Washington PSR

OREGON PSR PHYSICIANS FOR SOCIAL RESPONSIBILITY

Oregon & Washington Physicians for Social Responsibility
812 SW Washington Street, Suite 1050
Portland, OR 97205
(503) 274-2720
www.oregonpsr.org, www.wpsr.org
washpsr@gmail.com

October 31, 2013

Dr. Allison M. Macfarlane
Chairwoman
Nuclear Regulatory Commission
Commission Mail Stop O-16G4
Washington, DC 20555-0001

Dear Dr. Macfarlane,

Re: New Information regarding Seismic Hazards at the WPPSS-2/Columbia Generating Station nuclear power plant

Thank you for your reply, dated September 26, 2013, to our letter of July 19, 2013. It was gratifying to hear that you would consider accepting our invitation to visit with us and hear our concerns in person, should your travel and schedule permit. Nevertheless, it was disturbing that you did not address any of the concerns we raised with our letter.

Instead, you informed us that "[t]he NRC continues to conclude that CGS has been designed, built, and operated to safely withstand earthquakes likely to occur in its region."

We need to know what data you are using as the basis for your conclusion and are concerned this might presuppose a conclusion before Energy Northwest has reported back on its required seismic reevaluation. We are also having trouble understanding why this crucial seismic reevaluation is not due from Energy Northwest until March 12, 2015 – four years and one day after the Fukushima accident began in Japan. From what we can gather from your letter, the NRC, under your leadership, has no intention of independently evaluating readily available geological evidence about the increased seismic potential of the CGS-Hanford site until after receiving Energy Northwest's report. This does not seem in keeping with your duty as the chairwoman of the body

charged with regulating this nuclear power plant, particularly in face of a great deal of evidence that the plant may not be able to withstand a worst case earthquake.

You assert that "[t]o the extent that your letter provides new and significant information, the NRC will ensure CGS takes such information into account as the licensee reevaluates its seismic hazard." We assume this means that we will not see to what extent Energy Northwest takes new seismic information seriously until after March 12, 2015, which, again, we find to be an unacceptable long period of time to wait for such an important report.

As we stated in our original letter to you and have further documented since, your promised reevaluation of seismic hazard at the site, not due to begin for another year and half when Energy Northwest submits its report, is already several years behind the US Department of Energy's more current evaluation and decades behind the massive amount of new geological discoveries made since the original design criteria for the CGS was determined.

In the thirty years since the plant was licensed there have been numerous geologic investigations of the Hanford Reservation and surrounding region conducted by the U.S. Geological Survey, federal contractors, Battelle Pacific Northwest National Laboratory, the State of Washington, and several universities. The outcomes of these studies have piled up the geologic evidence that indicates the original WPPSS-2/Columbia Generating Station (CGS) nuclear plant's seismic risk assessment significantly underestimated the potential risks to the reactor and associated structures. We now know that the original design basis for earthquake hazard at the CGS site is critically out of date.

Among the evidence so far not considered by the NRC regulators, to our knowledge, and therefore "new" information, is the following:

1. Erroneous placement of the largest historical earthquake

The original CGS seismic risk analysis in 1981 relied on the erroneous conclusion that the largest historical earthquake to hit this region - the M6.5-M7.4 "1872 Earthquake" - was 180 miles away from the CGS. Based on this misinformation, the design criteria for the CGS were established using the M5.7, 1936 Milton-Freewater earthquake south of Walla Walla, Washington. Based on this and other information, it was determined that there was a low annual probability of exceedence (0.00011) of a 0.25 g vibratory ground motion threshold of the Safe Shutdown Earthquake for the CGS. It was licensed on that basis and this assessment has not been changed since. However, Bakun et al. (2002) determined that the "1872 Earthquake" actually had occurred 99 miles from the CGS site. The NRC should have reviewed the CGS design criteria then, but did not.

2. Number of known faults doubled from 6 to 12

The original CGS seismic design criteria was based on the six identified Yakima Fold and Thrust Belt structures:

1. Umtanum Ridge-Gable Mountain
2. Rattlesnake Ridge-Wallula Alignment
3. Horse Heaven Hills
4. Rattlesnake Hills
5. Yakima Ridge
6. Saddle Mountains

But, since CGS was constructed, six additional Yakima Fold and Thrust Belt structures were identified that could pose an earthquake risk to the CGS site:

1. Frenchman Hills
2. Manastash Ridge
3. Toppenish Ridge
4. Columbia Hills
5. Hog Ranch-Naneum Ridge
6. Hite Fault

3. Ground motion studies at Hanford Waste Treatment Plant show potential for 0.80 g vibratory ground motion (over 300% more than CGS estimate)

Subsequent seismic risk assessments performed for the U.S. Department of Energy for the Hanford Site, which factored in newly available structural geology data, generated estimates of peak vibratory ground motions that were significantly higher than those used to establish the CGS nuclear plant's license in 1981. The Geomatrix (1996) study estimated peak vibratory ground motion of 0.50 g on the Hanford site ten miles from the CGS nuclear plant. This was double that of the estimate in the CGS nuclear plant license. In 2005 new questions regarding information about earthquake hazards developed since the Geomatrix (1996) report forced the U.S. Department of Energy to suspend work on their Waste Treatment Plant (WTP) facility to allow for new data collection and updated seismic risk assessment.

Three studies (Youngs, 2007; Rohay and Brouns, 2007; Rohay and Reidel, 2005) determined that the previous vibratory ground motion estimate needed to be increased to 0.80 g, causing the US Department of Energy to order significant modification to the WTP facility. This was 300 % higher_than what the CGS was designed to meet. Given that this finding was for a facility only ten miles away from the CGS site, the NRC should have closed the CGS down at that time, pending a determination as to whether it, too, would need to have seismic upgrades to allow the nuclear reactor to meet the new seismic findings.

4. Uncoupled model incorrect – coupled model gives PGA >0.90 g

As noted by Geomatrix (1996), the seismic ground motion analysis they computed was very sensitive to uncoupled fault model versus coupled model selection. The uncoupled fault model predicted more earthquakes in the M5 to M6 range (and attendant peak ground accelerations to a maximum of 0.20 g) whereas the coupled fault model predicted more earthquakes in the M6 to M7+ range (with correspondingly greater peak ground accelerations to a maximum of over 0.90 g). Based on the available geologic data at that time, Geomatrix (1996) 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." But 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). Thus the Geomatrix (1996) data was based on an incorrect tectonic fault model and vastly underestimated the seismic risk at the CGS site.

5. Faults now known to be longer and capable of producing larger magnitude earthquakes

More detailed mapping of folds and faults in the region surrounding the CGS nuclear plant site since 1981 have shown that the folds and faults considered in the original seismic risk assessment have significantly longer lengths than originally thought. Work by the U.S. Geological Survey (Blakely et al., 2009, 2011) on the Umtanum Ridge-Gable Mountain fault will likely fundamentally change several key assumptions upon which past seismic risk assessments were based. The U.S. Geological Survey found that the maximum length of some of the Yakima Fold and Thrust Belt structures has been previously underestimated. The U.S. Geological Survey extended the Umtanum Ridge-Gable Mountain fault west across the Cascade Range and connected it with seismically active faults in the Puget Lowland. The Umtanum Ridge structure, which is located approximately 6.5 north of the CGS site, was increased from 77 miles to more than 124 miles in length, greatly increasing the known potential for larger magnitude earthquakes.

