UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

POOR ORIGINAL

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
PORTLAND GENERAL ELECTRIC COMPANY, ET AL.	)	Docket No. 50-344 (Proposed Amendment to Facility Operating License NPF-1 to Permit Storage Pool Modification)
(Trojan Nuclear Plant)	)	

AFFIDAVIT OF RICHARD B. McMULLEN

STATE OF MARYLAND) SS
COUNTY OF MONTGOMERY)

VOLCANISM

I, Richard B. McMullen, being duly sworn, depose and state:

1. I am a Geologist in the Geosciences Branch of the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

2. I have prepared the statement of Professional Qualifications attached hereto, and, if called upon, would testify as set forth therein.

3. I have prepared the assessments on landslides and volcanism attached hereto in response to the Atomic Safety and Licensing Board's Order of January 9, 1978 and I hereby certify that the statements made herein are true and correct to the best of my knowledge.

Richard B. McMullen
Richard B. McMullen

Subscribed & sowrn to
before me this 12th day
of April, 1978

[signature]
Notary Public

My Commission expires: July 1, 1978

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RICHARD B. McMULLEN
PROFESSIONAL QUALIFICATIONS
GEOSCIENCES BRANCH
DIVISION OF SITE SAFETY AND ENVIRONMENTAL ANALYSIS
NUCLEAR REGULATORY COMMISSION

I am a geologist in the Geosciences Branch, Division of Site Safety and Environmental Analysis, Nuclear Regulatory Commission. My present duties in this position include: (1) the evaluation of the geological aspects of sites for nuclear power generating facilities; (2) analyzing and interpreting the geological data submitted to the NRC in support of applications for construction and operation of nuclear facilities; (3) developing criteria; and acting as consultant to the Regulatory staff on engineering and construction matters. After completion of three years in the Marine Corps I attended the University of Florida and graduated in 1959 with a B.S. degree in Geology. During my professional employment, I completed correspondence courses in soils engineering and quarrying sponsored by the Army Engineer School at Ft. Belvoir, Va., and short courses in the effects of ground motions on structures, and airphoto interpreting. I am a registered Geologist and Engineering Geologist in the State of California.

After graduation I worked as a field geologist with the Corps of Engineers in Florida conducting field geological investigations for flood control structures, levees, canals, military installations, radar sites, and missile launching complexes. I evaluated and wrote reports concerning the stratigraphy, geologic structure, groundwater conditions, and foundation engineering aspects regarding these facilities in Florida, Puerto Rico, Bahama Islands, several of the West Indies Islands, and Panama. In 1963 I was assigned to the Corps of Engineers Canaveral District office at Cape Kennedy, Florida, first as a staff engineering geologist, and later as District Geologist. My duties were to plan, direct and evaluate the results of geological and foundation studies for missile launch pads and associated facilities for the NASA Manned Lunar Landing Program, the Air Force, and the Navy. I acted as consultant to other government agencies and architectural engineers in developing design features of structural foundations, monitored the performance of foundations during and after construction, and recommended and monitored necessary foundation treatment techniques such as vibraflotation, grouting, surcharging, dewatering and compaction. I wrote reports on the investigations, geology, foundation design, and construction regarding these projects.

In 1967 and 1968 I spent 6 months and 1 month respectively participating in the geological investigations for proposed sea level canal routes in Panama. The region investigated consisted of complex structures of volcanics and folded and faulted sedimentary strata. Among the techniques employed in this study were field geologic mapping, geophysical surveying, bore hole photography, and core borings. In 1968, I was transferred to the Huntsville, Alabama Corps of Engineers Division which was responsible for the siting, design and construction of 15 to 20 (later reduced to 4) safeguard antibalistic missile installations throughout the United States. My duties there were to plan, direct and participate in investigations to determine the suitability of these sites for construction of the missile complexes. I performed geological studies and some soil mechanics work to develop design parameters for foundations and excavations. I also served as technical consultant during design and construction to other government agencies, architectural engineers, and contractors.

I have been a member of the Regulatory staff since January 1971 and have participated in licensing activities for at least twenty-five nuclear facilities including Summer, Nine-Mile Point, Washington Nuclear 2, Pebble Springs, and Indian Point. These activities consisted of review of the geological aspects of the sites as presented by applicants and usually an independent evaluation conducted by a review of the most pertinent literature, site visits, and conversations with knowledgeable individuals or agencies.

