United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA. 22092

April 21, 1983

Mr. Robert E. Jackson
Chief, Geosciences Branch
Division of Engineering
U.S. Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, Maryland 20014
50-508

Dear Bob,

Enclosed are the U.S. Geological Survey questions on the WNP-3 site. If you have any questions, please contact me.

Sincerely,

Walter W. Hays
for S. T. Algermissen

Enclosures

C002

April 21, 1983

WNP-3 Site
Seismology Questions

1) The work by Ruff and Kanamori (1980) and others appears to support the view that the subduction of the Juan de Fuca plate creates a potential for large magnitude earthquakes in the subduction zone beneath WNP-3. In addition,

   a) Kanamori (1983) has published an equation relating the age of the subducting plate, convergence velocity, and the largest expected magnitude event. Does this equation apply to the Juan de Fuca plate and if not, why not? Alternatively, are there other convincing models that allow the estimation of the magnitude of subduction zone earthquakes under the site to values lower than would be predicted by the Kanamori (1983) relationship.

   b) Are there specific examples of aseismic subduction zones which share the following features with the Juan de Fuca subduction zone, young subducted lithosphere, low convergence rate, no back arc basin, similar maximum depths of seismicity, shallow oceanic trench, low free-air gravity anomaly small variation in surface topography of the subducted plate and, particularly, complete seismic quiescence down to the magnitude 5 level?

   c) Crustal uplift rates of approximately 2mm/yr were observed in the region from 120 km to 220 km inland of the Nankai Trough for the 50 years preceding the 1944, M=8.0 Tonankai and 1946, M=8.2 Nankaido earthquake. Why shouldn't the crustal uplift and NE-compressive strain reported by Savage (1981) for western Washington be considered consistent with a similar preseismic deformation? How is the Juan de Fuca subduction zone any different from the subduction zone in the Nankai Trough and the subduction zone associated with the Rivera plate?

   d) What is the magnitude of the largest shock in the plate or along the plate interface that could occur beneath the site without exceeding the SSE acceleration? Specify the attenuation and distance used in the discussion.

2) The depth and configuration of the subducting Juan de Fuca plate is critical to the calculation of the effect of the Benioff zone earthquake at the site.

   a) Attention is called to FSAR Figure 2.5-31. No location errors are specified for most of the earthquakes plotted thereon, especially for those occurring in a region which projects to the southwest of Olympia on section AA' and particularly for depth of focus. Referring to Crosson (1972), Figure 6, the site and most of the area in which these

earthquakes occur is off-scale and the location errors are likely to be large. Several factors influence the accuracy in depth of focus, most important of which is station coverage which changed greatly during the time interval covered. The applicant is therefore asked to provide a number of diagrams similar to Crosson's Figure 6 for periods which reflect significant changes in network coverage and showing error bars that indicate the accuracy of hypocentral locations.

b) Figure 2.5-36C shows seismicity (for example in the vicinity of Mt. St. Helens) that does not appear to have been plotted in the sections shown in Figure 2.5-31. Yet Figure 2.5-31 states that earthquakes within 150 km of a line striking N60°E through the site have been included on the section. Two questions arise: (1) what earthquakes (if any) have been omitted from the section (Figure 2.5-31), and (2) why is the aperture for the section so wide since a width of 300 km results in earthquakes in the Willamette depression being projected to points west of the site into what may be an entirely different tectonic province?

c) Expand your explanation of the decrease in seismicity on the sections through the site west of point B in Figure 2.5-31.

d) The geometry and location of the flexure in the subducting plate is assumed to be the western boundary to down-dip tension earthquakes. Therefore, its position is critical. Clarify your reasoning for locating the position of the flexure.

e) The Puget Sound earthquake of February 15, 1946, is a large earthquake with uncertain depth (Rasmussen, Millard, and Smith, 1974). If this event was relocated at a shallower depth or farther to the west, it may signficantly alter the applicant's conclusions about the earthquake potential of the subduction interface or the overriding plate. The International Seismological Summary for 1946 (1954) lists over 40 observations for this earthquake. The observations range in distance from as close as Seattle to as far as Lome in the Ivory Coast. Despite the existance of these data, the applicant chose not to do a computer relocation (FSAR p. 2.5-120). We request that the applicant relocate this earthquake using the published I.S.C. data and establish the relationship of this earthquake to the Juan de Fuca-North American plate interface.

3) a) Estimate the maximum magnitude possible for a "random earthquake" in the shallow crust within a 32-km radius around the site.

b) Inasmuch as the 17 March 1904 earthquake has not been associated with a structure at any of its various hypothetical locations (pp. 2.5-127, 128, FSAR), show why the size of this earthquake should not be considered the size of the "random earthquake."

c) With respect to the 17 March 1904 earthquake, provide all references not in the public sector for the intensities shown in Figure 2.5-90, as well as for any other locations for which information is available which could be used to assess intensity. Provide the documentation for the relocation of the earthquake to "south of Port Townsend" and the assignment of a smaller size (both attributed to the Pacific Science Center, Victoria, B.C., as "Milne, 1981, private communication: and "Rogers 1981, private communication").