6. Faults now known to be "younger" indicate more recent earthquakes

There is evidence that the faults are geologically "young," indicating relatively recent earthquakes. Blakely et al. (2009, 2011) 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. This data suggests that the Umtanum Ridge-Gable Mountain fault may be far more "active" along its length than previously believed.

This, coupled with the increase in the mapped length of this fault, has led Blakely et al. (2011) to suggest that this fault is capable of much larger magnitude and potentially more frequent large magnitude earthquakes than assumed in previous seismic hazard assessments.

7. Distance of active fault to CGS found to be within 2.3 miles of the reactor

In 1981 it was determined that no capable faults existed within a 5 mile radius of the CGS. 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 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, which began in January 2009. They interpret the Wooded Island earthquake swarm quakes 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.

8. Thin-skin model found inaccurate/thick skin model indicates larger area and potential for larger magnitude earthquake

Based on surface and subsurface geologic data and geophysical survey data, Blakely et al. (2011) analysis of the Umtanum Ridge fault shows that it is not just confined to the Columbia River basalt layer (which was defined as a "thin-skin fault model"). Their analysis interprets that this fault extends through the Columbia River basalt layer and continues downward into the "basement rock" ("thick-skin fault model"). Because this fault extends into the basement rock this means that the potential earthquake rupture area along this fault is far greater than previously expected and consequently can produce much larger magnitude earthquakes than previously assumed.

9. Newly found surface faulting

In the original design of the CGS, it was determined that surface faulting was not a factor. Blakely et al. (2011) trenching of surface scarps along Umtanum Ridge found evidence of geologically recent faulting indicating that this structural feature may be more seismically active than previously believed. This new information will be factored into the new probabilistic seismic hazards analysis being conducted by the US Department of Energy for the Hanford site, scheduled to be completed in 2014.

10. Faulty analysis in Energy Northwest 2010 reply letter to NRC

A July 2010 letter to Energy Northwest (ENW), the operator of the CGS nuclear plant, from the Nuclear Regulatory Commission, requested that ENW provide a review of the impact of recent U.S. Department of Energy seismic hazards work at the Hanford site for the Waste Treatment Plant in 2005 and 2007. We are concerned that the NRC is relying on the September 17, 2010 letter of reply from Energy Northwest to inform your present belief "that CGS has been designed, built, and operated to safely withstand earthquakes likely to occur in its region." If this is the case, then we urge you to carefully read the analysis of the ENW response in the Report #2 attached.

In their September 17, 2010 response, Energy Northwest confirmed their knowledge 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."

Report #2 notes that the "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 notable 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.

Energy Northwest also indicated in their response 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. [[

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Energy Northwest was correct in pointing out the "soil structure" is different below the Waste Treatment Plant than below CGS, however this means nothing unless the correct "coupled model" is used in the analysis of the soil structure. Energy Northwest also stated that the shear wave velocity profiles are different between the WTP and the CGS. But Energy Northwest has not integrated the Waste Treatment Plant shear wave velocity data with the Ringold Formation into which CGS is built. Even if they were to do this, the re-assessment would be of questionable value if it were based on the existing flawed model for the CGS site. 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.

In conclusion, 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 new and recent data and findings presented by the U.S. Geological Survey.

None of this new information has been addressed by Energy Northwest to our knowledge, and yet the Nuclear Regulatory Commission allows them to continue to operate the Columbia nuclear plant at full power under the clearly inadequate original licensed earthquake standards.

11. Plant not meeting current, inadequate seismic standards

The new earthquake data available on the Hanford Nuclear Reservation was not considered during the May 2012 relicensing of the Columbia nuclear plant by the Nuclear Regulatory Commission because it was said to be part of the "ongoing regulatory oversight." Just prior to and after approving the relicensing of the CGS nuclear power plant until 2043 without reviewing its inadequate earthquake standards, this NRC oversight seems to have consisted of two inspections.

In response to post-Fukushima requirements established by the NRC, on April 29, 2011, Energy Northwest carried out an inspection of the CGS. The inspection determined that the nuclear plant does not even meet the inadequate and unchanged original seismic standard. The 2011 Inspection Report stated that, "the licensee determined that the Emergency Response Facilities, the Tower Makeup system, the fire protection systems, floor drain isolation valves and sump level switches (used to mitigate internal flooding) were not seismically qualified." To date we have nothing in writing to show that these problems have been addressed and that they meet even the original seismic standards.

Then, on November 30, 2012 , a series of seismic walkdowns of the CGS was completed. The Walkdown Report specifically says that it is based on the 0.25 g maximum ground motion criteria from its 1983 license. 135 seismic walkdowns were planned, of which 120 seismic walkdowns were performed in time for the report. These resulted in 35 "potentially adverse seismic conditions" identified. A separate series of area walk-bys consisted of 55 unique areas that were examined, and resulted in the identification of 74 "potentially adverse seismic conditions."

15 walkdowns were deferred until the refueling outage in May 2013. As of October 2013, the results of these 15 walkdowns have not been made public. Even without that information, a finding of at least 109 potentially adverse seismic conditions - 35 from the walkdowns and 74 from the walk bys - that don't meet the original inadequate seismic criteria is of concern considering that the plant should be able to withstand ground motion forces that could be more than three times as strong as it was originally designed for.

All of this evidence leads us to urge you to fulfill your mandate as nuclear regulators and put the safety of the public in the Pacific Northwest above the utility's interests to

continue operating. We urge you to shut down the CGS nuclear power plant immediately until it can be shown that it meets adequate earthquake standards.

A Report by the Japanese Diet's Fukushima Nuclear Accident Independent Investigation Commission called their nuclear crisis a "profoundly man-made disaster that could and should have been foreseen and prevented." May we never have to say this about the NRC's lack of oversight at the CGS nuclear power plant. As you know, earthquakes are unpredictable and unforgiving – and are not respecters of person or politics.

Please read the enclosed reports we have commissioned to summarize current geological knowledge. When you do, I know you will want to lead the NRC in doing the right thing and closing this reactor until it can be properly shown that it can be safely operated in this seismically active area.

Sincerely,

John Pearson, MD
Oregon Physicians for Social Responsibility

Steven G. Gilbert, PhD, DABT
Washington Physicians for Social Responsibility

EARTHQUAKE RISK FACTORS AT THE COLUMBIA GENERATING STATION (formerly known as WPPSS WNP-2)

ORIGINAL EARTHQUAKE HAZARDS/RISK ASSESSMENT

The original earthquake risk assessment for the Columbia Generating Station (then known as "Washington Nuclear Power unit number 2" or "WNP-2") was done more than 30 years ago over a period from about 1974 to 1981. The primary goal of this work was to develop a quantitative estimate of the maximum vibratory ground motion expected at this site from the maximum credible earthquake. This estimate of maximum vibratory ground motion would be used to design the Columbia Generating Station.

