700,000
Factor of Safety[4]	--	1.8	3.4

Notes:
1. No bulking factor was applied to the overburden volume
2. A bulk density of 125 pcf was assumed for overburden
3. Laboratory testing indicates a density of 162 pcf for the basalt
4. Factor of Safety based on a need of approximately 900,000 CY (HDR 2018) or 1,685,880 tons using a bulking factor of 1.25 based on laboratory results of the basalt and assuming an in place density of 130 pcf.

4.0 Quarry Equipment and Operational Time

Quarry and aggregate processing assumptions reflect equipment and construction approaches typical of large-quantity, project-dedicated, stripping, quarrying, and quarried-rock aggregate processing. A wide variety of equipment and production approaches could be employed which the following assumptions should reasonably represent.

At this stage in the project, requirements for equipment to be used to mine the quarries and the time it takes cannot be determined, is highly dependent on a contractor means and methods, and requires a more detailed design of the project to adequately inform the required quantities of quarried material. The following list provides typical equipment required for a quarry operation:

- Multiple large scrapers
- Multiple large bulldozers
- Multiple large front-end loaders
- Multiple large rock dump trucks
- Drilling rigs for blasting
- Rock crushers
- Grizzley bars
- Multiple water trucks
- Support pickup trucks
- Multiple road graders
- Multiple skid steers
- Multiple conveyor belts
- Fuel trucks
- Lube trucks

Considering the current preliminary level of design, the assumed quarry operation duration will be the full duration of the construction schedule anticipated at 5 years.

To determine the air quality impact of the quarry operations, equipment selections would need to be determined from the equipment list above and then applied to the anticipated duration of the construction. Assuming quarry operations will run 6 days a week at 10 hours a day, crew hours total 3,120 a year and 15,600 hours for the 5-year duration.

4.1 North Quarry

Overburden excavation equipment would involve large dozers (100,000 to 200,000 pounds, 350- to 550-horsepower [hp]), large excavators (100,000 to 230,000 pounds, 450- to 550-hp), and 35- to 45-ton (400- to 500-hp) articulated off-road haul trucks and/or 50- to 70-ton (500- to

800-hp) off-road haul trucks. Overburden excavation operations could be expected to take 8-12 months.

Similar equipment should be expected for the quarry drilling, blasting, and excavation for crusher feed; but include rock drills (400 hp +/-).

Crushing and processing equipment is likely to include large jaw primary crushing, cone, or vertical shaft impact secondary crushing, and vertical shaft impact tertiary crushing; together with associated feeders, conveyors, screen decks, and potentially aggregate washing equipment. Aggregate processing operations could be expected to utilize 1,000 to 2,000 operating horsepower over a period of 12 to 20 months.

4.2 South Quarry

South Quarry operations would look similar to the North Quarry operations but be expected to involve approximately half of the time for overburden excavation.

5.0 ROM Quantity Estimate of Quarry Area

This section provides a ROM estimate for the overall area of operations for each quarry option. Excluded from this estimate is the material needed for road improvements. The HDR December 17, 2021 Access Road Memorandum includes those estimates. Also excluded from this estimate is the amount of offsite materials needed for the FRE facility and for the conventional concrete structures. Those estimates are provided in the Temporary Construction Memorandum.

Table 4. ROM Estimated Quantities

	North Quarry	South Quarry
Overburden (feet)	51.5	35
Base Area (sf)	820,000	750,000
Total Base Area (sf)	1,639,520	1,511,428
Overburden Quantity Volume (tons)	2,190,000	1,400,000
Base Truck Loads	52,000	33,000
Material Hauled (cubic yards)	1,500,000	980,000

General Assumptions:

- Due to the topography in the area, it is unlikely that the spoil material can be similarly placed to how it was excavated.
- The estimated area does not consider any designed interior quarry roads and quarry excavation benching distances that are informed by a geotechnical slope stability design.

- The total base area (sf) is a summation of the base area of the quarry multiplied by two as it is assumed that the spoil area for the overburden is the same size as the quarry area.
- Any additional laydown area required for quarry support. (i.e., flat area for parking equipment for maintenance, fueling, and other support activities) is assumed included within the area range but has not been specifically applied to the base value.
- The calculated base area is multiplied by the depth of the overburden and equals the overburden quantity volume assuming a unit weight of 1.4 ton/CY
- HDR suggests using the truck load base value of material hauled in 42 ton off-highway trucks approximately 0.75 miles.