A. Landslides

1. NRC Positions After CP and OL Reviews

In its Safety Evaluation Report (SER) for the Trojan site dated October 19, 1970, the staff concluded that "Based on the evidence provided by the applicant and field observations of our geologists and our geological consultants, we have concluded that the existing geological structure is acceptable for the construction and operation of the proposed plant at the Trojan site." The U. S. Geological Survey concluded that, "the applicant proposes to found all major plant structures in the volcanic rocks. Boring logs and test data indicate that the rocks are sound and will provide an adequate foundation for the proposed facility." In its SER following the OL review, the staff reaffirmed its original conclusions.

2. Current Staff Positions

It is the staff's position that landsliding in the site area does not present a threat to the Trojan plant. This conclusion is based on our review of several recent publications on landsliding in the region and the results of geological investigations in the site area including borings, seismic profiling, surface geologic mapping and the geophysical investigations that were supervised and evaluated by the Trojan Geophysical Advisory Board comprised of Dr. Peterson, Dr. White and Mr. Dodd. The results of these studies indicate that the immediate site area does not have the characteristics which typify large landslides along the Columbia River.

3. <u>Geology and Topography of Large Landslides in the Columbia River Gorge</u>

Palmer (1977) studied several large landslides that have occurred within the Columbia River Gorge. These slides were in an area characterized by steep terrain with relief on the order of 1200 meters, high rainfall (~250 cm/yr.), exposure of water saturated plastic clay layers under permeable rock masses, and regional dips of rock strata from 5° to 30° into the gorge.

A thick stratigraphic section of the Eocene to Oligocene Ohanapecosh formation underlies the area studied by Palmer. This formation is made up of varied claystone to pebble conglomerate of both sedimentary and volcanic materials. Portions of this rock have been weakened by weathering. An angular unconformity in the Miocene caused the development of a zone of soft clay rich saprolite on top of the Ohanapecosh formation. The Miocene Eagle Creek formation overlies the Ohanapecosh. The Eagle Creek is similar in composition to the Ohanapecosh but is less weathered and contains larger rock fragments. On the Washington side of the river, the strata within these formations dip toward the Columbia Gorge, while on the Oregon side they dip away from it. Basalt overlies the Eagle Creek formation.

River banks were oversteepened as the Columbia River cut through the basalt into the weak Eagle Creek and Ohanapecosh formations. Most large scale Pleistocene and Holocene landsliding occurred on the Washington shore where oversteepened slopes intersected the bedding planes of exposed incompetent rock, which dip to the south into the gorge. Lesser slides are found on the Oregon shore where several thousand feet of basalt overlie the clay of the Eagle Creek and Ohanapecosh formation which dip away from the gorge. The combination of exposure by erosion of the clays and the weight of the basalt caused squeezing updip of the clays, eventually undermining the basalt and causing large rock falls (Palmer, 1977).

4. Geology and Topography of the Site

Bedrock beneath the Trojan site consists of volcanic rocks of the Upper Eocene Goble series. Boring, seismic, and laboratory test data show that the rock is relatively sound and composed of tuff, flow breccia, tuff breccia, agglomerate, and basalt. Bedding planes within the rock are poorly developed, but those that have been mapped generally dip toward the west-southwest or southwest, away from the Columbia River. Geophysical data indicate that the volcanic rock also underlies the Columbia River east of the site thus precluding the exposure to erosion of continuous clay strata like those described in the Columbia River Gorge (Palmer, 1977).

The topography along the river valleys in the site region is characterized by many steep arcuate features. The Trojan site is located on a bedrock ridge just east of one of these steep arcuate features within the Columbia River Valley. This valley was subjected to intense flooding during post glacial time (Bretz 1969). It is likely, based on geologic evidence at the site, that the arcuate feature is the result of river bank scouring and erosion from rapid flood stage flow through a since-abandoned channel of the Columbia River, rather than landsliding.

Similar abandoned channels were reported by Piteau (1977) following his study of landslides in the Fraser River Valley in southern British Columbia. Piteau also presented evidence to show that the major single cause of landslides in that area was the presence of alluvial fans or earlier landslide debris on the opposite side of the river, which deflected the river laterally and caused undercutting and oversteepening of slopes. Such processes are not active at the site.

