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January 12, 2026
XO1-26-001

ATTN: Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

**Subject**: Acceptability of Historical Information - Geotechnical (Project #99902130)

Reference: 1. Energy Northwest New Nuclear. "Methodology for Determining the Acceptability of Historical Information," White Paper, XO1-25-009, July 2025, ML25183A400.

This letter transmits Energy Northwest New Nuclear LLC's (ENNN) Acceptability of Historical Information - Geotechnical white paper to the U.S. Nuclear Regulatory Commission (NRC). The paper is provided for NRC review, planning and familiarization in support of pre-application discussions.

ENNN intends to submit a Construction Permit Application (CPA) for up to twelve Xe-100 small modular reactors at a site adjacent to Columbia Generating Station (Columbia). The project will be known as the Cascade Advanced Energy Facility or Cascade. Using the methodology described in Reference 1, the enclosed white paper provides ENNN's evaluation of the acceptability of using existing geotechnical analyses from Columbia and the cancelled WNP-1 and WNP-4 reactors (WNP-1/4) to satisfy the requirements for assessing geotechnical hazards in Cascade's CPA.

ENNN requests the NRC review the enclosed white paper (Enclosure 1) and provide feedback on ENNN's evaluation of the acceptability of applying the historical analyses mentioned above to geotechnical evaluations necessary for the proposed Cascade license application.

This letter contains no commitments. If you have any questions or need any additional information, please contact Nathan Clark at ndclark@energy-northwest.com or 509-377-6069.

Sincerely,

Signed by:
Lisa Williams
D582EC1FE95E4D8...
Lisa Williams
Operations, Licensing, Environmental Manager, New Nuclear Development

Enclosures
1. Acceptability of Historical Information - Geotechnical, ENNN White Paper, Rev 0, January 2026.

cc:
Greg Cullen
Ken Langdon
Eric Andrews
Ms. Denise McGovern, NRR/DANU/UAL2
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**White Paper**

**Acceptability of Historical Information - Geotechnical**

**Revision 0**

**January 2026**

**Prepared by:** Signed by: Stephan C Moen 3E36B180D5B34C3... **Date:** 1/12/2026

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**Approved by:** Signed by: Lisa Williams D582EC1FE95E4D8... **Date:** 1/12/2026

## Executive Summary

Recent increases in demand for carbon-free energy have led to support for construction of new nuclear power capability. Energy Northwest New Nuclear, LLC (ENNN) is considering the construction and operation of up to twelve Xe-100 small modular nuclear reactors at the former Washington Nuclear Project No. 1 (WNP-1) and Washington Nuclear Project No. 4 (WNP-4; collectively WNP-1/4) site adjacent to the Columbia Generating Station (Columbia) in southeastern Washington State. The project will be called the Cascade Advanced Energy Facility (Cascade). The recently passed ADVANCE Act requires the NRC to make use of applicable licensing information of existing nuclear facilities when evaluating adjacent new nuclear sites. The projected Cascade site is in the same geologic/geotechnical environment as Columbia and WNP-1/4 and Cascade would benefit from the historical analyses done for these projects.

ENNN plans to submit a Construction Permit Application (CPA) for the Cascade facility, which will include geotechnical hazard evaluations for the proposed site in the Preliminary Safety Analysis Report (PSAR). Due to its location on the Hanford Site, the lithology and site geotechnical conditions on and near the Cascade site have been extensively studied. ENNN plans to use much of this information in its geologic and geotechnical evaluations. This paper specifically addresses 1) the site seismic characteristics leading to a ground motion response spectrum (GMRS) for use in seismic evaluations and 2) surface deformation, stability of subsurface material and foundations and stability of slopes.

Six questions were used to evaluate the historical geotechnical analyses. Responses to the questions support a conclusion that the geotechnical analyses near Cascade are applicable to the proposed site. In addition, ENNN plans to obtain results from site-specific, non-invasive subsurface investigations to perform sensitivity studies to confirm the existing analyses for vibratory ground motion, and develop a GMRS curve incorporating significant updates to use for the CPA and preliminary design. Additional development work will be done if the sensitivity studies indicate a need for a revised GMRS. Furthermore, ENNN plans to obtain results from a site-specific invasive exploration campaign, which will be provided with the Operating License Application (OLA).

# 1. INTRODUCTION

## 1.1 Purpose

The purpose of this white paper is to provide a basis for using existing historical geologic and geotechnical analyses for the proposed Energy Northwest New Nuclear, LLC (ENNN) Construction Permit Application (CPA). The project will be called the Cascade Advanced Energy Facility (Cascade). The historical analyses were developed in support of the operating license for Columbia Generating Station (Columbia) and the construction permits for Washington Nuclear Projects No. 1 (WNP-1) and No. 4 (WNP-4, collectively WNP-1/4) that are adjacent to Columbia in southeastern Washington State. All four projects are within the Department of Energy's (DOE) Hanford Site on land that Energy Northwest leases from the DOE. The historical analyses also include post-Fukushima reevaluations of Columbia's seismic hazard. This paper addresses analyses applicable to the Cascade site but does not evaluate the Cascade facility design.

Geotechnical analyses generated during the licensing phase for Columbia and WNP-1/4, such as soil properties, lithology, and water table, are used in various evaluations including subsurface and foundation stability, slope stability, soil structure interaction (SSI), and soil liquefaction. These data were collected in the same time frame and manner as data specifically used for seismic evaluations but evaluations requiring specific plant designs are not included. GMRS evaluations are based on site properties, not specific plant designs.

Section 505(c) of the ADVANCE Act requires that the Commission, to the extent practicable, use information that was part of the licensing basis of the utilization facility located at the site. ENNN intends to apply this concept to its CPA for NRC review.

This paper does not address volcanic hazards.

## 1.2 Project Background

ENNN is considering the construction and operation of up to twelve Xe-100 reactors at the former WNP-1/4 site adjacent to Columbia in southeastern Washington State. The Xe-100 reactor is a high temperature helium gas-cooled advanced reactor designed by X-energy. ENNN plans to submit a CPA for this project. The CPA will include a PSAR that addresses safety implications of the geotechnical environment.

The Cascade site is located in the Pasco Basin, a physiographic depression of the Columbia Plateau province in southeastern Washington state, about one mile east of Columbia, closer to the Columbia River, at a higher elevation, and located on the same relatively flat, featureless desert scrub plain. The relative position of Columbia and the Cascade site to the Columbia River is shown in Figure 1.

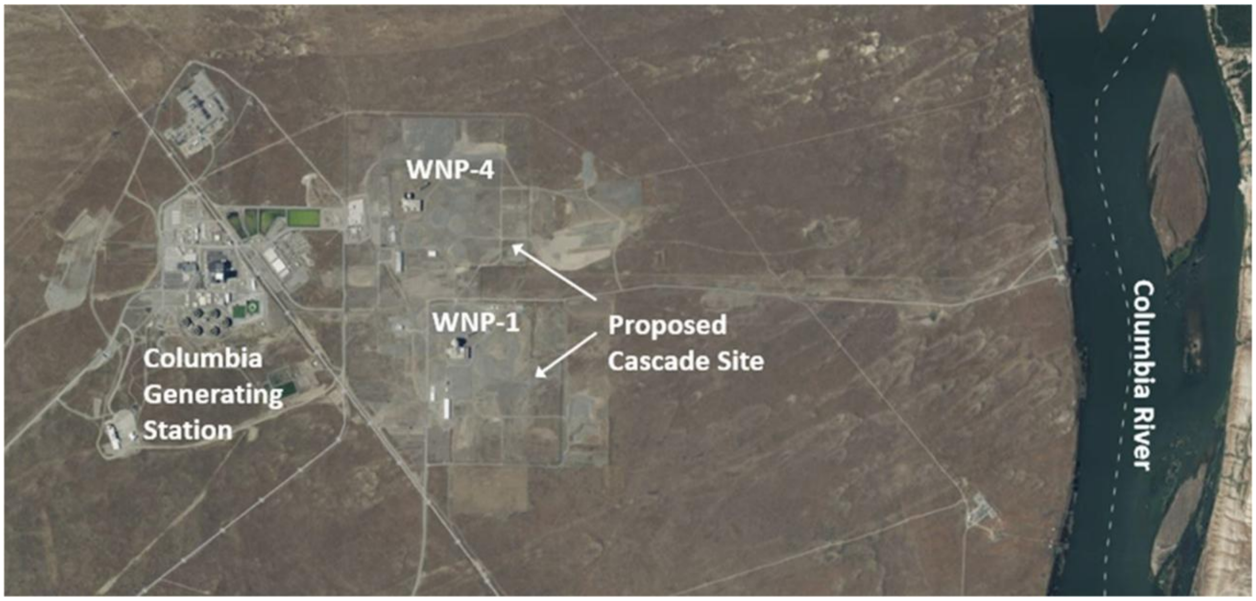


**Figure 1:** Cascade site relative to Columbia Generating Station and the Columbia River

### 1.3 Geologic Characteristics of the Cascade Site

Underlying the site of the Columbia Generating Station plant is a thin cover of eolian deposits; an average of 45 ft of Quaternary glaciofluvial sands known as Pasco Gravel; and approximately 480 ft of Pliocene Ringold sediments. The upper Ringold sediments consist of 205 ft of predominantly gravel with some interbedded layers and lenses of sand and silt with variable cementations. The lower Ringold sediments consist of 275 ft of interbedded claystone, siltstone, and conglomerate. Several hundred feet of Ringold Formation materials at the site were removed during Pleistocene floods, which implies the over-consolidated nature of Ringold Formation materials, particularly the fine-grained sediments. The Pasco Gravel was deposited over the eroded surface of the Ringold Formation and has not undergone significant loading history. These sediments in turn overlie several thousand feet of Miocene-Pliocene basalt flows and interbeds. All stratigraphic units beneath the site appear to be near horizontal. The generalized site stratigraphy (see Figure 2) is composed of supra-basalt sediments to the depth of approximately 525 ft and underlying Saddle Mountain Basalt (SMB) to the depth of approximately 1300 ft (top of Wanapum Basalt). This general site stratigraphy applies for the Columbia, WNP-1/4, and Cascade sites.

