## EXHIBIT H

### GEOLOGY AND SEISMICITY

OAR 345-021-0010(1)(h)

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H.1 INTRODUCTION

EC&R Development, LLC (Applicant) proposes to construct the Brush Canyon Wind Power Facility (Facility) in Wasco and Sherman counties, Oregon. The proposed Facility is expected to provide a nominal electric generating capacity of up to 535 megawatts (MW) from 223 turbines. Figures C-1, C-2, and C-3 in Exhibit C contain maps of the site vicinity, Facility layout, and Facility components, respectively.

This Exhibit provides information required by Oregon Administrative Rule (OAR) 345-021-0010(1)(h) to demonstrate that the structural standard in OAR 345-022-0020 can be satisfied.

H.2 EVIDENCE TO SUPPORT COUNCIL FINDINGS REQUIRED BY OAR 345-022-0020

OAR 345-021-0010(1)(h) Information from reasonably available sources regarding the geological and soil stability within the analysis area, providing evidence to support findings by the Council as required by OAR 345-022-0020, including:

Response: OAR 345-022-0020(1) requires the following:

"Except for facilities described in sections (2) and (3), to issue a site certificate, the Council must find that:

(a) The applicant, through appropriate site-specific study, has adequately characterized the site as to the Maximum Considered Earthquake Ground Motion as shown for the site in the 2009 International Building Code and maximum probable ground motion, taking into account ground failure and amplification for the site specific soil profile under the maximum credible and maximum probable seismic events; and

(b) The applicant can design, engineer, and construct the facility to avoid dangers to human safety presented by seismic hazards affecting the site that are expected to result from maximum probable ground motion events. As used in this rule “seismic hazard” includes ground shaking, ground failure, landslide, liquefaction, lateral spreading, tsunami inundation, fault displacement, and subsidence;

(c) The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and

(d) The applicant can design, engineer and construct the facility to avoid dangers to human safety presented by the hazards identified in subsection (c)."

This Exhibit provides evidence to support findings by the Council as required by OAR 345-022-0020. The Applicant reviewed regional geologic information, conducted a geologic, surface site field reconnaissance of the Facility within the site boundary and along proposed buildout corridors, and performed a site-specific characterization of potential seismic, geologic, and soils hazards. This Exhibit demonstrates that the Applicant can design, engineer, and construct the Facility to avoid dangers to human safety.

H.3 ANALYSIS AREA

The analysis area for structural standards (Exhibit H) is the area within the site boundary. “Site boundary” as defined in OAR 345-001-0010(53) is the area within the perimeter of the proposed energy facility, its related or supporting facilities, all temporary laydown and staging areas, and all micrositing corridors proposed by the Applicant.

H.4 METHODOLOGY FOR OBTAINING INFORMATION FROM REASONABLY AVAILABLE SOURCES

The Applicant contracted CH2M HILL to review available reference materials, conduct a geologic field reconnaissance, and perform a seismic hazard assessment.
H.4.1 Review Available Materials

CH2M HILL evaluated topographic and geologic conditions and hazards within the Facility site boundary by reviewing available reference materials such as topographic and geologic maps, aerial photographs, existing geologic reports, and data provided by the Oregon Department of Geology and Mineral Industries (DOGAMI), Oregon Water Resources Department, U.S. Geological Survey (USGS), and U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS).

H.4.2 Conduct Field Reconnaissance

CH2M HILL conducted a limited geologic field reconnaissance within the proposed Facility site boundary and proposed buildout corridors. The geologic reconnaissance consisted of a site drive-through and walk-through to identify potential geologic hazards, areas of soil erosion and potential slope instability, and confirm existing geologic mapping and unit descriptions. CH2M HILL did not conduct a subsurface investigation as part of the geologic reconnaissance.

H.4.3 Perform Seismic Hazard Analysis

CH2M HILL performed a seismic hazard analysis to characterize seismicity in the Facility vicinity and evaluate potential seismic impacts. This work was based on the potential for regional and local seismic activity as described in the existing scientific literature, and on subsurface soil and groundwater conditions within the Facility site boundary based on geotechnical subsurface investigations. The seismic hazard analysis consisted of the following tasks:

1. Detailed review USGS, National Geophysical Data Center (NGDC), and DOGAMI literature and databases.
2. Identification of potential seismic events for the site characterization of those events in terms of a series of design events
3. Preparation of conclusions and recommendations based on the characteristics of the subsurface soils and design earthquakes, including specific seismic events that might have a significant effect on the site, potential for seismic energy amplification at the site, and the site-specific acceleration response spectrum for the site
4. Evaluation of seismic hazards, including potential for fault rupture, earthquake-induced landslides, liquefaction and lateral spread, settlement, and subsidence.

Section H.15 contains a reference list of technical literature used to characterize the site and prepare Exhibit H.

H.5 GEOLOGIC REPORT ON SITE SETTING AND FINDINGS

OAR 345-021-0010(1)(h)(A) A geologic report meeting the guidance in Oregon Department of Geology and Mineral Industries open file report 00-04 “Guidelines for Engineering Geologic Reports and Site-Specific Seismic Hazard Reports.”

Response: The following sections describe the topographic and geologic setting within the Facility site boundary, and the findings of the literature review, geologic reconnaissance, and seismic analysis organized into discussions of surficial geologic units, bedrock geologic units, structural geology, and groundwater/springs.

H.5.1 Site Topographic Setting

The Facility is located approximately 35 miles northeast of Madras, Oregon, near the community of Shaniko. Most of the site is located on a flat plateau that is part of the Columbia Plateau Physiographic Province. The top of the plateau tends to be relatively flat and slopes gently to the north. The plateau has been dissected
by ephemeral streams and creeks into steep-sided canyons. U.S. Route (US 97) runs north-south along the western boundary of the site. East of Antelope, along Oregon Route 218 (OR 218), the southern part of the site is underlain by softer rock and has been eroded into more irregular topography in contrast to the northern part.

The canyon of the John Day River roughly forms the eastern boundary of the site. In the vicinity of Shaniko and northward, drainages on the site east of US 97, such as the Pine Creek drainage, flow east and northeast towards the John Day River. Drainages in the southern part of the site east of Antelope, such as Antelope Creek, flow generally westward.

Elevations on the plateau within the Facility site boundary range from approximately 2,600 feet mean sea level (msl) near Kent at the northern part of the site, to more than 3,600 east of Shaniko. In the portions of the Facility east of Antelope, the elevations range from 2,800 feet msl along Antelope Creek and OR 218 to over 4,280 feet msl at Hastings Peak and Maupin Butte.

H.5.2 Site Geologic Setting

The site is located within the Columbia Plateau physiographic province. The Columbia Plateau was formed by a series of layered basalt flows extruded from vents and fissures between 7 and 16 million years before present (Swanson et al., 1979). Collectively, these basalt flows are known as the Columbia River Basalt Group. The source for most of these flows was a series of north-northwest-trending linear fissure systems located in eastern Washington, northeastern Oregon, and western Idaho. Based on lithological properties, geochemistry, and magnetic polarity, the Columbia River Basalt Group has been subdivided into a number of formations and members. The individual basalt flows can be as much as 300 feet thick. These flood basalts cover an area of more than 200,000 square kilometers in Washington, Oregon, and western Idaho (Hooper et al., 2002; Camp et al., 2003).

Figure H-1 is a geologic map and elevation cross-section of the Facility vicinity, adapted using geographic information system (GIS) and the Oregon Geologic Database Compilation OGDC-5 (DOGAMI, 2009). The geologic map developed by Bela (1982) was used as a source of local geologic mapping and structures such as faults and folds. The geologic units shown on the Bela map are consistent with the geologic units represented on Figure H-1. The following is a description of the geologic units found in the area, summarized from Bela (1982).

Exhibit I describes properties of the site surficial soils based on NRCS data, in particular the texture, slopes, and erosive properties. The geotechnical engineering characteristics of the soils are summarized in Section H.5.2.1 and Table H-1.

H.5.2.1 Surficial Geologic Units and Soils

Surficial geologic units in the Facility vicinity consist primarily of windblown loess deposits, colluvium, and talus deposits. Loess consists of massive, wind-deposited quartzose fine sand and silt, and mantles much of the upland surfaces and hillslopes of the Columbia Plateau. This unit is generally as much as 15 to 30 feet thick, but thins to less than 3 feet thick on upland areas away from the Columbia River. This unit is not shown on the geologic map by Bela (1982) or on Figure H-1, because the unit is thin in the Facility area, and the geologic map primarily shows bedrock units.

Observations from the site visit in December 2011 indicate that the loess typically is tan to light brown and composed of silt-sized particles. The loess tends to mantle the flat tops and low-angle side slopes of the plateau but is absent on steeper slopes and the walls of drainages, either due to lack of deposition on slopes or subsequent erosion. The cultivated areas on the site are underlain by loess, but the loess is not well exposed and the thickness is unknown. Available information, including well logs and NRCS soil data, indicates that the thickness of the loess varies from very thin (less than 1 foot) to only around 5 feet thick.
Locally, this loess has been preferentially eroded at the surface where vegetative cover was lacking, leaving small “islands” of vegetated loess that are typically 5 to 30 feet wide, and separated by broad incised and disconnected channels of very shallow soil over rock. The soil survey refers to this effect as “biscuit land” topography.

Colluvium and talus deposits mantle the steeper side slopes of the drainages. These deposits are not shown on the geologic maps because typically they are thin. However, they were observed along the steep sideslopes of the drainages and canyons. The deposits comprise primarily boulder- to gravel-sized masses of angular rock debris with little or no soil at the base of steep cliff faces (talus), and hillslope deposits of poorly sorted soil and rock (colluvium). The deposits are formed by mechanical failure caused by gravity from locally derived materials. The thickness varies, but based on exposures of bedrock in most of the canyon walls, these deposits appear to be less than a few feet thick across most of the site.

Massive landslide deposits are mapped in large areas in the southern portion of the site where the John Day formation is exposed in sideslopes and has experienced slumping and landsliding. The landslide deposits consist of hummocky, chaotic masses of angular blocks, chiefly mixtures of basalt and tuffaceous sedimentary rocks. These landslides include debris flows and large talus piles, or in a few cases, entire hills. The largest landslides occur where basalt flows of the Columbia River group or welded tuff of the John Day formation overlie weak, tuffaceous sedimentary rocks of the John Day formation. Some individual blocks of basalt are as much as 3 miles long and 1.5 miles wide and have traveled miles from their source. Most of the landslides have subdued topography and lack fresh scarps, and probably originated during the Pleistocene (more than 15,000 years ago). However, according to Robinson (1975), many are still active.

Alluvial deposits consist of unconsolidated silt, sand, and gravel of fluvial origin. These deposits are mapped primarily along the bottom of the Antelope Creek valley, east of Antelope.

The Facility spans nearly 30 miles of terrain and encompasses many soil types. Exhibit I provides detailed descriptions of near-surface soils that could potentially be impacted by the Facility. Table H-1 describes the geotechnical engineering characteristics of the surficial soils, based on available NRCS data. Section H.6 describes site-specific geotechnical investigations that will be conducted to fully characterize the subsurface geotechnical conditions during Facility design.

Table H-1. Geotechnical Engineering Characteristics of Surficial Soils

<table>
<thead>
<tr>
<th>Soil Name</th>
<th>USCS Classification</th>
<th>Typical Depth to Bedrock (inches)</th>
<th>Corrosion Potential (Concrete/Steel)</th>
<th>Percent Silt</th>
<th>Percent Clay</th>
<th>Liquid Limit</th>
<th>Plasticity Index</th>
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<tr>
<td>8B – Condon</td>
<td>CL</td>
<td>30</td>
<td>Low/Moderate</td>
<td>68</td>
<td>22</td>
<td>30</td>
<td>9</td>
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<tr>
<td>10C – Condon/Bakeoven</td>
<td>CL</td>
<td>30</td>
<td>Low/Moderate</td>
<td>68</td>
<td>22</td>
<td>30</td>
<td>9</td>
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<tr>
<td>BcC – Bakeoven/Condon</td>
<td>GM</td>
<td>7</td>
<td>Low/Moderate</td>
<td>39</td>
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<td>CoC – Condon/Bakeoven</td>
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<td>BaC – Bakeoven</td>
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<td>CnC – Condon</td>
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<td>CtE – Curant and Tub</td>
<td>ML</td>
<td>&gt;80</td>
<td>Low/High</td>
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Notes:

CL = Lean Clay; ML = Silt; GM = Silty Gravel

Liquid limit (LL) is one of the standard Atterberg limits used to indicate the plasticity characteristics of a soil. It is the water content, on a percent by weight basis, of the soil (passing #40 sieve) at which the soil changes from a plastic to a liquid state. Generally, the amount of clay- and silt-size particles, the organic matter content, and the type of minerals determine the liquid limit.

Plasticity index (PI) is one of the standard Atterberg limits used to indicate the plasticity characteristics of a soil. It is defined as the numerical difference between the liquid limit and plastic limit of the soil. It is the range of water content in which a soil exhibits the characteristics of a plastic solid.
H.5.2.2 Bedrock Geologic Units

The basalt flows at the site are mapped as the Frenchman Springs Members of the Wanapum Basalt and Grande Ronde Formations of the Columbia River Basalt Group (Bela, 1982). The Frenchman Springs Member (Tcw on Figure H-1) underlies the northern portions of the plateau along US 97 in the vicinity of Kent. This unit is described as fine- to medium-grained basalt with abundant to sparse plagioclase phenocrysts, commonly 1 to 2 centimeters across, distributed throughout the flow. The unit has normal magnetic polarity. The Frenchman Springs Member commonly rests on a prominent, thin, tuffaceous or subarkosic sandstone and siltstone unit known as the Vantage Member, or “Vantage Horizon” of the Ellensburg Formation. Well logs from the Facility vicinity indicate the presence of varicolored clay layers at depths anywhere from 17 to 150 feet below ground surface, which could be the Vantage Horizon. The well logs used to obtain subsurface information were provided by the Oregon Water Resources Department and are provided in Attachment H-1. Figure H-1 shows the general locations of the wells.