5. Bases for Staff Position

Although landslides are evident in the site region, landsliding is not likely to pose a hazard to the Trojan site. The staff concludes that the Trojan site is not susceptible to landsliding for the following reasons:

1. Available data indicate that the volcanic bedrock in the site area is continuous from the hills west of the site, beneath the alluvial valley, through the site ridge, beneath the Columbia River, and on to the Washington side, and is not an active slide block.
2. Interpretive seismic profiles show that the surface of the bedrock beneath the alluviated channel is smoothly rounded, as would be expected in a rapidly eroded bedrock channel, and not sharp and angular as would characterize a relatively recent and unstable slide block.

3. Rock strata beneath the site and the area around the site on the Oregon shore dip, with relative consistency, southwest or west-southwest away from the River; and data presented by the applicant indicate that joints and shear zones are either not continuous or dip at steep angles, thus precluding the existence of a potential slide plane sloping toward the river.

   a. Geologic maps of the site vicinity on both sides of the Columbia River show that bedding dips either in a southerly or westerly direction.

   b. Figure 2.5-16 in the FSAR, which is the Geologic Map of Final Foundations, shows that joints and shear zones are either discontinuous, dip away from the river, or dip at a high angle such that a projection of that dip would not intersect the river valley.

   c. Correlation of bedding from boring to boring and interpretation of geophysical data show that, locally, bedding planes below foundat[illegible] level are generally horizontal or dip away from the river.

   d. On a broader scale, based on geophysical data and surface mapping, the site lies on the eastern flank of a northwest trending syncline within which the bedding dips to the west, away from the river.

   e. Dip of strata beneath the site show no evidence of rotation of beds as would be expected within a landslide mass.

f. The USGS reviewer examined the excavation for the plant on 1 October, 1970, and reported that although no real bedding planes were visible, some nearly horizontal, crude separations were observed that were consistent with observations made in natural exposures of these rocks nearby.

4. Based on a projection from mapped outcrops, the volcanic rocks underneath the site rest on the Cowlitz formation, which is described by the Applicant as well compacted but sometimes loosely cemented sandstones and siltstones. Sandstones or siltstones are generally less suceptible to landslide development than clays, such as those described (Palmer 1977) as being part of the Eagle Creek and Ohanapecosh formations. It is possible that there are clay zones in the Cowlitz formation beneath the site, either from deposition or weathering. However, the Cowlitz formation was subjected to the same deformation as the overlying volcanics, and bedding planes would likely dip in a westerly direction, away from the Columbia River Valley in contrast to the bedding in other parts of the gorge where large landslides have occurred.

5. Aeromagnetic and gravity profies show no anomalous break that might be associated with bedrock sliding.

6. A major landslide upstream could temporarily block the Columbia River; however, the site intake facility is located at a sufficiently low elevation relative to sea level, that the source of emergency cooling water would not be cut off.

7. In its report entitled "Geologic Hazards Review Trojan Nuclear Power Plant Site Columbia County, Oregon," the Oregon State Department of Geology and Mineral Industries concluded that "available geophysical data and geologic information collectively indicate that the site area is underlain by continuous bedrock and that deep mass movement is not a factor".

It is therefore our conclusion that landslides do not pose a potential threat to the site including the Spent Fuel Pool Facility.

References for Part A, Landslides

1. Bretz, J. H., 1969, The Lake Missoula floods and the Channeled Scabland: Jour. Geology, V. 77, No. 5, p. 505-543.

2. Palmer, L., 1977, Large Landslides of the Columbia River Gorge, Oregon and Washington, Geological Society of America, Reviews in Engineering Geology, Volume III, pp. 69-83.

3. Peterson, R. A., J. E. White & R. K. Dodds, 1972, Geophysical Survey Report Trojan Nuclear Power Plant Site; Prepared by the Trojan Geophysical Advisory Board for the U. S. Atomic Energy Commission, August, 1972.

4. Piteau, D. R., 1977 Regional Slope - Stability Controls and Engineering Geology of the Frazer Canyon, British Columbia; Geological Society of America Reviews in Engineering Geology, Volume III 1977.

5. Portland General Electric Company, 1973, Final Safety Analysis Report, Volume 1.

6. Portland General Electric Company, 1969, Preliminary Safety Analysis Report, Trojan Nuclear Plant, Volume 1.

7. State of Oregon Department of Geology and Mineral Industries, 1978, Geologic Hazards Review Trojan Nuclear Power Plant Site Columbia County, Oregon, Open File Report 78-1, March 14, 1978.

8. U. S. Atomic Energy Commission, 1974, Safety Evaluation Report Trojan Nuclear Plant, Docket No. 50-344, October 7, 1974.