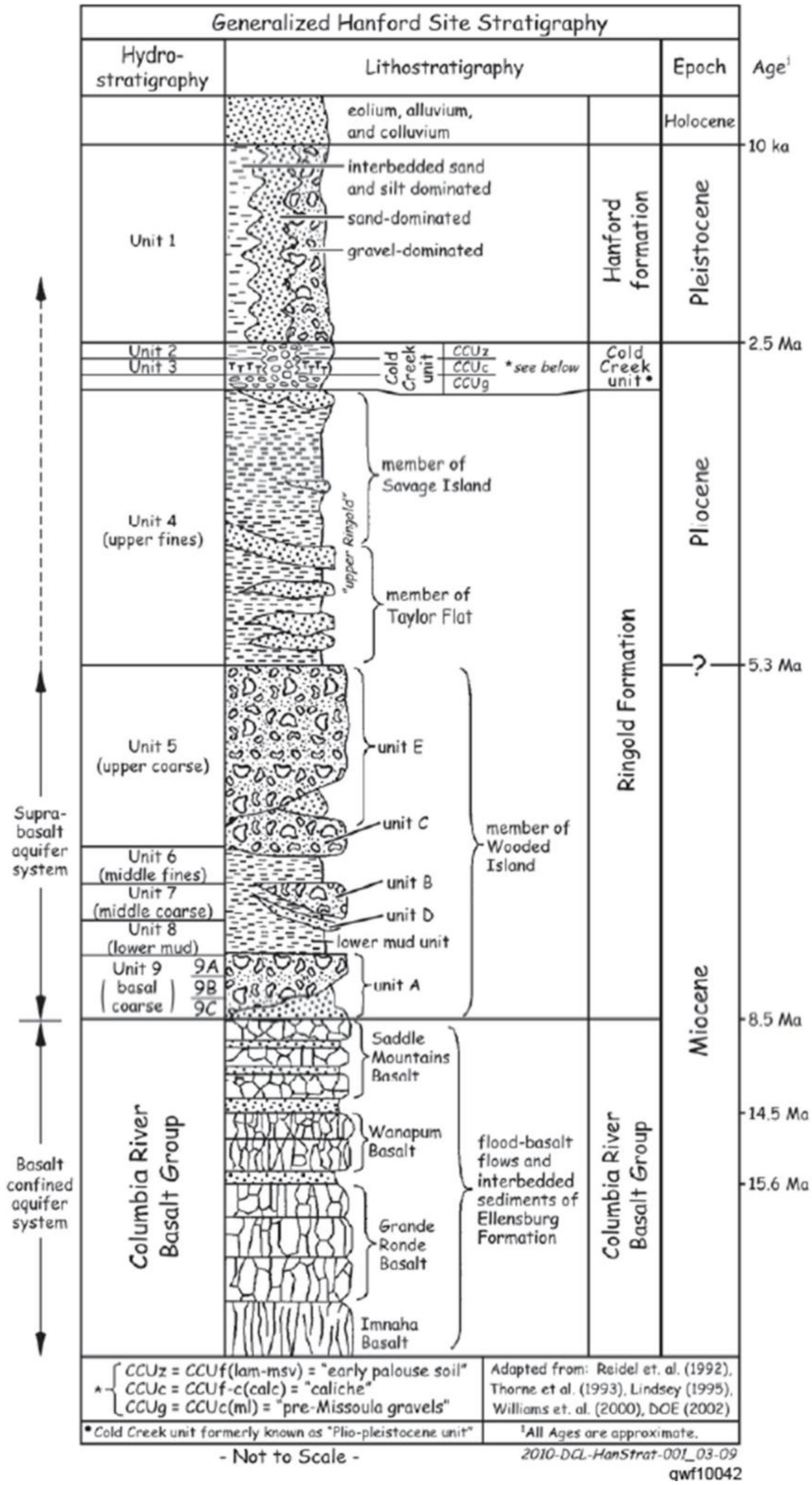


**Figure 1:** Generalized Hanford Site stratigraphy, including the Columbia and Cacade facility sites. (From "Hanford Site Groundwater Monitoring and Performance Report for 2009," Figure 3-2, DOE-RL, DOE/RL-2010-11, Revision 1, August 2010)

The SMB consists of four basalt members with thicknesses that range from about 110 ft to 215 ft, each underlain by a sedimentary interbed consisting mainly of sandstone and claystone with thicknesses from about 15 ft to 70 ft. The baserock for site response analysis (or reference rock for probabilistic seismic hazard analysis (PSHA)) is taken as the top of Wanapum Basalt (Lolo flow, excluding approximately 13 feet of flowtop) with a shear wave velocity (Vs) greater than 9200 ft/s.

## Historical Hanford Geotechnical Investigations

Geotechnical investigations throughout the Hanford Site contribute to the general understanding of local geotechnical and seismic characteristics. Figure 3 shows the locations of geotechnical borings and wells on the Hanford Site along with various facilities, including specifically the 100BC, 200-East (same location as the Waste Treatment Plant), 200-West, and 300 areas, relative to Columbia, illustrating the extensive geotechnical characterization of the Hanford Site. Geotechnical analyses performed are generally applicable to the proposed Cascade facility.

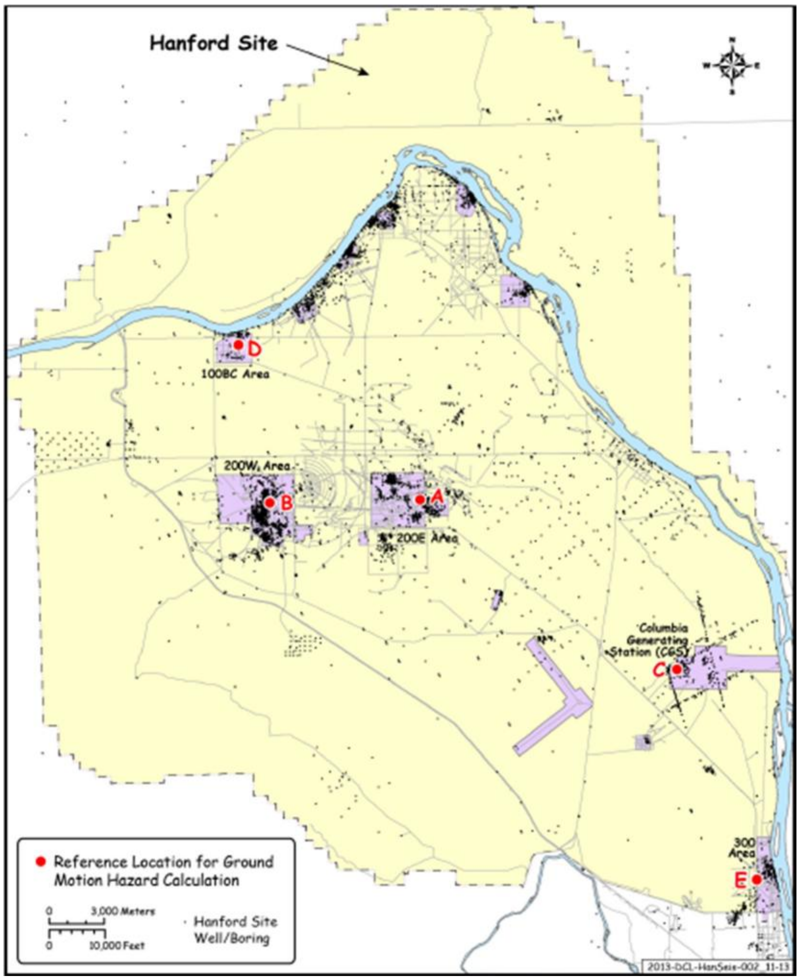


**Figure 3:** Geotechnical Investigations on Hanford Site. The reference locations A through E were used in developing the 2014 Seismic Safety Hazard Analysis Report (PNNL, 2014). (Figure 3 from "Stratigraphic Profiles for Selected Hanford Site Seismometer Stations and Other Locations," GV Last, PNNL-23126, February 2014.)

Geotechnical investigations to create stratigraphic profiles for the area around the Energy Northwest (EN) leased property are shown in Figure 4. Line L2-L2' is a north-south line that passes through the Columbia site approximately one mile west of the Cascade site. The profile is shown in Figure 5. Line L5-L5' is an east-west line that passes through both the Columbia site and the Cascade site. This profile is shown in Figure 6. Both profiles illustrate the relatively uniform nature of the stratigraphy in a roughly seven-mile square around the Cascade site where the historical data were collected.

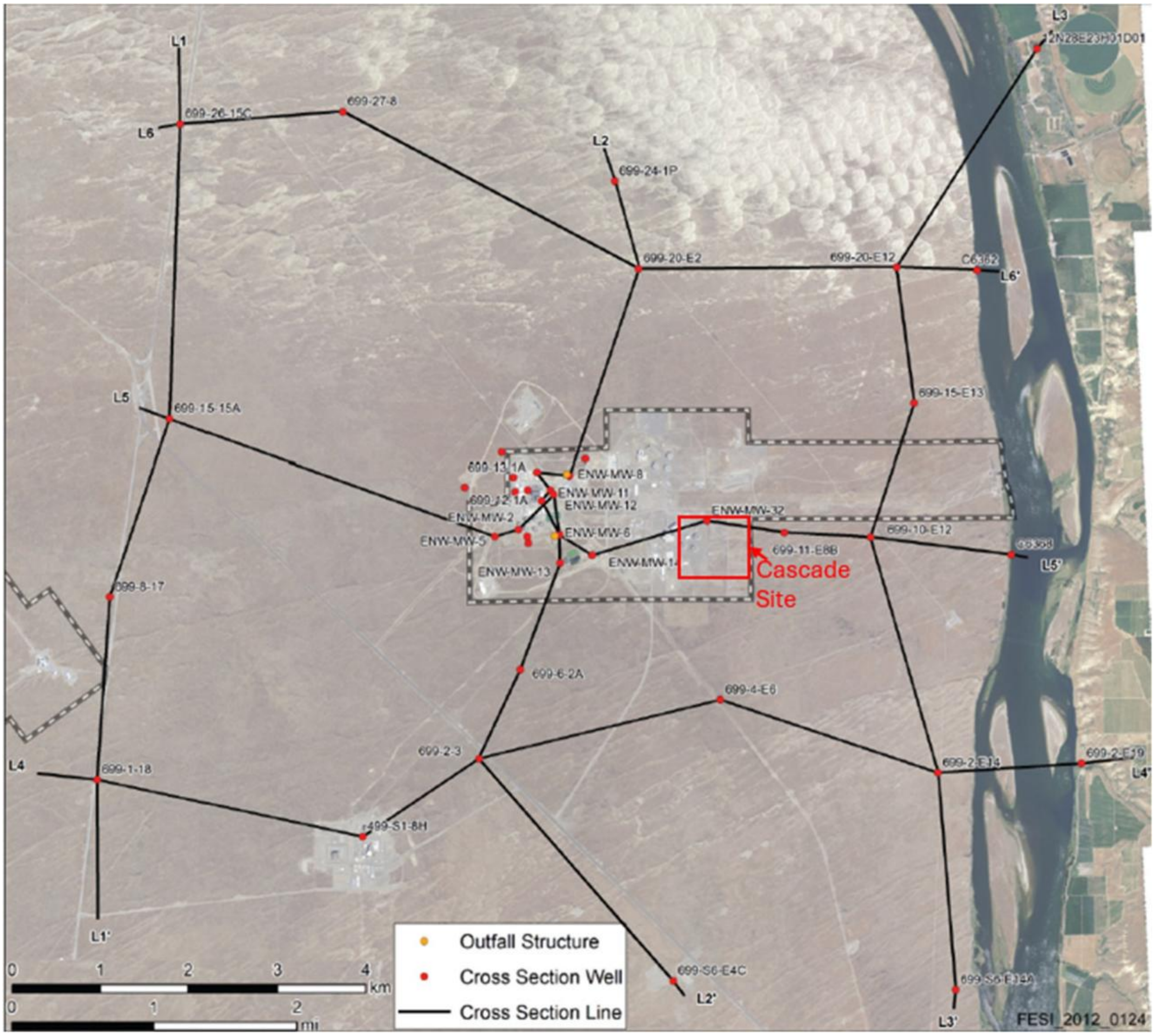


**Figure 4:** Location of stratigraphic profiles and borings used to obtain data to create them at the Columbia and WNP-1/4 sites. EN leased property is outlined in white/gray lines. (Fig. 3-2 from "Energy Northwest Columbia Generating Station Groundwater Quality Study Report," FESI-12-001, May 2012, Freestone Environmental Services, Inc.)