Their analysis of historical "felt" and instrumentally recorded earthquakes for the Columbia Generating Station (CGS) was used to determine magnitude and location of the largest historical earthquakes to hit this region. From historical accounts the December 14, 1872 earthquake was the largest earthquake to occur in the Pacific Northwest. Few seismographs existed in the Pacific Northwest region to record the "1872 earthquake", but based on historical accounts of the earthquake duration and damage patterns, it has been estimated to have been a M 6.5 to 7.4 (WPPSS, 1981; Bakun et al., 2002). The exact location of the epicenter for the 1872 earthquake was unknown, but based on the 1981 Washington Public Power Supply System analysis (accepted by the Nuclear Regulatory Commission, 1982) it was assumed to be in the North Cascades likely at least 180 miles from the Columbia Generating Station (WPPSS,1981). Given the distance of the 1872 earthquake epicenter from the Columbia Generating Station, its potential importance to seismic risk was greatly reduced with respect to smaller magnitude earthquakes that had epicenters closer to the Columbia Generating Station.

The earthquake that was selected for the Columbia Generating Station design (would have created the maximum vibratory ground motion at the site) was the M5.7 to 6.1 July 16, 1936 Milton-Freewater earthquake. The epicenter for this earthquake was located approximately 55 miles southeast of the Hanford Site within the Walla Walla Valley, but no faults were known to exist at this location. The estimated maximum vibratory ground motion from the 1936 Milton-Freewater earthquake at the Columbia Generating Station site would have been **0.015 g** (WPPSS, 1981, p 2.5-139).

To capture the potential seismic risk from earthquakes on unknown faults, their assessment assumed that a 1936 Milton-Freewater earthquake might potentially occur anywhere within a 16 mile radius of the Columbia Generating Station site (WPPSS, 1981). A peak vibratory ground motion of **0.25 g** for Columbia Generating Station site was derived from their analysis and was assigned as the "Safe Shutdown Earthquake" to be consistent with "*conservatism previously adopted for design criteria at the Hanford Reservation*" (WPPSS, 1981, p 2.5-139). The peak vibratory ground motion of **0.125g** was assigned as the "Operating Basis Earthquake" which is one-half that of the Safe Shutdown Earthquake.

Mapping and analysis of geologic structures (faults and folds) was conducted and their potential to generate earthquakes was also assessed. Based on the state of geologic knowledge at that time, it was determined that no **capable faults**[1] existed within a 5 mile radius of the Columbia Generating Station (WPPSS, 1981) and "*... surface faulting is not a factor in the design of the plant.*"(WPPSS, 1981, p 2.5-143). Their seismic risk assessment also included a panel of experts who evaluated all known geologic structures (faults) that might potentially generate earthquakes which could impact the Columbia Generating Station. Based on their review, six Yakima Fold and Thrust Belt geologic structures were identified as potential seismic (earthquake) sources (WPPSS, 1981). These six Yakima Fold and Thrust Belt structures were (highlighted in brown on Figure 1) :

1. Umtanum Ridge-Gable Mountain
2. Rattlesnake Ridge-Wallula Alignment
3. Horse Heaven Hills
4. Rattlesnake Hills
5. Yakima Ridge
6. Saddle Mountains

Their evaluation of these six geologic structures concluded that potential earthquakes generated by these sources would most likely fall within a less than M4 to M6 range with a low likelihood of potentially larger magnitude earthquakes (M6 to greater than M7; WPPSS, 1981, Appendix 2.5K). Given the *apparent* low probabilities of earthquakes of significantly large magnitude (greater than M6), relative distance of the earthquake-source structures from the Columbia Generating Station (assumed attenuation of vibratory ground motions), and probable frequency of recurrence of earthquakes of various magnitudes on these geologic structures it was concluded that there was a very low annual probability of exceedance (0.00011) of the **0.25** g vibratory ground motion threshold of the Safe Shutdown Earthquake for the Columbia Generating Station.

[1] As defined by Nuclear Regulatory Commission (NRC) Regulations (10 CFR, Appendix A, Part 100, III (g) 1, 2, 3) "A ***capable fault*** is a fault which has exhibited one or more of the following characteristics: (1) Movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years; (2) Macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) A structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other. In some cases, the geologic evidence of past activity at or near the ground surface along a particular fault may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these cases, evidence may exist elsewhere along the fault from which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence shall be used in determining whether the fault is a capable fault within this definition. Notwithstanding the foregoing paragraphs III(g) (1), (2), and (3), structural association of a fault with geologic structural features which are geologically old (at least pre-Quaternary) such as many of those found in the Eastern Region of the United States shall, in the absence of conflicting evidence, demonstrate that the fault is not a capable fault within this definition."

THIRTY YEARS OF NEW GEOLOGIC KNOWLEDGE ON SEISMIC HAZARDS AND RISK

Since the Columbia Generating Station's seismic risk assessment was completed in 1981, numerous geologic investigations of the Hanford Reservation and surrounding region have been conducted by U.S. Geological Survey, Federal government contractors, Battelle Pacific Northwest National Laboratory, State of Washington, and Universities. The outcomes of these studies conducted over the past thirty years have piled up the geologic evidence that indicates the original Columbia Generating Station's seismic risk assessment significantly under estimated the potential risks to the reactor and associated structures. This evidence includes:

- More detailed geologic mapping of the folds and faults in the region surrounding the Columbia Generating Station site. This work has shown that the folds and faults considered in the seismic risk assessment by WPPSS (1981) have significantly longer lengths (highlighted in red in Figure 1) and evidence of geologically " young" (Quaternary age) displacement on associated faults (e.g., see USDOE, 1988; Kienle, 1980; Campbell, 1989; Campbell and Bentley, 1981; Campbell et al., 1995; Geomatrix, 1990, 1996; Reidel, 1984, 1988; Reidel and Fecht, 1994a,b; Mann and Meyers, 1993; Reidel et al., 1994; Caggiano and Duncan, 1983; Watters, 1989; Schuster et al., 1997; Stoffel et al., 1991; West et al. 1995, 1996; West and Shaffer, 1989; Wood-Clyde Consultants, 1989; Blakely et al., 2011). Geologically "young" faults are indicators of relatively recent "earthquakes". Longer fault lengths also indicate that these longer faults may be capable of producing much larger magnitude earthquakes.

- Additional Yakima Fold and Thrust Belt structures were identified that could potentially generate earthquakes that could pose a risk to the Hanford Site and the Columbia Generating Station facilities (USDOE, 1988; Geomatrix, 1990, 1996). These additional "faults" included (highlighted in purple and red on Figure 1):

    - Frenchman Hills
    - Manastash Ridge
    - Toppenish Ridge
    - Columbia Hills
    - Hog Ranch-Naneum Ridge
    - Hite Fault

- The potential significance and importance of the M6.5 to 7.4 "1872 Earthquake", the largest historical earthquake to hit this region, to seismic risk analysis at the Columbia Generating Station was greatly reduced because the assumed location of the epicenter for this event was more than 180 miles away (WPPSS, 1981). Investigation of the "1872 Earthquake" by Bakun et al. (2002) determined that the epicenter for this event was located too far north by WPPSS (1981) and that the likely epicenter location for this earthquake is at the southern end of Lake

Chelan just north of Entiat, Washington. The revised location for the epicenter of the "1872 Earthquake" places it approximately 99 miles from the Columbia Generating Station.