9. U. S. Atomic Energy Commission, 1970, Safety Evaluation Report by the Division of Reactor Licensing, US AEC, In the Matter of Portland General Electric Company, City of Eugene, Oregon, Pacific Power and Light Co., Trojan Nuclear Plant, Docket No. 50-344, October 19, 1970.

B. Volcanism

1. Staff Position After CP and OL Reviews and Current NRC Position

In its Safety Evaluation Report dated October 14, 1970, following the Construction Permit review, the staff concluded that: "The applicant has evaluated potential lava flows, mud flows, and volcanic ash falls and determined that they would not adversely affect the safe operation of the Trojan reactor. We and our consultants, USGS, have reviewed the applicant's evaluations. We conclude that the assumptions and evaluation techniques used by the applicant were reasonable and we agree with the applicant's conclusion."

In the Safety Evaluation Report (October 7, 1974), after reviewing the Final Safety Analysis Report, in support of the application for an operating license, the staff concluded that: "based on this review, we conclude that investigations conducted since the issuance of our Safety Evaluation Report dated October 19, 1970, have disclosed nothing that would alter our original conclusion regarding the suitability of the Trojan Plant Site." Since publication of the SER, new information has become available. We have reviewed these data and we see no reason to change our original conclusion.

2. Basis for the Staff's Conclusions Following the CP and OL Review

During the review for the Trojan site the following potential volcanic hazards were evaluated as to their significance to the Trojan site: ashfall, mudflows, pyroclastic flow, flooding, and lava. Crandell and

Waldron (1969) indicate that if one of the Cascade volcanoes erupts, "we believe that ash eruptions and mudflows are the two greatest hazards."

a. Volcanic Ash. Ash is made up of fine volcanic particles that have been blown high into the air by explosions in a volcano. The extent and thickness of ash fallout is influenced by the altitude to which it has been erupted, sizes of the particles, the directions and velocities of the winds, and other meteorologic conditions. Mount St. Helens is the closest (33 miles east northeast) and most likely source of ash that could affect the site. The applicant stated in the PSAR that even if the ash fall from the Crater Lake eruption were superimposed over Mount St. Helens, the resulting ash fall would not have damaged the plant, nor caused interruption of the cooling water supply. Crater Lake is located in the Cascade Mountains in southern Oregon and was formed by violent eruptions of a volcano (Mt. Mazama) about 7000 years B.C. The staff agreed with that conclusion on the bases that : (1) the site lies near the maximum extent of ashfall when the contours showing the distribution of ash from the Mt. Mazama eruptions according to Williams (1942) are superimposed on Mount St. Helens and other nearby volcanoes (PSAR Figure 2.8-15); (2) the prevailing winds blow away from the plant toward the volcano most of the time and apparently have done so for thousands of years; and (3) the source of emergency cooling water is the Columbia River.

b. Mudflows. "Mudflows are masses of water saturated rock debris which move downslope in a manner resembling the flowage of wet concrete." (Crandell, 1976). Mudflows have been known to move many tens of kilometers down valley floors at speeds of 35 km/hr or more (Crandell, 1976). The possibility of a mudflow from Mount St. Helens endangering the site was considered during the CP stage. The applicant concluded that, "A large mudflow on Mount St. Helens would likely move either down the Kalama River Valley or the Lewis River Valley. The mouth of the Kalama River is close to the Trojan site, but on the opposite side of the Columbia River. It does not seem credible that a debris flow down the Kalama would even reach the Columbia River, let alone that it could block it. If it reached the Columbia River, its probable worst effect would be to muddy the river downstream as the Columbia removed and diluted the flow of debris emptying into it. The slopes are so flat at the point where the Kalama discharges into the Columbia that a mudflow extending that far would be moving very slowly." The staff also concluded that mudflows did not constitute a hazard to the plant.

c. Floods. Floods can be caused by melting of snow on the flanks of a volcano. These floodwaters can carry large amounts of rock debris which can be deposited many kilometers from the volcano. An analysis of the flooding potential due to volcano eruption was made by PGE during the CP stage of the licensing process. The worst case situation was failure of dams and reservoirs along the Lewis River. It was concluded that flooding from the Lewis River reservoirs would not raise the Columbia River enough to inundate the plant.

