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Memorandum

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Subject	**Expanded Borrow Source Desktop Study – Pine Creek Dam**
Project Name	Pine Creek Reservoir
Attention	Chris Hyland, Walla Walla Watershed Management Partnership (WWWMP)
From	Greg Warren and Jaco Esterhuizen, Jacobs Engineering Group, Inc. (Jacobs)
Date	December 10, 2019
Copies to	Brian Wolcott, Walla Walla Basin Watershed Council (WWBWC)

Jacobs' previous technical memoranda described the geological setting and the potential for active faults below the dam. Given the risk of active faulting, a concrete dam is not considered a suitable dam type for the site. Acceptable dam types would include an earthen dam or an earth core rockfill dam constructed with conservative geometrical dimensions and suitable material to accommodate movement. For the core of a dam, which may be subject to fault offset, the resistance to concentrated leakage is the most important factor in the decision. Sherard (1974) classified core material based on its resistance to concentrated leaks, as follows:

1) **Very good** materials: Very well-graded coarse mixtures of sand, gravel, and fines
2) **Good** materials: (i) Well-graded mixtures of sand, gravel, and clayey fines; (ii) highly plastic tough clay (CH) with plasticity index greater than 20
3) **Fair** materials: (i) Fairly well-graded gravelly, medium to coarse sand with cohesionless fines; (ii) clay of medium plasticity (CL) with plasticity index greater than 12; (iii) coarse mixtures of sand, gravel, and fines
4) **Very poor** materials: (i) fine, uniform, cohesionless silty sand; (ii) silt from medium plasticity to cohesionless (ML) (plasticity index less than 10) because these materials are highly erodible

If borrow material for the dam core must be designed for a dam with a potentially active fault in the foundation (with acceptable estimated rupture movement), it is imperative that a **very good** or **good** borrow source be identified. **Fair** materials should only be considered if it can be concluded with a high degree of certainty that there is no active fault in the dam foundation. Under no circumstances should **very poor** materials as defined herein be considered for the dam.

During previous studies, including a review of geological maps, published geological and geotechnical reports, a field investigation, and laboratory testing, it has been determined that material such as plastic clay or well-graded silt/sand/gravel mixtures, suitable to construct a large dam on a potentially active fault, is not available near the site (Jacobs 2019). Nearby existing gravel and sand pits were observed during the previous search for local sources, but the local gravel pits were all situated on floodplains where a very shallow water table was present, which would limit large-scale development.

Because of these constraints, Jacobs conducted a limited desktop search for suitable materials in a larger geographic area, to evaluate whether more distant sources could be used

economically. This desktop study focused on available information about existing material sources; including sand/gravel pits, sand/gravel deposits that have not been developed, and potential clay material in the Ringold Formation.

1. Expanded Desktop Study

2.1 Database and Literature search on Existing and Potential Sources

The expanded desktop study began with a database search for active and inactive material sources within an approximate 40-mile geographic radius. This search included searches for gravel/sand pits, and clay sources. No existing active clay sources were found.

Attachment 1 is a map that shows locations of active and inactive material sources and types in both Oregon and Washington within the 40-mile radius. Table 1 provide details of the available information about these sources and material types. Note, complete information about each material source is not readily available and would require onsite reconnaissance. If the listed sand/gravel pits contain materials with sufficient fines that are sufficiently well-graded, they could provide **Fair** to **Good** dam core materials (as described). Additional information, such as laboratory test results and field borings, would be needed to confirm the gradations and the quantities available. Many of the originally identified sand/gravel pits are actually rock quarries used to produce crushed rock and aggregate and would therefore not be useful for large-scale fines/sand/gravel production.

