Evaluation of Energy Northwest Response (letter dated 17 September 2010) to Nuclear Regulatory Commission Request 3a (letter dated 13 July 2010) for Additional Information on Seismic Hazards for the Review of the Columbia Generating Station License Renewal Application

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Introduction

The Nuclear Regulatory Commission (NRC) in their letter dated 13 July 2010 to Energy Northwest requested that Energy Northwest provide a review of the impact of recent U.S. Department of Energy seismic hazards work at the Hanford Site (i.e., Waste Treatment Plant; Rohay and Reidel, 2005; Rohay and Brouns, 2007; Youngs, 2007) on the existing seismic hazards assessment for the Columbia Generating Station (CGS) and justify its use with regards to Level 1 Probabilistic Safety Assessment (PSA) used for the Severe Accident Mitigation Alternatives (SAMA) analysis. Energy Northwest responded to this NRC request on pages 39 to 42 in a letter dated 17 September 2010 which is reproduced in Attachment A. Energy Northwest's response essentially stated that the newer seismic hazards investigations for the Hanford Site verified that the existing seismic hazard analysis for the CGS (WPPSS, 1981; Geomatrix, 1996) provides an adequate seismic input to PSA models to effectively identify all relevant SAMA candidates.

Evaluation of Energy Northwest Response to the NRC

Energy Northwest's response to the NRC can be basically broken down into 3 sections, delineated in Attachment A with red numbers, that each deal with aspects of the seismic hazard analysis for the CGS. Numbers 1 through 3 also indicate what we believe to be the relative order of importance of each item in the Energy Northwest's response and is discussed in the following sections.

Item 1: Failure to Reexamine Other Fundamental Components of Seismic Hazards Analysis

On pages 41-42 of Energy Northwest's response to the NRC (Attachment A), it is stated that other fundamental aspects of a seismic hazard assessment (e.g., location of faults, active fault lengths, fault models, earthquake frequencies/magnitudes, attenuation relationships, etc.) were not reexamined in the U.S. Department of Energy studies for the Waste Treatment Plant site nor by Energy Northwest. Selection of these parameters and the relative values assigned to these basic components are critical in developing a seismic hazards model and computing the peak ground acceleration at the CGS site. Not reexamining these fundamental aspects was a significant failure on Energy Northwest's part since geologic investigations and data collected by the U.S. Geological Survey (first published in 2009) indicates that many of the basic geologic assumptions and earthquake models used in the Energy Northwest's seismic hazards analysis for the CGS (WPPSS, 1981, Geomatrix, 1996) are incorrect and flawed.

For example, there were two tectonic or regional fault models for the Yakima Fold Belt considered by Geomatrix (1996) in their seismic hazards analysis. The first model assumes the major mapped faults along the Yakima folds are continuous downward through the Columbia

River basalt and pre-basalt basement rock and transect the entire seismogenic crust (termed "coupled fault model"). The second model interprets the major mapped faults along the Yakima folds as being localized within, and terminating at the base of, the Columbia River basalt portion of the crust and are not connected to faults within the pre-basalt basement crust (termed "uncoupled fault model"). As noted by Geomatrix (1996, Section 5.2.2), the seismic ground motion analysis they computed was very sensitive to uncoupled versus coupled model selection. The uncoupled fault model predicted more earthquakes in the M5 to M6 range (and attendant peak ground accelerations) whereas the coupled fault model predicted more earthquakes in the M6 to M7+ range with correspondingly greater peak ground accelerations. Based on the available geologic data Geomatrix (1996, p. 3-15) concluded that the major faults along the Umtanum Ridge-Gable Mountain and Yakima Ridge folds (faults closest to the CGS site) had a very high probability (0.85) of being "uncoupled".

By 2009 additional data from deep hydrocarbon exploratory wells and geophysical surveys provided compelling evidence that the major faults along the Yakima folds were "coupled" (Reidel and Tolan, 2009; Blakely et al., 2009; Tolan et al., 2009). Figure 1 presents a U.S. Geological Survey developed crustal model cross-section across the Umtanum Ridge structure depicting the "coupled" nature of the major faults.