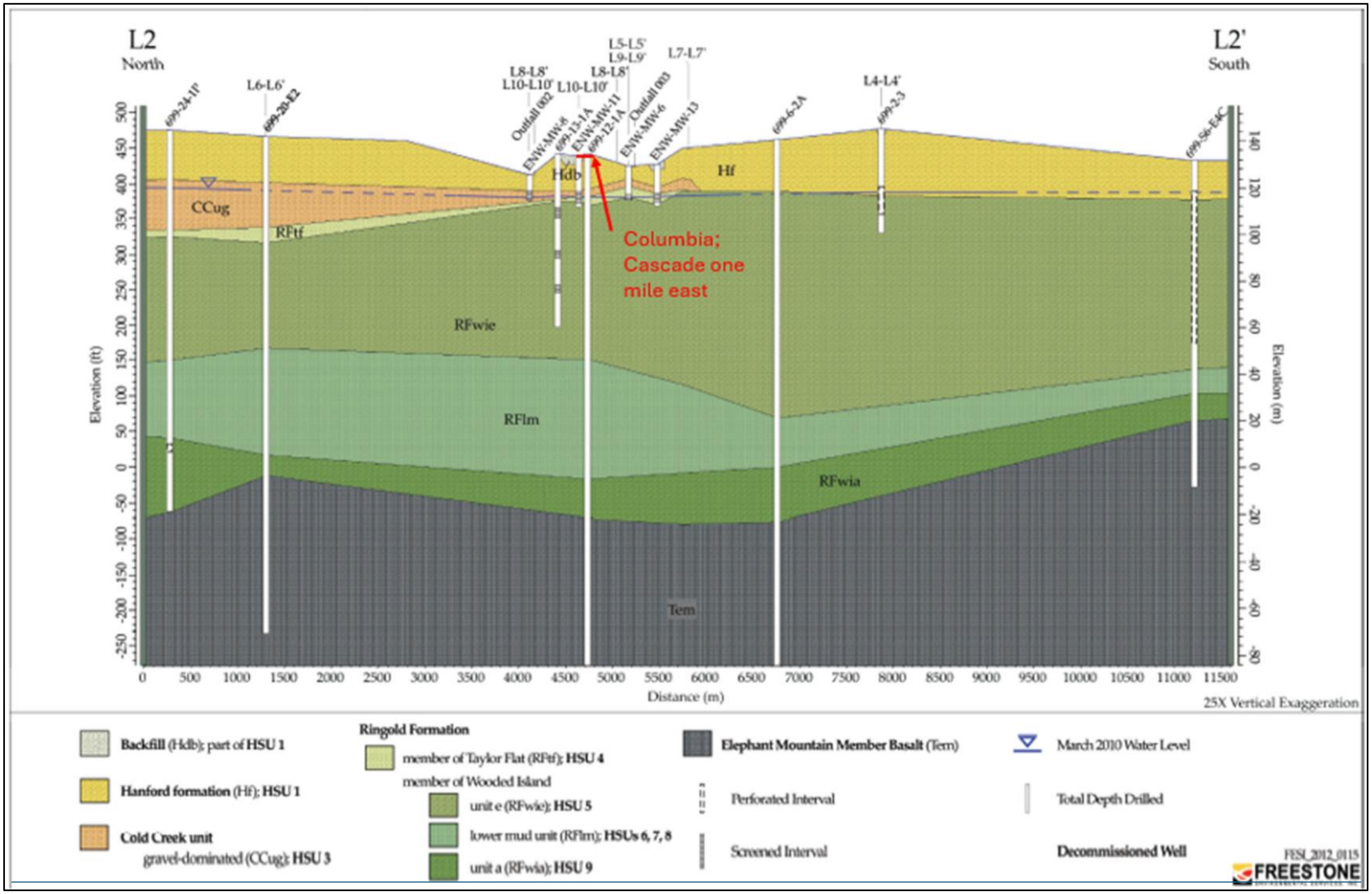


**Figure 5:** North-south stratigraphic line passing through Columbia site. (Fig. 3-3 from "Energy Northwest Columbia Generating Station Groundwater Quality Study Report," FESI-12-001, May 2012, Freestone Environmental Services, Inc.)

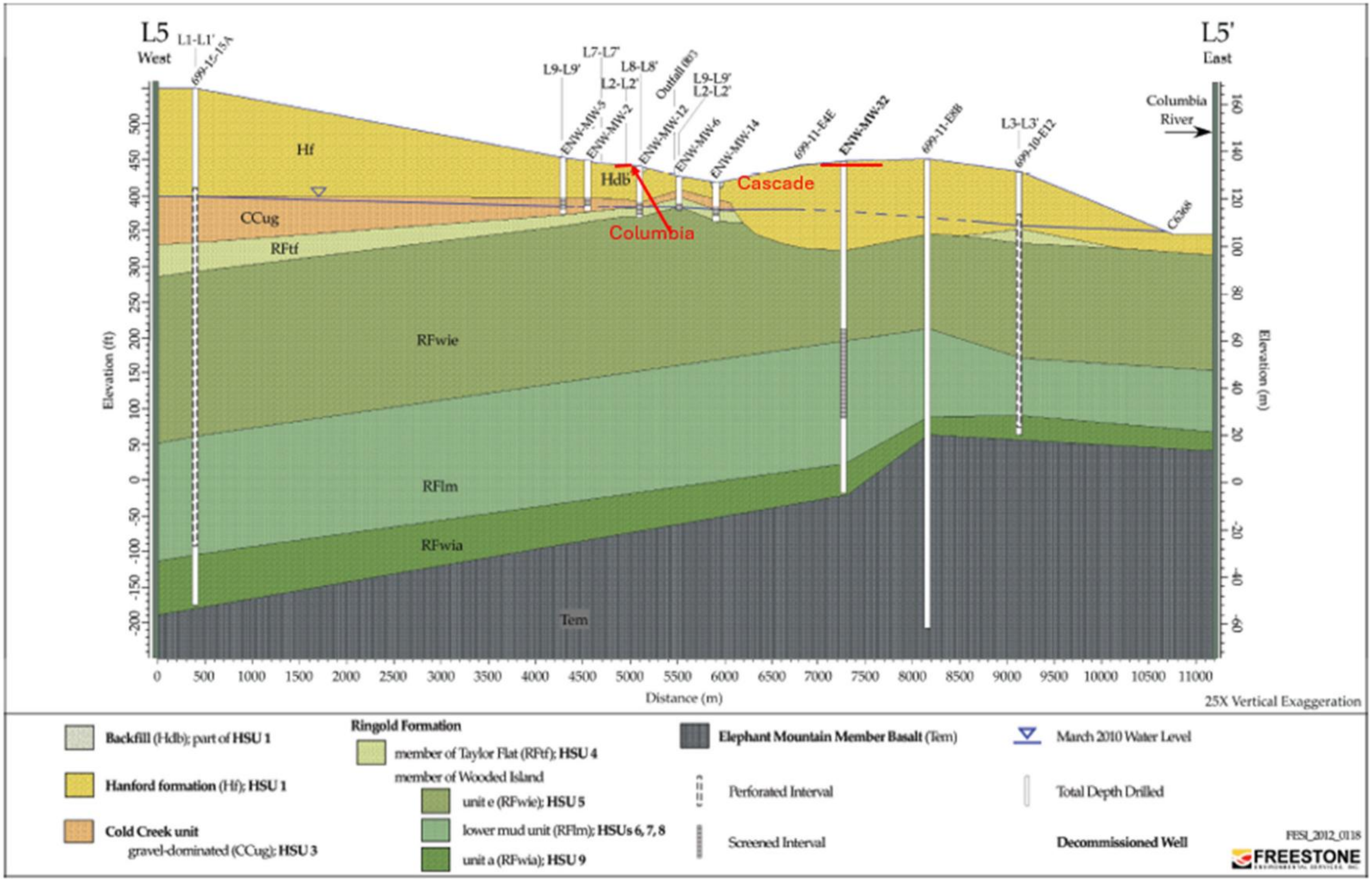


**Figure 6:** East-west stratigraphic line passing through Columbia and Cascade sites. (Fig. 3-4 from "Energy Northwest Columbia Generating Station Groundwater Quality Study Report," FESI-12-001, May 2012, Freestone Environmental Services, Inc.)

The locations of boreholes for geotechnical investigations performed in the 1970s for WNP-1 and the proposed location for the Cascade site are summarized in Figure 7. Figure 8 shows the borings and seismic refraction lines done to characterize the three sites (Columbia, WNP-1 and WNP-4) and the relative position of the Cascade site location.