6.0 Literature Cited

HDR Engineering, Inc. (HDR)

2017 Phase 2 Site Characterization Technical Memorandum for Chehalis River Basin Flood Damage Reduction Project. June 2017.

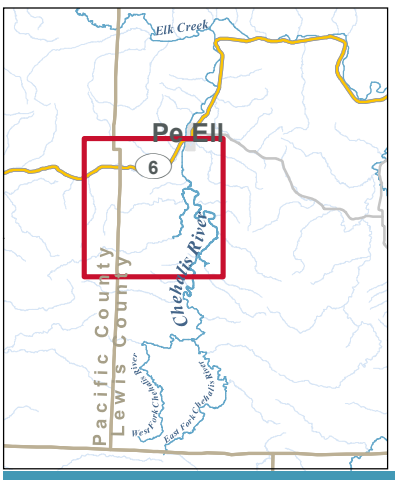
2018 Combined Dam and Fish Passage Supplemental Design Report FRE Dam Alternative. September 2018.

2021 Access Road Update and Best Management Practices. December 2021.

Shannon & Wilson (S&W)

2019 Phase 3 Chehalis Dam Geotechnical Data Report, Chehalis Basin Work Group, Pe Ell, Washington.

Attachment A. Figures



- Quarry Site
- Concrete Production Facility
- Existing roads to be improved for quarry site access
- Main channel OHWM

N

0 2,500 5,000
Feet

NAD 1983 STATE PLANE WASHINGTON SOUTH FT (FIPS 4602)

FIGURE 1

POTENTIAL QUARRY SITES UNDER CONSIDERATION

CHEHALIS RIVER BASIN FLOOD DAMAGE REDUCTION PROJECT

12/30/2020

Document Path: L:\Jobs\Chehalis\FIG-2_QR_SitePlan.mxd

Seismic Refraction Survey Line (2016)

RNQ-18-303

NORTH QUARRY

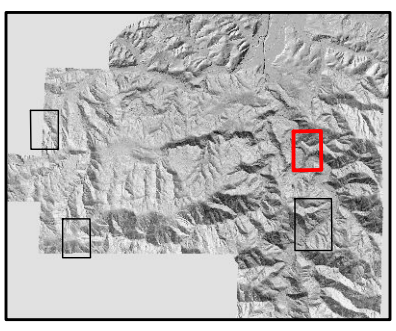
RNQ-18-302

RNQ-16-301(QB-1)

RNQ-18-301

Road 1013

Chehalis River



LEGEND

Landslide Location and Designation

LS-26

Quarry Site Location

Profile Location

Potential Dam Site Location

Completed Boring Locations

Recommended Boring Locations

NOTE:
Hillshade generated using ESRI 3D Analyst from LiDAR data provided by HDR. NAVD 88, Illumination 315

N
W E
S

0 300

Feet

Chehalis Dam
Rock Quarry Characterization
Pe Ell, Washington

NORTH QUARRY SITE PLAN

March 2019 21-1-21897-025

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FIG. 2

Document Path: L:\Jobs\Chehalis\FIG-2_QR_SitePlan.mxd

LS-13

LSB-18-311

LS-11

SOUTH
QUARRY

1,376,074 sf

RSQ-18-301

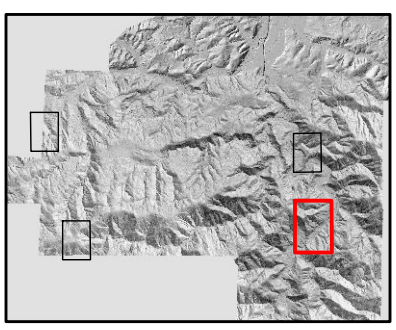
755,714 sf

Road 1020

LSB-18-309

LS-9

Road 1000



LEGEND

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N
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0 300
Feet

Chehalis Dam
Rock Quarry Characterization
Pe Ell, Washington

SOUTH QUARRY SITE PLAN

March 2019

21-1-21897-025

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FIG. 3