- Subsequent seismic risk assessments performed for the U.S. Department of Energy for the Hanford Site that factored in newly available structural geology data (e.g., Geomatrix, 1996) and generated estimates of peak vibratory ground motions were significantly higher than those used by WPPSS (1981) for the Columbia Generating Station site. The Geomatrix (1996) estimates of peak vibratory ground motion of 0.50 g was initially used in the design of the Waste Treatment Plant (WTP or "vit plant") facility which is located approximately 10 miles east of the Columbia Generating Station site. New information about earthquake hazards developed since the Geomatrix (1996) study forced the U.S. Department of Energy to suspend work on the WTP facility to allow for new data collection and an updated seismic hazard/risk assessment to be performed. The new WTP seismic assessment (Youngs, 2007; Rohay and Brouns, 2007; Rohay and Reidel, 2005) determined that the previous vibratory ground motion estimate of **0.50 g** needed to be increased to **0.80 g.** Based on this new seismic hazard/risk analysis the U.S. Department of Energy ordered significant modifications to be made to the WTP facility in 2007.

- In July 2010, a letter from the Nuclear Regulatory Commission to Energy Northwest (Letter dated July 13, 2010, NRC to W.S. Oxenford (Energy Northwest", Request for Additional Information for the Renewal Application – SAMA Review (ADAMS Accession No. ML 101760421) requested that Energy Northwest address the NRC concerns that the most recent seismic risk study for the Columbia Generating Station (from 15 years ago) had failed to address more recent geologic findings and increased seismic risk as determined for the WTP facility (Youngs, 2007). Energy Northwest responded to this issue in a September 2010 letter (Letter dated September 17, 2010, S.K. Gambhir (Energy Northwest) to U.S. Nuclear Energy Commission; p.39-42) and indicated that there were distinct geologic differences between the WTP Site and the Columbia Generating Station site that includes the Columbia Generating Station site's "increased distance from nearby seismic sources" and different subsurface geology conditions. The fact is that the WTP facility and the Columbia Generating Station sites are geographically and geologically linked and similar, being separated by only 10 miles, and yet no modifications have been made to the Columbia Generating Station to address the increased risk from strong seismic vibratory ground motion.

- In 2011 the U.S. Geological Survey published a paper that will likely fundamentally change several of the key assumptions that past seismic risk assessments were based upon. These "game changers" include:

    1. The maximum length of some of the Yakima fold and thrust belt structures have been previously under estimated. Generally longer faults are considered to be capable of generating larger earthquakes than shorter faults. Their

paper focused on Umtanum Ridge (Gable Mountain) which they were able to trace through the Cascade Range to where it merges with Quaternary ("active") faults (e.g., Southern Whidbey Island and Seattle faults) in the Puget Sound area. Based on their work the Umtanum Ridge structure increased from about 77 miles to more than 124 miles in length.

2. Their data indicated that the Umtanum Ridge fault is not just confined to the Columbia River basalt as assumed by some previous models ("thin-skin fault model), but extends below the Columbia River basalt into the "basement rock" (thick-skin fault model). This indicates that the Umtanum fault plane potential rupture area is far greater than expected and could produce larger magnitude earthquakes than previously assumed.

3. At several locations along the Umtanum Ridge trenching of surface scarps revealed evidence of geologically recent faulting indicating that this structural feature may be more seismically active than previously believed.

None of the more recent findings of Blakely et al. (2011) have been factored into any of the present Hanford Site seismic assessments or the U.S. Geological Survey (2008) seismic hazards maps. However, this new information will be factored into the new probabilistic seismic hazards analysis being conducted by the U.S. Department of Energy for the Hanford Site that is scheduled to be completed in 2014.

SUMMARY

When the Columbia Generating Station (WPPSS WNP-2) was designed and constructed thirty years ago, WPPSS (now Energy Northwest) assured the Nuclear Regulatory Commission that their facility could safely survive the worst potential earthquake that could impact this site.

Geologic studies conducted over the past thirty years have piled up a large volume of geologic evidence that indicates that the original design basis for the Columbia Generating Station's seismic risk assessment significantly under estimated the potential earthquake risks. Recent U.S. Department of Energy earthquake risk assessments for the Hanford Site completed in 2007 that use this new geologic evidence has significantly *raised the estimates of peak vibratory ground motion from large magnitude earthquakes to more than triple the 0.25 g peak vibratory ground motion for Columbia Generating Station site.* Recent U.S. Geological Survey study (Blakely et al., 2011) presented geologic and paleoseismic evidence that the potential for large magnitude earthquakes (greater than M 7) could be much greater for eastern Washington (and the Columbia Generation Station site) than previously assumed.

No seismic structural upgrades have been made at the Columbia Generating Station despite all of the geologic evidence that has been assembled over the past thirty years which has dramatically increased the seismic risk at this site.

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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

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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Attachment A. Excerpt from Energy Northwest response letter (dated 17 September 2010) to the Nuclear Regulatory Commission letter (dated 13 July 2010) requesting additional information on seismic hazards for the review of the Columbia Generating Station license renewal application. Red numbers along the left-hand margin of the pages correspond to numbered items/sections in the evaluation.

NRC Request:

3) Provide the following information with regard to the treatment and inclusion of external events in the SAMA analysis.

   a. ER Section E.3.2.2 states that the seismic hazard analysis used for the seismic PSA is the same as submitted for the CGS Individual Plant Examination of External Events (IPEEE) except for an extrapolation from the maximum peak ground acceleration to 1.5g. The seismic hazard analysis used for the IPEEE was developed in 1994 and documented in "*Probabilistic Seismic Hazard Analysis WNP-2 Nuclear Power Plant Hanford Washington*". Justify the use of the seismic PSA model given (1) since then the U.S Geological Survey (USGS) has updated its assessment of seismic hazards across the U.S. including Washington State, (2) seismic hazard analysis was performed specifically for the Hanford area in 1994 which is documented in WHC-SD-W236A-TI-016, *Seismic Design Spectra 200 West and East Areas DOE Hanford Site, Washington*", to provide better evaluation of subsurface materials and (3) work was performed in 2005 which is documented in PNNL-15089, "*Site-Specific Seismic Response Model for the Waste Treatment Plant, Hanford Washington*" that better characterizes the effect from deep layers of sediments "interbedded" with basalt. Address whether consideration of the more current seismic hazard analysis could impact the results of the SAMA analysis (both SAMA identification and SAMA evaluation).