A similar analysis was not done by the staff; however, the staff's hydrological engineering analysis showed that the plant was safe from flooding even assuming the failure of upstream dams including Grand Coulee Dam. Any flooding caused by volcanic activity would be less severe than the failure of upstream dams on the Columbia River.

d. Pyroclastic flow. As defined by Crandell (1976), pyroclastic flow is a mass of hot, dry rock debris that moves rapidly down the flanks of volcanoes. Because of the distance that Trojan lies from the nearest volcano, and the topography, pyroclastic flow was not regarded as a hazard to the site.

e. Lava Flows. According to Crandell (1976) lava flows generally erupt quitely, but can be proceeded by explosive activity. Lava flows are usually confined to the immediate slopes and toe of the volcano. In order for lava to reach the site it must be highly fluid and of great volume. This is not characteristic of Mount St. Helens and there is no evidence that lava from this volcano reached the

Columbia River. For these reasons lava flows were considered not to present a hazard to the Trojan site.

3. Variation of Volcanic Activity in the Pacific Northwest

The staff finds no evidence indicating that there has been a recent increase in activity of Cascade volcanoes. Evidence is that future activity will continue much as it has in the past 10,000 years. The volcanoes nearest to the Trojan site: Mt. St. Helens, Mt. Rainier, and Mt. Hood are considered active volcanoes. The available evidence indicates that activity has been essentially constant though episodic for at least the last 10,000 years. Historic data show that Mount St. Helens was substantially more active during the 19th Century than during the 20th Century. The enclosed figure is a compilation of known activity of several Cascade volcanoes including those most significant to the Trojan site. The illustration is based on data published by several investigators, which was presented in Portland General Electric's report entitled "Volcanic Hazard Study, Potential for Volcanic Ash Fall, Pebble Springs Nuclear Site, Gilliam County, Oregon." It can be seen from this illustration that Mt. Rainier and Mt. Hood have undergone sporadic activity for at least the last 10,000 years and Mount St. Helens for 4,000 years. This type of activity is expected to continue in the future.

Worldwide data on plate tectonic activity support this interpretation. The volcanic activity is related to processes at the plate boundary in this region. Data indicate that plate tectonic activity in the United States Pacific Northwest is either continuing at a relatively slow rate as compared to most tectonically active regions around the world, or has stopped completely. This would explain the relative inactivity of the Cascade volcanoes, when compared to world wide data. For example, in the vicinity of the Aleutian Trench, where the Pacific Plate is actively subducting beneath the Alaskan Plate, volcanoes have erupted far more frequently historically and with greater violence than in the U. S. Pacific Northwest.

It is not possible to absolutely rule out that Mt. Hood, Mt. Rainier, or Mt. St. Helens could experience similar eruptions like those that formed Crater Lake. Crater Lake was created after violent eruptions of Mt. Mazama about 7000 years B.C. However, such an occurrence is considered to be very unlikely within the next few centuries (Crandell and Mullineaux, 1975). It would represent a complete change in activity from that demonstrated during the last 10,000 years for Mt. Hood and Mt. Rainier and 4000 years for Mount St. Helens. Such an eruption at one of these volcanoes occurring simultaneously with the wind blowing toward the site is extremely remote. Therefore it is reasonable to assume that the worst events that have occurred in the geologic past at a specific volcano could occur there again.

It is the staff's position that any increase in volcanic activity that is postulated, based on a study of the activity of the Cascade volcanoes for the past 10,000 years is not likely to present a hazard to the Trojan site. We believe that there will be no increase in activity based on the experience of the past 10,000 years. Evidence from the plate tectonic theory supports this position.

4. Data Subsequent to the SER's

Considerable additional studies have been made of the volcanic hazards of the Pacific Northwest since publication of the Safety Evaluation Reports. Many of these studies have been conducted in regard to the siting of nuclear power plants, such as the Washington Public Power Supply System (WPPSS) Nuclear Project 3 and 5, the Puget Power Skagit site, and the Portland General Electric Pebble Springs site. The data included in the reports supporting license applications for these sites are compilations of data from many investigators. The USGS has published studies of volcanoes in the Pacific Northwest, among which are volcanic hazard assessment maps (Crandell, 1976 and Mullineaux, 1976).

The analysis of volcanic hazard for the WPPSS 3 and 5 site, which is 80 miles from the nearest volcano (Mt. Rainier and Mount St. Helens) indicated that only ash could affect the site. It further showed that less than 2 inches of ash would fall at the site even if the assumption is made that a Mt. Mazama type eruption occurred at Mt. Rainier or Mount St. Helens.