The haul distances to these sources are up to 40 miles. The haul times could be up to approximately 1 hour each way, based on local speed limits and road conditions. In Umatilla County, Oregon, numerous sand and gravel sources have been developed in Missoula Flood gravels along the Columbia River. The closest existing sources to Pine Creek in Umatilla County are near Hat Rock State Park, approximately 40 miles from the site via Highway 730 through Wallula Gap. However, a large, unmined gravel deposit is identified on the geological map closer to the south side of Wallula Gap, approximately 35 miles (Walker 1973).

2.2 Ringold Formation Evaluation

As previous documentation mentioned, one potential geological resource is the Ringold Formation. This geological unit is mapped beneath Eureka Flats, northwest of the proposed dam site, on the southeastern side of the Snake River.

This formation consists of a heterogeneous sequence of gravel, sand, silt, and clay. It is described by Newcomb (1958) and Lindsey (1996) as having a stratigraphic thickness of about 620 feet of horizontally bedded continental sediments from about 340 to 960 feet in altitude. The uppermost 505 feet of the type section, between 455 and 960 feet in altitude, is composed of silt, sand, gravel, clay, and volcanic ash. Geological sections in some areas indicate tan, greenish, brown, clay that is described as “plastic, silty, and massive” (Newcomb 1958) between altitudes of 465 and 650 feet in elevation.

The lower part, extending upward from river level at 340 feet to the base of the lacustrine deposits, at 455 feet, is composed of a weakly indurated conglomerate member that was deposited by river currents. The lowest lacustrine composite of the Ringold is commonly called the "blue clay" section, and lies below the conglomerate and below river level, where it rests

upon the basalt bedrock. The blue clay is likely too deep to be exploited, as it is below Columbia River level.

No existing borrow or commercial material sources, such as gravel pits, were identified in the Ringold Formation in the study area. Table 2 describes the lithology from selected nearby well drillers' logs (Ecology 2019). The lithological descriptions are not always accurate, and are typically only used as a guideline to steer further exploration and research. Attachment 2 is a map that shows the general location of the wells researched, very crude outlines of potential clay sources, and areas of sand and gravel. In general, these sources are between 30 and 40 miles from the site, based on existing roads. The haul times are anticipated to be between 45 minutes and 1 hour, depending on speed limits and local road conditions.

2. Conclusions

Numerous existing sand and gravel pits were identified within a 40-mile radius of the proposed Pine Creek Dam site(s). These indicate large quantities of sand and gravel have been historically mined and additional resources are likely available. These sand/gravel pits, if they contain sufficient fines (greater than 30 percent, for example) and are sufficiently well-graded, could provide **Fair** to **Good** core material for a dam. Depending on additional fault mapping, data, and research, **Fair** to **Good** core material (such as sand/gravel mixtures with sufficient fines) may be suitable for constructing a dam core, provided there is a relatively low risk of active faulting in the dam foundation. Additional information would be needed about these sources to confirm their suitability and quantities, such as laboratory test results including gradations and field borings.

In addition, well drillers' logs from the Ringold Formation in the Eureka Flats area indicate that thick, near-surface clay deposits may be present within approximately 35 miles. If it is determined that the risk of an active fault beneath the proposed dam is relatively high, but still acceptable, an enhanced search for clay that would qualify as **Good** core material should be conducted in the area. A highly plastic clay (CH) with plasticity index greater than 20 would qualify as **Good** core material.

3. References

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TABLE 1 DATABASE AND GEOLOGIC MAP SEARCH

DOGAMI Minerals

COMMODITY	SITE NAME	OWNER	LAT	LONG	MAP UNIT
sand and gravel	gravel pit	S.D. Spencer & Sons Co	45.977311	-118.384943	Alluvium
sand and gravel	Eastside Pit	Ready Mix sand and gravel, Inc	45.961461	-118.382414	Alluvium
sand and gravel	Eastside Pit	Umatilla Co Road Department	45.961461	-118.382414	Alluvium
sand and gravel	gravel pit	unnamed or NA	45.95096	-118.419236	Alluvium
sand and gravel	gravel pit	unnamed or NA	45.957636	-118.434689	Alluvium
sand and gravel	gravel pit	unnamed or NA	45.908466	-119.159454	Flood deposits