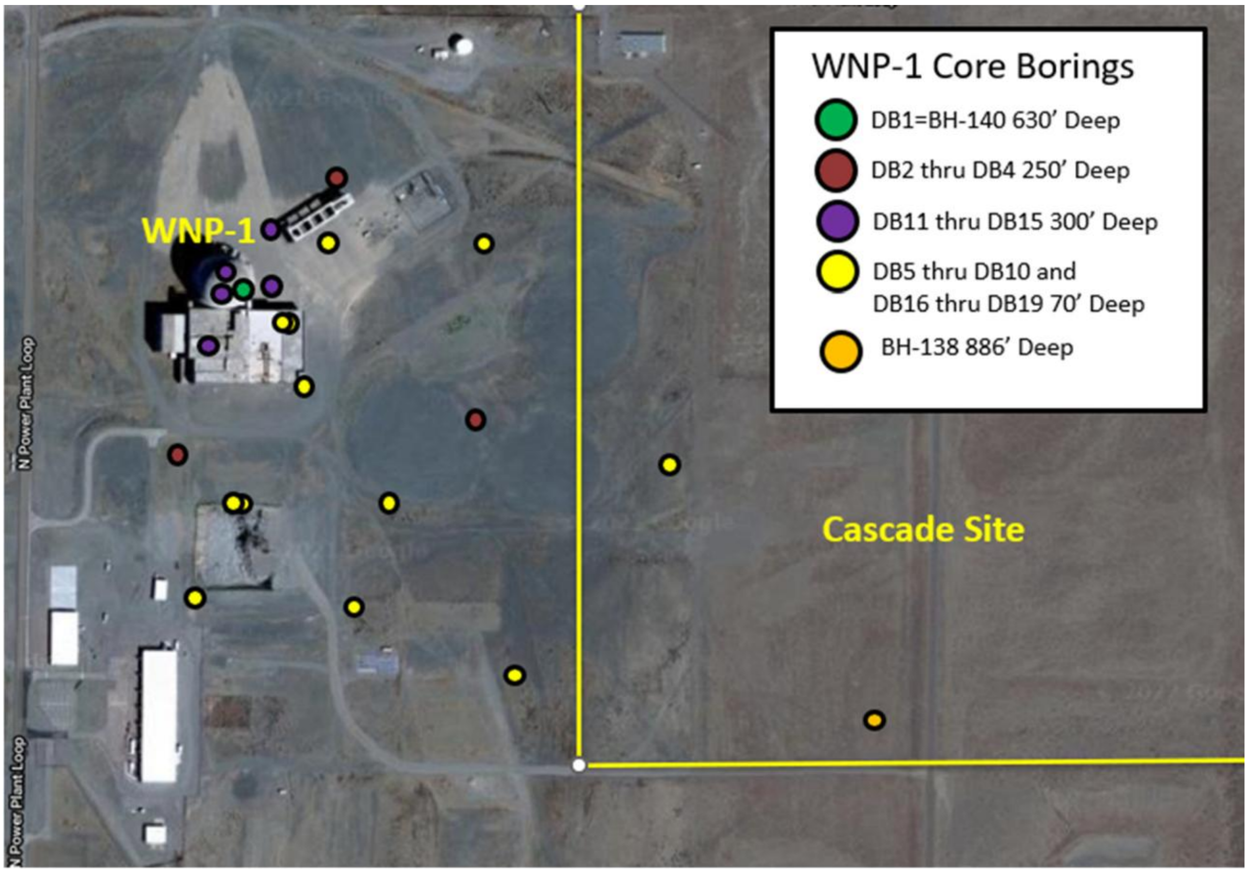


**Figure 7:** Core Borings around WNP-1. (From Figure 2.5.4-2 of WNP1/4 FSAR Amendment 1 October 1982.)

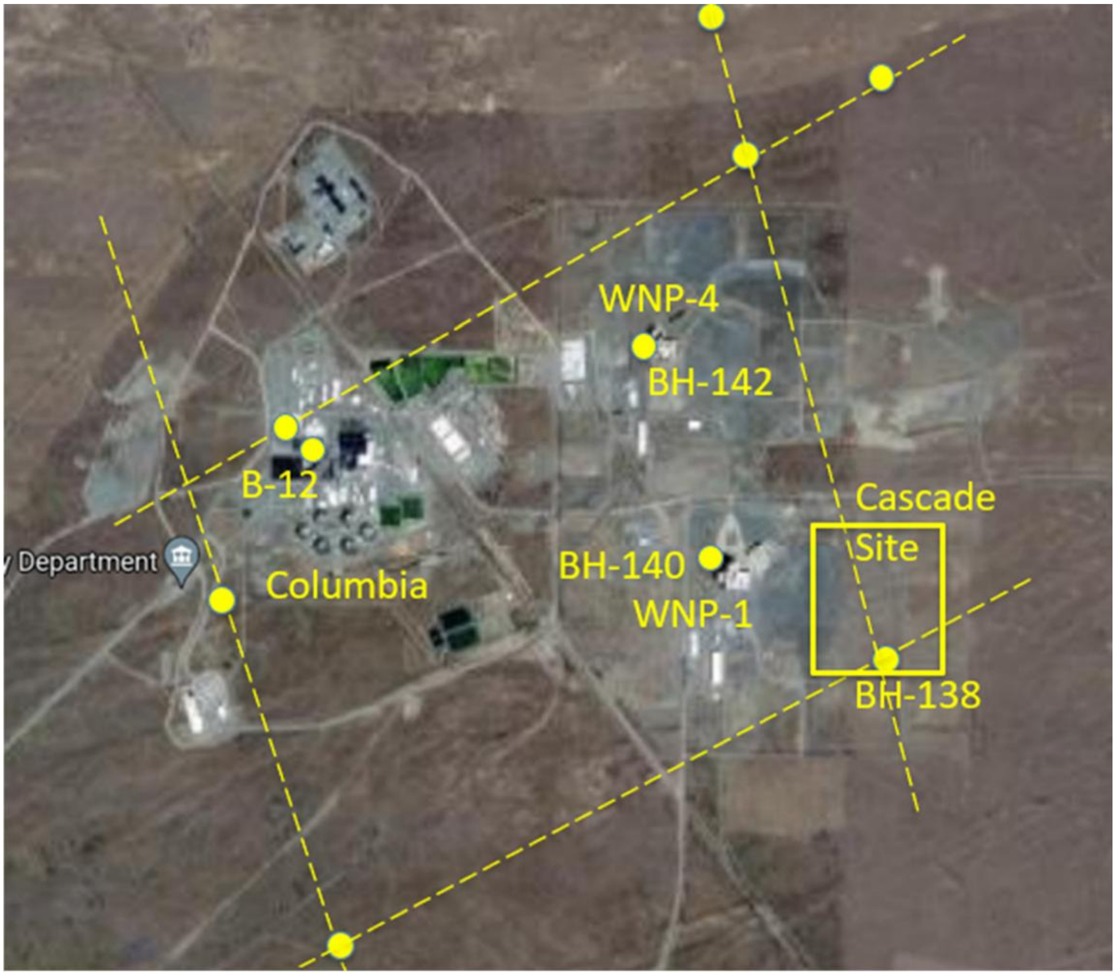


**Figure 8:** Seismic Refraction around Columbia, WNP-1 and WNP-4 Sites. (From Figure 2.5.4-2A of WNP-1/4 FSAR Amendment 1 October 1982.)

The uniform nature of the site stratigraphy is further seen by comparing the elevations of the tops of the different strata obtained from borings at Columbia, WNP-1, and WNP-4 in Table 1. Differences in elevations between WNP-1 and WNP-4 are within about 20 feet to depths of about 400 feet, despite being about 0.6 miles apart. Columbia and WNP-1/4 are about 1.0 mile apart yet differences in strata elevations are generally within about 20 feet to depths of about 300 feet. The differences in strata thicknesses may result in minor differences in calculated GMRSs.

Summarizing, the soils at the Energy Northwest leased sites consist primarily of glacial-fluvial cobble, gravel, and sand deposited on top of relatively level and thick basalt flows by the same events, leaving a uniform lithostratigraphy across the entire area. This uniformity supports the application of analyses from the previously licensed and permitted plants to the new Cascade facility.

**Table 1:** Comparison of elevations at the top of each stratigraphic unit for Columbia, WNP-1, and WNP-4

| | Columbia Based on Boring B-12 | | WNP-1 Based on Boring BH-140 | | WNP-4 Based on Boring BH-142 | |
|---|---|---|---|---|---|---|
| **Stratigraphic Unit** | **Elevation (ft NAVD88)** | **Description** | **Elevation (ft NAVD88)** | **Description** | **Elevation (ft NAVD88)** | **Description** |
| Pasco Gravel | 444.4 | Loose to medium dense fine to coarse sand with some gravel | 454.5 | Fine to coarse well graded sand | 454.5 | Coarse poorly graded sand |
| Ringold Formation Member of Wooded Island – Unit E | 401.4 | Very dense sandy gravel with cobbles | 394.5 | Sandy gravel with some cobbles | 404.5 | Sandy gravel to cobbles with some sand layers |
| Ringold Formation Member of Wooded Island – Fine Unit between C and B | 194.4 | Hard silt and clayey silt | 219.5 | Low plasticity soft silty clay, some sand and gravel | 219.5 | Clayey sand and silty sand with some gravel |
| Ringold Formation Member of Wooded Island – Unit B | 139.4 | Very dense gravely sand and sandy gravel | 159.5 | Gravel and cobbles | 169.5 | Sandy gravel and cobbles |
| Ringold Formation – Lower Mud | 28.4 | Layers of hard clay, clayey silt, sandy silt, and silty fine sand | 129.5 | Low plasticity soft silty clay, some sand and gravel | 119.5 | Clay clayey silt, and sandy silt with some gravel |
| Ringold Formation Member of Wooded Island – Unit A | -20.6 | Very dense sandy gravel and cobbles | 39.5 | Gravel | 59.5 | Gravel |
| | -43.6 | Conglomerate | 18.5 | Conglomerate | 49.5 | Conglomerate |
| | -50.6 | Hard clayey silt with basalt fragments | | | | |
| | -66.6 | Conglomerate | | | | |

### 1.4 Geotechnical Evaluations

A brief history of the analyses associated with Columbia and WNP-1/4 is given in the next sections. These analyses are directly applicable to the proposed Cascade facility.

**Columbia Final Safety Analysis Report**

The Columbia Final Safety Analysis Report (FSAR), submitted as part of the initial OLA, includes Section 2.5 Geology, Seismology, and Geotechnical Engineering. The OLA was approved by the NRC through the granting of the original operating license (Facility Operating License Number NPF-21, April 1984). The original construction permit application was submitted about early 1971.

**WNP-1 and WNP-4 PSAR and FSAR**

The WNP-1/4 site contains partially constructed pressurized light water reactors from the 1970's. The WNP-1/4 PSAR, submitted as part of the CPA for the WNP-1/4 project, includes Section 2.5 Geology and Seismology. The CPAs were submitted in October 1973 and August 1974, respectively. The CPA for WNP-1 was approved by the NRC through the granting of Construction Permit CPPR-134 in December of 1975. A combined FSAR for WNP-1/4 was submitted to the NRC in May, 1982, but was not approved because construction was halted in 1982 prior to issuance of an operating license. WNP-4 was cancelled in 1982 and the WNP-1 project was cancelled in 2007. Due to timing and proximity, much of the geotechnical work was shared between the three plants and reflected in Columbia's FSAR Section 2.5.

**Technical Memo TM-2143**

Columbia's FSAR Section 2.5, including appendices, figures, and tables, was removed from its FSAR and placed in Technical Memorandum TM-2143 (EN, 2005) to facilitate maintenance of the FSAR. The technical memo is incorporated by reference into the Columbia FSAR as Section 2.5, Geology, Seismology, and Geotechnical Engineering. The change was made as part of Amendment 58 to the Columbia FSAR in December 2005. The report compiles investigations and evaluations predating 1972 through 2005. No changes have been made to the technical memorandum since issuance.

**Post-Fukushima Accident Reanalysis for Columbia**

In response to the March 2011 tsunami and Fukushima Dai-Ichi accident in Japan, the NRC issued a series of recommendations for improving nuclear safety known as the Near-Term Task Force (NTTF) recommendations. In March of 2012, the NRC issued an information request under 10 CFR 50.54(f) (NRC, 2012a) that required EN to reevaluate seismic hazards for Columbia. In the NTTF letter, the NRC required the following evaluations:

> Addressees are requested to perform a reevaluation of the seismic hazards at their sites using present-day NRC requirements and guidance to develop a GMRS. … Addressees whose plants lie in the Western United States (WUS) are requested to develop seismic source and ground motion models to characterize their regional and site-specific seismic hazards. Consistent with current practice for 10 CFR Part 52, new reactor licensing, WUS addressees should perform a SSHAC [Senior Seismic Hazard Analysis Committee] Level 3 study to develop a probabilistic seismic hazard analysis. For plants where the reevaluated hazard exceeds the current design basis, addressees may opt to perform an SPRA [seismic probabilistic risk assessment]. In addition, an SPRA, rather

> than a SMA [seismic margin assessment], may be necessary for cases where the SMA screening tables are not usable due to a higher reevaluated hazard (i.e., GMRS).

As required, EN developed a GMRS for Columbia that was based on a 2014 SSHAC Level 3 study and submitted it to the NRC in 2015 (EN, 2015). EN determined that the reevaluated GMRS was higher than the current design basis and submitted an SPRA report in September 2019 (EN, 2019). These analyses are discussed below.

## 2014 SSHAC Level 3 Hanford Sitewide Probabilistic Seismic Hazard Analysis

The 2014 "Hanford Sitewide Probabilistic Seismic Hazard Analysis," November 2014, (PNNL, 2014) was performed by Pacific Northwest National Laboratory (PNNL) using SSHAC Level 3 procedures in accordance with the provisions of the Nuclear Regulatory Commission 50.54(f) letter (NRC, 2012a). The SSHAC Level 3 was conducted per NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts" (NRC, 1997), and the detailed implementation guidance provided in NUREG-2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies" (NRC, 2012b). It specifically utilized data from the five sites A through E shown in Figure 3. The SSHAC Level 3 report provides a detailed characterization of the vibratory hard-rock motion hazard at the Columbia location from potential future earthquakes. A participatory peer review panel (PPRP) oversaw all details of the performance of the PSHA and confirmed that the work was done in conformance with SSHAC guidance.