Based on a recommendation from the USGS, Puget Power postulated that a mudflow similar to the Osceola mudflow from Mt. Rainier could occur at Mt. Baker, which is about 22 miles east of the Skagit site. The analysis showed that such a mudflow would not adversely affect the site. Ashfall is believed to be the only form of eruption that poses a direct hazard to the Skagit site (USGS, 1977). The Skagit site is located about 56 miles from Glacier Peak, the nearest volcano with an explosive history. Based on the superposition of the 1912 Katmai Alaska eruption on Glacier Peak, about 2 inches of ash would fall at the site. The Applicant assumed a maximum ash accumulation of 6". The staff and the USGS concluded that this was a conservative approach.

Unlike the WPPSS 3 and 5, Skagit and Trojan sites, the Pebble Springs site is located east and downwind of the Cascade volcanoes. During the review of the volcanic hazard for the Pebble Springs site, it was our position, and that of the U. S. Geological Survey, that a conservative and reasonable estimate of a maximum potential ash fall at the site should be modeled after the Yn ash layer which was erupted from Mt. St. Helens between 3,000 and 4,000 B.C. This analysis resulted in the assumption of a thickness of 8 1/2 inches of uncompacted ash at the site, which is located 80 miles and 105 miles east of Mt. Hood and Mount St. Helens respectively. Since publication of the SER's the USGS has published 2 Volcanic Hazards Maps (Crandell, 1976 and Mullineaux, 1977). The former designates zones in the state of Washington within which specific volcanic hazards are possible. The latter shows volcanic hazard zones in the western United States. The USGS also open filed a report entitled Potential Hazards from Future Eruptions of Mount St. Helens Volcano, Washington (Crandell and Mullineaux, 1976).

5. Impact of Subsequent Data on Original Conclusions

Based on the data that the staff is aware of, which has come to light since the CP & OL proceedings, the only form of volcanic eruption that could directly affect the Trojan site is ash fall. However, new information has become available regarding several of the other potential hazards. These will be addressed first, followed by a discussion of ashfall.

Crandell (1976) and Figure 2.5.18 of the WPPSS Nuclear Project No. 3 Preliminary Safety Analysis Report, which is based on data presented by Crandell (1973), shows mud flow deposits just north of Longview, Washington in the Cowlitz River Valley. During its evaluation of this phenomenon PGE concluded that because of the distance from the volcano, and consideration that the intersection of the Cowlitz and Columbia Rivers was located downstream from the plant there was no potential hazard to the Trojan plant. Crandell (1976) also shows a potential mudflow hazard within the Kalama River Valley extending to about 8 miles from its intersection with the Columbia River. This does not present a threat to the Trojan site. Much larger mudflows have occurred in the region such as the Osceola mudflow from Mt. Rainier, which was used as a model for the maximum possible mudflow during the Skagit site review. However, since Mount St. Helens is a relatively young and unaltered volcano, one would not expect such large quantities of potential mudflow material to be available on its flanks as on those of the older altered volcanoes like Mt. Rainier and Mt. Baker. According to Crandell and Mullineaux (1976), "The absence of an appreciable amount of clay in mudflows from Mount St. Helens suggests that large areas of hydrothermally altered rock did not exist on the volcano in the past; nor are they present today. For this reason, mudflows as large as the largest from Mount Rainier volcano (Crandell, 1971) are not likely to occur in the foreseeable future at Mount St. Helens." Because of the distance from the Trojan site to the volcano, the nature of the intervening topography, the site being outside of the mudflow hazard zone specified by Crandell (1976), and the youthfulness of Mount St. Helens, we consider our earlier conclusion that mudflows do not constitute a threat to the Trojan site, as being still valid.

Crandell (1976) shows the potential for volcano induced flooding at the Kalama and Lewis Rivers. As stated earlier, flooding from these sources would be less than the assumption of failure of upstream dams on the Columbia River. The site is considered to be safe from such events.

The distribution and thickness of ash deposits east of the Cascade volcanoes are relatively well documented, at least those that originated within the last 10,000 years. The distribution of ash to the west of the volcanoes is not well documented, partly because the prevailing winds blow mostly toward the east, therefore, most ash has been transported in that direction; and partly because investigations have not been conducted west of the volcanoes to the extent that they have to the east. According to Crandell (1976) "No significant amount of tephra has fallen in the western sector beyond the base of the source volcano during the last 4,000 years at Mt. St. Helens, or during the last 10,000 years at the other large volcanoes in Washington." Crandell (1976) and Mullineaux (1976) selected the respective tephra hazard zones west of each volcano to be 25% as great as those in the eastern sector, although the few ash beds known to exist west of their source vents are less than 10% of the distance that similar beds extend east of the source vents (Mullineaux 1976). This number is not completely arbitrary as it is based on the knowledge that not only do the prevailing winds blow to the east most of the time, but on the rare occasions when they are blowing to the west, velocities are significantly less. This is demonstrated by attached tables 3 and 4 from Crandell and Mullineaux (1976).

