1. Introduction and Background

The Pine Creek fault (DOGAMI) is mapped as a northwest-southeast trending fault along the floor of the valley. However, the precise trace of the fault is not known. In addition, the late Quaternary activity on the fault has not been documented. The Pine Creek fault is part of the larger Wallula Fault system, which is described by the U. S. Geological Survey (USGS) (Personius et al., 2003) as a prominent northwest-striking fault zone that extends from near Milton-Freewater, Oregon, to near Kennewick, Washington. The fault system includes several named faults in Oregon, including the Milton-Freewater, Pine Creek, Umapine, Wallula, and Wallula Gap faults. More information on the fault is available in the Technical Memorandum “Evaluation of Potential Active Fault in Dam Foundation, Pine Creek Reservoir Project”, prepared by Jacobs in October 2018.

2. Site Investigation Activities

Greg Warren, Jacobs geologist, and Jaco Esterhuizen, Jacobs geotechnical engineer, conducted a site reconnaissance on April 17 and 18, 2019 in preparation of a site investigation consisting of a limited fault study and initial borrow source identification. The site investigation will include field work consisting of test pitting and trenching to be performed the week of May 6th, 2019. The purpose of the reconnaissance was to:

1. Identify the general locations and extents of the test trenches for the fault study and
2. Identify potential borrow sources and test pit locations at these sources

Brian Wolcott from WWBWC and Mike Ingham from Gardena Farms Irrigation District met Jacobs in Umapine. They accompanied Jacobs to identify potential trench locations in the Pine Creek canyon. Brian then showed Jacobs potential borrow source locations in the valley, north of the site.

3. Fault Reconnaissance

3.1 Methods

Prior to the reconnaissance, Greg Warren performed a desk study by reviewing available published geologic mapping, and LiDAR and aerial photograph interpretations. He also had email discussions with Dr. Kevin Pogue, a geology professor from Whitman College.
To evaluate evidence of an active fault trace, the reconnaissance included driving and walking the proposed dam site and up and down Pine Creek to look for any indications of a Holocene-age (<10,000 year-old) fault rupture. Geologic evidence of active faulting can include offset geomorphic surfaces such as alluvial fans and young stream alluvium, linear drainage features, lines of springs, vegetative changes, changes in drainage patterns and density. Fault offsets (scarps) can be obscured by anthropomorphic changes (that is, plowing fields, buildings, roads), or covered by younger geologic deposits (e.g., Missoula flood sediments, windblown loess, or young stream alluvium).

### 3.2 Fault Reconnaissance Findings

1. Geologic evidence, including offset basalt flows, confirms the presence of a normal (dip-slip) or oblique-slip fault along the valley Pine Creek. The Pine Creek fault is a splay off the main Wallula Fault strand, which has been mapped north of the site.

2. The Pine Creek fault trace is interpreted to run beneath the northeast side of the valley, where bedrock is exposed in the creek channel. This would result from the valley being tilted northeastward by Quaternary faulting.

3. Young (Holocene-age) fault scarps in the recent alluvial floodplain appear to be absent. No fault scarps that offset geomorphic surfaces were observed during the field reconnaissance. These either don’t exist (i.e. have not been offset by faulting), or have been obscured by meandering creek channels, covered by younger stream deposits (overbank silts), or flattened during anthropomorphic processes (farming).

4. No offset alluvial deposits were observed in the vertical stream cuts along Pine Creek. However, Pine Creek was running relatively high during the site visit. More alluvium will be exposed as the creek recedes, and additional observations can be made.

5. If the main fault runs in a relatively straight line, then it may cross beneath the thick loess deposits on the southeast side of the valley. These are interpreted to be Pleistocene-age and would be offset by late-Pleistocene or Holocene faulting and scarps would be visible.

6. In general, the geomorphic expression of the Pine Creek valley does not suggest Holocene faulting. The valley is somewhat sinuous and not as linear as, for example, the drainage characteristics of nearby Dry Creek; or the Waterman Fault which has visible scarps.