Energy Northwest Response to 3.a:

The 1994 seismic hazard analysis used at CGS was developed by Geomatrix Consultants for Energy Northwest. A similar hazard model was used by Geomatrix to evaluate the United States Department of Energy (USDOE) facilities located elsewhere on the Hanford site in 1994 (Seismic Design Spectra 200 West and East Areas DOE Hanford Site, Washington, WHC-SD-W236A-TI-016, referenced in the RAI). This USDOE work was superseded by a revised report in 1996 (Probabilistic Seismic Hazard Analysis DOE Hanford Site, Washington, Report Number WHC-SD-W236A-TI-002, Rev. 1, dated February 1996). The application of this hazard model to each different Hanford site requires revision of the distances between the site being evaluated and the known and postulated seismic sources contained in the model. Site specific hazard curves are developed for each site evaluated.

3 The CGS site is located approximately 10 miles southeast of the USDOE Waste Treatment Plant (WTP) that is located adjacent to the 200 East area of the Hanford site. The CGS site has distinct differences from the WTP due to its increased distance from nearby seismic sources and different foundation conditions. The more northerly WTP site is located in close proximity to Central

fault on Gable Mountain (about 8 km north of the WTP site) and is incrementally closer to the other Yakima fold seismic sources compared to the more distant CGS site location to the southeast. Other factors being equal, increased distance from a seismic source tends to reduce the expected ground motions at a site.

At the CGS site the soil structure is thicker than at the WTP. However, the deeper basalt flows and alternating sedimentary interbed sequence is similar between the two sites. The combined thickness of the Hanford and Ringold soil formations is approximately 380 feet thick at the WTP (PNNL-16652, Figure 2.2) in contrast to approximately 480 feet at CGS (FSAR Figure 2.5-28). In general the upper Hanford formation is thinner (250' WTP vs. 65' CGS), and the Ringold sediment section is thicker at the CGS site (130' WTP vs. 415' CGS).

3 A large body of geotechnical data was gathered by Energy Northwest during the initial site investigations for CGS and the adjacent WNP-1 and WNP-4 plant sites. These investigations included the acquisition of extensive velocity data for the combined sites. During initial plant licensing for CGS (FSAR Appendix 2.5Q), Energy Northwest performed comparative site response studies using the soil velocity profile for the CGS site and typical firm alluvial soil profiles representative of California strong motion recording sites. For frequencies above about 3 Hz, the California sites used in the site-specific spectrum showed more amplification than the CGS site (FSAR Appendix 2.5Q, Figures 361.17-23 and 24). The conclusion of that analysis was that the empirical strong motion data from firm alluvial sites in California was appropriate for use at the CGS site (FSAR Appendix 2.5Q and the NRC Safety Evaluation Report, NUREG-0892, Supplement 1). This conclusion was adopted for the CGS 1994 seismic hazard study.

During a design review, the Defense Nuclear Facilities Safety Board questioned the original WTP seismic design (based on their 1996 hazard analysis) regarding the assumptions used in developing the original seismic criteria and the adequacy of the WTP site geotechnical surveys. To allow the project to proceed until new data could be acquired, a very conservative interim seismic design spectrum was developed that was documented in PNNL-15089 (2005, referenced in the RAI). Geotechnical work was initiated in 2005 to obtain new WTP site-specific data. This work was primarily directed at obtaining new shear wave velocity data including an improved understanding of the velocity contrast between the basalt flows and intervening sedimentary interbeds.

In 2007 USDOE issued another round of reports based on the new data provided by the site-specific geotechnical investigations (see reports PNNL-16407, PNNL-16652, and PNNL-16653). In general, the overall ground motion response was less than the interim values estimated in 2005 due to the new velocity

Attachment A (Continued) .Excerpt from Energy Northwest response letter (dated 17 September 2010) to the Nuclear Regulatory Commission letter (dated 13 July 2010) requesting additional information on seismic hazards for the review of the Columbia Generating Station license renewal application. Red numbers along the left-hand margin of the pages correspond to numbered items/sections in the evaluation.

information that indicated a greater shear wave velocity contrast between the basalts and interbeds and new data from the sediments that reflected greater damping.

3 Of importance to the CGS site is their conclusion regarding the 1996 ground motion models which was based on the seismic hazard model adopted from CGS. They concluded in PNNL-16653 (Updated Site Response Analysis for the Waste Treatment Plant, DOE Hanford Site, Washington, 2007, page 37), that "the hazard results obtained using the new ground motion models at the WTP site are similar to those obtained using the 1996 set of ground motion models." The relative amplification function (ratio of Hanford / California response) for the WTP site based on the updated site response model is generally below 1.0 (i.e., WTP site response is less than predicted using California recordings) with the exception of minor isolated peaks at 2, 4 and 20 Hz (see PNNL-16653, Figure 35). This is a large reduction over the interim relative amplification factors developed for the WTP in 2005 (PNNL-15089, Figure 3.3.9) where the Hanford response is predicted to be greater than the California data for most frequencies greater than about 1 Hz.

2 The United States Geological Survey (USGS) recently updated (2008) its assessment of seismic hazard for the United States. The results of this national program provide an opportunity for an updated independent validation of the results determined by Geomatrix for the CGS site. The USGS website offers its results either in the form of a contour map or more directly by the gridded data set that was used to construct the maps. The grid file (0.05 degree increment) was used to avoid interpolation of the small scale map contours. The USGS hazards results from two of the grid files (for 119.35° W, 46.50° N) are compared with the mean results from the Geomatrix 1994 report for the CGS site in Table 3.a-1 below. The Geomatrix (CGS) values are similar but slightly larger than those calculated by the USGS.

Table 3.a-1: Comparison of USGS and Geomatrix (CGS) Data

Study	PGA for T = 500 years (10% in 50 years)	PGA for T = 2500 years (2% in 50 years)
USGS 2008	0.072 g	0.169 g
Geomatrix 1994	0.081 g	0.178 g

1 Although differences exist in the methods used to develop the individual site response models for different Hanford facilities, Energy Northwest concludes that the recent site-specific work performed by USDOE for the WTP validates earlier conclusions regarding the applicability of the California strong motion database to the estimation of ground motions at Hanford. Further, it should be noted that the other aspects of the hazard analysis such as fault locations, earthquake magnitudes and frequencies and attenuation relationships were not reexamined

1 in the course of the USDOE studies (PNNL-15089, Summary statement, page iv) and thus those fundamental components of the earlier hazard studies have not changed and would still apply. Comparison of the mean CGS hazard to the independently determined 2008 USGS hazard calculations verifies that the CGS model is conservatively predicting an appropriate ground motion for the CGS site. Accordingly, Energy Northwest concludes that the 1994 seismic hazard study still provides an adequate seismic input to the PSA models to effectively identify all relevant SAMA candidates.