The Grande Ronde Basalt underlies the Frenchman Springs Member, and is exposed across much of the site, primarily northeast, east, and southeast of Shaniko at the plateau surface and in steep-sided drainages (Tcg on Figure H-1). The Grande Ronde Basalt is described as “flow-on-flow sequence of bluish-black, aphyric to sparsely plagioclase phryic iron-rich basaltic andesite and andesite lava flows.” Individual flows generally weather to orange-brown, angular blocks and also form distinctive bench topography. The flows of Grande Ronde Basalt include normal and reverse magnetic polarity.

The John Day Formation (Tsfj) is Miocene to middle Eocene age (18 to 36 million years old) and crops out in the mountainsides east of Antelope, along the Antelope Creek drainage and OR 218. This unit has been divided into several members that consist of varicolored air-fall and water-deposited ash and tuff, welded tuff, tuffaceous claystones, and volcanic rhyolite flows. In addition, several basalt flows are within this formation. Because this unit is a weak sedimentary rock, it is prone to landsliding.

The Clarno Formation (Tct and Tca) crops out in a small area in the very southern end of the site, southwest of Maupin Butte. This formation has been divided into several members that include lava flows and breccias of altered dark greenish-gray andesite flows, domes, and flow breccias, bedded volcaniclastic rocks, rhyolite and dacite flows and domes, mafic vent rocks, and basaltic andesite. This unit underlies the John Day formation and the contact is marked by a prominent red clay layer.

Several quarries and borrow pits have been developed in the vicinity in the basalt bedrock; these quarries appear to be used to produce crushed rock for road surfacing or aggregate.

H.5.2.3 Structural Geology

No potentially active faults have been mapped within the site area (Bela, 1982; Weldon et al., 2002; USGS, 2010). The basalt flows that underlie the site are very gently dipping to the north. Bela (1982) mapped and named structural geologic features in the area, including the Condon anticline east of the site, across the John Day River. Bela (1982) also mapped an unnamed north-trending, down-to-the-west normal fault that roughly parallels the John Day river canyon, and a north-trending, down-to-the-west normal fault approximately 5 miles west of Shaniko.

East- and northeast trending anticlines and synclines and north- to northwest-trending normal faults are mapped west of Kent, between Kent and Shaniko on both sides of US 97 north and northeast of Shaniko (Figure H-1 and Bela, 1982). These faults, anticlines, and lineaments were formed from regional compressional and extensional tectonic forces, and do not represent active, ongoing faulting. Potentially active faults are discussed under Section H.10.1 Earthquake Sources. A northeast-trending fault is mapped east of Antelope along the western side of Hastings Peak and Maupin Butte.
H.5.2.4 Groundwater/Springs

Regional groundwater is deep across much of the northern part of the site vicinity because of the dissection of the plateau by tributaries downcutting to meet the John Day River. Well logs from Oregon Water Resources Department records indicate that wells within the northern portion of the Facility site boundary (north and east of Shaniko) encountered groundwater between 157 and 323 feet below ground surface. In the southern part of the site, in the area east of Antelope, well logs indicate that static water levels are between 46 and 95 feet below ground surface (see well logs in Attachment H-1).

In the northern portion of the site in particular, areas of shallow perched zones of groundwater appear to exist, as indicated by springs present in the canyon walls and drainages (for example, Kelsey Spring). These springs likely result from downward-percolating water encountering either a relatively impermeable sedimentary interbed within basalt flows, or more-permeable inter-flow layers that readily transmit groundwater. Well logs indicate the presence of varicolored clay layers at depths anywhere from 17 to 150 feet below ground surface. This layer is possibly the Vantage Horizon, which could act as a low-permeability layer that causes the groundwater to flow horizontally and discharge from the canyon walls as springs and seeps. These springs and seeps are evidenced by clusters of vegetation in the canyon walls, are observable on aerial photographs, and are marked on topographic maps (for example, Kelsey Spring).

H.6 SITE-SPECIFIC GEOTECHNICAL WORK

OAR 345-021-0010(1)(h)(B) A description and schedule of site-specific geotechnical work that will be performed before construction for inclusion in the site certificate as conditions.

Response: To prepare this Exhibit, CH2M HILL conducted a limited geological field reconnaissance of the entire proposed Facility area, and portions of the surrounding area, to observe the existing features at the site and look for evidence of past or potential geologic hazards. The field reconnaissance included evaluation of existing exposures of soil and rock (in road cuts, quarries, and within drainages), confirmation of mapped geologic features such as faults and landslides, and observation of typical slopes in the proposed turbine and transmission line areas.

CH2M HILL also performed a detailed literature review of the local and regional geology within and surrounding the vicinity of the Facility site boundary. Existing reports on adjacent sites were evaluated, and published literature and geologic mapping were reviewed. The literature review included a detailed evaluation of seismic hazards at the site (Section H.10).

The following detailed geologic hazards and geotechnical investigations will be conducted during turbine siting, access road and other facility layout, and foundation design:

- Test pits, soil borings, and rock cores will be advanced at each turbine location, structure location, and along access road alignments in order to determine soil strength and rock mass properties and evaluate foundation conditions. Seismic refraction surveys may also be used to evaluate depth to suitable foundation materials. The final layout of the turbines, roads, and associated structures will dictate the locations of the site-specific geotechnical investigations.

- During the final design geotechnical investigations, landslide hazard mapping will be conducted using the best available resources, including stereo pairs of aerial photographs, available Light Detection and Ranging (LIDAR) coverage, and field mapping. Drilling will be used to evaluate unstable areas, the characteristics of landslide-prone areas, and the depth to the Vantage Horizon and its engineering properties in order to avoid placing turbines, roads, or other facilities on existing landslides or potentially unstable areas.
• Conversely, based on the results of the detailed geotechnical investigations, the turbines, roads, and other structures will be sited to avoid or minimize geologic hazards and areas of poor foundation conditions, and foundations will be designed to appropriate factors of safety. The turbines and associated infrastructure such as roads and transmission towers will be sited to minimize or avoid geologic impacts of the turbines on the environment (for example, causing accelerated erosion or reconfiguring the landscape), and to minimize or avoid geologic impacts of the environment on the turbines (for example, a movement on a landslide damaging a turbine).

• Data and design reports will summarize the geologic hazards and geotechnical conditions, describe soil and rock properties and foundation conditions, present laboratory testing results of soils and rock, and provide detailed foundation recommendations for structural designers.

• A qualified engineer will provide oversight and inspection during construction, including foundation inspection by a qualified engineering geologist or geotechnical engineer, to ensure that the Facility is built according to plans and specifications and the stability of the turbines is not compromised.

H.7 EVIDENCE OF CONSULTATION WITH OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

OAR 345-021-0010(1)(h)(C) Evidence of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate site-specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.

Response: While preparing this Exhibit, CH2M HILL consulted DOGAMI publications and other guideline documents, including Oregon Board of Geologist Examiners (2000) and Oregon Board of Examiners for Engineering and Land Surveying (1996). In addition, a CH2M HILL geotechnical engineer spoke with Bill Burns at DOGAMI on January 25, 2012, to discuss the general details of the site terrain and geology, any geologic concerns that DOGAMI may have, and CH2M HILL’s recommendations for geotechnical exploration prior to construction (see Attachment H-2). Discussion results are summarized as follows:

• The Applicant will ensure that the planned future geotechnical exploration will follow the OAR guidelines for site-specific geotechnical work.

• The general scope and methods of the proposed future geotechnical exploration appeared satisfactory to DOGAMI at this time (for example, test pits, drilling, or geophysics at each turbine location).

• The State LIDAR database showed no activity in the Facility vicinity.

• The schedule of the exploration appears satisfactory to DOGAMI at this time (that is, pending permit and completion of turbine micrositing, the geotechnical exploration will be conducted following a timeline that is 6 months to 1 year in advance of the proposed start of construction).

• This information will be reviewed in order to make an accurate and up-to-date assessment of the activity of local faults, as well as the seismic potential of the site in order to guide the design criteria for the facility. The appropriate levels of subsurface exploration to support foundation design of facility components will be evaluated. Additional exploration such as drilling, test pits, CPT sounding, geophysics, or other appropriate methods will be considered and recommended before final design and Facility construction occur. Any additional recommendations for exploration will be reflected in the final Application for Site Certificate.

The Applicant will consult further with DOGAMI before planning and initiating the site-specific geotechnical exploration.
H.8 OVERHEAD 230-KV TRANSMISSION LINE

**OAR 345-021-0010(1)(h)(D)** For all transmission lines, a description of locations along the proposed route where the applicant proposes to perform site-specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, dead ends, corners, and portions of the proposed route where geologic reconnaissance and other site-specific studies provide evidence of existing landslides or marginally stable slopes that could be made unstable by the planned construction.

**Response:** The Applicant is proposing a new, 32-mile overhead, 230-kilovolt (kV) transmission line that will connect the Facility to Bonneville Power Administration’s (BPA’s) 500-kV transmission line at the existing Buckley substation. The 230-kV transmission line corridor will extend for approximately 12 miles from the southern collector substation to the northern Facility collector substation, and continue for 20 miles from the northern collector substation to BPA’s existing 500-kV line at the Buckley substation (Figure H-1).

The proposed transmission line will cross US 97 and Finnegan Canyon (see Figure H-1). Finnegan Canyon is steep-sided, V-shaped, and has approximately 500 feet of vertical relief from the plateau surface to the bottom of the drainage. Despite the steep slopes in Finnegan Canyon, the canyon walls are formed by stable basalt rock. However, the contact between the Wanapum Basalt and the Grande Ronde Basalt is exposed in the walls of Finnegan Canyon. This contact is often marked by the Vantage Member of the Ellensburg formation, which is a sedimentary interbed that is weaker than the basalt, can form perched groundwater zones, and can be prone to landsliding. The majority of transmission line alignment will cross flat-lying to very gently dipping Frenchman Springs and Grande Ronde basalt bedrock. No landslides have been previously mapped along the proposed alignment.

On the basis of observations made in the field and existing geologic mapping, transmission tower foundations can be located in the alignment without adversely affecting slope stability or long-term erosion. During final design of the transmission line and towers, geotechnical investigations and landslide hazard mapping will be conducted to characterize the soils and bedrock along the alignment. The investigation will consist of soil and rock borings at tower locations and any other locations that appear to have weak soils or poor foundation conditions. In particular, geologic hazard and landslide mapping will be conducted at the steep-walled Finnegan Canyon crossing.

H.9 PIPELINES

**OAR 345-021-0010(1)(h)(E)** For all pipelines that would carry explosive, flammable or hazardous materials, a description of locations along the proposed route where the applicant proposes to perform site-specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, and portions of the proposed alignment where geologic reconnaissance and other site-specific studies provide evidence of existing landslides or marginally stable slopes that could be made unstable by the planned construction.

**Response:** No pipelines will be constructed as part of the Facility.

H.10 SEISMIC HAZARD ASSESSMENT

**OAR 345-021-0010(1)(h)(F)** An assessment of seismic hazards. For the purposes of this assessment, the maximum probable earthquake (MPE) is the maximum earthquake that could occur under the known tectonic framework with a 10 percent chance of being exceeded in a 50-year period. If seismic sources are not mapped sufficiently to identify the ground motions above, the applicant shall provide a probabilistic seismic hazard analysis to identify the peak ground accelerations expected at the site for a 500-year recurrence interval and a 5000-year recurrence interval. In the assessment, the applicant shall include:
H.10.1 Maximum Considered Earthquake Ground Motion

(i) Identification of the Maximum Considered Earthquake Ground Motion as shown for the site under the 2009 International Building Code.

Response: The USGS Seismic Hazard Mapping project developed ground motions using a probabilistic seismic hazard analysis that covered the Facility site. Though these motions are not considered site-specific, they provide a reasonable estimate of the ground motions at the Facility site. The USGS data show that the 500- and 5,000-year earthquakes have bedrock peak ground accelerations of 0.08 times the acceleration from gravity (g) and 0.25g, respectively (USGS, 2011a).

For new construction, the site should be designed for the maximum considered earthquake, according to the International Building Code (IBC, 2009) as amended by the Oregon Structural Specialty Code (OSSC, 2010). This code adheres to the 2003 National Earthquake Hazards Reduction Program (NEHRP) Seismic Design Provisions (FEMA, 2003), and the 2002 USGS seismic hazard mapping project. This event has a 2 percent probability of exceedance in 50 years (or an approximate 2,475-year return period). For the Facility, this event has an estimated peak ground acceleration (PGA) of 0.18g at the bedrock surface based on the USGS seismic hazard mapping project. This value of PGA on rock is an average representation of the acceleration for all potential seismic sources (crustal, intraplate, or subduction) mapped as active at the time of the study (USGS, 2002).

Seismic design parameters were developed in accordance with the International Building Code (2009). Analysis of existing subsurface information (including a preliminary review of geologic mapping and nearby well logs) suggests that the Facility will be conservatively designed for Site Class D (stiff soil profile), in accordance with IBC requirements. Site classes B or C are anticipated to be likely based on the available literature. Once site-specific geotechnical subsurface information is collected, the actual site class determination may improve or worsen. Final site class determination cannot be made until further site exploration is performed, including a possible evaluation of shear wave velocity in shallow rock, and drilling at specific structure locations to obtain parameters for soil strength and consistency. The current recommended seismic design parameters are summarized in Table H-2.