Work by the U.S. Geological Survey (Blakely et al., 2009, 2011) on the Umtanum Ridge-Gable Mountain fault has also extended this feature west across the Cascade Range and has connected it with seismically active faults in the Puget Lowland (Figure 2). As Blakely et al. (2011, p.31) stated "*Generally speaking, long faults are potentially more dangerous than short faults (Wells and Coppersmith, 1994), and the throughgoing faults proposed here would pose significantly increased seismic hazards if they should prove to be active along their entire lengths*". Blakely et al. (2009, 2011) work has also found several locations of previously unknown late Quaternary/Holocene (250,000 years ago to present day) movement on, and associated with, the Umtanum Ridge fault (Figure 2). This data suggests that the Umtanum Ridge-Gable Mountain fault may be far more "active" along its length than previously believed (WPPSS, 1981; Geomatrix, 1996).

Geophysical surveys conducted by the U.S. Geological Survey (Blakely et al., 2009, 2011; Wicks et al., 2009) indicates that Umtanum, Ridge-Gable Mountain and Yakima Ridge anticlinal folds/faults (Figure 2) both extend farther east than previously believed by Geomatrix, 1996). The eastward extension of the Yakima Ridge fault across the Hanford Site also goes through the location of the Wooded Island earthquake swarm (Figure 2). They interpret the Wooded Island earthquake swarms to be related to reactivated faults on the Yakima Ridge extension. The eastward extension of the Umtanum Ridge-Gable Mountain and Yakima Ridge faults place "active" faults approximately 6.5 miles north of, and 2.3 miles south of, the CGS site, respectively.

Since both the U.S. Department of Energy's (Reidel, 2005; Youngs, 2007) and Energy Northwest's seismic hazard analyses rely on the flawed and outmoded seismic assessment model developed by Geomatrix (1996), one needs to question the basic adequacy of the existing CGS seismic hazards analysis in light of the recent data and finding presented by the U.S. Geological Survey.

Item 2: Agreement between Updated U.S. Geological Survey Seismic Peak Ground Acceleration Data and CGS Seismic Model Data

On page 41 of Energy Northwest's response to the NRC they point out that the U.S. Geologic Survey has recently completed an update of seismic ground motion maps for the United States (Petersen et al., 2008) and that the U.S. Geological Survey maps provided an "independent validation" of the Geomatrix (1996) peak ground acceleration (PGA) results for the CGS site. In performing their update Petersen et al. (2008) incorporated data from existing seismic hazards assessments which included data and analysis presented in Geomatrix (1996) for the Hanford Site. Petersen et al. (2008) employed the similar methodology as Geomatrix (1996), but on a much larger scale. Given the commonality of the basic data and analytical methodology, it would be surprising if Petersen et al. (2008) results were not essentially the same as that of Geomatrix (1996).

Note that none of the recent U.S. Geological Survey data and information discussed above in Item 1 was factored into the updated U.S. Geological Survey seismic hazard maps of Petersen et al. (2008). In fact the U.S. Geological Survey in a recently published paper (Blakely et al., 2011) suggests that earthquake hazards in eastern Washington (which includes the CGS site) be re-examined and re-assessed based on all of the new data and information which has fundamentally revised our understanding of the Yakima fold faults and associated earthquakes.

Item 3: CGS Site Geology Differences and Seismic Model Comparisons

Item 3 covers the bulk of Energy Northwest's response to the NRC request and presents a discussion of the relative subsurface geologic differences between the U.S. Department of Energy's Waste Treatment Plant site and the impact of the new subsurface velocity profiles data from beneath the Waste Treatment Plant site (Figure 3) might have on the seismic hazards model for the CGS site. As noted in Item 1, both the U.S. Department of Energy's (Reidel, 2005; Youngs, 2007) and Energy Northwest's seismic hazard analyses rely on the flawed and outmoded seismic model developed by Geomatrix (1996). It begs the question as to the fundamental adequacy of the existing CGS seismic hazards model and raises the important question as to why Energy Northwest has not undertaken the effort to develop a revised seismic hazards model in light of the data and finding presented by the U.S. Geological Survey (Blakely et al., 2009, 2011)? A revised basic seismic model is needed before the subsurface velocity data collected by both the U.S. Department of Energy (Rohay and Reidel, 2005; Youngs, 2007; Figure 3) and Energy Northwest (Geomatrix, 1996: Figure 4) can be properly utilized in determining peak ground accelerations for these sites. However despite these overarching concerns, we do have several specific comments that are presented in the following paragraphs.