The PSHA scope was limited to the estimation of ground motions in a defined baserock horizon (i.e., top of Wanapum Basalt). The study did not develop site amplification factors for specific sites. Instead, it provides guidance on the methodology that could be used to develop site amplification factors for specific site locations.

## Columbia Reevaluations ~2015

In order to develop seismic response spectra, including a GMRS, EN produced a Seismic Hazard and Screening Report (SHSR) for Columbia (EN, 2015) that utilized the Hanford SSHAC Level 3 (PNNL, 2014). The resulting GMRS curve is also called the Bechtel 2015 GMRS curve. The SHSR was submitted to the NRC by EN in March 2015. The NRC's assessment that the SHSR is suitable for other NTTF actions was provided in November 2016 (NRC, 2016). This GMRS curve was used for the SPRA report submitted to the NRC in September 2019 (EN, 2019).

## Seismic Hazard Analysis (SHA) for Columbia Generating Station 2019

EN commissioned a peer review of the SPRA prior to submitting it to the NRC. The peer review resulted in a number of Facts and Observations (F&O) that were resolved through a revised seismic hazard analysis (Wood, 2019a). The resolutions to the F&O were subjected to a team peer review that fully closed all but one F&O, 20-10, which was partially closed (Jensen Hughes 2019a). The Wood, 2019a, report had used soil characteristics that produced acceptable results but were not the most appropriate for the Columbia site. The impact of the partially closed F&O, 20-10, on the SPRA results was assessed in the SPRA report (EN, 2019). Subsequently, Wood, 2019a, was revised using weighting of modulus reduction and damping relationships more appropriate to soil characteristics at the Columbia site, and a follow-on peer review determined that "the updated horizontal response spectral shape is now sufficiently site-specific" (Jensen Hughes 2019b). Full closure of the partially closed F&O 20-10 occurred during the 2019-2020

NRC audit of the Columbia SPRA and F&O resolutions. The NRC was notified of the closure and included this in their 2020 audit closure report (NRC, 2020a) with the conclusion "that no further response or regulatory actions associated with NTTF Recommendation 2.1 "Seismic" are required." The resulting GMRS curve (Wood, 2019b) is shown in Figure 9. ENNN intends to develop, under an Appendix B program, a GMRS for Cascade's PSAR based on this curve that is suitable for preliminary design.

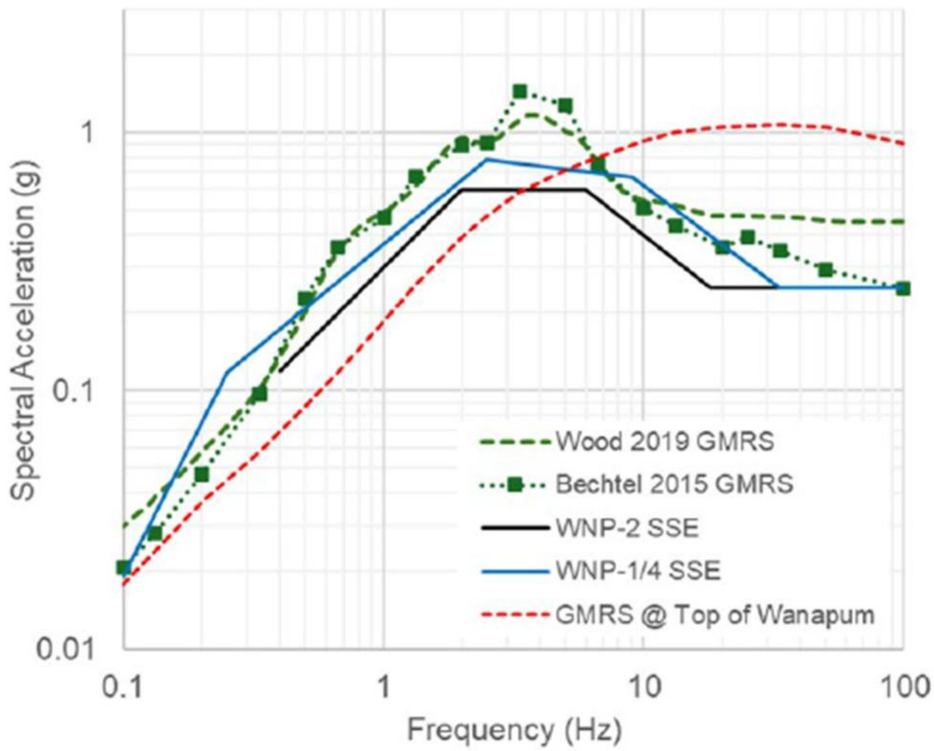


**Figure 9:** Comparison of GO2-15-045 (EN, 2015) and Wood, 2019b, GMRS along with WNP-2 SSE, WNP-1/4 SSE and GMRS at the Top of Wanapum Basalt Flow.

## 2. EVALUATION PROCESS

As described in ENNN White Paper "Methodology for Determining the Acceptability of Historical Information" (ENNN, 2025), the following criteria (questions) are used to determine the acceptability of historical analyses:

1. Regulatory Changes—Are the applicable regulations associated with the required information the same as during the time of the historical analysis?
2. Analysis Methodology—Is the same analytical methodology in effect today as was when the historical analysis was performed?
3. Scope of Analysis—Does the scope of the historical analysis fully address the project site?
4. Site Changes—Is the project site today consistent with the project site that was analyzed?
5. Quality Assurance (QA)--Was the historical analysis developed under an Appendix B QA program?
6. Copy of Record—Is a copy of the historical analysis still available today?

For each question, if the answer is "yes" then no new analysis is needed. If an answer is "no" then ask, "Does a reasonable basis for applying the historical analysis to the current project exist?" If "yes", document the basis and conclude that the historical analysis is adequate. If not, then conclude that a new or revised analysis is needed.

## 3. VIBRATORY GROUND MOTION ACCEPTABILITY EVALUATION

<u>Introduction</u>

The vibratory ground motion evaluation addressed in DANU-ISG-2022-02, “Advanced Reactor Content of Application Project, Chapter 2, Site Information,” Interim Staff Guidance,” (NRC, 2024). Section 2.6.2, Vibratory Ground Motion, uses soil properties under safety-related structures and seismic characteristics of the region within 200 miles (320 km) of the site to determine a GMRS that is used for the design of structures, systems, and components (SSCs) to ensure the health and safety of the public are protected.

The six questions posed in Section 2 above for evaluating the acceptability of historical analyses are addressed in the sections below for vibratory ground motion.

**Analyses Considered:** Hanford Sitewide PSHA (PNNL, 2014), Columbia Seismic Hazard Reevaluation (EN, 2015), and Seismic Hazard Analysis for Columbia Generating Station (Wood, 2019b)

**Methodology Applied:** Regulatory Guide (RG) 1.208, “A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion,” (NRC, 2007), EPRI 1025287, “Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic,” (EPRI, 2012), NUREG/CR-6372 (NRC,1997), NUREG-2117 (NRC, 1012b)

**NRC Documentation of Acceptance:** NRC assessment of response to NTTF seismic response (NRC, 2016), Staff Review of SPRA Associated with Reevaluated Seismic Hazard Implementation (NRC, 2020a)

<u>Question 1, Regulatory Changes</u>

*Are the applicable regulations associated with the required information the same as during the time of the historical analysis?*

No. The reason for this response is:

Table 2 summarizes the requirements applicable to Columbia for the post-Fukushima reevaluations compared to the current requirements.

**Table 2:** Summary of Regulations used for Seismic Analyses

| Post-Fukushima Reevaluation | Current Requirements |
|---|---|
| 10 CFR 50 App. A GDC 2<br>10 CFR 100.23<br>10 CFR 100 Appendix A | 10 CFR 50 App. A GDC 2[1]<br>10 CFR 100.23 |

[1] Applicable as guidance for non-light water reactors.

1. Columbia and WNP-1/4, as light water reactors, fall under the general design criteria (GDC) requirements of 10 CFR 50 Appendix A. The Cascade facility is a non-light water reactor and will be subject to principal design criteria (PDC) developed in accordance with RG 1.232, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors," Revision 0, April 2018.

2. Columbia and WNP-1/4 were licensed or permitted prior to January 1997 and so were subject to 10 CFR 100 Appendix A. Cascade is subject to Subpart B, which includes 100.23.

However, a reasonable basis for applying the historical analysis to the current project exists based on the following details.

1. ENNN intends to apply PDCs associated with the Xe-100 design to Cascade. The PDCs were presented by X-energy in their NRC-approved licensing topical report, "Xe-100 Licensing Topical Report Principal Design Criteria," 004799-A, Rev. 3, 12 Aug 2023 (X-energy, 2023). X-energy's PDC-2, Design Bases for Protection Against Natural Phenomena, is nearly identical to GDC 2 such that the GDC and PDC are the same for the present purpose of evaluating geotechnical hazards. Table 3 compares GDC 2 and PDC-2. Differences are underlined and highlighted in red text.

**Table 3:** Comparison of 10 CFR 50 Appendix A GDC Criterion 2 to X-energy PDC-2

| GDC 2 | X-energy PDC-2 |
|---|---|
| Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect:<br>(1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated,<br>(2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and<br>(3) the importance of the safety functions to be performed. | Safety-significant structures, systems, and components shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect:<br>(1) Appropriate consideration of the severity of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated,<br>(2) appropriate combinations of the effects of normal, anticipated operational occurrence, design basis event, and design basis accident conditions with the effects of the natural phenomena,<br>(3) the safety-significance of the functions to be performed. |

2. While the post-Fukushima seismic hazard reevaluation was completed using present-day methods per 10 CFR 100.23, some of the underlying physical data such as shear wave velocities, stratification, and soil properties were based on

historical data collected to support original licensing of Columbia, which was collected as required by 10 CFR 100 Appendix A.

Appendix A contains both requirements and guidance on how to satisfy the requirements. This appendix requires, in part, investigations to obtain the geologic and seismic data necessary to determine site suitability. In December 1996, a new 10 CFR 100 Subpart B was created containing Sections 100.20, 100.21, and 100.23. This subpart is applicable to plants whose construction permit applications were made on or after January 10, 1997. The detailed guidance in Appendix A on *how* to satisfy the regulation to determine the geological, seismological, and engineering characteristics of the site was moved to guidance documents such that the final regulation is streamlined with a reduced level of detail. Required geotechnical evaluations are substantially the same between the early 1970s and today. Therefore, the data gathered for Columbia and WNP-1/4 are consistent with current regulations and may be used for Cascade. Further discussion of the relevant guidance documents is presented in Section 4 question 2.

Question 2, Analysis Methodology

*Is the same analytical methodology in effect today as was when the historical analysis was performed?*

No. Reasons for this response are:

Table 4 identifies the guidance documents and standards used for the historical analyses, here referring to the post-Fukushima reevaluations, and current guidance that would be used today for new construction.

