Wallowa Falls Hydroelectric Project
FERC Project No. P-308
Study Progress Report
(Draft Technical Report)

Geology and Soils

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PACIFICORP ENERGY
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TABLE OF CONTENTS

List of Figures

Photo Exhibits

1.0 BACKGROUND AND STUDY OBJECTIVES

PacifiCorp Energy owns and operates the Wallowa Falls Hydroelectric Project (Project) located on the East Fork Wallowa River in Wallowa County, Oregon. The Project diverts up to 16 cubic feet per second (cfs) from the East Fork Wallowa River at the Wallowa Falls dam, located 1.7 miles upstream of the confluence of the East and West Forks of the Wallowa River. Diverted flows are conveyed via flow-line and penstock to the Wallowa Falls Powerhouse, which discharges to the West Fork Wallowa River. The layout of the Project results in a 1.7 mile bypassed reach on the East Fork Wallow River (East Fork Bypass) which extends from the confluence of the East and West Forks to the diversion dam. The lower half of the East Fork Bypass is considered suitable fish habitat.

The existing Federal Energy Regulatory Commission (FERC) license for the Project will expire on February 28, 2016. In advance of the upcoming license expiration, PacifiCorp Energy filed a Notice of Intent and Pre-Application Document (NOI/PAD) with FERC on February 23, 2011 to initiate the relicensing process. The NOI/PAD identified resource studies that PacifiCorp Energy proposed to conduct in order to provide information necessary to make informed decisions about the continued operation of the Project. Included was a proposal to conduct a Geology and Soils Study to meet Federal Energy Regulatory Commission (FERC) licensing requirements, and a study request by the Oregon Department of Fish and Wildlife. FERC acknowledged the proposal in a scoping document issued in April 2011, and Company subsequently filed a Revised Geology and Soils Study Plan (Plan) with FERC in December 2011. The Plan was approved by FERC without modification in the Study Plan Determination issued on January 3, 2012.

The objectives of this assignment are to satisfy the Geology and Soils Study outlined above. Key tasks include the following: (i) characterize the existing geology; (ii) identify long-term surficial erosion and mass-wasting potential in the Project area; and (iii) identify potential geologic hazards that could pose a risk to both the Project facilities (i.e. the penstock and the access road) and the surrounding drainages. Cornforth Consultants, Inc. (Cornforth) was retained by PacifiCorp Energy to perform this study and to identify conceptual mitigation measures where necessary.

The scope of work to implement the Study Plan included the following components: Task 1 - a desktop evaluation of site geology, Task 2 - a site reconnaissance, Task 3 - a risk and needs assessment with conceptual mitigation options if warranted, Task 4 – provide technical geology and soils expertise on PacifiCorp Energy's behalf during results presentation with stakeholders, Task 5 – study reporting, Task 6 – Additional Support, and Task – 7 Monthly Status Reports.

2.0 SITE DESCRIPTION

The project is located south of Wallowa Lake along the East Fork of the Wallowa River (see Figure 1). The existing project features consist of the following: (i) a 2-foot-high, 9-foot-long concrete diversion dam, having a 1-foot-wide spillway, at elevation 5,838 feet on Royal Purple Creek which is a tributary to the East Fork Wallowa River; (ii) a 240-foot-long, 8-inch diameter PVC pipeline discharging flows into the 0.2-acre Wallowa Falls forebay, 200 feet upstream of the East Fork Wallowa River dam; (iii) an 18-foot-high, 125-foot-long, buttressed rock-filled timber crib dam with impervious gravel and asphalt core, having a 30-foot-wide spillway, at elevation 5,795 feet on the East Fork Wallowa River; (iv) a 5,688-foot-long steel penstock varying in diameter from 18 inches to 16 inches; (v) a powerhouse containing a single generating unit with a rated capacity of 1,100 kW; (vi) a tailrace discharging Project flows into the West Fork Wallowa River; and (vii) an access road that runs along the east side of the East Fork Wallowa River.