<table>
<thead>
<tr>
<th>Earthquake Scenario</th>
<th>Site Class</th>
<th>Controlling Earthquake Magnitude</th>
<th>Peak Horizontal Ground Acceleration on Bedrock</th>
<th>Soil Amplification Factor, F_a</th>
<th>Peak Horizontal Ground Acceleration at Ground Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Probable Earthquake (MPE)</td>
<td>S0 (475-yr return)</td>
<td>9.0</td>
<td>0.08g</td>
<td>1.60</td>
<td>0.14g</td>
</tr>
<tr>
<td>Maximum Considered Earthquake</td>
<td>S0 (2,475-yr return)</td>
<td>5.2</td>
<td>0.18g</td>
<td>1.44</td>
<td>0.27g</td>
</tr>
</tbody>
</table>

Note: Earthquake magnitude in this table is a modal representation of all known seismic sources. The peak ground acceleration is assumed to be roughly 40 percent of the 0.2-second spectral acceleration, following the recommendations of the IBC.
g = acceleration from gravity.

The following additional parameters for the two different earthquake scenarios may be used for structural design:

- Maximum Probable Earthquake (MPE) - 10 Percent Exceedance in 50 Years (475-Year Return Interval)
  - Short period (0.2-second) spectral response acceleration at the ground surface, $S_{M5} = 0.318g$ for Site Class S0

- 1-second period spectral response acceleration at the ground surface, $S_{M1} = 0.174g$ for Site Class S0

Maximum Considered Earthquake - 2 Percent Exceedance in 50 Years (2,475-Year Return Interval):
Short period (0.2-second) spectral response acceleration at the ground surface, $S_{MS} = 0.649g$ for Site Class $SD$

1-second period spectral response acceleration at the ground surface, $S_{M1} = 0.332g$ for Site Class $SD$

The design spectral response accelerations, $SD_S$ and $SD_1$, for both short period and 1-second period are determined by multiplying the Maximum Considered Earthquake spectral response accelerations ($S_{MS}$ and $S_{M1}$) by a factor of 2/3.

H.10.2 Earthquake Sources

(ii) Identification and characterization of all earthquake sources capable of generating median peak ground accelerations greater than 0.05g on rock at the site. For each earthquake source, the applicant shall assess the magnitude and minimum epicentral distance of the maximum credible earthquake (MCE).

Response: The potential seismic hazards in the Facility vicinity result from three seismic sources: Cascadia Subduction Zone (CSZ) interplate events, CSZ intraslab events, and crustal events.

H.10.2.1 Interplate and Intraslab Events

Interplate and intraslab events are caused by the subduction of the Juan de Fuca plate beneath the North American plate. Interplate events are caused by the frictional interface between these two tectonic plates. Intraslab events originate within the subducting Juan de Fuca plate, and they are generally associated with normal faulting that results from bending stresses built up within the plate as it is subducted beneath the North American plate. The combination of these factors is often referred to as the CSZ source mechanism. The CSZ is located beneath western Oregon, Washington, and British Columbia. The two source mechanisms associated with the CSZ are thought to be capable of producing maximum earthquakes with moment magnitudes of approximately 9.0 and 7.2 for the interplate and intraslab events, respectively (Geomatrix, 1995; USGS, 2011a, 2011b). The estimated depth to the intraslab source mechanism in the Brush Canyon area is +90 kilometers (McCrory et al., 2006). However, upon closer examination of the USGS source data, none of the seismic sources for the site has a depth that corresponds to the intraslab source depth, and therefore it does not appear to be a significant source for the Facility area.

H.10.2.2 Crustal Events

Earthquakes caused by movements along crustal faults, generally in the upper 10 to 15 miles, result in the third source mechanism. In the Facility vicinity, earthquakes occur within the crust of the North American tectonic plate when built-up stresses near the surface are released through fault rupture.

No known or active faults are mapped within the Facility boundaries (USGS, 2010, Weldon et al., 2002). A number of potentially active, late Quaternary-age faults are mapped in central Oregon. As shown in Table H-3, the crustal faults nearest to the site with the most recent rupture history are the Warm Springs fault zone, the Sisters Fault zone, and the Green Ridge, Rimrock-Tumalo and Northwest Rift Zone sections of the Metolius fault zone. Potentially active faults within an 80-kilometer (50-mile) radius of the site are shown on Figure H-2.
Table H-3. Summary of Potentially Active Faults

<table>
<thead>
<tr>
<th>Fault</th>
<th>Distance to Facility (km)a</th>
<th>Fault Length (km)</th>
<th>Maximum Estimated Magnitude (Wells and Coppersmith, 1994)b</th>
<th>Most Recent Movement</th>
<th>Slip-Rate Category (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm Springs Fault Zone</td>
<td>53</td>
<td>34</td>
<td>6.9</td>
<td>&lt; 750 ka</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Sisters Fault Zone</td>
<td>109</td>
<td>53</td>
<td>7.1</td>
<td>&lt; 15 ka</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Metolius Fault Zone, Green Ridge Section</td>
<td>80</td>
<td>29</td>
<td>6.8</td>
<td>&lt; 750 ka</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Metolius Fault Zone, Rimrock-Tumalo Section</td>
<td>103</td>
<td>45</td>
<td>7.0</td>
<td>&lt; 130 ka</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Metolius Fault Zone, Northwest Rift Zone Section</td>
<td>109</td>
<td>43</td>
<td>7.0</td>
<td>&lt; 15 ka</td>
<td>&lt; 0.2</td>
</tr>
</tbody>
</table>

Notes:

a Closest mapped portion of fault to the Facility site boundary.

b Wells and Coppersmith (1994) relationship for estimating maximum magnitude for crustal faults is based on the following relationship: 5.08+1.163*LOG (Fault Length [in km]).

ka = Thousands of years ago.

km = kilometer.

mm/yr = millimeters per year.

Sources: Personius 2002a, 2002b, 2002c, 2002d, and 2002e.

Warm Springs Fault Zone

The Warm Springs fault zone is a 30-kilometer-wide zone of mostly west-dipping, north-trending normal faults that offset early Pleistocene, Pliocene, and Miocene volcanic rocks and sediments along the eastern margin of the Cascade Range in north-central Oregon. Fault scarps with heights of 3-12 m have been identified along some strands of the Warm Springs fault zone. The geomorphic expression of the youngest scarps in this fault zone suggests latest movement in the middle and late Quaternary (Personius, 2002a).

Sisters Fault Zone

The Sisters fault zone comprises numerous, northeast- and southwest-dipping, northwest-striking normal faults that offset Miocene to upper Pleistocene volcanic rocks and sediments along the eastern margin of the Cascade Range in central Oregon. The structural setting of the Sisters fault zone is probably a structural transition zone between the northwest-trending, right-lateral Brothers fault zone and the more northerly trending parts of the Metolius normal fault zone. Most of the fault strands that comprise the Sisters fault zone have latest displacements in the middle and late Quaternary, but two fault strands north of Tumalo may offset glacial outwash deposits and thus may have been active in the late Quaternary (Personius, 2002b).

Metolius Fault Zone

The Green Ridge section of the Metolius fault zone is a north-striking normal fault that parallels a 750-meter-high, linear escarpment in Miocene volcanic rocks on the western margin of Green Ridge. Despite its height and linearity, little geomorphic evidence of Quaternary faulting has been found along this escarpment. The Green Ridge fault offsets upper Miocene (5.27 ± 0.04 Ma) volcanic rocks of the Deschutes Formation. No detailed fault slip data have been documented, but the lack of significant geomorphic evidence of Quaternary displacement on most faults in the Green Ridge section suggest low rates of slip (Personius, 2002c).

The Rimrock-Tumalo section of the Metolius fault zone consists of several mostly southwest-dipping, northwest trending fault strands in gently east-tilted late Tertiary and Quaternary volcanic rocks. These faults are marked by prominent scarps up to 70 meters high in Miocene-Pliocene volcanic rocks, 2- to 10-meter-high scarps in middle Pleistocene ash-flow tuffs and lavas, and in places have been mapped as faulting glacial outwash or alluvial surfaces (Personius, 2002d).
The discontinuous en echelon faults in the Northwest Rift zone section are marked by 2- to 25-meter-high scarps in Tertiary and Quaternary volcanic rocks. In addition to fault scarps, numerous Pleistocene and Holocene volcanic vents are aligned along the fault trends, thus all these features may be surface expressions of dikes at depth, formed in response to the regional stress field. Faults in the Northwest Rift zone offset older Plio-Pleistocene through middle to late Pleistocene volcanic rocks. Some basaltic andesites that overlie these deposits on the northwest flank of Newberry volcano are younger than the last major glaciation, and thus were deposited less than 15 thousand years ago (Personius, 2002e).

**H.10.2.3 Peak Ground Acceleration**

The PGA at the site resulting from a seismic event on one of these source mechanisms was estimated using information developed by USGS in its seismic hazard mapping database (USGS, 2011a; 2011c). This information includes estimated PGA at a theoretical soft rock/stiff soil interface for different probabilities of exceedance. The USGS database also provides the seismic deaggregation information for the seismic hazard, including estimates of the mean and modal earthquake moment magnitude and epicentral distance associated with a given probability of exceedance at a given location.

**H.10.2.4 Maximum Probable Earthquake and Maximum Considered Earthquake**

The maximum probable earthquake (MPE) is an earthquake that has a 10 percent probability of exceedance in 50 years (a nominal 475-year recurrence interval). The Maximum Considered Earthquake (MConE) is an earthquake with a nominal 2,475-year recurrence interval (a 2 percent probability of exceedance in 50 years). Figures H-3 and H-4 show the probabilistic seismic hazard deaggregation for the MPE and MConE events, respectively.

The Maximum Credible Earthquake (MCE), is the maximum event that each source is believed to be capable of producing. To provide an estimate of the MCE events from each principal source mechanism, the maximum moment magnitude for each fault was estimated using the relationship developed by Wells and Coppersmith (1994), which relates magnitude to fault length (USGS, 2011a) and distance from the Facility. These analysis parameters were summarized for the potentially active faults near the Facility, and shown in Table H-3. In addition to these estimated magnitudes for crustal faults, Table H-4 summarizes the magnitudes for the random, unnamed crustal event from the USGS gridded hazard, and the CSZ intraslab and interplate events.

<table>
<thead>
<tr>
<th>Earthquake Source</th>
<th>Maximum Moment Magnitude</th>
<th>Epicentral Distance (miles [kilometers])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Hazard (Shallow Gridded WUS)</td>
<td>6.0</td>
<td>6 [10]</td>
</tr>
<tr>
<td>Crustal</td>
<td>6.8 to 7.1</td>
<td>33 to 68 [53 to 109]</td>
</tr>
<tr>
<td>Intraslab</td>
<td>7.2</td>
<td>119 to 126 [192 to 203]</td>
</tr>
<tr>
<td>Interplate</td>
<td>9.0</td>
<td>156 to 167 [251 to 268]</td>
</tr>
</tbody>
</table>

Notes:
The magnitude for all crustal events is determined from the fault length/distance by Wells and Coppersmith (1994).

WUS = Western United States.

**H.10.3 Recorded Earthquakes**

(iii) A description of any recorded earthquakes within 50 miles of the site and of recorded earthquakes greater than 50 miles from the site that caused ground shaking at the site more intense than the Modified Mercalli III intensity. The applicant shall include the date of occurrence and a description of
the earthquake that includes its magnitude and highest intensity and its epicenter location or region of highest intensity.

Response: Figure H-2 displays the location, approximate magnitude, and approximate date of occurrence of all recorded earthquakes within 50 miles of the Facility site boundary. The historical seismic events are grouped by magnitude, and are displayed in differently-sized and -colored icons based on the strength of event. Because of the high number of events in the vicinity, several of the icons overlap in the figure.

Table H-5 provides a summary of all recorded earthquakes known to have caused Modified Mercalli Intensity (MMI) III shaking intensity or greater within the Facility site boundary, regardless of epicentral distance from the site boundary. For reference, an intensity of MMI III is associated with shaking that is “noticeable indoors, but may not be recognized as an earthquake.” An intensity of MMI VII is “noticed by people driving cars, everyone runs outdoors, and slight to moderate damage is caused to well-built, ordinary buildings.” (USGS, 2011d).

The greatest historical event known for the area is the January 26, 1700, Cascadia megathrust earthquake which occurred along North America’s west coast between Vancouver Island and northern California (USGS, 2011). This is the only event with an estimated intensity at the site of MMI VI.

The largest recorded earthquake within 50 miles (80 kilometers) of the Facility site boundary was the magnitude 4.8 event, which occurred in 1976 approximately 5 miles west of the nearest site boundary of the proposed Facility and within 1 mile of the planned transmission line (Madin, 1994; Wong and Bott, 1995; USGS, 2011b). This event and the 1700 magnitude 9.0 CSZ megathrust event southwest of Tacoma (approximately 160 miles west of the Facility), are the only two known events to have produced an intensity of MMI V at the Facility. The most distant events to have produced a minimum intensity of MMI III at the site include the 1915 magnitude 7.1 (Richter scale) Pleasant Valley event in northern Nevada, located over 350 miles from the nearest site boundary, and the 1906 magnitude 7.8 San Francisco earthquake in northern California, located over 500 miles from the Facility.