7. The mapping indicates that the Pine Creek Fault bifurcates along Pine Creek both downstream and upstream from the proposed dam site. No evidence of offset was observed on the strands of the fault that cross the ridge northeast of Pine Creek.

Because of lack of surface expression of Holocene faulting, specific locations for test trenching could not be identified. Jacobs approach will therefore be to perform a relatively long trench that would span the alluvial deposits that mantle the valley floor, to attempt to detect the presence of Holocene offset on the Pine Creek fault. The trench will be excavated to expose the stream-deposited alluvium that is covered by thick silty overbank deposits that have been extensively farmed.

Attachment A shows a site-specific geologic map with the targeted area for the subsurface fault investigation. This map shows the geologic units in the vicinity of the proposed dam site, and the proposed trench location(s). The trench would be excavated perpendicular to the inferred fault trace (i.e., perpendicular to the valley), along the width of the alluvium. Based on exposures of basalt in the creek bed and the geometry of the valley, it is inferred that the trace of the fault is closer to the northeast side of the valley. Thus, the trenching will begin and run from NE to SW on the north side of the creek. Based on the findings, we may excavate a second trench on the south side of the creek.

### 4. Borrow Source Reconnaissance

#### 4.1 Methods

Based on the potential for an active fault and the fact that an earthfill or rockfill dam is a more suitable dam type to mitigate the effects of fault rupture under the dam, a preliminary borrow source investigation will be conducted to assess the availability and suitability of clay material to use as clay core in the dam. Jacobs visited potential borrow sources identified during literature review and discussions with local
irrigators about potential clay sources. Literature reviewed included a GIS search, geologic mapping, water well logs, and reports by Groundwater Solutions Inc., (GSI 2007) and the Corps of Engineers (COE, 2015).

Attachment B1 shows a geologic map of the area (combined from the Walla Walla and Pendleton Quadrangle maps). This map shows the unconsolidated geologic units and descriptions – these were used to guide the initial borrow source investigation locations. The unconsolidated geologic units in the area consist primarily of silty windblown loess on surfaces higher than 1,200 feet in elevation (Ql and Qtol), interbedded silt to fine sand Lake Missoula sediments (Qs and Qfs), and stream alluvium that consists of gravels and re-worked loess and Lake Missoula flood sediments (Qa and Qal). In general, the depositional environment in the vicinity is not conducive to clay formation. Silt and fine sand are the predominant soil types in the area.

Attachment B2 shows a map based on a GIS search for clay materials and borrow sources. The map noted the “Walla Walla Borrow Pit” with “common clays and shales” but no other information could be found on this source. This map also shows an area highlighted on the plateau south of the site, that has “Older Loess” mapped covering the basalt. This material has not been proved as a viable dam core source because it mainly consists of silt and is located in a remote location that would require construction of haul roads. GSI (2007) describes this unit as “massive to poorly developed thickly bedded silt and clayey silt displaying a variety of pedogenic (soil) structures, including blocky peds, root and burrow casts, and a variable caliche (calcium carbonate) overprint”.

WWBWC noted an old brick factory in the town of Weston, approximately 13 miles south of the proposed reservoir site (via existing roads). The Jacobs team visited Weston and researched local records to find the source of the clay used for brick making. No records of the clay source could be found. According to records the brick factory began in 1879 and operated for 40 years. Therefore, it has been out of service for almost 100 years and replaced by a frozen food manufacturing plant.

Based on the site observations of material types and access in the immediate vicinity of the proposed Pine Creek dam site, Jacobs prepared a Geology and Materials map that shows potential borrow sources and test pit exploration plan (Attachment B3). This map is based on site observations of geologic materials, and the COE materials map that showed potential material sources. Existing gravel pits were also located on this map. In addition, input from the WWBWC helped assess land access.

4.2 Borrow Source Reconnaissance Findings

1. No clay deposits were observed during the initial site reconnaissance. This observation is consistent with geologic maps and unit descriptions, and published reports (e.g. GSI, COE).