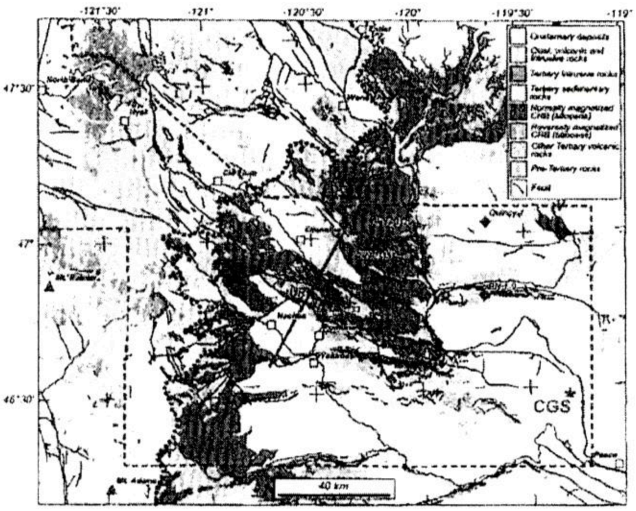


Figure 4. Generalized geology of the YFTB and surrounding regions, simplified from *Walsh et al.* [1987], *Schuster et al.* [1997], *Stoffel et al.* [1991], and *Dragovich et al.* [2002]. Black solid lines are faults of all types and ages, modified from the above references. Note that these faults differ from those shown on Figures 1, 2, 6, 7, 9, 10, and 20, which reflect Quaternary faults only (http://earthquake.usgs.gov/hazards/qfaults). Black dotted line indicates western limit of exposed Columbia River Basalt Group. Black dashed line shows extent of high-resolution aeromagnetic surveys discussed in text. Red line is location of gravity and magnetic model discussed in text and shown in Figure 20. Magenta symbols are deep exploratory boreholes [*Reidel et al.*, 1989b] discussed in text. UR, Umtanum Ridge.

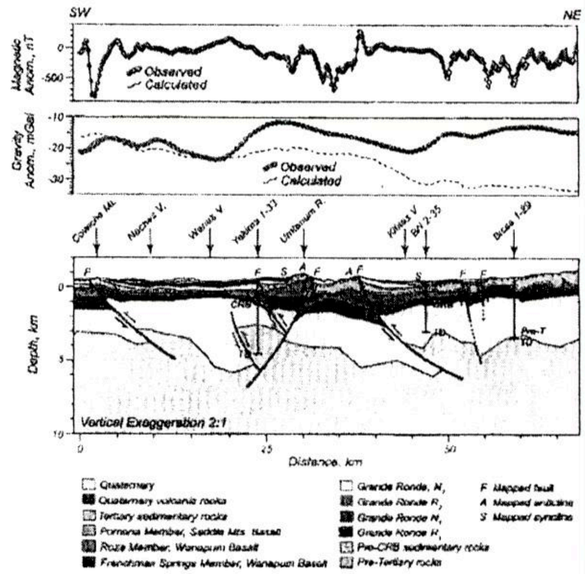


Figure 20. Crustal model across Umtanum ridge. Forward model is based on gravity and magnetic data constrained by geologic mapping and three deep exploratory boreholes. Model assumed infinitely extended in the directions perpendicular to the profile. Dashed gravity profile is calculated anomaly without pre-Tertiary interface. See Figures 4, 6, and 10 for profile location. See Table 1 for magnetizations and densities used. Well labels: CRB, base of CRBG; Pre-T, top of pre-Tertiary; TD, total depth of penetration.

Figure 1. Regional geologic map ("Figure 4") and crustal model cross-section across Umtanum Ridge ("Figure 20") reproduced from Blakely et al. (2011). The location of the crustal model cross-section shown in Figure 20 is indicated by the bold red line on Figure 4. Based on their interpretation of Yakima Fold Belt geology and recent geophysical data sets, Blakely et al. (2011) couple the faults within the Columbia River basalt (Yakima folds) to basement structures.

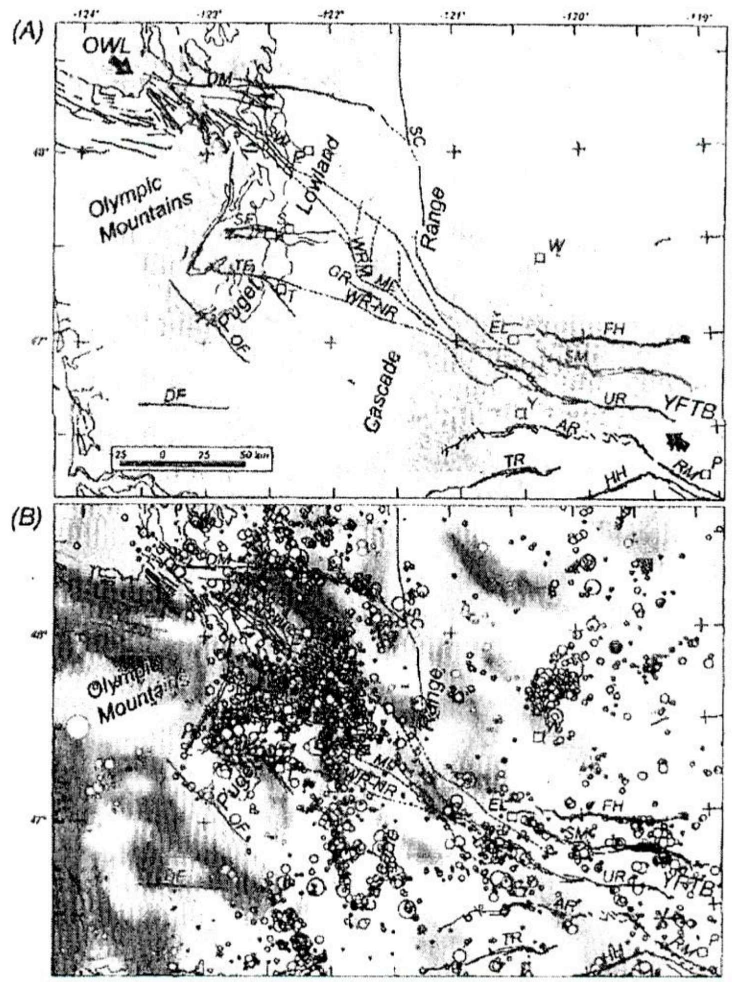
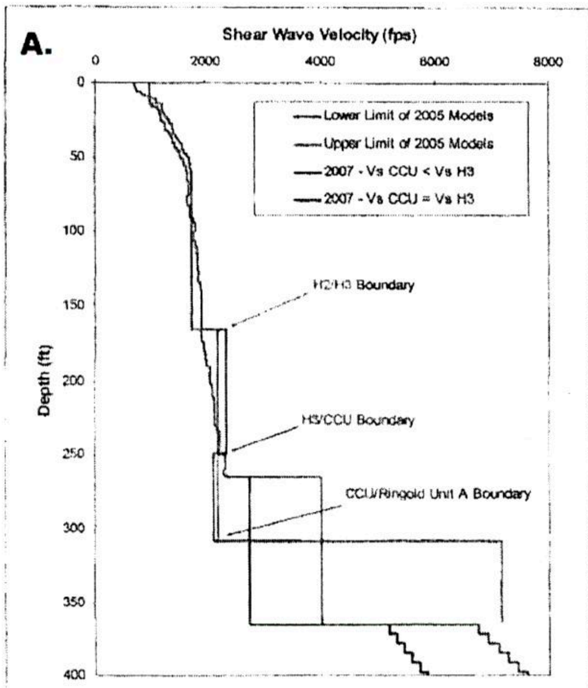


Figure 22. Interpretation of regional structures connecting Quaternary faults of the YFTB to active faults of the Puget Lowland. (a) Aeromagnetic anomalies. White dotted line indicates limit of high-resolution surveys discussed in this paper. Black solid lines are Quaternary faults (http://earthquake.usgs.gov/hazards/qfaults). Black dashed lines are interpreted structures. White dotted lines show limits of high-quality aeromagnetic data. Blue arrows indicate the Olympic-Wallowa lineament (OWL). See Figure 2 for label definitions. (b) Isostatic residual gravity anomalies and upper plate earthquakes, sized according to magnitude. See Figure 2 for magnitude scale.