Table H-5 is derived from earthquake databases provided by DOGAMI (Madin, 1994), Berg and Baker (1963), the USGS National Earthquake Information Center, Earthquake Search Data Bases (USGS, 2011b), and the NGDC, U.S. Earthquake Intensity Database (NGDC, 2010). For earthquakes reported by magnitude, a relationship between PGA and MMI (Kramer, 1996, and Wald et al., 1999) was used to define a PGA associated with an MMI III event. A distance-attenuation relationship then was used to determine the combination of earthquake magnitude and distance producing an intensity of MMI III within the Facility site boundary. The Abrahamson & Silva 2008 Next Generation Attenuation (NGA) model was used to develop the magnitude-distance information (PEER, 2009) for seismic events in the northwest United States capable of producing accelerations within the Facility site boundary strong enough to cause MMI III intensity shaking. For earthquakes that were reported in terms of intensity (such as the NGDC database), the reported intensity is listed in Table H-5. It is noteworthy that the reported intensity for some events does not agree with the intensity estimated by the method described above. For distant events (more than 150 miles from the nearest Facility site boundary), the reported intensity typically is higher than the estimated intensity. For more proximal events, the reported intensity typically is less than the estimated intensity.
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Latitude (dec. deg)</th>
<th>Longitude (dec. deg.)</th>
<th>Distance from Facility (miles)</th>
<th>Moment Magnitude (unless otherwise noted)</th>
<th>Estimated MM Intensitya</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700</td>
<td>1</td>
<td>26</td>
<td>*</td>
<td>*</td>
<td>180</td>
<td>9.0</td>
<td>V</td>
</tr>
<tr>
<td>1872</td>
<td>12</td>
<td>15</td>
<td>47.9</td>
<td>-120.3</td>
<td>192</td>
<td>6.8</td>
<td>II</td>
</tr>
<tr>
<td>1906</td>
<td>4</td>
<td>18</td>
<td>38</td>
<td>-123</td>
<td>506</td>
<td>7.8</td>
<td>III</td>
</tr>
<tr>
<td>1915</td>
<td>10</td>
<td>3</td>
<td>40.5</td>
<td>-117.5</td>
<td>357</td>
<td>7.1</td>
<td>III</td>
</tr>
<tr>
<td>1949</td>
<td>4</td>
<td>13</td>
<td>47.1</td>
<td>-122.7</td>
<td>168</td>
<td>7.0</td>
<td>IV</td>
</tr>
<tr>
<td>1976</td>
<td>4</td>
<td>13</td>
<td>45.22</td>
<td>-120.77</td>
<td>9</td>
<td>4.8</td>
<td>IV</td>
</tr>
<tr>
<td>1976</td>
<td>4</td>
<td>17</td>
<td>45.08</td>
<td>-120.8</td>
<td>8</td>
<td>4.2</td>
<td>II</td>
</tr>
<tr>
<td>1993</td>
<td>3</td>
<td>25</td>
<td>45.03</td>
<td>-122.61</td>
<td>96</td>
<td>5.6</td>
<td>III</td>
</tr>
<tr>
<td>1994</td>
<td>4</td>
<td>13</td>
<td>45.14</td>
<td>-120.85</td>
<td>10</td>
<td>2.8</td>
<td>III</td>
</tr>
<tr>
<td>1994</td>
<td>4</td>
<td>16</td>
<td>45.14</td>
<td>-120.84</td>
<td>10</td>
<td>2.6</td>
<td>III</td>
</tr>
<tr>
<td>1997</td>
<td>3</td>
<td>22</td>
<td>45.19</td>
<td>-120.07</td>
<td>28</td>
<td>3.9</td>
<td>III</td>
</tr>
<tr>
<td>1998</td>
<td>11</td>
<td>1</td>
<td>45.1</td>
<td>-120.83</td>
<td>10</td>
<td>2.9</td>
<td>IV</td>
</tr>
<tr>
<td>1998</td>
<td>10</td>
<td>31</td>
<td>45.1</td>
<td>-120.82</td>
<td>9</td>
<td>2.7</td>
<td>III</td>
</tr>
<tr>
<td>2000</td>
<td>1</td>
<td>30</td>
<td>45.2</td>
<td>-120.12</td>
<td>25</td>
<td>4.1</td>
<td>III</td>
</tr>
<tr>
<td>2000</td>
<td>2</td>
<td>1</td>
<td>45.19</td>
<td>-120.11</td>
<td>25</td>
<td>3.6</td>
<td>III</td>
</tr>
<tr>
<td>2000</td>
<td>1</td>
<td>30</td>
<td>45.19</td>
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Table H-5. Significant Historical Earthquakes Causing MM III or Greater Intensity Shaking within the Facility Site Boundary

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Latitude (dec. deg)</th>
<th>Longitude (dec. deg.)</th>
<th>Distance from Facility (miles)</th>
<th>Moment Magnitude (unless otherwise noted)</th>
<th>Estimated MM Intensitya</th>
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Notes:
* - Location for this event is not precisely known. Reported MM Intensity is for a minimum estimated epicentral distance for the Cascadia subduction zone source location.

= MM Intensity estimated at the Facility.

Sources: Madin, 1994; USGS, 2011b; NGDC, 2011.

H.10.4 Median Ground Response Spectrum

(iv) Assessment of the median ground response spectrum from the MCE and the MPE and identification of the spectral accelerations greater than the design spectrum provided in the 2010 Oregon Structural Specialty Code. The applicant shall include a description of the probable behavior of the subsurface materials and amplification by subsurface materials and any topographic or subsurface conditions that could result in expected ground motions greater than those characteristic of the Maximum Considered Earthquake Ground Motion identified above.

Response: Figure H-5 compares the USGS-derived, IBC 2009/ASCE 7 design spectral response accelerations for the MConE and MPE (for Site Class B), with the MCE spectral response occurring on the CSZ source mechanisms and on each of the crustal faults identified in Table H-3, and using the inputs summarized in Table H-4. The NGA model inputs for the crustal fault sources are summarized in Table H-4, and are based on the magnitude-distance relationship developed by Wells and Coppersmith (1994). For the CSZ sources, the geometric characterization is based on the modeling done by McCrory at al. (2006). These geometric inputs are used in the attenuation relationships by Youngs et al. (1997), Atkinson and Boore (2003), Zhao et al. (2006), and Garcia et al. (2005). Weighting of each of these models follows the 2008 USGS National Seismic Hazards Mapping scheme. An epicentral depth of 20 kilometers is used for the interface source, and a 50-kilometer depth is used for the intraslab source. In addition to the crustal faults and parameters listed in Table H-3, an unknown fault with a moment magnitude of M6.0 and source-to-site distance of 10 km was also included to account for uncertainty of unmapped faults. Figure H-5 compares the response on the bedrock surface between the design spectra and the median response spectra from the principal sources. Therefore, all plots in Figure H-5 are presented at the bedrock surface (or the B/C boundary, where no site-specific amplification is applied to spectral accelerations).

H.10.5 Seismic Hazards Expected to Result from Seismic Events

(v) An assessment of seismic hazards expected to result from reasonably probable seismic events. As used in this rule “seismic hazard” includes ground shaking, ground failure, landslide, lateral spreading, liquefaction, tsunami inundation, fault displacement and subsidence.

Response: For facilities designed to the current IBC and OSSC guidelines for Site Class D (or B), the design seismic event will have a 2 percent chance of exceedance in the next 50 years (or an event with an approximate 2,475-year recurrence interval). For this event, the Facility will be designed for no life-threatening structural damage from either the vibrational response of the structure or from secondary hazards associated with ground movement or failure, such as landslides, lateral spreading, liquefaction, fault...
displacement, or subsidence. It is generally assumed that if significant structural damage can be prevented, the risk to human safety will be minimal.

Seismic hazards associated with a design seismic event could potentially include surface fault rupture, ground shaking, liquefaction, and lateral spreading, including adverse effects of groundwater, and slope instability from landslides or subsurface movement. Impacts to the Facility from these hazards are anticipated to be low, as discussed below.

H.10.5.1 Potential for Surface Fault Rupture
The probability of a fault displacement at the Facility is considered to be low because of the absence of known or mapped potentially active faults in the area, and particularly within the site boundary. Unknown faults could possibly exist, or new fault ruptures could form during a significant seismic event, but the likelihood of either occurrence is low based on the relatively stable region and lack of active faults identified during previous geologic investigations. This hazard is further reduced by the small chance that a new or unknown fault offset would actually displace the ground surface at the location of one of the wind turbines, a Facility structure, or underground cables between turbines. This low probability, in combination with the limited occupancy of the structures, results in minimal risk from fault rupture.

H.10.5.2 Potential for Ground Shaking
Low levels of ground shaking are expected at the site given the seismic setting. However, the probability of damage to structures from ground shaking is considered to be low because the Facility components will be designed for the seismic potential of the area. Little or no structural damage is anticipated from MMI III intensity shaking, which is the predominant level of ground shaking anticipated at the site based on the historical record. Higher intensity shaking (MMI IV or MMI V) is not anticipated to cause significant damage to the Facility components. For comparison, MMI VII shaking is considered to result in “negligible damage in buildings of good design and construction.” The period of historical record (1700 to present) is relatively brief from a geologic standpoint, and larger events (including greater intensity shaking) at the site are a possibility. Based on the historical record from 1700 to present, no earthquakes at the Facility would have resulted in MMI VII intensity shaking.

H.10.5.3 Potential for Liquefaction and Lateral Spreading
Soil liquefaction refers to the loss of shear strength that saturated soil deposits can experience during undrained cyclic loading, such as earthquake loading. The susceptibility of a soil deposit to liquefaction is primarily a function of the degree of saturation (depth to groundwater), soil grain size, relative density, percent fines, plasticity of fines, and earthquake ground motion characteristics. Lateral spreading takes place when liquefaction occurs in a relatively widespread and continuous layer on low-angle slopes (less than 1 percent) or adjacent to an open face.

Based on available well logs, regional groundwater is relatively deep. In addition, based on available information, basalt rock is anticipated to be relatively shallow across the site. The soil that does overlie the bedrock typically is silty, which is not generally susceptible to liquefaction because of the very fine grain size. Because of the absence of groundwater in the surficial soil, the silty nature of the surficial soils and shallow depth to basalt rock, liquefaction (and its associated impacts, such as lateral spreading) is not considered a seismic hazard for the site.

H.10.5.4 Slope Instability
Areas of steep slopes, exceeding 10 feet in height and composed of thick soil deposits, generally are not present at the locations of Facility components. However, should these areas exist near Facility components, a seismic event could induce a slump or landslide and cause an unacceptable amount of soil movement. Results of simplified seismic stability analyses suggest that loess slopes steeper than 30 degrees could be unstable for the 500-year seismic event and that slopes steeper than 21 degrees could be unstable for the
2,500-year seismic event. Sliding of the soil is not expected to be a design consideration for the turbine structures because they will be located on relatively flat ground. Other facilities, such as roads, could possibly be constructed on slopes steeper than 21 to 30 degrees in some locations. Soil movement could affect these facilities if the slopes were to fail. Because these roads are used infrequently, however, the risks associated with slope movement are very low.

In steep slopes formed by rock outcrops, risk of a seismically induced landslide in the rock or rockfalls exists; however, the risk of this occurrence is expected to be very low. Basalt rock has high internal shear strength, even in highly fractured rock masses, and is unlikely to undergo significant movements during either 500- or 2,500-year seismic events. Rockfalls may originate from rock outcrops, but these will tend to be of limited extent and would be limited to steep slopes and canyon walls, where no structures would be constructed. Seismically induced landslides and rockfalls are not expected to affect the safety and performance of the Facility.

Historical landslides are evident throughout the southern area of the Facility boundary. These landslides are typified by large blocks of rock and hillslopes that were displaced large distances, by sliding over the weaker clayey soils of the John Day formation. Although no observations were made during the site visit that would indicate these landslides are currently active, the literature review has indicated that some landslides may still be active. In addition, it is possible to reactivate historical landslides by modifying land usage, new construction, or extremes in seasonal precipitation. The shear strength of soils in this area of the site will be reduced where past sliding has occurred. Areas of reduced (also called “residual”) shear strength that are locally saturated from rainfall or changes in land use, could be further weakened or induced to fail by seismic shaking during an earthquake. New structures and changes to land use will be avoided in areas where weak soils and historical landslides exist, in order to avoid the risks associated with these hazards.

The overall potential for seismic-induced hazards generally is low at the Facility. Mitigation measures to address these hazards in the siting, design, and construction of the Facility are described in Section H.12. The design of the Facility components can readily accommodate the level of seismic energy described in Section H.10.4, Median Ground Response Spectrum.

H.11 NONSEISMIC GEOLOGICAL HAZARDS

OAR 345-021-0010(1)(h)(G) An assessment of soil-related hazards such as landslides, flooding and erosion which could, in the absence of a seismic event, adversely affect or be aggravated by the construction or operation of the facility.

Response: Nonseismic geologic hazards in the Columbia Plateau region typically include landslides, volcanic eruptions, soil erosion, collapsing soils and piping, shrinking and swelling soils, and flooding. A discussion of potential geologic hazards is presented below. Mitigation measures for possible geologic hazards are discussed in Section H.13.

H.11.1 Landslides

In 2011, DOGAMI released an update of the publication called Statewide Landslide Information Database for Oregon (SLIDO-2; DOGAMI, 2011). The purpose of this document was to establish a statewide database of previously mapped landslide-related features. The features included in this database include landslides, debris flows or alluvial fans, and colluvium or talus. The primary sources of this historical landslide information are published geologic reports and geologic hazard studies by the USGS, DOGAMI, and to a lesser extent regional studies by the U.S. National Forests and thesis studies in the state. The landslide database from this study, which is compiled in GIS format, was used to overlay landslide areas or landslide-related features on Figure H-1.
No landslides are indicated in the site vicinity north and east of Shaniko, based on the SLIDO database and mapping. The field reconnaissance also confirmed the lack of landslide terrain in this area. In most of the side slopes in drainages, bedrock outcrops and basalt layers were observed which indicates stable rock underlying the slopes.