4) What physical explanation is there for the reduction in response spectrum produced at foundation level and at 10 to 20 hz when the given SSE motion is run through the deconvolution analysis? To what degree does the assumed nonlinearity of the constitutive law effect the solution? If the nonlinearity is important, how can the three components of motion be treated independently? Of what relevance are the comparisons with 60% design level spectra which are made for the foundation level motions? Please give ground acceleration, velocity, and displacement for assumed free-field motions before deconvolution analysis and the motions at grade level and foundation level after deconvolution analysis. Use consistent scales.

5) Estimate the annual exceedance probability for the SSE, using as sources random earthquakes, subduction zone earthquakes, as well as earthquakes on significant, capable linears. Show the relative contribution of these sources to the annual exceedance probability.

References

Crosson, R. W., (1972). Small earthquakes, structure and tectonics of the Puget Sound region, BSSA, vol. 62, no. 5, pp. 1133-1171.

International Seismology Summary for 1946 January to March (1954), Kew Observatory, Richmond, Surray.

Kanamori, H., (1983). Global Seismicity Preprint, California Institute of Technology.

Rasmussen, N. H., Millard, R. C., and Smith, S. W., 1974, Earthquake hazard evaluation of the Puget Sound region, Weashington State: Seattle, Washington Univ. Press, 99 p.

Ruff, L., and Kanamori, H., (1980). Seismicity and the subduction process, Physics of the Earth and Planetary Interiors, 23, 240-252.

Savage, J. C., Lisowski, M., and Prescott, W. H., 1981, Geodetic strain measurements in Washington, J. Geoph, Res., vol. 86, pp. 4929-4940.

Geology Questions

1) A major northwest-trending fault in the Humptulips River area (Tabor and Cady, 1978) projects northwestward under Quaternary deposits to an outcrop of steeply dipping Pleistocene deposits (op. cit) on the west Fork of the Humptulips River. The capability of this fault may be important to the site in light of the following. Offshore studies by Silver (1972) and Snavely and Wagner (1982) indicate a subduction tectonic style characterized by eastward (landward) dipping thrust faults that generally steepen westward (upwards) and that have offset sediments as young as Quaternary. Considering this structural framework, evaluate the possibility that the Humptulips fault, if capable, extends southeastward as a continuous fault or fault zone along the steepened west limb of the Wynochee anticline (Rau, 1967) and on into the less well-defined Melbourne anticline (Gower and Pease, 1965) or alternatively to the southeast of these structures. Is the Humptulips fault throughgoing and capable? If so, evaluate the effects on the site. Vibroseis records along the Chehalis River Valley might help evaluate the thrust fault hypothesis and reportedly have been obtained by AMOCO.

2) The applicant has dismissed offset magnetic anomalies KK and HH on the Juan de Fuca plate as probably due to episodic jumping of short transform faults connecting offset segments of the spreading ridge a la Hey (1977) (FSAR 2.5-44). Provided that sucessive jumps are in the same direction and occur after equal increments of spreading, the jumps should produce a V-shaped wake consisting of a pair of lineaments intersecting at the ridge. Although KK seems to form such a wake, mirrored in the Pacific plate, HH is less convincingly matched (c.f. Barr, 1974 and Elvers and others, 1973). Considering the difficulty of identifying the mirror image of HH, evaluate the hypothesis that HH is a fault as suggested by Pavoni (1966), and that the on-shore subcrustal extension of HH could be the source of deep-seated major earthquakes in the Puget Sound region (Fox, 1983). Evaluate the response at the site of a major earthquake on fault HH.

References

Barr, S. M. 1974, Sea Mount formed near the crest of Juan de Fuca Ridge, NE Pacific Ocean; Marine Geology, vol. 17, p1-19.

Elvers, Douglas, Srivastava, S, P., Potter, Kenneth, Moorley, Joseph, Sdidel, Dean, 1973. A symetric spreading across the Juan de Fuca and Gorda rises as obtained from a detailed magnetic survey; Earth and Planetary Sciences Letters, vol. 20 p. 211-219.

Fox, Kenneth F., Jr., 1983, Northeast-trending subcrustal fault transects western Washington: U.S. Geological Survey Open-File Report 83-398.

Gower, H. P., and Pease, H., Jr., 1965, Geology of the Monteseno Quadrangle, Washington: U.S. Geological Survey GQ Map 374.

Hey, Richard, 1977, A new class of "pseudofaults" and their bearing on plate tectonics: a propagating rift model: Earth and Planetary Sciences Letters, v. 37, p. 321-325.

Pavoni, N., 1966, Tectonic interpretation of the magnetic anomalies southwest of Vancouver Island: Pure and applied geophysics, v. 63, p. 172-178.

Rau, W. W., 1967, Geology of the Wynoochee Valley Quadrangle, Washington: Washington State Division of Mines and Geology Bulletin no. 46, 51 p.

Silver, E. A., 1972, Pleistocene Tectonic Accretion of the Continental Slope off Washington: Marine Geology, v. 13, p. 239-249.

Snavely, P. D., Jr., and Wagner, H., 1982, Geologic cross section across the continental margin off Greys Harbor, southwestern Washington: U.S. Geological Survey Open-File Report 82-459, 11 p.

Tabor, R. W., and Cady, W. M., 1978, Geologic map of the Olympic Peninsula, Washington: U.S. Geological Survey Miscellaneous Field Investigations Map I-993.