On page 39, Energy Northwest indicates that one of the "distinct differences" between the CGS and Waste Treatment Plant sites is that the CGS site is farther away from nearby seismic sources. This is no longer a true statement based on work by the U.S. Geological Survey discussed in Item 1. Geophysical surveys conducted by the U.S. Geological Survey (Blakely et al., 2009, 2011; Wicks et al., 2009) indicates that Umtanum, Ridge-Gable Mountain and Yakima Ridge anticlinal folds/faults (Figure 2) both extend farther east than previously believed (Geomatrix, 1996). The eastward extension of the Yakima Ridge fault across the Hanford Site also goes through the location of the Wooded Island earthquake swarm (Figure 2). They interpret the Wooded Island earthquake swarms to be related to reactivated faults on the Yakima Ridge extension. The eastward extension of the Yakima Ridge fault place "active" faults approximately 2.3 miles south of the CGS site.

Energy Northwest was correct in pointing out that the "soil structure", consisting of Hanford Formation, Cold Creek unit, and Ringold Formation sedimentary units that overlie the Columbia River basalt, at the CGS is different than found beneath the Waste Treatment Plant site. Table 1 presents a brief description and thickness comparison of these sedimentary units between the CGS and Waste Treatment Plant sites. At the Waste Treatment Plant site the geologically recent, non-indurated sands and gravels of the Hanford Formation comprises most of the "soil" section whereas at the CGS site the geologically older, indurated sediments of the Ringold Formation comprise the bulk of the section. At the CGS site the foundations for the reactor were excavated and set into the Ringold Formation and not the overlying Hanford Formation (WPPSS, 1981). The physical characteristics and thickness of these sedimentary units are important as they can significantly affect resultant vibratory ground motion (amplification or de-amplification) relative to the underlying Columbia River basalt.

Table 1. Brief descriptions and estimated thicknesses of the suprabasalt sedimentary units that comprise the "soil structure" beneath the Columbia Generating Station (CGS) and Waste Treatment Plant (WTP) sites. From WPPSS (1981) and Rohay and Reidel (2005).

UNIT NAME	WTP	CGS
Hanford Formation (non-indurated sands and gravels deposited by the cataclysmic Missoula Floods approx. 13,000 to more than 1 million years ago)	250 ft-thick	65 ft-thick
Cold Creek unit (non-indurated to poorly indurated sands and gravels eroded from the underlying Ringold Formation and deposited by the Columbia River between approx. 2.5 to 3.4 million years ago)	65 ft-thick	0 ft-thick
Ringold Formation (poor to well indurated sands, gravels, and silt/clay deposited by the Columbia River between 3.4 to 10.5 million years ago)	65 ft-thick	415 ft-thick

Figures 3 presents shear wave velocity profiles for the sedimentary units and Columbia River basalt/Ellensburg Formation interbeds beneath the Waste Treatment Plant site (Youngs, 2007). Note that measured shear wave velocities in the non-indurated Hanford Formation are much lower than that for the indurated Ringold Formation which in turn appears to be more akin to the Columbia River basalt flows (Figure 3B). Note the significant difference in the vertical shear wave velocity profiles (through the Hanford and Ringold Formations) at the CGS site (Figure 4) in comparison to that for the Waste Treatment Plant site (Figure 3).

Energy Northwest's response (p. 40-41) cited the revised Waste Treatment Plant site ground motion models based on the vertical shear wave profiles (Figure 3; Rohay and Reidel, 2007; Youngs, 2007) as being similar to ground motion results obtained from the seismic hazards model used by CGS (Geomatrix, 1996). As noted by WPPSS (1981), Geomatrix (1996), Rohay and Reidel (2005), and Youngs (2007), site-specific models for seismic ground motion need to be developed and used. For the CGS site this would require Energy Northwest to integrate the Waste Treatment Plant shear wave velocity data for the Columbia River basalt/Ellensburg Formation interbeds (Figure 3B) with the Ringold Formation shear wave velocity profile (Figure 4). This re-assessment has not been done for the CGS site.

However such a re-assessment would be of questionable value if it relied solely on the existing flawed seismic model developed by Geomatrix (1996) for the CGS site discussed in Item 1 above. A new seismic model for the CGS site would have to be developed (incorporating a "coupled" fault model, extended active fault lengths, reevaluation of earthquake magnitude/frequency, etc.) before the CGS site-specific subsurface velocity data could be used to help constrain estimates of vibratory ground motion from various earthquake scenarios.

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