However, a large area of the southern portion of the site, primarily northeast, east, and southeast of Antelope is underlain by the John Day formation. These sedimentary beds are low-strength, contain several clay and volcanic ash layers, and prone to sliding. The landslide deposits are irregular and hummocky and consist of soil, rock, also include large relatively intact blocks of basalt derived from the higher plateaus. The resistant basalt cliffs form prominent cliffs above many of the landslide deposits. The subsurface material in the landslide terrain appears to be composed of a jumbled mix of sedimentary rock and basalt fragments, some of which are very large. Most of the landslides have subdued topography, lack fresh scarps, and according to Robinson (1975), probably originated during the Pleistocene (more than 15,000 years ago). However, Robinson (1975) notes that many of the landslides are still active. Historical landslides can be reactivated by modifying land usage, adding loads by new construction, or enduring extremes in seasonal precipitation (for example, large rainfall events).

Colluvium and talus deposits that mantle the canyon walls incised into the basalt plateau within the northern part of site boundary could experience slow downhill movement or creep due to the steep slope angles. However, no turbines, structures, or roads will be constructed on these steep slopes in the canyons, and therefore potential impacts would be avoided.

H.11.2 Volcanic Eruptions

The Pacific Northwest region is home to a large number of active volcanoes along the Cascade Mountain Range. The closest volcanoes to the Facility site boundary are as follows, with distances from each mountain to the Facility site boundary:

- Mount St. Helens—110 miles northwest
- Mount Jefferson—60 miles west-southwest
- Mount Adams—95 miles northwest
- Mount Hood—55 miles west-northwest

The locations of Mount Hood and Mount Jefferson (the two closest volcanoes) are shown on Figure H-2. Most of the volcanic hazards impacts would occur within a 50-mile radius of the erupting volcano. Depending on the prevailing wind direction at the time of the eruption and the source of the eruption, ash fallout in the region surrounding the Facility may occur. Because of the distance to the nearest volcanoes, impacts to the Facility from volcanic activity would be indirect and likely be limited to ash fallout.

Mount Hood has had at least four major eruptive periods during the past 15,000 years (Gardner et al., 2000). The last three occurred within the past 1,800 years from vents high on the southwest flank and produced deposits that were distributed primarily to the south and west along the Sandy and Zigzag rivers. The last eruptive period took place around 170-220 years ago, when dacitic lava domes, pyroclastic flows and mudflows were produced without major explosive eruptions. Minor 19th-century eruptions were witnessed from Portland. The last episode ended shortly before the arrival of Lewis and Clark in 1805. When Mount Hood erupts again, it will severely affect areas on its flanks and far downstream in the major river valleys that head on the volcano. Volcanic ash (tephra) may fall on areas up to several hundred kilometers downwind, and the effects are dependent on wind direction, speed, volume of tephra ejected, and duration of eruption.

In the last 200 years, only Mount St. Helens has erupted more than once (USGS, 2010). During the past 4,000 years, Mount St. Helens has erupted more frequently than any other volcano in the Cascade Range. The May 18, 1980, eruption was the most economically destructive volcanic event in U.S. history. The volcanic ash cloud from this eruption drifted east across the United States in 3 days and encircled Earth in
15 days. The ash fall caused problems for transportation operations, decreased visibility that closed highways and roads, and disrupted air transportation. The fine-grained, gritty ash also caused problems for internal-combustion engines and other mechanical and electrical equipment and caused short circuits in electrical transformers, which in turn caused power blackouts. The removal and disposal of ash from highways, roads, buildings, and airport runways were monumental tasks for local communities (USGS, 2009a).

Geologic evidence shows that Mount Jefferson is capable of large explosive eruptions. The largest such eruption occurred between 35,000 and 100,000 years ago, and caused ash to fall as far away as the present-day town of Arco in southeast Idaho. Although there has not been an eruption at Mount Jefferson for some time, experience at explosive volcanoes elsewhere suggests that Mount Jefferson cannot be regarded as extinct. If Mount Jefferson erupts again, areas close to the eruptive vent will be severely affected, and even areas tens of kilometers (tens of miles) downstream along river valleys or hundreds of kilometers (hundreds of miles) downwind may be at risk.

Mount Adams has been less active during the past few thousand years than neighboring Mount St. Helens, Mount Rainier, and Mount Hood. Future eruptions will probably occur more frequently from vents on the summit and upper flanks of Mount Adams (Scott et al., 1995).

H.11.3 Soil Erosion

Soils can be eroded from water runoff and wind erosion. The soil erodibility factor (K) ranges from 0.02 to 0.69. The higher the value, the more susceptible the soil is to erosion. Data from the NRCS Web Soil Survey (NRCS, 2011) indicate that the predominant silt loam soils on the site have a soil erodibility factor that ranges from 0.10 to 0.43. The soils that underlie the majority of the northern flat plateau east and north of the Shaniko area include the Condon silt and Condon-Bakeoven complex. These soils have a K factor of 0.43, which indicates moderately erodible soils that could be subject to sheet erosion and rill erosion by water. The soils that underlie the southern portions of the site include the Curant and Tub soils, which have K factors of 0.24 to 0.43, which also indicates moderately erodible soils that could be subject to sheet erosion and rill erosion by water.

The soils on the site could also be subject to wind erosion. The soils that underlie the site are in the Wind Erodibility Group (WEG) of 5. On a scale of 1 to 8, 1 is the most susceptible and 8 is the least susceptible to wind erosion. Therefore, the soils are expected to have a low to moderate wind erosion potential. Mitigation for potential soil erosion is discussed in Section H.13.

H.11.4 Collapsing Soils/Piping

Because of the nature of its depositional formation and silty, low- to no-plasticity behavior, loess has a structure that is sometimes susceptible to collapse or swelling when wetted or saturated. This occurs due to rearrangement of the soil particles, and can have a detrimental effect on embankments or foundations constructed on loess. Although loess soils within the Facility area may become temporarily saturated near the ground surface during spring thaw or a heavy rainstorm, the overall stratum of loess soils are unlikely to maintain long-term saturation because of their position above the groundwater table and floodplain. However, the loess soils in the site vicinity could potentially be subject to piping or collapse. In area where the soils are very thin to absent, the piping or collapse potential is very low, as the structures would be founded directly on rock.

H.11.5 Shrinking and Swelling Soils

Changes in soil moisture cause certain clay minerals in soils to either expand or contract. The amount and type of clay minerals in the soil influence the change in volume. Structures or roads built on shrinking or swelling soils could be damaged by the change in volume of the soil. Linear extensibility (shrink-swell potential) refers to the change in length of an unconfined clod as its moisture content is decreased from a moist state to a dry state. The volume change is reported as percent change for the soil. The surficial soils
that underlie the majority of the site (Condon silt loam) have a linear extensibility of 1.5 percent, which is considered to be low for shrink-swell potential. These soils are not expected to affect the Facility or require special evaluation and construction (NRCS, 2011).

The Curant and Tub soils that underlie the southernmost portion of the site have linear extensibility between 3.2 and 6.9 percent, which indicated moderate to high potential for shrink-swell. Roads, turbines, and structures constructed in areas underlain by these soils may require mitigation and special construction techniques, as discussed in Section H.13.

H.11.6 Corrosion Potential of Soils and Rock

Corrosion of buried steel or concrete usually results from an electrochemical reaction between the metal and water or moist soil. “Risk of corrosion” to concrete, as defined by the NRCS, pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. The risk of corrosion of concrete is expressed as “low,” “moderate,” or “high.”

“Risk of corrosion” to steel, as defined by the NRCS, pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The risk of corrosion is expressed as “low,” “moderate,” or “high.”

The onsite surficial soils are rated as “Low” risk of corrosion to concrete, and “Moderate” risk of corrosion to steel, except for the Curant and Tub soils in the southernmost portion of the site, which are rated as “High” risk of corrosion to steel (Table H-1). Typical resistivity values for rock range from 10,000 to 100,000 ohm per centimeter, which indicate mildly corrosive to noncorrosive potential.

H.11.7 Flooding

The Facility site boundaries are well above the 100-year FEMA floodplain (FEMA, 2011). The Facility structures will be constructed on ridges and plateau surface, rather than in the bottoms of drainages that are subject to flooding. Seasonal thunderstorms and snowmelt can result in concentrated stormwater runoff and localized flooding. However, the engineered roads and drainages will direct stormwater runoff to away from structures and into drainage ditches and culverts. The risks and potential impacts to the Facility from flood hazards are expected to be low.

H.12 SEISMIC HAZARD MITIGATION

OAR 345-021-0010(1)(h)(H) An explanation of how the applicant will design, engineer and construct the facility to avoid dangers to human safety from the seismic hazards identified in paragraph (F). The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring for seismic hazards.

Response: The state of Oregon uses the 2009 IBC, with current amendments by the OSSC and local agencies. Pertinent design codes as they relate to geology, seismicity, and near-surface soil are contained in IBC Chapter 16, Section 1613, with slight modifications by the current amendments of the state of Oregon and local agencies. The Facility will be designed to meet or exceed the minimum standards required by these design codes.

A limited, reconnaissance-level geologic assessment was performed during preparation of the Application for Site Certificate. The data collected during the final geotechnical exploration and design of the Facility will be used to mitigate potential hazards that could be created during a seismic event. The hazard of a surficial rupture along a fault trace is anticipated to be low, given the seismic history of the site displayed in geologic mapping and the low probability that a fault rupture would actually displace the ground surface at the
location of one of the wind turbines or the underground cables between turbines. No mitigation for potential fault rupture is anticipated.

The flat terrain and basalt bedrock that underlie the Facility area is not expected to be prone to seismically induced landslides, except in the southern area of the Facility where conditions could be exacerbated to increase the potential for new or reactivated landsliding during a seismic event. Wind turbines or structures will not be built on steep slopes that could be prone to instability, thus avoiding potential impacts.

Hazards typically associated with saturated soils such as liquefaction and lateral spread also are anticipated to be essentially nonexistent because of the shallow bedrock and nonsaturated, fine-grained soils. Areas where Facility components are located on fine-grained soils, alluvial deposits, or on the John Day formation will be evaluated for site-specific liquefaction potential (and mitigated if the potential exists) prior to construction. Based on the present layout of Facility structures, no mitigation measures are anticipated to be required.

H.13 NONSEISMIC HAZARD MITIGATION

OAR 345-021-0010(1)(h)(I) An explanation of how the applicant will design, engineer and construct the facility to adequately avoid dangers to human safety presented by the hazards identified in paragraph (G).

Response: As discussed in Section H.11, nonseismic geologic hazards and impacts are anticipated to be minimal. Typical mitigation measures for nonseismic hazards include avoiding potential hazards, conducting subsurface investigations to characterize the soils to adequately plan and design appropriate mitigation measures, creating detailed geologic hazard maps to aid in laying out facilities, providing warnings in the event of hazards, and purchasing insurance to cover the Facility in the event of a hazard. The following sections discuss specific mitigation measures and best management practices (BMPs) for potential nonseismic geologic and soil hazards.

H.13.1 Proposed Mitigation Measures for Potential Nonseismic Geologic and Soil Hazards

H.13.1.1 Landslides

The flat terrain underlain by basalt bedrock that comprises the northern portion of the Facility area is not prone to landslides, as evidenced by the lack of these types of features in the area and the stable geologic conditions. The turbine strings will be situated on flat-lying areas and tops of ridges rather than on steep slopes so that if slope failure were to occur, the turbines and their associated foundation structures would not be impacted.

The landslide-prone terrain that underlies the southern portion of the site, where the John Day formation is exposed, must be characterized more completely to evaluate the shear strength of subsurface materials, potential ongoing movement, and possibility of continued slope instability.

If slope stability issues are identified during the final design geotechnical investigations, the Facility components will either be relocated during the micrositing process or else remedial measures to improve slope stability will be implemented. For slope stability, the remedial measures could include use of ground improvement methods (such as retaining structures) and dewatering to limit the movement to acceptable levels.

The turbine strings will not be placed on steep slopes. Thus, if a slope failure were to occur, the turbines and their associated foundation structures would not be impacted. The turbines would be placed on stable basalt bedrock at a safe distance back from the edges of the potentially unstable slopes.

In accordance with the Wasco County Geologic Hazards Overlay District, new roads and structures will be designed and graded with respect to surface topography and surface drainage. The design will avoid cutting
toeslopes of slump blocks and causing over-steepened cut banks. Proposed roads or structures planned for slopes greater than 25 percent will be carefully reviewed for suitability and site stability.

H.13.1.2 Volcanic Eruptions

The U. S. Geological Survey has established a National Alert Notification System for Volcanic Activity, which consists of advisories, watches and warnings (USGS, 2009b). The alert-notification system has been standardized and the goals are to (1) communicate a volcano’s status clearly to nonvolcanologists, (2) help emergency response organization determine proper mitigation measures, and (3) prompt people and businesses at risk to seek additional information and take appropriate actions. In the event of a volcanic eruption that could damage or impact affect Facility components, the Facility would be shut down until safe operating conditions return. If an eruption occurred during construction, a temporary shutdown would most likely be required to protect equipment and human health.

The Mount Hood Coordination Plan has been developed to coordinate efforts among governmental agencies in the event of volcanic unrest at Mount Hood (Mount Hood Facilitating Committee, 2005). This plan provides vital Mount Hood volcanic event response information for the areas that will be most affected by a volcanic event.

In the event of a volcanic eruption and ensuing ash fallout that reaches the site, the Facility would be shut down until safe operating conditions return. If an eruption occurred during construction, a temporary shutdown would be required to protect equipment and human health.

H.13.1.3 Soil Erosion

To reduce the potential for soil erosion, a detailed construction Stormwater Pollution Prevention Plan (SWPPP) will be developed for the Facility. The SWPPP will include both structural and nonstructural BMPs. Examples of structural BMPs include the installation of silt fences or other physical controls to divert flows from exposed soils, or otherwise limit runoff and pollutants from exposed areas of the site. Examples of nonstructural BMPs include management practices such implementation of materials handling, disposal requirements, and spill prevention methods.

