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Dr. Robert E. Jackson, Chief
Geosciences Branch
Division of Engineering
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Jackson:

This letter responds to your request that I prepare a preliminary and independent assessment of fault capability and maximum earthquake parameters for the Washington Public Power Supply System's Nuclear Power Project No. 3, near Satsop, Washington. My review of the local and regional relations that affect seismic design at the site includes local and regional study of reports, responses to questions, and the relevant geological, seismological and geophysical data.

If you require further information, please request additional comments by letter or telephone.

Sincerely yours,

D. B. Slemmons

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1 INTRODUCTION

1.1 Purpose of Study

This report was requested by Dr. Robert E. Jackson, Chief, Geosciences Branch, Division of Engineering, U. S. Nuclear Regulatory Commission. The statements and conclusions are preliminary comments that are based on a partly incomplete data base. The appraisal of regional and site-specific geological, seismological and geophysical information are summarized and important remaining major issues are listed.

1.2 Scope of Work

This report is based on a site visit and study of reports on the geological, seismological and geophysical information on the local and regional geology. My previous work in the Pacific Northwest includes study of regional seismicity, evaluation of the 1872 Pacific Northwest earthquake, evaluation of data on active or capable faults, compilation of faults and lineaments from various scales of topographic maps and several types of imagery. My investigations included the determinations of fault capability and earthquake parameters for the U.S. Corps of Engineers at six dams along parts of the Columbia and Snake Rivers and for the U.S. Nuclear Regulatory Commission in the Columbia Plateau at the U.S. Nuclear Project No. 2, the Skagit/Hanford Nuclear Project, Units 1 and 2, and the BWIP high level waste repositories.

2 GEOLOGICAL FEATURES

The following are comments regarding the geological and tectonic setting for the site and surrounding region:

1. None of the mapped and trenched faults at the site show any evidence for activity. This is suggested by the unfaulted older soils and terraces, and the accordant ridgelines that are about 2 million years old. I see no need for further active fault investigations at the site.

2. The Olympic Mountains are the nearest major structure that may be active tectonically. This is an area of slow uplift (Gable and Hatton, 1983). The eastern periphery of the Olympic Mountains has at least one short segment with Holocene offsets (Carlson, 1979; Wilson, and others, 1979). Similar appearing structures have capable faults along parts of their boundary zones or on radiating structures. The tectonic deformation of the border zone of the Olympic Mountains should be assessed in relation to the effects on faults that are near the WNP-3 site. One zone, that may be of this type, needs further evaluation. This zone of possible Quaternary deformation, the Humptulips-Wynoochee-Melbourne zone, is discussed in the main text of this report. This zone may extend about 12 km west of the site and

report. This zone may extend about 12 km west of the site and needs to be investigated for structural continuity or noncontinuity, fault capability and seismogenic potential. New imagery, remote sensing data and shoreline deformation needs to be evaluated for the site region and major geologic structures.

3. The Olympic lineament is mainly identified from its gravity gradients. It is postulated to be a potential source of a magnitude (Ms) 7-1/2 shallow-focus crustal earthquake. The closest approach of this lineament is 22 mi (35 km). There is no evidence for activity along this zone, although the Pleistocene erosion and deposition could obscure evidence for activity for faults with recurrence intervals of over about 11,000 years. The latest worldwide data would suggest the following magnitudes for a 2/3 rupture length:

The assumed normal-slip mechanism, using the formulation of Slemmons (1982) the magnitude is:

$$Ms = 0.809 + 1.341 \log 59{,}000 = 7.2$$

For an assumed reverse-slip mechanism, using the formulation of Slemmons (1982) the magnitude is:

$$Ms = 2.021 + 1.142 \log 59{,}000 = 7.5$$

For an assumed normal-oblique-slip mechanism, using the formulation of Slemmons (1982) the magnitude is:

$$Ms = 0.875 + 1.348 \log 59{,}000 = 7.3$$

For an assumed reverse-oblique-slip mechanism, using the formulation of Slemmons (1982) the magnitude is:

$$Ms = 1.199 + 1.271 \log 59{,}000 = 7.3$$

If the structure is a capable reverse-slip fault, or a normal-slip fault, the use of 2/3 rupture length may require reevaluation, since the worldwide demonstration of fractional lengths for magnitude estimates is not documented, and the specific fraction has not been carefully assessed. There is no specific data on the type of fault that may control the Olympic lineament. The interrelationship of this feature with other faults of similar orientation toward the southeast requires more detailed investigations for possible capability and tectonic connection to the Dalles area (U.S. Army Corps of Engineers, 1982) or to Mt. St. Helens (Carlson, 1979; Wilson and others, 1979). In addition, this feature has not been assessed for relationship to regional stress axes or possible conjugate relationships.