Figure 2. Maps showing locations of mapped Quaternary faults within the "Yakima Fold and Thrust Belt (YFTB)" and their interpreted connection to active faults in the Puget Lowland area. Red "*" denotes the location of the Columbia Generating Station. Figures reproduced from Blakely et al. (2011).



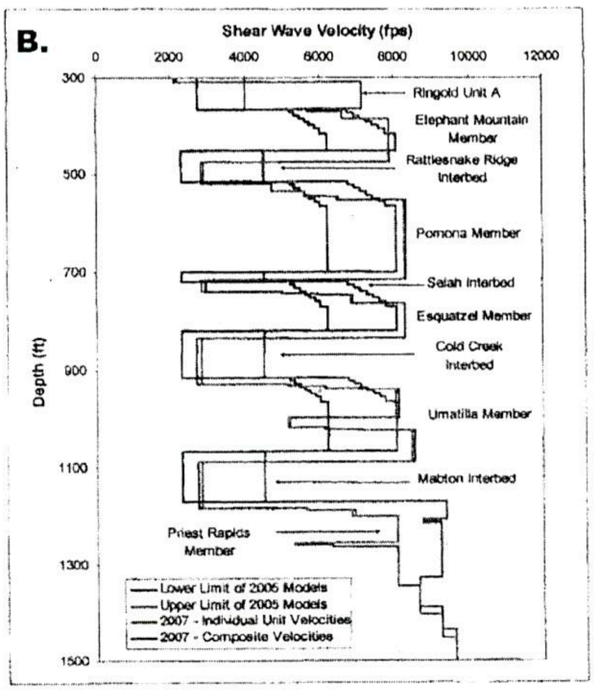


Figure 3. Geometric mean velocity profiles for the suprabasalt sediments ((A) Hanford Formation - H2 & H3 units, Cold Creek Unit – CCU, and Ringold Formation – Unit A of the Wooded Island Member), Columbia River basalt ((B) Elephant Mountain, Pomona, Esquatzel, Umatilla, and Priest Rapids Members), and Ellensburg Formation ((B) Rattlesnake Ridge interbed, Selah, interbed, Cold Creek interbed, and Mabton interbed). Although the Ringold Formation is part of the suprabasalt sediment package that overlies the Columbia River basalt, its shear wave velocity profile is more similar to the underlying Columbia River basalt units than the Cold Creek Unit and Hanford Formation. Figures 1A and 1B reproduced from Youngs (2007, Figures 3 and 4).

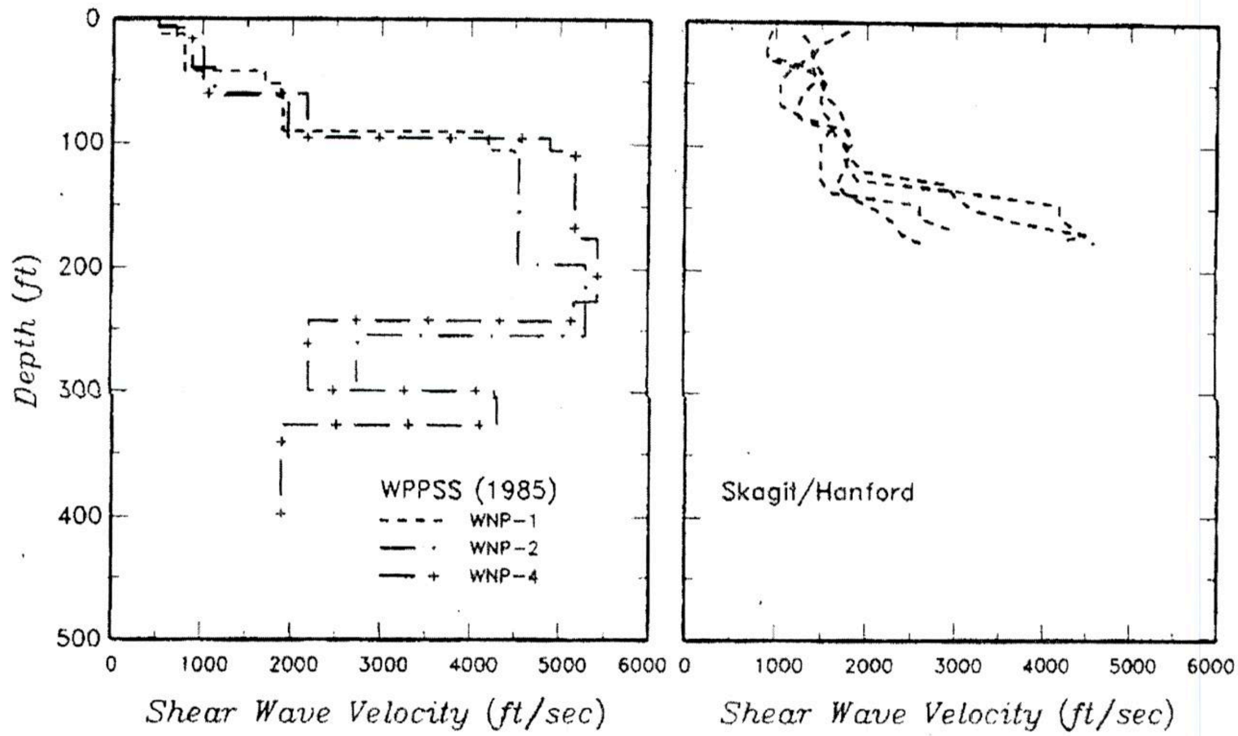
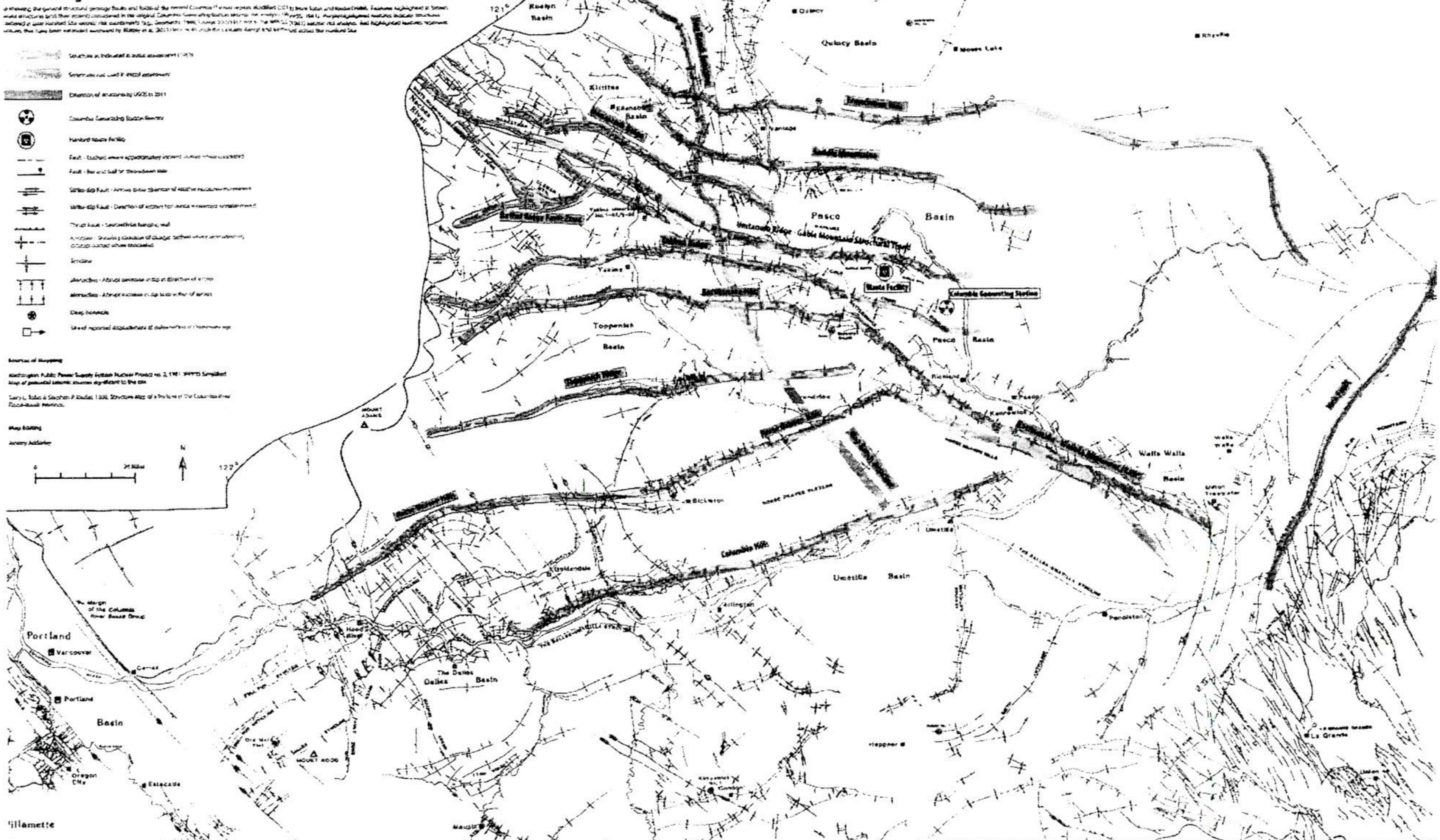