**Table 4:** Summary of Guidance Documents for Seismic Hazard Analysis Comparing Guidance for Post-Fukushima Reevaluations to 2025 Guidance

| Evaluation | Eval Date | Guidance Used for Historical Analyses | Rev Used | Current Guidance | Current Rev |
|---|---|---|---|---|---|
| Geotech - Geology, Seismology, and Geotechnical Engineering | 2015 | NTTF letter (NRC, 2012a) | 3/12/2012 | DANU-ISG-2022-02 | 3/2024 |
| Vibratory Ground Motion | 2015 | RG 1.208 | R0, 3/2007 | RG 1.208 | R0, 3/2007 |
| SSHAC L3 – Rock Reference | Nov 2014 | NUREG/CR-6372<br>NUREG-2117 | 4/1997<br>R1, 4/2012 | NUREG/CR-6372<br>NUREG-2117<br>NUREG-2213 | 4/1997<br>R1 4/2012<br>8/2018 |
| PSHA, SRA – Probabilistic Seismic Hazard Analysis | 2019 | NUREG/CR-6728<br>NUREG/CR-6372<br>NUREG-2117 | 10/2001<br>4/1997<br>2012 | NUREG/CR-6372<br>NUREG-2117 | 4/1997<br>2012 |
| SPRA Peer Review | 2019 | RG 1.200 | R2, 3/2009 | RG 1.200 | R3, 12/2020 |

1. Guidance for site-specific GMRS development changed from the post-Fukushima NTTF request letter (NRC, 2012a) to DANU-ISG-2022-02 (NRC, 2024) Section 2.6. Per DANU-ISG-2022-02, site response analyses should also be used to determine foundation input response spectra (FIRS) for seismic Category I structures. The DANU introduces NUREG-2213, "Updated Implementation Guidelines for SSHAC Hazard Studies," (2018). RG 1.200, "Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities," (NRC, 2020c) was revised in 2020.

2. Research since the 2014 SSHAC Level 3 has not been reviewed for new information that could affect the seismic evaluations as directed by "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," RG 1.208, Revision 0, March 2007 (NRC, 2007). The Cascadia subduction zone characterization, in particular, needs to be examined.

3. Change in the expected control point location per RG 1.208: A minimum 1000 fps Vs is generally used to define competent material.

4. Expectation to use "Documentation Report for SSHAC Level 2: Site Response, Research Information Letter RIL 2021-15," (Rodriguez-Marek, 2021) for Site Response Analysis (SRA) in PSHA for developing a GMRS.

5. New and modified data collection methods, such as surface geophysics testing methods, are available.

However, a reasonable basis for applying the historical analysis to the current project exists based on the following points that address each of the items above, respectively:

1. Methodologies put forth in DANU-ISG-2022-02 Section 2.6.2 (NRC, 2024) are generally consistent with those used for the post-Fukushima seismic reevaluations, as shown in Table 4. The Columbia post-Fukushima seismic hazard reevaluations were performed per current methodologies using updated seismic hazard information. Limited historical analyses such as shear wave velocities, stratification and soil properties from the original site investigations were inputs to the analysis. Results were accepted by the NRC per reference (NRC, 2016), based on a review of the Columbia Seismic Hazard Reevaluation (EN, 2015), thus validating the methodologies used for the evaluations. The Seismic Hazard Analysis for Columbia Generating Station (Wood, 2019b) utilized consistent methods as those in (EN, 2015).The CPA will include FIRS in accordance with DANU-ISG-2022-02.

   RG 1.200 Revision 3 continues to endorse ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008 Standard for Level I/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," which was used in developing the 2019 "Seismic Hazard Analysis for Columbia Generating Station" (Wood, 2019b) in development of a GMRS. The endorsement was not changed from Revision 2. RG 1.200 does not otherwise add guidance for development of a GMRS.

NUREG-2213, "Updated Implementation Guidelines for SSHAC Hazard Studies," serves as an update to the original SSHAC guidance in NUREG/CR-6372 and the implementation guidance provided in NUREG–2117. Specifically, NUREG-2213 (i) clarifies terminology and key concepts that are essential for all SSHAC studies; (ii) strengthens the implementation framework for Level 3 studies, based on extensive recent experience; (iii) provides guidance on the attributes of Level 1 and 2 studies; and (iv) presents a revised and more rigorous framework for decision-making regarding the updating of existing SSHAC studies. Per the NUREG-2213 Abstract, "this document builds on the framework described in the prior NUREGs and incorporates lessons learned from conducting recent SSHAC studies. This document does not invalidate the prior guidance documents or the studies conducted accordingly; however, the intent of this NUREG is to provide the most current standalone guidance."

In summary, the 2014 SSHAC Level 3 (PNNL, 2014) and 2019 Wood (Wood, 2019b) reports are consistent with guidance identified by DANU-ISG-2022-02.

2. Literature reviews are documented in the 2014 L3 SSHAC (PNNL, 2014). A review of published and ongoing research since the SSHAC work in 2014 that could affect the seismic evaluations, e.g., ground motion models for the Cascadia Subduction zone in "NGA-Subduction Ground Motion Models with Regional Adjustment Factors" (Parker et al., 2020; Abrahamson and Gülerce, 2020; Kuehn et al., 2020), is expected to be included in the CPA per RG 1.208 and DANU-2022-02 Section 2.6.1.1. Literature reviews will be conducted and a sensitivity study performed to evaluate the impact of new information on the GMRS curve. Results will be discussed in the PSAR.

3. ENNN intends to develop a GMRS curve for the CPA and preliminary design that incorporates significant updates. The selection of a corrected GMRS control point per RG 1.208, Revision 0, is anticipated to have an "insignificant impact …on the GMRS, provided that there is no major change in the Vs profile logic tree." (Rizzo, 2025). This will be confirmed in a sensitivity study to evaluate the impact on the GMRS curve. Results will be discussed in the PSAR.

4. The SRA input model and SRA computations presented in Wood, 2019b, are mostly consistent with the recent NRC SRA guidance issued as NRC RIL 2021-15 (Rodriguez-Marek, 2021); however, inclusion of updated assessments of minimum epistemic uncertainty may affect high-frequency motions. In addition, the potential use of the KAPPA2 approach to address overdamping in equivalent linear site response at large strains could also affect the high-frequency motions, depending on computed strain levels. ENNN intends to develop a GMRS curve for the CPA and preliminary design that incorporates significant updates. A

sensitivity study will be performed to evaluate the impact of these approaches on the GMRS curve. Results will be discussed in the PSAR.

5. In order to increase confidence in the new GMRS curve, ENNN plans to conduct non-invasive, surface geophysical investigations to confirm the velocity profiles in the WNP-1 site area and increase confidence in the applicability of the velocity profiles that were used to develop the curve. Vs data will be obtained with a combined Microtremor Array Measurement (MAM) and Multi-Channel Analysis of Surface Waves (MASW) survey. The MAM/MASW arrays will target the Hanford and Ringold formations and extend into the top of the SMB. Results of the supplemental investigations are expected to confirm existing results and will be discussed in the PSAR.

Question 3, Scope of Analysis

*Does the scope of the historical analysis fully address the project site?*

No. Reasons for this response are:

Site-specific geotechnical properties and GMRS and FIRS using site-specific investigations have not been developed for the proposed safety significant structures. RG 1.132, “Geologic and Geotechnical Site Characterization Investigations for Nuclear Power Plants,” December 2021, Revision 3, ML21298A054 (NRC, 2021), has general guidelines for site-specific borings.

However, a reasonable basis for applying the historical analysis to the current project exists based on the following:

Geotechnical analyses from Columbia and WNP-1/4 are acceptable for use with Cascade due to the proximity of the three projects and the geotechnical uniformity described in Section 1.3 above. Geotechnical information such as soil properties was collected for Columbia and WNP-1/4. These projects are within about one mile of Cascade, which is located on the Hanford Site. The lithology of the EN leased property and Hanford Site has been extensively characterized in support of the three nuclear projects on the EN leased property and activities on the Hanford Site, as illustrated in Figure 3. Consequently, the general lithology, consisting of glacial-fluvial deposits left by the same events on top of thick, relatively level basalt layers, as described in Section 1.3 and below, is well characterized and since it is relatively uniform in the area that includes the EN projects, geotechnical properties are expected to be similar at the Cascade site. The closest geotechnical boring to the proposed safety-related structures, BH-138 as shown in Figure 8, is within the footprint of the Cascade site, well within the characterized area around the EN projects. Borings and other geotechnical investigations are planned to support design and construction and are expected to confirm the developed GMRS and other lithological properties. Results will not be available for the CPA but will be included in the FSAR.

Some of the Vs profiles show inconsistencies with comparable profiles collected at different times and nearby locations in the Hanford Site, as illustrated in Figure 10 below. Sensitivity analyses show that amplification functions are sensitive to the velocity of the supra-basalt units; however, a re-weighting of the alternative SRA models developed in Wood, 2019b, produced similar amplification factors.

Non-invasive subsurface investigations using MAM/MASW are planned to obtain additional Vs data for use in sensitivity studies to increase confidence in results. If sensitivity analyses using the additional Vs data do not change the mean amplification factor, it can be concluded the uncertainty in supra-basalt properties is sufficiently represented and changes to GMRS results are not expected.

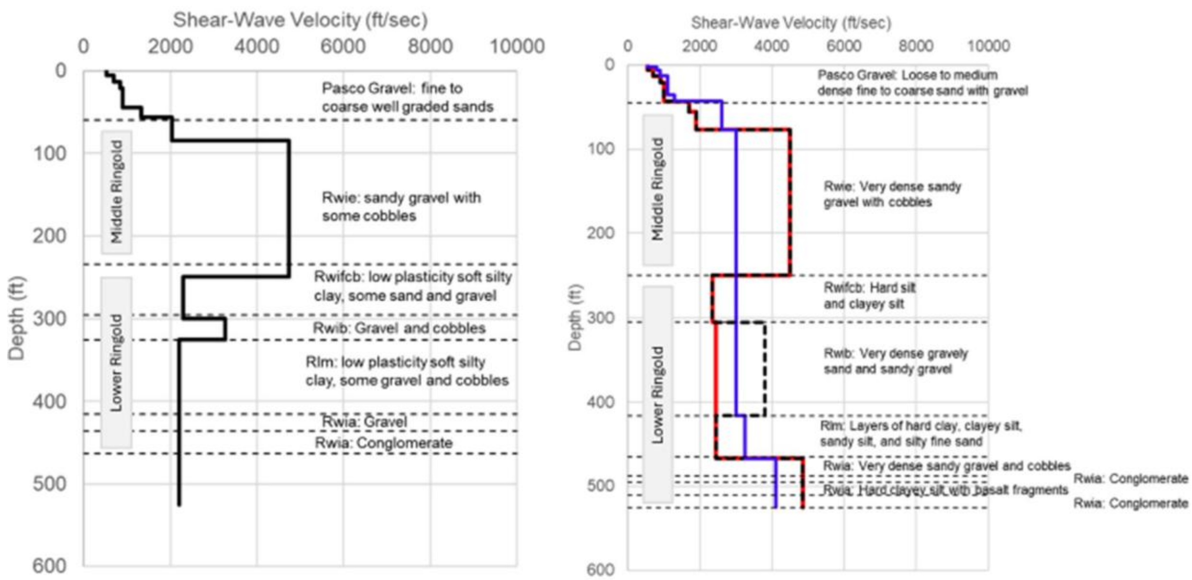


**Figure 10**: Correlation Between Base Case Vs Profile and Site Stratigraphy (Left: GO2-15-045 (EN, 2015) Base Case Vs Profile with Site Stratigraphy at WNP-1 [Boring BH-140]; Right: Wood Base Case Vs Profiles A (Red), B (Black Dashed), C (Blue) and Site Stratigraphy at Columbia [Boring B-12])

<u>Question 4, Site Changes</u>

*Is the project site today consistent with the project site that was analyzed?*

Yes. Subsurface stratigraphy has not changed since deposition of the Pasco gravels roughly 15,000 years ago.