Because roads, turbine foundations, and other Facility components will be engineered, they will be subject to the requirements of a National Pollutant Discharge Elimination System (NPDES) stormwater construction permit and other pertinent construction and operation permits and pollution control. These regulations require the development of an erosion control plan and implementation of erosion control BMPs during Facility construction and operation.

In accordance with the Wasco County Environmental Protection Overlay and Geologic Hazards Overlay District, vegetation will be maintained as practicable to eliminate its destruction, careful grading and drainage will be applied, and disturbed areas will be revegetated as soon as possible after construction.

H.13.1.4 Collapsing Soils/Piping

The loess soils within the Facility area could become temporarily saturated near the ground surface during spring thaw or a heavy rainstorm. However, the loess soils are unlikely to maintain long-term saturation because of their position above the groundwater table and floodplain. Construction of the Facility components is not expected to cause saturation and collapse of materials that have not previously experienced saturation. During final design of the Facility, the collapse potential of the loess at each turbine location will be evaluated by geotechnical investigations and laboratory testing and analysis. If areas of soils with collapsing or settling potential are identified, these soils will be mitigated by over-excavating the soils and replacing with compacted structural fill, placing impermeable material around the foundations to prevent wetting or saturation, or placing the foundations deeper on a stable bearing layer such as basalt rock.
H.13.1.5 Shrinking and Swelling Soils

Based on preliminary data, shrinking and swelling soils are not anticipated to exist in the northern portion of the Facility site boundary. The Curant and Tub soils, which underlie the southernmost portion of the site, could potentially be subject to shrinking and swelling. During final design, the shrink-swell potential of these soils will be evaluated by geotechnical investigations and laboratory testing and analysis. If shrinking or swelling soils are present at foundation locations or along road alignments, soil improvements will include reworking and compacting onsite soils, over-excavating and placing with compacted structural fill, constructing an impermeable barrier to prevent saturation, or mixing with other soils to reduce the potential for shrinking and swelling.

H.13.1.6 Corrosion Potential of Soils and Rock

During the final design, the corrosion properties of the soils and rock will be evaluated by collecting samples during the geotechnical investigation and laboratory testing for resistivity, pH, moisture, texture, and sulfate content. Corrosion protection measures will be implemented to protect facility structures based on the findings of the laboratory testing and geotechnical design recommendations.

H.13.1.7 Flooding

Mitigation for potential localized flood hazards includes developing a grading and drainage plan to handle design storm events, and constructing engineered drainage ditches, properly-sized culverts, and check dams to direct stormwater runoff to away from structures and into detention ponds or natural drainages.

H.13.2 Site-Specific Best Management Practices

Site-specific BMPs will be identified on the construction plans for the site slopes, construction activities, weather conditions, and vegetative buffers. Erosion control measures will meet local, county, and state erosion control measures, including procedures described in Exhibit I. Specific erosion control measures to be installed during Facility construction are anticipated to include the following, and will be implemented as appropriate:

- **Stabilized Construction Entrance/Exit:** A stabilized construction entrance/exit will be installed at locations where dirt (exposed, disturbed land) or newly constructed roads intersect existing paved roads. Stabilized entrances will also be installed at the construction laydown areas. The stabilized construction entrance/exits will be inspected and maintained for the duration of Facility life.

- **Maintain Existing Vegetation:** To the extent practicable, existing vegetation will be preserved.

- **Silt Fencing:** Silt fencing will be installed at various locations throughout the Facility. The fencing will be installed on contours downgradient of all excavations, including the turbine foundations, and will be used as perimeter control around material stockpiles and construction staging areas.

- **Straw Wattles:** Straw wattles may be installed to decrease the velocity of sheet-flow stormwater. The wattles will be used along the downgradient edge of access roads adjacent to slopes or sensitive areas.

- **Mulching:** Mulch will be provided to immediately stabilize soil exposed as a result of land-disturbing activities. Mulch will also be used during the reseeding of disturbed areas.

- **Stabilization Matting:** Jute matting, straw matting, or turf reinforcement matting may be used to stabilize slopes that could become exposed during installation of access roads, or to stabilize intermittent streams disturbed during construction of road crossings. The use of erosion control matting, along with revegetation techniques, will allow for stabilization.
• **Soil Binders and Tackifiers:** Soil binders and tackifiers may be used on exposed slopes to stabilize them until vegetation is established.

• **Stockpile Management:** During construction of the turbine footings and other foundations, large excavations may be created. The soil and rock from these excavations will be temporarily stockpiled and used as backfill at the completion of the footing. While the material is stockpiled, silt fencing will be used as perimeter control, and the stockpiled material will be covered with a thick layer of mulch or by plastic sheeting that is adequately anchored.

• **Revegetation:** At the completion of land-disturbing activities, the site will be revegetated with an approved seed mix. The seed will be applied with mulch to protect the seeds as the grass establishes.

• **Pollutant Management:** During construction, source control measures will be implemented to reduce the potential of chemical pollution of surface water or groundwater during construction. Chemical pollution could occur as a release of diesel fuel or lubricating oils, or from improper debris and waste handling. All fuels and oils will be stored in a dedicated area, and construction vehicles will be fueled and maintained only in dedicated areas. All handling, storage, and disposal of materials will be consistent with federal, state, and local ordinances, and in a manner that will not cause stormwater contamination.

**H.14  CONCLUSION**

The Applicant reviewed regional geologic information, conducted a geologic, surface site field reconnaissance of the Facility site boundary, and performed a site-specific characterization of potential seismic, geologic, and soils hazards. This Exhibit demonstrates that the Applicant can design, engineer, and construct the Facility to avoid dangers to human safety. The following supporting evidence is provided:

• The risk of seismic hazards to human safety at the proposed Facility is considered low. The Applicant has adequately characterized the site in accordance with OAR 345-022-0020(1)(a) and considered seismic events and amplification for the Facility’s site-specific subsurface profile. Facility components include improved roadways, wind turbine towers, and mainly underground collector cables. There will be no continually staffed facilities other than the operations and maintenance (O&M) building and, in general, the area is used for agriculture and is sparsely populated. As a result, the probability of a large seismic event occurring while the Facility is occupied is much lower than for a normal building or similar facility. This very low probability results in minimal risk to human safety. Because this proposed wind power generation facility is located in a sparsely populated area, and is not a more critical structure (such as a petroleum pipeline or an earth dam), the risks to human safety related to seismic hazards are minimal.

• The Applicant has demonstrated that the Facility can be designed, engineered, and constructed to avoid dangers to human safety in case of a design seismic event by adhering to IBC requirements, per OAR 345-022-0020(1)(b). These standards require that for the design seismic event, the factors of safety used in the Facility design exceed certain values. For example, in the case of slope design, a factor of safety of at least 1.1 is normally required during the evaluation of seismic stability. This factor of safety is introduced to account for uncertainties in the design process and to ensure that performance is acceptable. In the event that factors of safety for slope stability are not met, the Facility components will either be relocated during the micrositing process or else remedial measures to improve slope stability will be implemented. For slope stability, the remedial measures could include use of ground improvement methods (such as retaining structures) to limit the movement to acceptable levels. Given the relatively low level of risk for the Facility, adherence to the IBC requirements will ensure that appropriate protection measures for human safety are taken.

• The Applicant has provided appropriate site-specific information and demonstrated (in accordance with OAR 345-022-0020(1)(c)) that the construction and operation of the proposed Facility, in the absence of
a seismic event, will not adversely affect or aggravate the geological or soil conditions of the Facility site or vicinity. The risks posed by nonseismic geologic hazards are generally considered to be low because the Facility can be designed to avoid the hazards of landslides, rockfall, and soil erosion. Landslide and slope stability issues will be identified during final design and mitigated. Erosion hazard resulting from soil and wind action will be minimized with the implementation of an engineered erosion control plan.

- Finally, the Applicant has demonstrated that the Facility can be designed, engineered, and constructed to avoid dangers to human safety resulting from the geological and soil hazards of the site, pursuant to OAR 345-022-0020(1)(d). Site-specific studies have been conducted, additional geotechnical work will be done once the final locations of the turbines are selected, and adequate measures will be implemented to control erosion. Accordingly, given the relatively small risks these hazards pose to human safety, standard methods of practice (including implementation of the current IBC) will be adequate for the design and construction of the Facility.

**H.15 REFERENCES**


DOGAMI. See Oregon Department of Geology and Mineral Industries.


Figures
FIGURE H-1
Geologic Map and Elevation Cross-Section
Brush Canyon Wind Power Facility Application for Site Certificate

Notes:
1. Main Map Background Source: National Geographic Society
2. Geology Data Source: U.S. Geological Survey
3. Faults Data Source: USGS Mineral Resources Division, Oregon Faults Dataset
4. Landslide Data Source: DOGAMI SLIDO dataset
5. See report text for descriptions of geologic units.

LEGEND
- Oregon Water Resources Department Well Log Location
- Spring
- Site Boundary
- Area Not Included in Site Boundary
- Geologic Profile Location
- Fault (age unknown)
- Landslide Area

Geologic Unit
- Qal - Alluvial deposits
- Qls - Landslide and debris-flow deposits
- Tc - Columbia River Basalt Group
- Tcp - Picture Gorge Basalt, Columbia River Basalt Group
- Tcg - Grande Ronde Basalt, Columbia River Basalt Group
- Tct - Predominantly tuffaceous facies of Clarno Formation
- Tcw - Wanapum Basalt, Columbia River Basalt Group
- Tr - Rhyolite & dacite domes & flows & small hypabyssal intrusive
- Tsfj - John Day Formation of east-central Oregon

Geologic Profile

Distance (meters)

Elevation (feet)

Distance (meters)

Notes:
1. Main Map Background Source: National Geographic Society
2. Geology Data Source: U.S. Geological Survey
3. Faults Data Source: USGS Mineral Resources Division, Oregon Faults Dataset
4. Landslide Data Source: DOGAMI SLIDO dataset
5. See report text for descriptions of geologic units
FIGURE H-2
Historical Seismicity and Potentially Active Faults
Brush Canyon Wind Power Facility
Application for Site Certificate

Notes:
1. Earthquake Data Source: National Earthquake Information Center, 2011 (labeled with year)

LEGEND
- Site Boundary
- Historical Earthquake Magnitude
  - unknown
  - 2.5 to 2.9
  - 3.0 to 3.4
  - 3.5 to 3.9
  - 4.0 to 4.4
  - 4.5 to 4.9
- USGS Faults (Age)
  - Mid to Late Quaternary (<750,000 years)
  - Quaternary (<1,600,000 years)
  - Class B (age suspect or older than Quaternary)
  - Other Fault (age unknown)*
- River
- Water
- Interstate
- Highway
- County Boundary
- State Boundary

Notes:
1. Earthquake Data Source: National Earthquake Information Center, 2011 (labeled with year)

**FIGURE H-2**
Historical Seismicity and Potentially Active Faults
Brush Canyon Wind Power Facility
Application for Site Certificate
PSH Deaggregation on NEHRP BC rock
Brush_Canyon 120.633° W, 45.126 N.
Peak Horiz. Ground Accel.>=0.08172 g
Ann. Exceedance Rate .213E-02. Mean Return Time 475 years
Mean (R,M,ε₀) 84.9 km, 6.55, 0.22
Modal (R,M,ε₀) = 249.2 km, 9.00, 0.61 (from peak R,M bin)
Modal (R,M,ε*) = 249.2 km, 9.00, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 10. km, deltaM=0.2, Deltaε=1.0
PSH Deaggregation on NEHRP BC rock
Brush_Canyon 120.633° W, 45.126 N.
Peak Horiz. Ground Accel.>=0.1821 g
Ann. Exceedance Rate .411E-03. Mean Return Time 2475 years
Mean (R,M,ε₀) 41.2 km, 6.25, 0.48
Modal (R,M,ε₀) = 7.9 km, 5.20, 0.08 (from peak R,M bin)
Modal (R,M,ε*) = 8.0 km, 5.20, 0 to 1 sigma (from peak R,M,ε bin)
Binning: DeltaR 10. km, deltaM=0.2, Deltaε=1.0

Probabilistic Seismic Hazard Deaggregation: 2,475-Year Event
Brush Canyon Wind Power Facility
Application for Site Certificate
5%-Damped Pseudo-Absolute Acceleration Response Spectrum

[(CSZ sources modeled by Youngs et al. (1997), Atkinson & Boore (2003), Zhao et al. (2006), Garcia et al. (2005); Crustal sources modeled after NGA (2008))]

FIGURE H-5
Median Ground Response Spectra Plots

Brush Canyon Wind Power Facility
Application for Site Certificate
ATTACHMENT H-1

Oregon Water Resources Department Well Logs
From: Bill Burns [mailto:bill.burns@dogami.state.or.us]
Sent: Wednesday, February 01, 2012 12:24 PM
To: Butler, Josh/BOI
Cc: Warren, Greg/BOI; Rudie Watzig; mo.walker@state.or.us
Subject: RE: Brush Canyon Wind Power Facility

Josh. Below looks to cover what we discussed on the phone.

Bill

______________________________
Bill Burns, MS, CEG
Engineering Geologist
Oregon Department of Geology and Mineral Industries
800 NE Oregon Street, Portland, OR 97232
(971) 673-1538
bill.burns@dogami.state.or.us
http://www.oregongeology.org/

From: Josh.Butler@CH2M.com [mailto:Josh.Butler@CH2M.com]
Sent: Monday, January 30, 2012 7:26 AM
To: Bill Burns
Cc: Greg.Warren@CH2M.com
Subject: Brush Canyon Wind Power Facility

Hello Bill. Thanks for the phone call last week for the Brush Canyon project. Below is a brief summary of what we discussed.