WA Surface Mine Sites

Sand and Gravel		WALLA WALLA GRAVEL & ROCK	46.136341	-118.24354	Basalt

Undeveloped

sand and gravel	n/a	Undeveloped; large gravel deposit identified on Geologic map.	45.951661	-119.040339	Flood deposits

WA Nonmetallic Minerals - old historical inactive sources

Common clays and shales	Kennewick	(not active)	Silty alluvial clay	Used in making common brick by Columbia Clay Co. about 1910
Common clays and shales	Dayton	(not active)	Palouse Formation clay.	Brick yard formerly used this material.
Common clays and shales	Walla Walla	(not active)	Recent alluvium	A good grade of brick and tile formerly made from this material at brick plant near the site.

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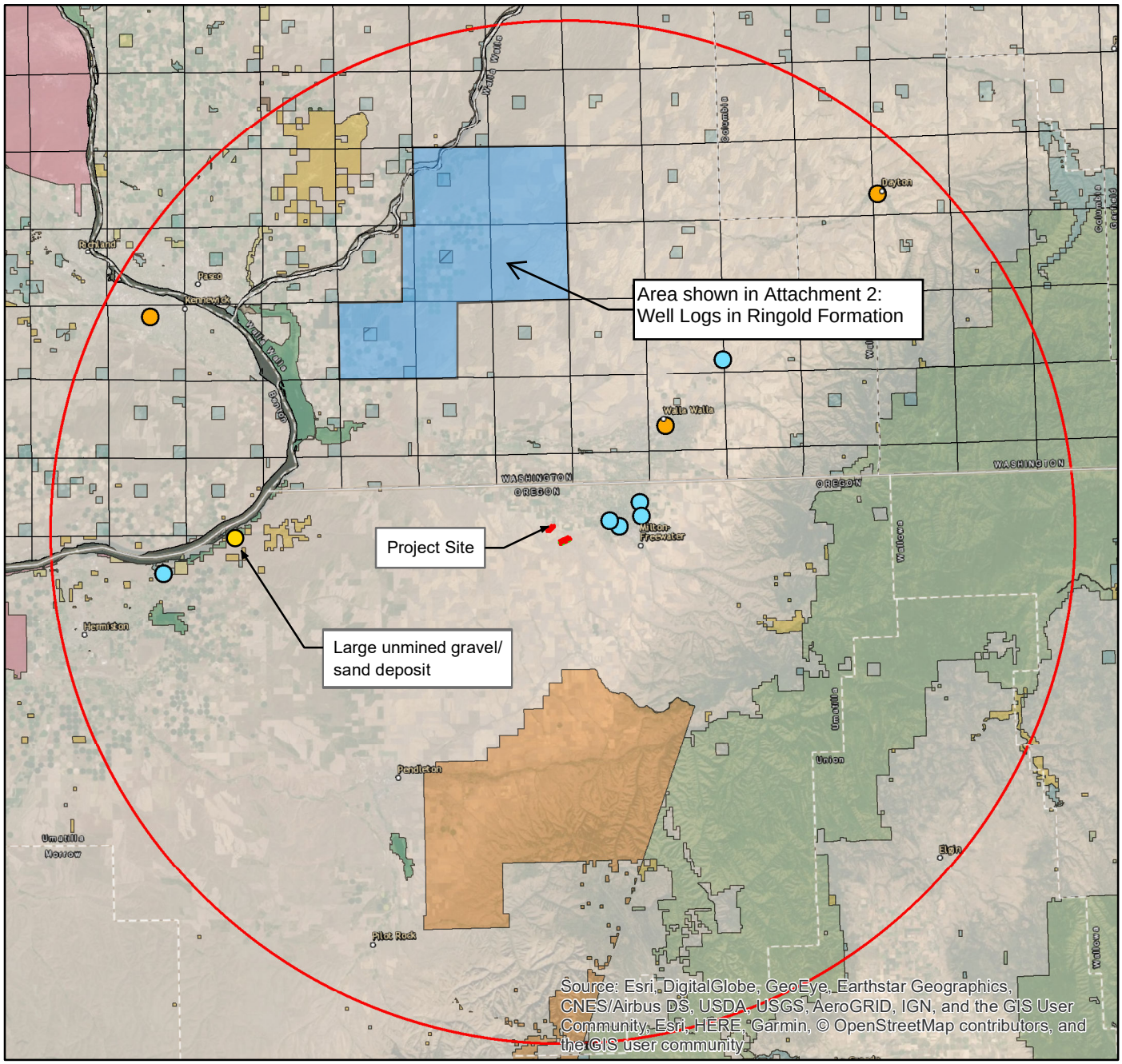
TABLE 2 WELL LOGS AND LITHOLOGY