The access road, which roughly follows the alignment of the original penstock construction trail along the east side of the East Fork Wallowa River, was improved in 1994 when the dam was re-built. The penstock runs on the outboard side (downslope side) of the access road for approximately 1,500 feet below the dam and then crosses under and runs along the east (upslope) side of the access road for the majority of the remaining alignment (see Figure 1). The penstock is below grade (buried) for the majority of the alignment; however, it is supported above-ground at two trestle locations located approximately 600 feet below the dam (upper trestle) and approximately 1,000 feet above the powerhouse (lower trestle), respectively.

3.0 METHODOLOGY

A desktop evaluation task was performed to gather background information and an understanding of the site so that the subsequent site reconnaissance could be conducted in a more efficient, informed manner. Available geologic and operations reports, geologic and topographic maps, and photographs were reviewed to develop a general understanding of the geology and known geologic hazards in the area. Interpretations of geomorphology were made from aerial images and topographic maps. These interpretations were spot checked in the field. In addition, facility personnel and other individuals familiar with the project were interviewed to obtain a historical background concerning facility operations and first-hand knowledge of maintenance efforts at the Project.

Following the desktop study, a site reconnaissance was performed by a senior engineering geologist and geotechnical engineer from Cornforth on September 16 through the 18, 2012. The reconnaissance efforts were focused on the forebay area, the slopes adjacent to the access road and the penstock, and the tailrace. During the reconnaissance, the geomorphology and surficial geology was observed and documented; potential geologic hazards, slope stability and erosion concerns were assessed; and conceptual mitigation measures were evaluated. Select features and areas were photographed. Representative photographs are included in this report and the others are on file at our office.

4.0 GEOLOGY AND POTENTIAL HAZARDS OVERVIEW

The following sections provide an overview of the geology and soils within the Project area. In addition, an overview describing the potential geologic hazards, slope stability, and erosion issues that could be of potential concern are described below.

4.1 Geologic Overview

The Project is located on the southern flank of the Wallowa Mountains within the Blue Mountain physiographic providence of northeast Oregon. The regional geology is dominated by diastrophic processes that formed the mountains and subsequent erosion and glaciation that carved much of the landforms (Orr 2000). Starting in the early Cenozoic Era, the Wallowa batholith crystalized existing late Paleozoic and early Mesozoic rocks and caused considerable uplift. By the late Oligocene, most of the surficial bedrock had been eroded away, exposing the metamorphic rocks (Orr 2000). The area was subsequently covered by lava flows associated with the Columbia River Basalts by the late Miocene. Relatively recent uplift formed the basalt escarpments associated with the Wallowa Fault (Kuehn 1995). The rock types associated with the mountain building process include Tertiary aged lavas, Mesozoic aged crystalline and sedimentary rocks, and a highly metamorphosed series of interbedded volcanic rocks late Paleozoic in age (Wagner 1955).

The dominant rock type observed near the upper (southern) portion of the Project appears to be andesite from the Clover Creek Greenstone formation (Wagner 1955) and basaltic andesite from the Columbia River Basalt Group. The lower (northern) portions of the Project (the powerhouse and tailrace) are dominated by alluvial and glacial deposits. The Project area was formed by extensive glaciation that occurred during the last ice age (Wisconsin Glacial Episode) as recently as 10,000 years ago (Budlong et. al. 2005). The Wallowa Glacier was thought to be at its deepest near the junction of the East Fork and West Fork Wallowa River resulting in very deep glacial deposits in the area around the powerhouse and tailrace. Conversely, the upper Project area is located in a recently scoured area with relatively shallow soils.

4.2 Overburden and Soils Overview

The overburden materials found at the upper (southern) portion of the Project are characterized by relatively thin, granular soils associated with colluvium and talus deposits. The overburden present at the lower (northern) portion of the Project (which includes the tailrace, powerhouse, and lower penstock section) consists of glacial deposits and alluvium. These materials are characterized by relatively thicker, non-plastic silts and granular soils.