The purpose of our phone call was to satisfy the requirement outlined in OAR 345-021-0010(1)(h)(C), by discussing with DOGAMI the specific type of subsurface and geologic information that either has already been reviewed, or that will be obtained or recommended in the future for the project.

As we discussed, the site is in an area with low to moderate seismicity. There are also many potentially-active faults in the area, including the Warm Springs, Sisters, and Metolius fault zones. Several others are mapped in the vicinity (within ~10 miles), but with Quaternary displacements. Our biggest concern along with seismicity, is the prevalence of historic landslides in the southern portion of the project. Thanks for looking into the LiDAR database, but it looks like there is nothing specific to the project area. Our text focuses on the landslide-prone soils in the southern part of the project, and the overall seismic hazard of the site.

- The Applicant will ensure that the planned future geotechnical exploration will follow the OAR guidelines for site-specific geotechnical work.
- The general scope and methods of the proposed future geotechnical exploration appeared satisfactory to DOGAMI at this time (test pits, drilling, or geophysics at each turbine location, etc.).
- The schedule of the exploration appears satisfactory to DOGAMI at this time (that is, pending permit and completion of turbine micrositing, the geotechnical exploration will be conducted following a timeline that is 6 months to 1 year in advance of the proposed start of construction).
This information will be reviewed in order to make an accurate and up-to-date assessment of the activity of local faults, as well as the seismic potential of the site in order to guide the design criteria for the facility. The appropriate levels of subsurface exploration to support foundation design of facility components will be evaluated. Additional exploration such as drilling, test pits, CPT sounding, geophysics, or other appropriate methods will be considered and recommended prior to final design/construction of the facility. Any additional recommendations for exploration will be reflected in the final ASC.

Bill, can you please reply and let me know if you have any questions or concerns regarding our approach? Thanks again for your time, and I look forward to hearing back from you.

jb
ATTACHMENT H-2

Consultation with Oregon Department of Geology and Mineral Industries
NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

WATER WELL REPORT
STATE OF OREGON
(Do not write above this line)
WATER RESOURCES DEPT.

RECEIVED
AUG 10, 1976
State Well No. 53/76-10
State Permit No. 53/76-10

(1) OWNER:
Name: Philip Von Bostel
Address: Machen Canyon Ranch
Kent, Oregon 97033

(2) TYPE OF WORK (check):
New Well [ ] Deepening [ ] Reconditioning [ ] Abandon [ ]
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL: (4) PROPOSED USE (check):
Rotary [ ] Driven [ ] Domestic [ ] Industrial [ ] Municipal [ ]
Cable [ ] Jetted [ ] Irrigation [ ] Test Well [ ] Other [ ]

CASING INSTALLED:
6” Diam. from 0 ft. to 18 ft. Gage .250

PERFORATIONS:
Type of perforator used

<table>
<thead>
<tr>
<th>Size of perforations</th>
<th>In. by</th>
<th>perforations from</th>
<th>ft. to</th>
<th>ft. to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>perforations from</td>
<td>ft. to</td>
<td>ft. to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>perforations from</td>
<td>ft. to</td>
<td>ft. to</td>
</tr>
</tbody>
</table>

(7) SCREENS:
Manufacturer's Name

Type: [ ] Model No.

Diam.: Slot size: Set from: ft. to: ft. ft. ft.
Diam. Slot size: Set from: ft. to: ft. ft. ft.

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level.

Was a pump test made? [ ] Yes [ ] No
If yes, by whom?

Well: gal./min. with ft. drawdown after hrs.

6 gal/min air test

Dewater test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m.

Nature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well sealed—Material used: Bentonite
Well sealed from land surface to 18 ft.
Diameter of well bore to bottom of seal 10 in.
Diameter of well bore below seal 6 in.
Number of bags of cement used in well seal 0 bags
Number of bags of bentonite used in well seal 2 bags
Brand name of bentonite International
Number of pounds of bentonite per 100 gallons of water: 100 lbs./100 gals.
Was a drive shoe used? [ ] Yes [ ] No
Size: location: ft.
Did any strata contain usable water? [ ] Yes [ ] No
Type of water:

Method of sealing strata off

Was well gravel packed? [ ] Yes [ ] No
Size of gravel:
Gravel placed from ft. to ft.

WATER WELL REPORT

COUNTY SHERMAN
Driller's well number
NE 1/4 NE 1/4 Section 10 T. 5S R. 17E W.M.

(11) WATER LEVEL:
Depth at which water was first found 192 ft.
Static level 330 ft. below land surface. Date 7/25/76
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing 6 ft.
Depth drilled 380 ft. Depth of completed well 380 ft.
Formation: Describe color, texture, grain size and structure of materials;
and show thickness and nature of each stratum and aquifer penetrated.
with at least one entry for each change of formation. Report each change in
position of Static Water Level and indicate principal water-bearing strata.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>From</th>
<th>To</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Basalt gray</td>
<td>1</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Rock maroon visic.</td>
<td>32</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Basalt gray</td>
<td>45</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Rock brown &amp; clay seams</td>
<td>70</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Basalt gray</td>
<td>90</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>Rock brown</td>
<td>137</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>Clay white</td>
<td>143</td>
<td>151</td>
<td></td>
</tr>
<tr>
<td>Rock brown</td>
<td>151</td>
<td>192</td>
<td></td>
</tr>
<tr>
<td>Basalt gray WB</td>
<td>192</td>
<td>237</td>
<td></td>
</tr>
<tr>
<td>Basalt brown</td>
<td>237</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>Basalt gray</td>
<td>260</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td>Basalt brown WB</td>
<td>330</td>
<td>380</td>
<td>330</td>
</tr>
</tbody>
</table>

Work started 24 July 1976 Completed 25 July 1976
Date well drilling machine moved off of well 25 July 1976

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my
best knowledge and belief.

[Signature] Richard Murray
(Drilling Machine Operator) Date 6 Aug. 1976

Drilling Machine Operator's License No. 737

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is
true to the best of my knowledge and belief.

Name: Richard J. Murray
Address: 3712 W 8th The Dalles, Oregon

[Signature] Richard J. Murray
(Water Well Contractor) Date 6 August 1976

Contractor's License No. 606
NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filled out with the
STATE ENGINEER, SALEM, OREGON 97309
within 30 days from the date of well completion.

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

WATER RESOURCES DEPT.
SALEM, OREGON

(1) OWNER:
Name: Jay McKay
Address: Kent, Oregon 97033

(2) TYPE OF WORK (check):
New Well □ Deepening □ Reconditioning □ Abandon □
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL: □ Drilled □ Bored □ Irrigation □ Stock

(4) PROPOSED USE (check):
□ Domestic □ Industrial □ Municipal □ Other

(5) CASING INSTALLED:
Stock 8 ft. Diameter from 0 ft. to 20 ft. Gage 250 ft.

(6) PERFORATIONS:
Type of perforator used: Perforated? □ Yes □ No

(7) SCREENS:
Manufacturer's Name
Type
Diam. Slot size
Diam. Slot size

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? □ Yes □ No If yes, by whom?
Yield:
gal./min. with ft. drawdown after hrs.

(9) CONSTRUCTION:
Well seal—Material used: cement grout
Well sealed from land surface to 19 ft.
Number of sacks of cement used in well seal 0 sacks
Brand name of bentonite used in well seal none
Number of pounds of bentonite per 100 gallons of water
Was a drive shoe used? □ Yes □ No Plugs: Size: location
Did any strata contain unusable water? □ Yes □ No
Type of water: depth of strata
Method of sealing strata off
Was well gravel packed? □ Yes □ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County: Sherman
Driller’s well number
SW 1/4 SE 1/4 Section 22 T.5 S. R. 17 E. W.M.
Bearing and distance from section or subdivision corner:

(11) WATER LEVEL: Completed well.
Depth at which water was first found 275 ft.
Static level 207 ft. below land surface Date 4-3-78
Artesian pressure lbs. per square inch Date

(12) WELL LOG:
 Diameter of well below casing 6 ft.
Depth drilled 400 ft. Depth of completed well 400 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL
Rock, decomposed grey
Rock, grey
Rock, brown decomposed
Rock, grey
Rock, brown
Rock brown/clay
Clay, brown
Clay, yellow
Rock, porous brown
Rock, grey
Rock, brown
Rock grey
Rock, clay & conglomerate
Rock, grey
Rock, porous grey
Rock, black
Rock decomposed
Rock, grey porous
Rock, slates

Artesian flow g.p.m.

Drilling Machine Operator's Certification:
This well was drilled under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.

(Signed) Gilbert Clayton Drilling Machine Operator's License No. 129

Drilling Machine Operator's License No. 129

Date: April 3, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)
STATE OF OREGON
WATER SUPPLY WELL REPORT
(Water supply required by O.R.C. 537.765)

(1) OWNER:  Mobley Ranch
Name:  Mobley Ranch
Address:  P.O. Box 362
City: Kent
State: OR
Zip: 97033

(2) TYPE OF WORK:
New Well  [X]  Deepening  [ ]  Alteration (repair/recondition)  [ ]  Abandonment  [ ]

(3) DRILL METHOD:
Rotary Air  [X]  Rotary Mud  [ ]  Cable  [ ]  Auger  [ ]
Other  [ ]

(4) PROPOSED USE:
Domestic  [X]  Community  [ ]  Industrial  [ ]  Irrigation  [ ]
Thermal  [ ]  Injection  [ ]  Livestock  [ ]  Other  [ ]

(5) BORE HOLE CONSTRUCTION:
Special Construction approval:  [X]  No
Depth of Completed Well:  413 ft.
Explosives used:  [X]  No
Type:  Other

(6) BORE HOLE:
Diameter of hole:  12"  From 0 to 38.5  Material: Bentonite
Diameter of seal:  8"  From 0 to 38.5  Material: 23 sacks

(7) CASING/LINER:
Difference in casing:  8"  From 1.5 to 250  Material: Steel Plastic Welded Threaded
Difference in liner:  8"  From 1.5 to 250  Material: Steel Plastic Welded Threaded

(8) WELL TESTS: Minimum testing time is 1 hour
Pump  [X]  Bailer  [ ]  Air  [ ]  Flowing Artesian  [ ]

Yield gal/min:  25
Drawdown:  100+
Drill stem at Time:  393 1 hr.

(9) LOCATION OF WELL by legal description:
County:  Sherman  Township  5S  Range  17E  Section  28
State or S. Range  E or W. of WM.  3W  1/2 NW
Tax Lot:  2200  Lot:  52363 Decker Rd., Kent, OR 97033
Block:  Subdivision
Street Address of Well or nearest address:

(10) STATIC WATER LEVEL:
Date:  5/1/99
Artesian pressure:  245 lbs. per square inch.

(11) WATER BEARING ZONES:
Depth at which water was first found:  275

(12) WELL LOG:
Ground elevation

Material  From  To
Brown Claye Top Soil  0  3
Purple Basalt  3  6
Black Basalt  6  17
Yellow Brown Clay  17  33
Gray Basalt  33  66
Blue Basalt  66  93
Brown Basalt  93  117
Black Basalt  117  156
Brown Basalt  156  189
Black Basalt  189  237
Brown Basalt  237  275
Broken Gray Basalt WB  275  283 245
Black Basalt  283  371 245
Broken Brown & Gray Basalt WB  371  378 245
Hard Black Basalt  378  413 245

WATER RESOURCES DEPT.
SALEM, OREGON

Date started:  5/10/99  Completed:  5/11/99

Western Water Development Corporation

Date:  5/12/99

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT  SECOND COPY - CONSTRUCTOR  THIRD COPY - CUSTOMER
**STATE OF OREGON**  
**WATER SUPPLY WELL REPORT**  
(as required by ORS 337.765)

Instructions for completing this report are on the last page of this form.