Figure A-2 Shear wave velocity profiles reported for nuclear power plant sites in the Hanford region.

Figure 4. Vertical shear wave velocity profile beneath the Columbia Generating Station (WNP-2 on left-hand graph). Reproduced from Geomatrix (1996, Appendix A, Figure A-2, p. A-18).

igure 1: Columbia Generating Station and Hanford Site:
urrounding Fault Structures



Remsburg, Kristy

From: johnsonc20@gmail.com on behalf of Charles K. Johnson <washpsr@gmail.com>
Sent: Friday, November 01, 2013 2:28 PM
To: CHAIRMAN Resource
Cc: Uselding, Lara
Subject: response to September 26, 2013 letter regarding changing seismic knowledge at the Columbia Generating Station
Attachments: response to Macfarlane letter - Oct 31, 2013.docx; Tolan EQ Report #1 Oct31-13.pdf; Tolan EQ Report #2 Oct31-13 Eval ENW res.pdf

Follow Up Flag: Follow up
Flag Status: Flagged

Dear Chairman Macfarlane,

Enclosed are Dr. John Pearson and Dr. Steve Gilbert's, Presidents of Oregon and Washington Physicians for Social Responsibility, response to your letter dated September 26, 2013 regarding the changing seismic knowledge of the area surrounding the WNP-2/Columbia Generating Station.

We also enclose two reports from Terry L. Tolan, LEG, Consulting Engineering Geologist, Kennewick, WA that examine existing knowledge of the seismic activity in the region with regard to the standards set when the WNP-2/CGS was licensed and Energy Northwest's response to NRC concerns about whether this new information changes the seismic profile of the WNP-2/CGS site.

In addition, we will send in a separate email (due to the size of the documents) a seismic map of the Mid-Columbia basin color-coded to illustrate changes in knowledge since 1983 and attachments that correspond with text in Tolan's second report.

We hope that, given your learned background on this particular topic, you will take a personal interest in pursuing the issue of the seismic adequacy of the WNP-2/CGS nuclear power plant.

Sincerely,
Chuck Johnson

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Charles K. Johnson
Director, Joint Task Force on Nuclear Power
Oregon and Washington Physicians for Social Responsibility
812 SW Washington Street, Suite 1050
Portland, OR 97205
(503) 777-2794 cell
washpsr@gmail.com
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Remsburg, Kristy

From:	johnsonc20@gmail.com on behalf of Charles K. Johnson <washpsr@gmail.com>
Sent:	Friday, November 01, 2013 2:42 PM
To:	CHAIRMAN Resource
Cc:	Uselding, Lara
Subject:	Re: response to September 26, 2013 letter regarding changing seismic knowledge at the Columbia Generating Station
Attachments:	Attachment 1 ENW response sept 2010 letter excerpt vf.pdf; Figure 1 Blakely et al 2011 geo map & fault model VF.pdf; Figure 2 Blakely et al 2011 Quat faults & regional connections.pdf; Figure 3 mean shear wave vel profiles.pdf; Figure 4 Geomatrix 1996 vel profiles WNP 2.pdf
Follow Up Flag:	Follow up
Flag Status:	Flagged

Here are the additional attachments

Draft_CGS_30_3.pdf

On Fri, Nov 1, 2013 at 11:28 AM, Charles K. Johnson <washpsr@gmail.com> wrote:
Dear Chairman Macfarlane,

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--

Char[illegible] K. Johnson
[illegible] on [illegible]uclear Power

Oregon and Washington Physicians for Social Responsibility
812 SW Washington Street, Suite 1050
Portland, OR 97205
(503) 777-2794
washpsr@gmail.com

--

Charles K. Johnson
Director, Joint Task Force on Nuclear Power
Oregon and Washington Physicians for Social Responsibility
812 SW Washington Street, Suite 1050
Portland, OR 97205
(503) 777-2794 cell
washpsr@gmail.com