The Trojan site is near the outer boundary designated as zone B by Mullineaux (1976), and described as an area subject to 5 cms or more of ash from a "large" eruption similar to the Mount St. Helens eruption about 3,400 years ago. The site is located in an area designated by Crandell (1976) as one of very low to low potential hazard to known human life and health, and one of probable maximum tephra thickness of less than 5 cms. With regard to the spent fuel building, the weight of 5 cm of uncompacted ash on the fuel building roof would impose loads well within the design limits of the roof. (FSAR Table 3.8-2 gives live load design limits for facility roofs.)

The staff concludes that information that has become available since publication of the SER's does not cause us to alter our original conclusions that the site is suitable from a volcanic hazards standpoint including the spent fuel pool.

6. Conclusions

a. It is the staff's position that there is no present increase in volcanic activity in the Cascade volcanoes. Available evidence indicates that activity has been relatively consistent over the past 10,000 years. The historic record shows that Mount St. Helens was far more active during the 19th Century than during the 20th Century. Future activity is expected to be similar to that which has occurred during the past 10,000 years. A very large eruption, like the Crater Lake eruptions, of one of the larger Cascade volcanoes cannot be completely ruled out. However, such an occurrence simultaneous with high altitude winds blowing toward the site is considered to be extremely remote. Any increase in volcanic activity that is postulated, based on the activity of the Cascade volcanoes for the past 10,000 years is not likely to present a hazard to the site.

b. Because the Trojan site was shown to be safe from a more severe hydrologic event (failure of upstream dams on the Columbia River, including Grand Coulee Dam), floods caused by volcanic activity will not present a hazard to the site.

c. Due to the distance of the Trojan site from the Cascade volcanoes and the topography, pyroclastic and lava flows do not pose a threat to the site.

d. Mount St. Helens is a young, unaltered volcano; therefore, large quantities of potential mudflow material are not likely to be available on its flanks. We conclude that mudflows are not likely to threaten the site.

e. Ashfall is considered to represent the greatest potential hazard in this part of the Northwest. It is unlikely that any ash will fall on the Trojan Plant because the prevailing winds blow away from the plant and toward the volcano; and even during those rare times when they blow toward the plant, velocities are significantly lower. Superposition of the ash distribution from the Mt. Mazama eruptions at Mount St. Helens would not adversely affect the safe shutdown capability of the site.

f. In its March 18, 1978 report to the State Department of Energy entitled "Geologic Hazards Review Trojan Nuclear Power Plant Site, Columbia County, Oregon," the State of Oregon Department of Geology and Mineral Industries concluded that "no new evidence has come to light to require modification of conclusions regarding volcanic hazards as they are presented in the FSAR."

g. The Applicant committed in the SAR's to take the necessary steps to mitigate the effects of a volcanic eruption including shutting down the plant.

References in items (a) through (e) to the "site" include the spent fuel pool.

Based on the above, the staff reaffirms its conclusion following the licensing reviews, that the Trojan site, including the spent fuel pool, is suitable from the volcanic hazards point of view.

REFERENCES
FOR PART B - VOLCANISM

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2. Crandell, D. R., 1976, Preliminary Assessment of Potential Hazards from Future Volcanic Eruptions in Washington, U. S. Geological Survey Misc. Field Studies Map MF-774.

3. Crandell, D. R., 1973, Map Showing Potential Hazards from Future Eruptions of Mount Rainier, Washington, USGS Map I-836.

4. Crandell, D. R., and H. H. Waldron, 1969, "Volcanic Hazards and the Cascade Range," Office of Emergency Preparedness, Region Seven, Geologic Hazards and Public Problems Conference Proceeding, Santa Rose, Calif. (May 27-28, 1969).

5. Crandell, D. R., and D. R. Mullineaux, 1976, Potential Hazards from Future Eruptions of Mount St. Helens, Volcano, Washington, U. S. Geological Survey Open File Report 76-491.