<u>Question 5, Quality Assurance</u>

*Was the historical analysis developed under an Appendix B QA program?*

No. Reasons for this response are:

1. The SSHAC Level 3 work was performed to the NRC-approved process rather than specifically to an Appendix B QA program.

2. The Wood, 2019a and 2019b, GMRS work was not performed as safety related.

However, a reasonable basis for applying the historical analysis to the current project exists based on the following:

1. The 2014 SSHAC Level 3 (PNNL, 2014) work was performed and approved in accordance with the NRC-approved process in NUREG/CR-6372. The project Quality Assurance Plan and procedures were developed to meet the requirements of ANSI/ANS 2.29-2008, "Probabilistic Seismic Hazard Analysis," which in turn was developed to be consistent with NQA-1-2008. Software used for the SSHAC Level 3 work was developed and controlled under a quality assurance program based on NQA-1-2008 Subpart 2.7, Quality Assurance Requirements for Computer Software for Nuclear Facility Applications.

2. ENNN intends to use these analyses to develop a GMRS under an Appendix B program that is suitable for preliminary design. The GMRS will include any significant updates, including minimum epistemic uncertainty.

<u>Question 6, Copy of Record</u>

*Is a copy of the historical analysis still available today?*

Yes. The analyses presented are all available in public documents or EN records.

# 4. GEOTECHNICAL ACCEPTABILITY EVALUATION

Introduction

This section addresses potential geotechnical hazards in DANU-ISG-2022-02 Section 2.6.3, Surface Deformation, Section 2.6.4, Stability of Subsurface Materials and Foundations, and Section 2.6.5, Stability of Slopes.

For Surface Deformation, the findings documented in the Columbia Technical Memo TM-2143 show no evidence of surface deformation or capable faults within five miles of Columbia that could affect Cascade. Moreover, the USGS Interactive Quaternary faults map indicates that there are no capable faults within 5 miles of the site. Hence, this potential hazard is not further addressed in this paper.

For Stability of Subsurface Materials and Foundations, the Cascade PSAR will address the historical analysis soil properties used to evaluate the static and dynamic stability of safety significant structures.

For Stability of Slopes, the Cascade PSAR will use the same soil properties to evaluate the stability of slopes that may affect safety significant structures. However, just as there are no slopes at the Columbia site, either natural or manmade (both cut and fill), the failure of which could adversely affect the safety of Columbia, there are no slopes on the Cascade site that could adversely affect safety significant SSCs, and none are anticipated. There are no embankments or dams at the Columbia or Cascade sites for flood protection or for impounding cooling water required for the operation of the nuclear power plant.

The six questions posed in Section 2 for evaluating historical analyses related to the engineering properties of the site soils collected from exploration activities are addressed below.

**Analyses Considered:** TM-2143 with field data reports for Columbia and WNP-1/4 (EN, 2005), WNP-1/4 FSAR Section 2.5 (WPPSS, 1986)

**Methodology Applied:** 10 CFR 100 Appendix A

**NRC Documentation of Acceptance:** Columbia Operating License (Facility Operating License Number NPF-21, April 1984); WNP-1 Construction Permit No. CPPR-134 (December 1975) and WNP-4 Construction Permit CPPR-174

Question 1, Regulatory Changes

*Are the applicable regulations associated with the required information the same as during the time of the historical analysis?*

No. Reasons for this response are:

Table 5 summarizes the requirements applicable to Columbia and WNP-1/4 compared to the current requirements.

**Table 5:** Summary of Regulations used for Geotechnical Analyses Comparing Guidance for Original Licensing with 2025 Guidance

| Original Licensing | Current Requirements |
|---|---|
| 10 CFR 50 App. A GDC 2<br>10 CFR 100.10<br>10 CFR 100 Appendix A | 10 CFR 50 App. A GDC 2[2]<br>10 CFR 100 Subpart B<br>10 CFR 100.23 |

1. Columbia and WNP-1/4, as light water reactors, fall under the GDC requirements of 10 CFR 50 Appendix A. The Cascade facility is a non-light water reactor and will be subject to PDC developed in accordance with RG 1.232, Revision 0, April 2018.

2. Columbia and WNP-1/4 were licensed or permitted prior to January 1997 and so were subject to 10 CFR 100.10. Cascade is subject to Subpart B, which includes 100.23.

3. 10 CFR 100.23 was added in 1997.

However, a reasonable basis for applying the historical analysis to the current project exists based on the following details.

1. See the discussion in Section 3 for Question 1 that addresses the change from GDC to PDC for Cascade.

2. Required geotechnical evaluations are substantially the same between the early 1970s and today. 10 CFR 100 was introduced in 1962 and included Sections 100.10 and 100.11. Appendix A was added in 1973. In December 1996, a new 10 CFR 100 Subpart B was created containing Sections 100.20, 100.21, and 100.23. This subpart is applicable to plants whose construction permit applications were made on or after January 10, 1997. The content of Appendix A not associated with site suitability or establishment of the Safe Shutdown Earthquake Ground Motion (SSE) was moved to 10 CFR 50 Appendix S. The detailed guidance in Appendix A on *how* to satisfy the regulation to determine the geological, seismological, and engineering characteristics of the site was moved to guidance documents. Finally, the approach for determining the SSE was expanded to allow the option of using a probabilistic seismic hazard methodology. The change in regulations was made to provide regulatory flexibility and was not substantive for evaluations of geotechnical characteristics. Guidance documents were subsequently revised to be consistent with the revisions in the regulations. Therefore, the analyses for Columbia and WNP-1/4 are consistent with current regulations and may be used for Cascade.

3. The removal of 10 CFR 100 Appendix A and the addition of 10 CFR 100.23 and 10 CFR 50 Appendix S for applications after January 10, 1997, were all part of

[2] Applicable as guidance for non-light water reactors.

the same change discussed in response 2 above. Appendix A iv (b) and 10 CFR 100.23 (d)(2) address surface deformation. Appendix A iv (d)(1) and (2) and 10 CFR 100.23 (d)(4) address soil stability, liquefaction, and slope stability, among others. There is not a substantive difference in required evaluations.

No material changes to 10 CFR 50 Appendix A GDC 2, 10 CFR 100.20 or 10 CFR 100.23 have occurred since the historical analyses were completed.

<u>Question 2, Analysis Methodology</u>

*Is the same analytical methodology in effect today as was when the historical analysis was performed?*

No. Reasons for this response are:

Table 6 identifies the guidance documents used for the historical analyses generated in the 1970s and current guidance that would be used today for new construction.

**Table 6**: Summary of Guidance Documents for Other Hazard Analysis Comparing Guidance for Original Licensing with 2025 Guidance

| Evaluation | Eval Date | Guidance Used for Historical Analyses | Rev Used | Current Guidance | Current Rev |
|---|---|---|---|---|---|
| Geotech - Stability of Subsurface Materials and Foundations | 1971-1980 | NUREG-0800 | R0, 11/1975 | DANU-ISG-2022-02 | 3/2024 |
| Geologic and Geotechnical Site Characterization Investigations | 1971-1980 | 10 CFR 100 Appendix A | 11/27/1973 | RG 1.132<br>RG 1.198 | R3, 12/2021<br>R0, 11/2003 |
| Field Investigations for Foundations of Nuclear Power Facilities | 1971-1980 | 10 CFR 100 Appendix A | 11/27/1973 | NUREG/CR-5738 | 11/1999 |
| Laboratory Investigations of Soils and Rocks for Engineering Analysis | 1971-1980 | 10 CFR 100 Appendix A | 11/27/1973 | RG 1.138 | R3, 12/2014 |

However, a reasonable basis for applying the historical analyses to the current project exists based on the following:

1. Table 6 identifies that guidance for the historical analyses generated in the 1970s was 10 CFR 100 Appendix A; pertinent RGs were not identified. Guidance that would be used today for new construction is identified in DANU-ISG-2022-02 and is reflected in Table 6. As explained in the basis section for Item 2 in Question 1 above, the regulations driving the geotechnical investigations were reorganized and simplified in 1997. The investigations and methodologies for Columbia and WNP-1/4 were done to then-current methods to satisfy the requirements of what is now 10 CFR 100 Subpart A as summarized in Table 6. The scope of Appendix A requires, “Each applicant for a construction permit shall investigate all seismic

and geologic factors that may affect the design and operation of the proposed nuclear power plant irrespective of whether such factors are explicitly included in these criteria." Initial versions of RG 1.132 and RG 1.138, "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants," currently at Revision 3, December 2014, ML14289A600 (NRC, 2014), were issued in 1977 and 1978, respectively, shortly after the construction permits for these projects were issued. The exploration and analysis completed for the Site's CPAs was in accordance with the nuclear industry standard of care as illustrated by the subsequent licensing by the NRC. Moreover, RG 1.132 and RG 1.138 documented this standard of care and did not significantly modify the approach to collecting subsurface data and would have reflected then-current methodologies that the historical geotechnical work would have been based on. Comparison of the investigation methods in initial and current revisions of the RGs show that generally the same methods and material properties are identified in both. Furthermore, the Safety Evaluation Report for Columbia (NUREG-0892) states that the NRC staff reviewed the site "in the context of … Regulatory Guide 1.132."

ENNN concludes that the methods used for historical analyses are consistent with current regulations and will use the historical analyses for the PSAR submittal. Site-specific investigations will be performed using current methodologies to confirm the historical analysis results and will be reported in the FSAR. Any differences in results will be addressed and incorporated into design and licensing.

<u>Question 3, Scope of Analysis</u>

*Does the scope of the historical analysis fully address the project site?*

No. Reasons for this response are:

Soil properties using site-specific investigations have not been developed for the proposed safety significant structures. RG 1.132 has general guidelines for site-specific borings.

However, a reasonable basis for applying the historical analysis to the current project exists based on the following:

Geotechnical analyses such as soil properties obtained for the construction permits and operating license applications for Columbia and WNP-1/4 are acceptable for use with Cascade due to the proximity of the three projects and the geotechnical uniformity described in Section 1.3 above for the general area around the site. These projects are within about one mile of the Cascade site. The extensive characterization of the lithology of the EN leased property and Hanford Site, consisting of glacial-fluvial deposits on top of thick, relatively level basalt layers, as described in Section 1.3, demonstrates the relative uniformity over a large area.

The closest geotechnical boring to the proposed safety-related structures, BH-138 as shown in Figure 8, is within the footprint of the proposed project, well within the characterized area around the EN projects. Borings and other geotechnical investigations are planned to be performed per NRC guidance such as RG 1.208, RG 1.132, and NUREG/CR-5738 and are expected to confirm the lithological properties and will be included in the FSAR.