Well Name	Lat	Long	Formation	Depth/Lithology	Est. Haul Distance (mi)
KZH Farms	46.2987	-118.636	Ringold	0 - 3 overburden 3 - 220 Gray clay	32
Willits	46.2963	-118.6827	Ringold	0 - 3 topsoil 3 - 40 Silty sand gravel cobble	35
Provencher	46.2308	-118.7246	Ringold	0 - 38 Brown sandy clay 38 - 45 light clay and boulders	35
Alpha 6	46.1992	-118.7404	Ringold	1 - 10 silty sand 10 - 35 brown clay	26
Grand View farms	46.1455	-118.8082	Ringold	0 - 31 sandy brown clay 31 - 34 brown claystone 34 - 86 brown clay	28
Kolke	46.1991	-118.8662	Ringold	0 - 89 brown silty clay 89 - 108 gravel	36
Davies	46.1924	-118.7591	Ringold	3 - 29 Till? Silty sand 29 - 67 blue sand	36
Hansen	46.3416	-118.6412	Ringold	1 - 3 topsoil 3 - 137 brown clay	36
Cowell	46.3494	-118.54893	Ringold	0 - 10 soil 10 - 90 sand - clay mix	36

Mesa	46.352	-118.5303	Ringold	0 - 15 sand	36
				15 - 29 clay	

Notes:

1. Haul distances approximated; don't include local roads/farm roads.
2. Lithology derived from well drillers logs



LEGEND

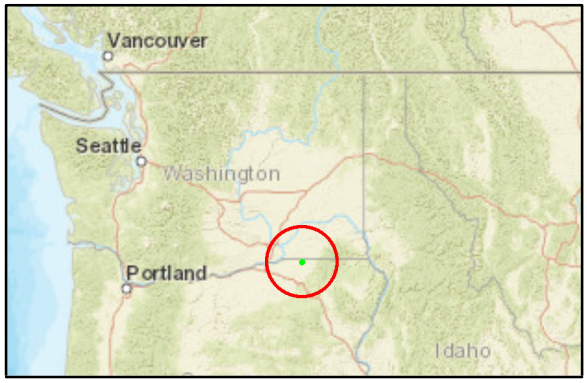
- Historic Clay Source
- Historic Sand & Gravel Source
- 40 Mile Radius from Project Site
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Corps of Engineers
- State
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Private