According to a soil survey conducted by the United States Department of Agriculture and Natural Resources Conservation Service (USDA-NRCS), there are three reported soil types within in the Project area. They include the Anatone-Klicker-Rock-Outcrop complex (60 to 90 percent south slopes), the Limberjim-Anatone complex (30 to 60 percent north slopes), and Rondowa Boulder Loam (2 to 15 percent slopes).

While the upper portion of the Project was not specifically covered in the USDA-NRCS document, it is reasonable to assume the majority of the penstock alignment, diversion dams and forebay are on south facing Anatone-Klicker-Rock-Outcrop complex soils. This soil type occurs between 4,000 and 6,000 feet mean sea level (msl) and is comprised of Anatone type soils on convex south facing slopes and Klicker type soils on concave south facing slopes. Both Anatone and Klicker soil types are derived from basalt based loess and colluviums and are thought to be relatively thin (less than four feet thick). Klicker soils have an additional volcanic ash component in upper profiles.

A mid to lower section of the penstock is on north facing Limberjim-Anatone complex soils. This soil type occurs between 4,700 and 5,400 feet msl and is comprised of Limberjim type soils on north facing concave slopes and Anatone type soils on north facing convex slopes. The Limberjim soil type is derived from volcanic ash over colluvium and residuum derived from basalt and andesitic tuff breccias. The powerhouse, tailrace, and short section of penstock immediately above the powerhouse are on the Rondowa bouldery loam. Parent material is mixed glacial till with an influence of loess and minor amounts of ash in the upper spoil sections. These soils are thought to be relatively thick (greater than five feet).

4.3 Potential Geologic Hazards Overview

One of the primary focuses of the site reconnaissance was to ascertain the existence of geologic hazards that could have the potential to cause a failure or rupture of the penstock which could result in excessive erosion and river sedimentation. The geologic hazards of concern consist of ancient landsides, historically active landslides, rockfalls, and debris flow slides in the steep slopes within the East Fork Wallowa River drainage. Brief explanations of each are given below.

Ancient Landslides. Ancient landslides are defined as those formed in the geologic past, probably during periods of glaciation or tectonic uplift. In some cases, these ancient slides may be thousands of years old. Ancient landslides are often marginally stable and are subject to move or creep during periods of prolonged, intense rainfall. The term “ancient landslide terrain” refers to topography that has formed in the geologic past due to landslide activity. A hummocky appearance along with other distinguishing features in the topography and landforms are often discernible in ancient landslide terrain. Minor changes in slide conditions due to natural processes (i.e. unseasonable high precipitation) or earthwork activities such as cuts, fills, or changes to groundwater and surface runoff patterns can activate a marginally stable ancient landslide.

Historically Active Slides. Historically active slides are defined as those landslides that have been documented with geotechnical studies, mitigation work, or information passed on by report or word-of-mouth. These historically active slides typically range from translational slides, deep-seated slumps or rotational slides, slump-flows, and shallow sloughing.

Debris Flow Slides. Drainages in areas that have steep mountainous terrain and thin soils overlying bedrock are susceptible to debris flow slides. They typically occur during high intensity rainfall events and give little to no warning before they occur. Debris flows are a natural geologic process by which young valleys widen and deepen and are likely to occur at periodic intervals (Cornforth 2005).

Rockfalls. Rockfall from outcrops can also be considered a geologic hazard. Rockfall is the natural movement of a rock from a slope that is steep enough that the rock continues down the slope by free falling, rolling, bouncing, or sliding. Rockfalls can be attributed to any number of conditions/processes such as: adverse discontinuities, weathering, freeze-thaw cycles, root wedging, wind jacking, age, poor blasting techniques, etc.