<table>
<thead>
<tr>
<th>(1) LAND OWNER</th>
<th>WELL NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: ART DECKER</td>
<td>Well Number:</td>
</tr>
<tr>
<td>Address: PO BOX 528</td>
<td></td>
</tr>
<tr>
<td>City: KENT</td>
<td>State: OR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(2) TYPE OF WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Well</td>
</tr>
<tr>
<td>Deepening</td>
</tr>
<tr>
<td>Alteration (repair/condition)</td>
</tr>
<tr>
<td>Abandonment</td>
</tr>
<tr>
<td>Conversion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(3) DRILL METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary Air</td>
</tr>
<tr>
<td>Rotary Mud</td>
</tr>
<tr>
<td>Cable</td>
</tr>
<tr>
<td>Auger</td>
</tr>
<tr>
<td>Cable Mud</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(4) PROPOSED USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
</tr>
<tr>
<td>Community</td>
</tr>
<tr>
<td>Industrial</td>
</tr>
<tr>
<td>Irrigation</td>
</tr>
<tr>
<td>Thermal</td>
</tr>
<tr>
<td>Injection</td>
</tr>
<tr>
<td>Livestock</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(5) BORE HOLE CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of Completed Well: 286 ft</td>
</tr>
<tr>
<td>Explosives used: Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Type:</td>
</tr>
<tr>
<td>Amount:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BORE HOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter: 8 in</td>
</tr>
<tr>
<td>From: 18 in</td>
</tr>
<tr>
<td>To: 238 in</td>
</tr>
<tr>
<td>Material:</td>
</tr>
<tr>
<td>From: 18 in</td>
</tr>
<tr>
<td>To: 238 in</td>
</tr>
<tr>
<td>SEAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How seal placed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method:</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>Other:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Backfill placed from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ft to ft</td>
</tr>
<tr>
<td>Material:</td>
</tr>
<tr>
<td>Gravel placed from:</td>
</tr>
<tr>
<td>ft to ft</td>
</tr>
<tr>
<td>Size of gravel:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(6) CASING/LINER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter: 6 in</td>
</tr>
<tr>
<td>From: 2 in</td>
</tr>
<tr>
<td>To: 18 in</td>
</tr>
<tr>
<td>Gauge: 0.250</td>
</tr>
<tr>
<td>Steel:</td>
</tr>
<tr>
<td>Plastic Welded Threaded:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Casing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liner:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drive Shoe used:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside</td>
</tr>
<tr>
<td>Outside</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Final location of shoe(s):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(7) PERFORATIONS/SCREENS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforations:</td>
</tr>
<tr>
<td>Method:</td>
</tr>
<tr>
<td>Screens:</td>
</tr>
<tr>
<td>Type:</td>
</tr>
<tr>
<td>Material:</td>
</tr>
</tbody>
</table>

| From: |
| To: |
| Slot Size: |
| Number: |
| Diameter: 18 in |
| Tele/pipe: |
| Casing: |
| Liner: |

<table>
<thead>
<tr>
<th>(8) WELL TESTS: Minimum testing time is 1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield gpm:</td>
</tr>
<tr>
<td>Drawdown:</td>
</tr>
<tr>
<td>Drill stem at:</td>
</tr>
<tr>
<td>Time:</td>
</tr>
</tbody>
</table>

| Temperature of water: 58 °F |
| Depth Artesian Flow Sound: |
| Was a water analysis done? Yes |
| No |
| Did any strata contain water not suitable for intended use? |
| Too little |
| Salty |
| Muddy |
| Odor |
| Colored |
| Depth of strata: |

**SHER 50283**

<table>
<thead>
<tr>
<th>WELL I.D. # L</th>
<th>96372</th>
</tr>
</thead>
<tbody>
<tr>
<td>START CARD #</td>
<td>199227</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(9) LOCATION OF WELL (legal description)</th>
</tr>
</thead>
<tbody>
<tr>
<td>County: Shrinell</td>
</tr>
<tr>
<td>Tax Lot: 2100</td>
</tr>
<tr>
<td>Township: S 5</td>
</tr>
<tr>
<td>Section: 23</td>
</tr>
<tr>
<td>Lat:</td>
</tr>
<tr>
<td>Long:</td>
</tr>
<tr>
<td>(degrees or decimal)</td>
</tr>
</tbody>
</table>

| Street Address of Well (or nearest address): INDEED RD VENTER 97033 |

<table>
<thead>
<tr>
<th>(10) STATIC WATER LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: 12-20-88</td>
</tr>
<tr>
<td>ft below land surface: 188</td>
</tr>
<tr>
<td>Artesian pressure: 10 lb per square inch</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(11) WATER BEARING ZONES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth at which water was first found: 211</td>
</tr>
<tr>
<td>From:</td>
</tr>
<tr>
<td>To: 211</td>
</tr>
<tr>
<td>Estimated Flow Rate: 10</td>
</tr>
<tr>
<td>SWL: 188</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(12) WELL LOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Elevation: 1900</td>
</tr>
<tr>
<td>Material:</td>
</tr>
<tr>
<td>From: 0</td>
</tr>
<tr>
<td>To: 5</td>
</tr>
<tr>
<td>Swale: 3</td>
</tr>
<tr>
<td>Red Barette: 75</td>
</tr>
<tr>
<td>Grey Barette: 110</td>
</tr>
<tr>
<td>Grey Class: 211</td>
</tr>
<tr>
<td>Grey Barette 46</td>
</tr>
<tr>
<td>Grey Barette (S) 211</td>
</tr>
<tr>
<td>Grey Barette 231</td>
</tr>
</tbody>
</table>

| Date Started: 12-4-98 |
| Completed: 12-20-98 |

<table>
<thead>
<tr>
<th>(unbonded) Water Well Constructor Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.</td>
</tr>
<tr>
<td>WWC Number:</td>
</tr>
<tr>
<td>Date:</td>
</tr>
</tbody>
</table>

| Signed: |

<table>
<thead>
<tr>
<th>(bonded) Water Well Constructor Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.</td>
</tr>
<tr>
<td>WWC Number: 1792</td>
</tr>
<tr>
<td>Date: 1-20-99</td>
</tr>
</tbody>
</table>

| Signed: |

**ORIGINAL – WATER RESOURCES DEPT.**  
**FIRST COPY – CONSTRUCTOR**  
**SECOND COPY – CUSTOMER**  
**06/16/2004**

**RECEIVED**  
**WATER RESOURCES DEPT.**  
**SACRAMENTO, OREGON**  
**JAN 26 2009**
NOTICE TO WATER WELL CONTRACTOR:
The original and first copy of this report are to be
filed with the
STATE ENGINEER, SALEM, OREGON 97301
within 30 days from the date of well completion.

(1) OWNER:
Name: STANLEY KABER
Address: P.O. Box 38 ANTELOPE, ORE

(2) TYPE OF WORK (check):
New Well □ Deepening □ Reconditioning □ Abandon □
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL: (4) PROPOSED USE (check):
Rotary □ Jetted □ Domestic □ Industrial □ Municipal □
Cable □ Bored □ Irrigation □ Test Well □ Other □

(5) CASING INSTALLED: Threaded □ Welded □
12" Diam. from 0 ft. to 20 ft. Gage 250 W.M.
12" Diam. from 20 ft. to 40 ft. Gage
12" Diam. from 40 ft. to 60 ft. Gage

(6) PERFORATIONS:
Perforated? □ Yes □ No.
Type of perforator used
Size of perforations in. by in.

(7) SCREENS:
Manufacturer's Name
Type: Model No.
Diam. □ Slot size □ Set from ft. to ft.
Diam. □ Slot size □ Set from ft. to ft.

(8) WELL TESTS:
Drawdown is amount water level is
lowered below static level
Was a pump test made? □ Yes □ No 
If yes, by whom?
Gal/min. with ft. drawdown after hrs.

(9) CONSTRUCTION:
Well seal—Material used:
Bentonite:
Well sealed from land surface to ft. of well.
Diameter of well bore to bottom of seal in.
Diameter of well bore below seal in.
Number of sacks of cement used in well seal
Number of sacks of bentonite used in well seal
Number of pounds of bentonite per 100 gallons
of water
Was a drive shoe used? □ Yes □ No
Type of water
Method of sealing strata off
Was well gravel packed? □ Yes □ No
Size of gravel
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County: WASCO Driller's well number
S.E.W. E 28 77S 177 17E W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL:
Depth at which water was first found ft.
Static level ft. below land surface. Date - 1/22/75
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing ft.
Depth drilled ft. Depth of completed well ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>From</th>
<th>To</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>YELLOW CLAY</td>
<td>0</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>GREY CLAY</td>
<td>94</td>
<td>328</td>
<td></td>
</tr>
<tr>
<td>BLUE LAVA</td>
<td>438</td>
<td>484</td>
<td>128</td>
</tr>
<tr>
<td>LAVA CHUNKS</td>
<td>467</td>
<td>471</td>
<td>94</td>
</tr>
<tr>
<td>GREY LAVA</td>
<td>471</td>
<td>481</td>
<td>12</td>
</tr>
<tr>
<td>BROKEN BASALT</td>
<td>481</td>
<td>496</td>
<td>95</td>
</tr>
<tr>
<td>BLACK LAVA</td>
<td>486</td>
<td>470</td>
<td></td>
</tr>
<tr>
<td>BLUE GREEN CLAY</td>
<td>478</td>
<td>487</td>
<td></td>
</tr>
</tbody>
</table>

Work started SEPT. 27 1974 Completed JAN. 22 1975
Date well drilling machine moved off of well MARCH 5 1975

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision.
Materials used and information reported above are true to my
best knowledge and belief.

(Signed) Lawrence Kowaleski
(Drilling Machine Operator)

Date: MAR 5 1975

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is
true to the best of my knowledge and belief.

Name: LAWRENCE KOWALESKI
Address: 741-44 MADRAS ORE

(Signed) Lawrence Kowaleski
(Water Well Contractor)
Contractor's License No. 37 Date Mar. 5 1975
WATER WELL REPORT
STATE OF OREGON

(1) OWNER:
Name
Address PO Box 47
City MADRON, OREGON 97411 State

(2) TYPE OF WORK (check):
New Well □ Deepening □ Reconditioning □ Abandon □
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL: □ (4) PROPOSED USE (check):
Rotary Air □ Driven □ Domestic □ Industrial □ Municipal □
Rotary Mud □ Dog □ Irrigation □ Test Well □ Other □
Cored □ Borehole □ Terrestrial Withdrawal □ Rejection □

(b) CASING INSTALLED:
Steel □ Plastic □ Threaded □ Welded □
8-in. Dia. from 12 ft. to 123 ft. Gauge 2.50
Diam. from x ft. to x ft. Gauge

LINER INSTALLED:
Dia. from x ft. to x ft. Gauge

(6) PERFORATIONS:
Perforated? Yes □ No □
Type of Perforator used
Size of perforations
6 in. by 1/2 in.
130 perforations from 1/2 ft. to 132 ft.

(7) SCREENS:
Manufacturer's Name
Type
Diam. Slot Size Set from Diam. Slot Size Set from

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level.
Was a pump test made? Yes □ No □
If yes, by whom:

Air test 520 gal/min, with drill stem at 630 ft. 1 hr.
Bailer test 52 gal/min, with drawdown after hr.
Artesian flow gpm
Permeability of water 700
Depth artesian flow encountered...

(9) CONSTRUCTION:
Well seal - Material used PORTLAND CEMENT
Well sealed from land surface...
Diameter of well bored to bottom of seal...
Diameter of well bored below seal...
Number of sacks of cement used in well seal...
Was cement grout placed? PLUNGED

(10) LOCATION OF WELL: (M-3)
County WASC State Permit No. 295
Ne § 16 Sec 15 T 8S R 38E W.M.

(11) WATER LEVEL: Completed well.
Depth at which water was first found ft.
Static level ft. below land surface, Date 8-28-82
Artesian pressure...

(12) WELL LOG:
Diameter of well below casing ft. Depth of completed well
Formation: Describe color, texture, grain size and structure of materials, and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL
From To SWL
BOULDER & CLAY 0 3
DARK GOLD CLAY 3 11
LITE YELLOW CLAY 11 14
DICED LAY 14 19
DARK GOLD CLAY 19 37
DICED LAY 37 74
YELLOW CLAY 74 89
DARK GREY MIX CLAY 89 94
RED CLAY 94 178
GREY CLAY 178 179
GREEN CLAY 179 209
GREEN CLAY 209 210
RED CLAY 210 239
GREY MIX CLAYSTONE 239 240
RED CLAY 240 247
GREEN MIX CLAYSTONE 247 249
WHITE (WHITE) WITH CHALKY FRONTAL COLORS
249 278
GREENISH TUFF WITH CRYSTAL SEAMS 278 32.5

Work started 8-19 1982 Completed 8-27 1982
Date well drilling machine moved off of well
Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my own knowledge and belief.
(Signed) Date 6-30 1982
Drilling Machine Operator's License No. 768
Drilling Machine Operator's License No.
Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name: MARHT WELL DRILLING (Person, firm or corporation)
Address: 500 NAPA, OR
(Signed) Date 6-30 1982
Contractor's License No. 584 Date 6-30 1982

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
WATER RESOURCES DEPARTMENT,
SALEM, OREGON 97310
within 30 days from the date of well completion.
<table>
<thead>
<tr>
<th>Soil Name</th>
<th>USCS Classification</th>
<th>Typical Depth to Bedrock (inches)</th>
<th>Corrosion Potential (Concrete/Steel)</th>
<th>Percent Silt</th>
<th>Percent Clay</th>
<th>Liquid Limit</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>8B – Condon</td>
<td>CL</td>
<td>30</td>
<td>Low/Moderate</td>
<td>68</td>
<td>22</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>10C – Condon/ Bakeoven</td>
<td>CL</td>
<td>30</td>
<td>Low/Moderate</td>
<td>68</td>
<td>22</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>BcC – Bakeoven/ Condon</td>
<td>GM</td>
<td>7</td>
<td>Low/Moderate</td>
<td>39</td>
<td>24</td>
<td>34</td>
<td>9</td>
</tr>
<tr>
<td>CoC – Condon/ Bakeoven</td>
<td>CL</td>
<td>30</td>
<td>Low/Moderate</td>
<td>68</td>
<td>22</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>BaC – Bakeoven</td>
<td>GM</td>
<td>7</td>
<td>Low/Moderate</td>
<td>39</td>
<td>24</td>
<td>34</td>
<td>9</td>
</tr>
<tr>
<td>CnC – Condon</td>
<td>CL</td>
<td>30</td>
<td>Low/Moderate</td>
<td>68</td>
<td>22</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>CtE – Curant and Tub</td>
<td>ML</td>
<td>&gt;80</td>
<td>Low/High</td>
<td>68</td>
<td>23</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>TvD - Tub</td>
<td>CL</td>
<td>&gt;80</td>
<td>Low/High</td>
<td>31</td>
<td>38</td>
<td>44</td>
<td>24</td>
</tr>
</tbody>
</table>

Notes:
CL = Lean Clay; ML = Silt; GM = Silty Gravel.

Liquid limit (LL) is one of the standard Atterberg limits used to indicate the plasticity characteristics of a soil. It is the water content, on a percent by weight basis, of the soil (passing #40 sieve) at which the soil changes from a plastic to a liquid state. Generally, the amount of clay- and silt-size particles, the organic matter content, and the type of minerals determine the liquid limit.

Plasticity index (PI) is one of the standard Atterberg limits used to indicate the plasticity characteristics of a soil. It is defined as the numerical difference between the liquid limit and plastic limit of the soil. It is the range of water content in which a soil exhibits the characteristics of a plastic solid.