2. The COE test pits only found non-plastic silt in their test pits. This material is not suitable for a clay core in an earthfill or rockfill dam, because it is highly erodible and vulnerable to internal erosion and piping in the dam.

3. A deeper blue clay and cemented gravel unit has been noted in the valley – but this material is not exposed, and well logs indicate it is at least 25 to 250 feet deep. The Ringold Formation is mapped west of the site and may contain clay, but is located a long distance away and is buried by younger deposits (not economical).

4. Exposures in Road Cuts in the vicinity confirm material type typically consists of non-plastic silty loess.

5. As previously mentioned, the plateau south of the site is mantled by “older” Pleistocene-age loess, which may contain clayey beds. However, this unit was described by GSI (2007) as thickly bedded silt and clayey silt.

6. Otherwise, the likelihood of finding an economic source of soil with the appropriate material characteristic for a clay-cored dam in the vicinity appears to be low.
5. **Next Steps**

1. Excavate a linear trench at the location shown on the map in Attachment A to confirm if Holocene fault ruptures have offset the alluvium of Pine Creek. This activity is planned for Wednesday, May 8th.

2. Confirm the material properties of COE (2005) sources and other potential local clay sources with test pits. The test pits will be excavated at locations shown in Attachment B-3 to confirm if clayey soils are present, and if groundwater will be a limiting factor to excavate in low-lying areas. Test Pit Area 1 is north of the site and is a thick deposit of unconsolidated sediments that may contain clayey layers. Test Pit Area 2 lies in the alluvial floodplain that may contain thick silt and clay overlying gravels. The test pit excavation and property access are being coordinated between Jacobs and WWBWC. This activity is planned for Thursday, May 9th.

3. The Older Loess material on the plateau south of the site will be investigated via road cut and streambank exposures to confirm the material descriptions by GSI (2007). In addition, road cut exposures of loess and Missoula Flood sediments in the Walla Walla valley north of the site will be observed and the material described. This activity is planned for Friday May 10th.

4. The on-site geologist will log the test pits and describe the soils according to ASTM D-2488 "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)." Soil grab samples will be collected from the test pits, road cut exposures, and streambank exposures for laboratory analyses including gradation and Atterberg Limits. The samples will be transported back to Boise and delivered to a certified laboratory for testing. The as-built test pit and soil sample locations will be indicated on a map in the final report.

5. Based on the findings from the fault trench investigation and the borrow source test pits, prepare a Technical Memorandum that summarizes the fault trench interpretations, laboratory results and material properties, and presents general recommendations for a suitable dam type and concept.

**References**


ATTACHMENTS
ATTACHMENT A - SITE GEOLOGIC MAP, 1/2

Notes:
1. The North arrow is indicative of both the main map window and the vicinity map window.
2. The hillshade layer was developed from the Walla Walla 2017 LiDAR data collected by OSI (accessed from the Washington LiDAR Portal on April 29, 2019).

1 inch = 400 feet

Sources: Esri, HERE, Geonovis, Earthstar Geographics, AutoMap, USGS, Airphoto (US), and the GIS User Community

Sheet 1 of 2
ATTACHMENT A - SITE GEOLOGIC MAP, 2/2

Notes
1. The North arrow is indicative of both the main map window and the vicinity map window.
2. The hillshade layer was developed from the Walla Walla 2017 LiDAR data collected by QSI (accessed from the Washington LiDAR Portal on April 29, 2019).

1 inch = 400 feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

NO OFFSETS OBSERVED IN PLEISTOCENE-AGE LOESS

APPROXIMATE LOCATION OF FAULT BIFURCATION (BASED ON USGS MAP)
Notes:
1. Borrow pit locations were obtained from the Washington Department of Natural Resources, Oregon Department of Geology and Mineral Industries, and the United States Geological Survey.

FIGURE 1
Potential Clay Borrow Sources
Walla Walla Project