4.4 Slope Stability (cuts and fills) and Erosion Concerns

Construction activity associated with road building, slope grading, and other civil engineering features (i.e. penstocks) have the potential to destabilize ground and increase erosion potential. Typically, instability is associated with over-steepened cuts and fills that are poorly controlled and compacted (loose) or that are constructed too steep. Seeps (the interception of perched groundwater) can also contribute to slope instability. Changes in surface runoff and the loss of vegetation cover due to grading activities can also lead to increased erosion. Erosion is one of the principal causes of slope instability and landslides (Cornforth 2005). Cohesionless (granular) soils are especially vulnerable to erosion because their strength is derived from the weight of overburden acting on them. At the ground surface, granular soils possess little to no resistance to erosion unless vegetation is present.

4.5 Other Hazards

Throughout the history of the Project, the only penstock failure and subsequent uncontrolled discharge of water due to natural hazards was the result of a tree fall event. On September 26, 1999, a large tree fell on a penstock/trestle guy wire at the upper end of the lower trestle causing two sections of penstock pipe to separate. Water discharged from the penstock rupture until the intake gate could be manually closed at daybreak the following day. Approximately ten to thirty cubic yards of decomposed sand and gravel along with associated vegetation and debris washed down-slope and into the East Fork Wallowa River. Remedial actions made in response to this incident included the inspection of the penstock alignment for hazard trees, and the removal of ninety-one hazard trees in November 1999 and fifteen hazard trees in January 2000.

5.0 SITE OBSERVATIONS

The site reconnaissance effort on September 17-18, 2012 involved walking traverses to look for signs of slope instability, geologic hazards, and erosion potential along the penstock alignment and the access road (see Figure 2 for approximate stationing). The slopes above the east side of the East Fork Wallowa River (where the penstock alignment and access road are located) are comprised of colluvium which consists of silty sand to sandy silt with numerous gravel- to boulder-sized rock fragments. In addition, expansive talus fields associated with the steep to near vertical rock outcrops located at higher elevations to the east were observed. In general, the slope angles on the east side of the river are roughly 32 to 35 degrees, and the slopes are sparsely to moderately vegetated with shrubs and trees. In contrast, the slopes on the west side of the East Fork Wallowa River are relatively less vegetated, have steeper overall inclinations (35 to 45 degrees), and are covered by finer-grained granular soils (scree) and relatively younger talus and rockfall debris. In general, mass wasting appears to be more prevalent and the slopes appear more active on the west side of the river as compared to the east side of the East Fork Wallowa River (where the penstock alignment and access road are located).

The slopes immediately around the dam's forebay are relatively flat and well vegetated (see Photo Exhibit 1A); however, they steepen considerably over a short distance to the east and west (i.e. outside of the river channel). No signs of landslide activity, slope instability, or erosion were observed around the forebay and the dam. Downstream of the dam, the penstock goes below grade and is covered by granular fill material (see Photo Exhibit 1B). The slopes in this area have been benched and graded relatively flat. The penstock is located northwest (downslope) of the access road in this area. No signs of landslide activity, slope instability, or excessive erosion were observed along this section of the penstock alignment.

Approximately 200 feet upstream of the forebay, a diversion structure diverts water from Royal Purple Creek to the forebay through a 240-foot long, 8-inch diameter PVC pipe. This pipe is exposed above ground approximately half of its length (roughly 132 feet). Several hazard trees were observed along the flow-line (see Photo Exhibit 2). A localized shallow slough approximately 10 feet wide was observed on the outboard edge of the access trail to the diversion structure. No landslide activity or excessive erosion was observed in this area.

An approximately 600-foot section of the original access trail, located between the East Fork Wallowa River and Royal Purple Creek (northeast of the dam), was improved when the dam was rebuilt in 1994 (see Figure 1). The access road through this area (approximate Station 1+45) is approximately eight feet wide and was built using cut and cast construction techniques. Control cables that run from the generating unit to the intake gate controls at the dam are buried along the inboard edge of the road. An approximately 100-foot long portion of the cut slope on the inboard side of the road is over-steepened (greater than 50 degrees) and shows signs of sloughing and erosion (see Photo Exhibit 3). This area of localized surficial sloughing does not appear to pose a risk to the buried control cables, nor does it pose a risk to the penstock which is located 100 feet to the west of the access road. However, worsening conditions have the potential to cause localized instability concerns and increased road maintenance efforts. In addition, there is the potential for increased erosion activity.