Question 4, Site Changes

*Is the project site today consistent with the project site that was analyzed?*

Yes. Subsurface lithology has not changed since deposition of the Pasco gravels roughly 15,000 years ago. While some near surface land disturbance occurred during the construction of WNP-1, relics (foundations, uncontrolled fill, roadways and utilities) of that construction will be removed as needed and the new safety significant structures will be founded on naturally deposited soils or qualified fill.

Question 5, Quality Assurance

*Was the historical analysis developed under an Appendix B QA program?*

Yes. Historical investigation results are taken from the Columbia and WNP-1/4 FSARs and collected in the Technical Memo (EN, 2005). EN had a quality assurance program based on ANSI N45.2 that incorporated 10 CFR 50 Appendix B.

Question 6, Copy of Record

*Is a copy of the historical analysis still available today?*

Yes. The analyses presented are all available in public documents or EN records.

## 5. SUMMARY OF RESULTS

As summarized in Table 7, the six questions for evaluating the WNP-1/4 and Columbia original analyses and Columbia post-Fukushima reevaluation have all been answered as "yes" or a basis for applying the historical seismic reevaluation analysis has been provided in discussions above.

**Table 7**: Summary of responses to evaluation questions for Project Site

| Evaluation | Seismic | Geotechnical |
|---|---|---|
| **Same Regulations?** | No but justified | No but justified |
| **Same Methods?** | No but justified | No but justified |
| **Same Scope of Analysis?** | No but justified | No but justified |
| **Site Consistent?** | Yes | Yes |
| **App B Program?** | No but justified | Yes |
| **Copy of Record?** | Yes | Yes |

# 6. CONCLUSIONS

ENNN concludes that the historical analyses (i.e., the GMRS and other evaluations such as surface deformation, soil stability, liquefaction, foundation design, and stability of slopes) performed during the original licensing phase for Columbia and WNP-1/4 and the post-Fukushima reevaluations for Columbia are applicable to Cascade for evaluating the seismic hazard. Specific justification for using historical analyses will be documented in the Cascade PSAR.

Five actions are planned to confirm the historical analyses being applied to Cascade. These actions will be performed under 10 CFR 50 Appendix B quality programs.

1. Since the information in the Wood, 2019b, report was not collected specifically within the Project Site footprint and due to some variation in Vs data, ENNN plans to perform non-invasive MAM/MASW testing to obtain additional Vs profiles specifically for the proposed Project Site.

2. Sensitivity studies will be performed to assess the impact of the following items on the PSHA (PNNL, 2014) and Wood GMRS curve (Wood, 2019b), as applicable, with results discussed in the PSAR:

    a. Published and ongoing research since the publication of the SSHAC Level 3 (PNNL, 2014) that could affect the seismic evaluations, including examination of the Cascadia subduction zone.

    b. The selection of a corrected control point elevation per RG 1.208.

    c. Inclusion of updated assessments and approaches in RIL 2021-15 that may affect high-frequency motions.

    d. Incorporation of the new MAM/MASW results.

3. The CPA will include FIRS in accordance with DANU-ISG-2022-02.

4. ENNN intends to develop a GMRS under an Appendix B program that is suitable for preliminary design. The GMRS will include any significant updates, including minimum epistemic uncertainty.

5. Borings and other geotechnical investigations specifically for Cascade that are not included in TM-2143 (EN, 2005) are planned per NRC and industry guidance and will provide site-specific geotechnical analyses for project design and construction. Pertinent results will be reported in the OLA.

## 7. REFERENCES

**Abrahamson, N., and Gülerce, Z., 2020, "**Regionalized Ground-Motion Models for Subduction Earthquakes Based on the NGA-SUB Database," PEER Report No. 2020-25, Pacific Earthquake Engineering Research Center, December 2020.

**Energy Northwest (EN), 2005.** "Geology, Seismology, and Geotechnical Engineering Report," TM-2143, Revision 0, November 2005.

**EN, 2015.** "Columbia Generating Station, Docket No. 50-397 Seismic Hazard and Screening Report, Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident." GO2-15-045, 12 March 2015, ML15078A243.

**EN, 2019.** "Columbia Generating Station Docket No. 50-397 Seismic Probabilistic Risk Assessment Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-Ichi Accident (MF3726, MF3727)", GO2-10-136, 26 September 2019, ML19273A907.

**Energy Northwest New Nuclear (ENNN), 2025.** "Methodology for Determining the Acceptability of Historical Information," White Paper, XO1-25-009, July 2025, ML25183A400.

**Electric Power Research Institute (EPRI), 2012.** "Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," EPRI 1025287, November 2012, ML12333A170.

**Jensen Hughes, 2019a,** "Risk Management Finding Level F&O Independent Assessment & Focused-Scope Peer Review, Columbia Generating Station," 026022-RPT-01 Revision 0, 27 August 2019.

**Jensen Hughes 2019b,** "PRA Finding Level F&O Independent Assessment & Focused-Scope Peer Review Addendum 1, Columbia Generating Station," 026022-RPT-01 Addendum 1 Revision 0, 13 November 2019.

**Kuehn, N. et al., 2020, "**Partially Non-Ergodic Ground-Motion Model for Subduction Regions Using the NGA-Subduction Database," PEER Report No. 2020-04, Pacific Earthquake Engineering Research Center, September 2020.

**NRC, 1975.** "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," NUREG-0800 Chapter 2, "Site Characteristics and Site Parameters," Mar 2007.

**NRC, 1997.** "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR-6372, Volume 1, April 1997, ML080090003.

**NRC, 2007.** "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," Regulatory Guide 1.208, Revision 0, March 2007, ML070310619.

**NRC, 2012a**. "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated 12 March 2012, ML12056A046 (Pkg.), ML12053A340 (Ltr.).

**NRC, 2012b,** "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," NUREG-2117, Revision 1, dated April 2012, ML12118A445.

**NRC, 2013**. Endorsement of Electric Power Research Institute Final Draft Report 1025287, "Seismic Evaluation Guidance," 15 February 2013, ML12319A074.

**NRC, 2014,** "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants," Regulatory Guide 1.138, Revision 3, December 2014, ML14289A600.

**NRC, 2016**. "Columbia Generating Station - Staff Assessment of Information Provided Under Title 10 of the Code of Federal Regulations Part 50, Section 50.54(F), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident (CAC NO. MF5274)," 4 November 2016, ML16285A410.

**NRC, 2020a.** "Columbia Generating Station – Staff Review of Seismic Probabilistic Risk Assessment Associated with Reevaluated Seismic Hazard Implementation of the Near-Term Task Force Recommendation 2.1: Seismic (EPID NO. L-2019-JLD-0009)," 28 April 2020, ML20076A547.

**NRC, 2020b.** "Columbia Generating Station – Documentation of the Completion of Required Actions Taken in Response to the Lessons Learned from the Fukushima Dai-Ichi Accident," 25 November 2020, ML20324A618.

**NRC, 2020c.** "Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities," Regulatory Guide 1.200, December 2020, Revision 3, ML20238B871.

**NRC, 2021,** "Geologic and Geotechnical Site Characterization Investigations for Nuclear Power Plants," Regulatory Guide 1.132, December 2021, Revision 3, ML21298A054.

**NRC, 2024,** "Advanced Reactor Content of Application Project, Chapter 2, Site Information," Interim Staff Guidance," DANU-ISG-2022-02, March 2024, ML23277A140.

**Parker, G., et al., 2020, "**NGA-Subduction Global Ground-Motion Models with Regional Adjustment Factors," PEER Report No. 2020-03, Pacific Earthquake Engineering Research Center, August 2020.

**Pacific Northwest National Laboratory (PNNL), 2014.** "Hanford Sitewide Probabilistic Seismic Hazard Analysis," PNNL-23361. Pacific Northwest National Laboratory. November 2014.

**Rodriguez-Marek,** A, E Rathje, J Ake, C Munson, S Stovall, T Weaver, K Ulmer, and M Juckett, **(2021),** "Documentation Report for SSHAC level 2: Site Response," Research Information Letter RIL 2021-15, U.S. Nuclear Regulatory Commission, ML21323A056.

**Washington Public Power Supply System** (**WPPSS, 1986**), Nuclear Projects Nos. 1 & 4 Final Safety Analysis Report. Amendment 5, May 1986.

**Wood Environment & Infrastructure Solutions, Inc.** (**Wood**), **2019a,** "Seismic Hazard Analysis for Columbia Generating Station," Revision 0, May 2019.

**Wood**, **2019b,** “Seismic Hazard Analysis for Columbia Generating Station,” Revision 1, October 2019.

**X-energy, 2023.** “Xe-100 Licensing Topical Report Principal Design Criteria,” 004799-A, Revision 3, 12 Aug 2023, ML24319A155.

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## Certificate Of Completion

| | | |
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| Envelope Id: DA7495C9-3E93-45B4-8B2F-AD4A9AFE18E6 | | Status: Completed |
| Subject: ACTION: Docusign: XO1-26-001 Geotechnical Letter and White Paper.pdf | | |
| Source Envelope: | | |
| Document Pages: 36 | Signatures: 4 | Envelope Originator: |
| Certificate Pages: 5 | Initials: 0 | Angela Homuth |
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## Record Tracking

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| Status: Original<br>1/12/2026 1:46:29 PM | Holder: Angela Homuth<br>amhomuth@energy-northwest.com | Location: DocuSign |
| Security Appliance Status: Connected | Pool: FedRamp | |
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| Signer Events | Signature | Timestamp |
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| Stephan C Moen<br>scmoen@energy-northwest.com<br>Licensing Engineer<br>Security Level: Email, Account Authentication (Optional) | Signed by:<br>Stephan C Moen<br>3E36B180D5B34C3...<br><br>Signature Adoption: Pre-selected Style<br>Using IP Address: 66.119.205.190 | Sent: 1/12/2026 1:50:52 PM<br>Viewed: 1/12/2026 1:51:59 PM<br>Signed: 1/12/2026 1:54:12 PM |
| **Electronic Record and Signature Disclosure:**<br>Accepted: 1/12/2026 1:51:59 PM<br>ID: bb3bc859-46ff-41d9-8bfd-038b55b8059f<br>Company Name: Energy Northwest | | |
| Nathan Clark<br>ndclark@energy-northwest.com<br>Security Level: Email, Account Authentication (Optional) | Signed by:<br>Nathan Clark<br>AAFBBC92031B450...<br><br>Signature Adoption: Pre-selected Style<br>Using IP Address: 66.119.205.190 | Sent: 1/12/2026 1:54:13 PM<br>Viewed: 1/12/2026 1:55:08 PM<br>Signed: 1/12/2026 2:09:32 PM |
| **Electronic Record and Signature Disclosure:**<br>Accepted: 1/12/2026 1:55:08 PM<br>ID: b96df2d7-1d74-4ccd-899e-c01bb10c8b08<br>Company Name: Energy Northwest | | |
| Lisa Williams<br>llwilliams@energy-northwest.com<br>Manager - Operations, Licensing & Environmental<br>Security Level: Email, Account Authentication (Optional), Logged in | Signed by:<br>Lisa Williams<br>D582EC1FE95E4D8...<br><br>Signature Adoption: Pre-selected Style<br>Using IP Address: 104.36.233.20 | Sent: 1/12/2026 2:09:33 PM<br>Viewed: 1/12/2026 9:00:37 PM<br>Signed: 1/12/2026 9:04:07 PM |
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