Several questions remain unresolved; these include:

Is this a capable fault?

What, if any, are the interconnections to the southeast?

What is the probable type of fault shown by direct or conjugate relationships?

The data for estimating the magnitude, taken from Slemmons (1977 and 1982), give Ms magnitudes that are somewhat greater than 7.3, but answers to the above questions are more important issues.

3 SEISMOLOGICAL SETTING

3.1 General Statement

The WNP-3 site appears to be in a tectonically stable region for shallow focus earthquakesas as is shown by the historical record of seismicity and the record of known active or capable faults of the region. However, the cross section of the site seismicity and the evidence cited by Heaton and Kanamori (1983) suggest that subduction in the northwestern part of United States is seismic that a great earthquake could occur in this region. Two possible maximum earthquakes should be considered for this site, shallow focus and deeper Benioff or subduction zone earthquakes.

3.2 Shallow Focus Earthquakes

The number of shallow focus earthquakes is relatively low in the site area and no capable faults are defined by current seismicity. Seismicity patterns do not resolve the issue of whether or not the Olympic lineament or structures near the Olympic Mountains are capable. Focal mechanism studies are useful for defining the orientations of conjugate faults. The limited data that is available for the site-area suggest that most of the faults are reverse-slip faults, although strike-slip components are common. The activity at Mt. St. Helens appears to be right-slip on a north-south fault zone (Weaver and Smith, 1981). The seismologic evaluation of the site area should be reevaluated with the cross sections for narrower belts of seismicity, so that the vertical display of focal depths is more representative of local distributions.

3.3 Deeper Shallow Focus Earthquakes

The most critical single issue that needs to be resolved for the seismic design for the nuclear power generator is the question of whether or not the underlying Benioff zone or subduction plate boundary is seismogenic or aseismic. The volcanic activity of the Cascade volcanoes, and the known motions between the North American and Juan de Fuca plates clearly show that there is subduction with a relative movement between the plates of from 2 to 4 cm/yr. The seismological debate on whether or not this zone is seismic or aseismic has not been resolved and this issue, along with a maximum earthquake magnitude value, if it is seismic, must be addressed on the basis of newer analyses that were present at the time of preparation of the FSAR.

John Adams (oral communication, 1983) has suggested that geological studies could be made of both continental lacustrine and marine sediments to determine whether or not liquefaction and landslide events are recorded at the base of bodies of water. Coring and dredging methods have shown the effects of paleoseismic activity. This method may provide a geological measure of whether earthquakes occur in the northwestern United States or the movement between the plates is aseismic.

4 GEOPHYSICAL SETTING

The geophysical studies of the region and for the site area are mostly adequate, but they should be reexamined to determine if any of the geophysical (e.g. intratelluric, seimic reflection profiles, etc.) methods can be expanded with new data to resolve the issue of whether or not the boundary between the North American and Juan de Fuca plates is seismic or aseismic.

5 CONCLUSIONS

1. The most important single issue is the question of whether or not the Benioff zone beneath the site is capable of a large earthquake that should be considered in the design at WNP-3. This issue has not been resolved.

2. Two possible shallower focus earthquakes may need to be considered for seismic design at WNP-3. The seismic motion at the site may have a different spectral content and the distance to the site may be closer than for 1, above. This should include a reassessment of the Olympic lineament, to determine if it is a capable fault, and to examine structures around and near the Olympic Mountains to determine capability. The latter should include an evaluation of the Humptulips-Wynoochee-Melbourne zone.

3. Site faults are older, inactive faults that show no evidence for current activity. The old upland surfaces with their accordant ridgelines show no evidence for faults with vertical components of displacement during the past 2 or 3 million years. Subsurface exploration at the site does not appear to be warranted.

The most important single issue is the question of whether or not the Benioff zone beneath the site is capable of an earthquake that should be considered in the design of vital structures at the Satsop site. I believe that until this issue is resolved, no specific earthquake magnitudes should be estimated for this type of earthquake.