The penstock daylights above grade (is no longer buried) downslope of the access road near Station 8+85 (see Figure 2). Here the penstock is supported by wooden trestles for approximately 115 feet (see Photo Exhibit 4). PacifiCorp reports this trestle was rebuilt in 2000. No signs of landslide activity or slope instability were observed in the vicinity of the trestle footings, the penstock, or the access road. In addition, no signs of excessive erosion were observed. A potential hazard tree was observed on the south end of the trestle (see Photo Exhibit 4). Local sloughing of the outboard shoulder of the access road was observed at Station 11+50.

From the vantage point along the access road (approximate Station 11+50) a significant debris flow channel was observed on the west slope across the East Fork Wallowa River (see Photo Exhibit 5). Subsequent conversations with the Forest Service recreation maintenance supervisor indicated that the debris flow event occurred in 2006 and caused significant damage to the USFS 1804 trail located on the opposite side of the river from the penstock. Based on the size of the scour channel it left behind, the debris flow appears to have deposited a significant amount of debris and sediment in the river, and may have temporarily dammed the river.

At approximate Station 17+50 (see Figure 2) the penstock crosses to the upslope (east) side of the access road. The penstock stays above the cut slope section of the access road until it crosses under the road again at approximate Station 34+66. No signs of landslide activity, slope instability, or excessive erosion were observed along this section of the penstock alignment. The penstock does cross the toe of a large talus field between Stations 20+30 and 21+45 (see Photo Exhibit 6). An approximately 17-foot segment of the penstock is exposed above grade on the southeast end of the talus pile. Several large logs have been stacked on the upslope side of the penstock to offer a level of protection from potential rockfall (see Photo Exhibit 6A). The reminder of the penstock through this segment has been encapsulated (covered) by hand-placed talus boulders to protect it (see Photo Exhibit 6B). The hazards associated with rockfall or instability of the talus pile along this segment is considered low.

No signs of landslide activity, slope instability, or excessive erosion were observed along the penstock alignment or the access road from Station 34+66 to the powerhouse. The lower trestle is located approximately 1,000 feet above the powerhouse (see Photo Exhibit 7). No signs of landslide activity or slope instability were observed in the vicinity of the trestle footings. PacifiCorp reports that on September 26, 1999, a large tree fell on a penstock/trestle guy wire at the upper end of the lower trestle causing two sections of penstock pipe to separate. Remedial actions made in response to this incident included replacement of the penstock trestle and the inspection of the penstock alignment for hazard trees and the removal of ninety-one hazard trees in November 1999 and fifteen hazard trees in January 2000.

6.0 CONCLUSIONS AND RECOMMENDATIONS

As previously stated, the objectives of this study are to characterize the existing geology, identify long-term surficial erosion potential in the area, and identify potential geologic hazards that could pose a risk to both the Project facilities (i.e. the penstock and the access road) and the surrounding drainages.

Based on the desktop evaluation, the project area has no history of large translational landslides, and no signs of ancient landslide terrain or global instability were observed during the site reconnaissance. No historically active deep-seated slumps or rotational slides were observed as well. In addition, the hazards associated with rockfall or instability of the talus piles within the project area is considered relatively low.

Drainages in areas that have steep mountainous terrain and thin overburden soils overlying shallow bedrock are susceptible to debris flow slides. They typically occur during high intensity rainfall events. These destructive events give little to no warning before they occur. As previously discussed, a significant debris flow slide occurred in 2006 on the west slope across the East Fork Wallowa River. The debris flow slide caused significant damage to the USFS 1804 trail located on the opposite side of the river from the penstock, and the event deposited a significant amount of debris and sediment that temporarily dammed the river and undoubtedly caused major river sedimentation. Based on the steeper slopes and thinner soil and vegetation cover, the western slopes above the East Fork Wallowa River appear more susceptible to debris flows than the eastern slopes; therefore, the penstock and access road are less vulnerable to this type of slide event. However, there is the potential for debris flow slides to occur upstream of the dam that could generate significant quantities of sediment and debris that could cause sedimentation issues at the forebay.