N

0 3 6 9 12

Miles

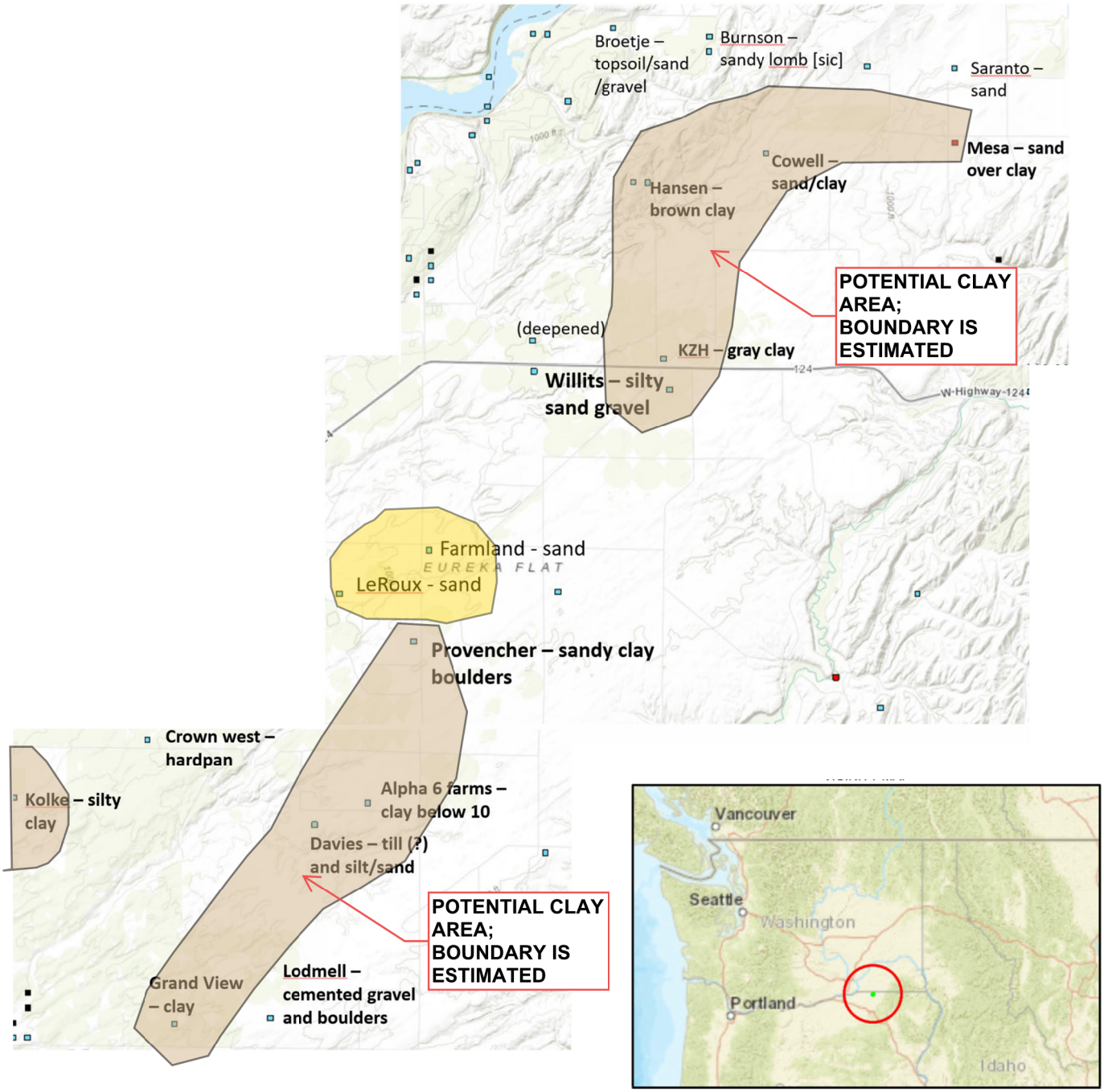
VICINITY MAP



Notes:

1. Refer to Table 1 for additional information on historic material sources.
2. Well Driller's Logs used to interpret lithology of Ringold Formation. See Table 2.

ATTACHMENT 1
Potential Borrow Sources
Expanded Desktop Borrow Source Study
Pine Creek Dam and Reservoir



ATTACHMENT 2
Well drillers logs - Ringold Formation
EUREKA FLATS AREA
Pine Creek Dam and Reservoir