Localized areas of minor sloughing associated with cut and side cast construction techniques along the access road were observed during the site reconnaissance. These areas do not pose an immediate risk to the penstock; however, worsening conditions have the potential to cause localized instability concerns. They will likely continue to be an access road maintenance issue. Localized areas of minor soil erosion associated with the access road were also observed during the site reconnaissance. The amount of sedimentation associated with these localized erosion areas is relatively small and likely on par with what the USFS trails experience throughout the area. However, worsening conditions could lead to increased erosion and sedimentation concerns in the future.

Trees in the proximity of the Royal Purple Creek diversion flow line and the two trestle locations represent a significant hazard. As previously discussed, the only penstock failure and subsequent uncontrolled discharge of water due to natural hazards was the result of a tree fall event.

The following tasks and monitoring activities are recommended:

- Assess the tree conditions and remove any tree along the penstock alignment and the Royal Purple Creek diversion flow line that represents a hazard.
- Continue erosion control practices and vegetation management throughout the project area. If worsening conditions are observed, implement additional erosion control measures such as bioremediation techniques, water bars, rock inlays, natural or geo-synthetic mats, and cellular grids. In addition, culvert inlets and outlets should regularly be cleared of debris.
- Continue to monitor the access road and cut and fill slopes along the penstock alignment paying particular attention to the Royal Purple Creek drainage area, the localized sloughing at approximate Station 11+50, and the segment between the dam and where the penstock is located on the west side (down slope) of the access road (approximate Stations 0+00 to 17+50). If localized areas of slope instability develop, mitigate using rock inlays, pinned

Tecco® mesh, gabion baskets/mattresses or other appropriate measures.

- Retain an engineering firm that specializes in landslides and geologic hazards to perform a geologic hazards reconnaissance every three to five years to evaluate developing or worsening conditions. The perspective of an outside professional in addition to PacifiCorp Energy's staff would be beneficial. The assessment should pay particular attention to the specific hazards outlined in this report.

7.0 REFERENCES

Allen, J.E., The Wallowa "Ice Cap" of Northeastern Oregon – An exercise in the interpretation of glacial landforms, December 1975, The Ore Bin – DOGAMI Vol. 37, No. 12.

Budlong, Bryce, J.R. Collier, Calvin Davis, David E. Gilbert, Rob Ledgerwood, and Jay Van Tassell. September 2005. Eastern Oregon Geology Vol. 2, The Bathymetry and Sediments of Wallowa Lake, Northeast Oregon. Science Department- Badgley Hall, Eastern Oregon University, La Grande, OR 97850-2899. http://www.eou.edu/geology/wallowalake.html.

Cornforth, Derek, H., PhD, PE., Landslides in Practice – Investigation, Analysis, and Remedial/Preventative Options in Soils. 2005. John Wiley & Sons, Inc., Hoboken, New Jersey.

Kienzle, J., Soil Survey of Wallowa County Area Oregon. No Date. NRCS. http://soildatamart.nrcs.usda.gov/Manuscripts/OR670/0/Wallowa OR.pdf.

Kuehn, S.C., The Olympic -Wallowa Lineament, Hite Fault System, and Columbia River Basalt Group Stratigraphy in Northeast Umatilla County, Oregon (Master's thesis). May 1995. Washington State University. http://academics.concord.edu/sckuehn/msthesis/msthesis.html

Orr, E., Orr W., Geology of Oregon, Fifth Edition. 2000. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Pitt, R., Clark, S., Lake, D., Construction Site Erosion and Sediment and Controls. 2007. DEStech Publications, Inc., Lancaster, Pennsylvania.

Wagner, N.S., Summary of Wallowa Mountains Geology, May 1955, The Ore Bin – DOGAMI Vol. 17, No.5