6. Mullineaux, D. R., 1976, Preliminary Map of Volcanic Hazards in the 48 conterminous United States, MF-786.

7. Portland General Electric Company, 1973, Final Safety Analysis Report, Volume 1.

8. Portland General Electric Company, 1969, Preliminary Safety Analysis Report, Trojan Nuclear Plant, Volume 1.

9. Puget Sound Power and Light Company, 1973, Preliminary Safety Analysis Report Skagit Nuclear Power Project, Volume No. 4.

10. Shannon & Wilson, Inc., 1976, Volcanic Hazard Study Potential for Volcanic Ash Fall Pebble Springs Nuclear Plant Site, Gilliam County, Oregon, Revision 1, May 17, 1976, Report to Portland General Electric Company.

11. U. S. Atomic Energy Commission, 1970, Safety Evaluation Report by the Division of Reactor Licensing, US AEC, In the Matter of Portland General Electric Co., City of Eugene, Oregon. Pacific Power & Light Co. Trojan Nuclear Plant, Docket No. 50-344, October 19, 1970.

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13. U. S. Geological Survey, 1977, Status of Review Puget Sound Power and Light Company, Skagit Nuclear Power Project, Units 1 & 2 Project No. 514, Skagit County, Washington, NRC Docket Nos. 50-522 and 50-523.

14. State of Oregon Department of Geology and Mineral Industries, 1978, "Geologic Hazards Review Trojan Nuclear Power Plant Site Columbia County, Oregon," Open File Report 78-1, March 14, 1978.

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16. Washington Public Power Supply System, 1974, Preliminary Safety Analysis Report WPPSS Nuclear Project No. 3, Volume 3.

17. Williams, H. A., 1942, "The Geology of Crater Lake National Park, Oregon," Carnegie Institution of Washington Publication 540, 1942.

Table 3.--Mean wind speeds, in knots (1 knot = 1.15 mi/h or 1.85 km/h), at various altitudes. Based on 20-year record (1950-1970) at Quillayute, Wash. (Winds Aloft Summary of the Air Weather Service, U.S. Air Force, available from the National Climatic Center, Asheville, N.C.)

FROM-----	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
TOWARD---	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
Approx. alt. (m)																
3,000	18.6	16.3	14.8	11.5	11.6	12.4	13.8	18.1	24.2	25.7	25.4	24.2	23.5	21.8	22.4	21.2
4,300	26.7	21.7	18.7	15.1	13.7	15.5	18.2	21.5	27.2	30.7	31.3	31.1	31.0	29.4	29.6	28.5
5,500	33.2	27.8	27.9	18.5	17.6	16.8	20.8	22.9	32.2	36.6	38.6	38.3	38.4	37.3	35.7	36.9
9,100	48.6	43.8	36.5	29.9	30.2	26.4	32.2	38.0	46.8	52.5	55.9	55.4	56.2	50.8	51.6	53.9
12,200	40.9	31.5	30.3	14.9	19.7	16.9	18.8	28.0	35.8	43.8	48.5	50.3	50.9	46.2	46.3	45.4
16,200	20.1	12.4	11.3	6.3	6.4	9.0	9.7	13.8	15.5	21.1	23.7	25.8	26.2	25.1	23.7	21.4
Average--	31.4	25.6	23.2	16.0	16.5	16.1	18.9	23.7	30.3	35.1	37.2	37.5	37.7	35.1	34.9	34.6

From: Crandell, D.R. and D.R. Mullineaux, 1976, Potential Hazards from Future Eruptions of Mount St. Helens Volcano, Washington, US Geological Survey Open File Report 76-491.

POOR ORIGINAL

Table 4.--Percentage of winds, by month, at six altitudes from about 3,000 to 16,000 m, averaged. Based on 20-year record (1950-1970) at Quillayute, Wash. (Winds Aloft Summary of the Air Weather Service, U.S. Air Force, available from the National Climatic Center, Asheville, N.C.)

FROM-----	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
TOWARD---	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
JAN------	3.4	1.4	0.7	0.5	0.5	0.2	0.5	1.0	2.7	6.8	12.5	16.9	18.4	15.2	11.9	7.0
FEB------	3.9	1.9	1.3	.6	.8	1.1	2.0	1.8	3.7	6.5	10.8	14.2	16.4	15.2	12.3	7.4
MAR------	4.5	2.1	1.1	.5	.9	.9	.9	1.5	4.3	8.4	12.2	14.2	15.5	12.7	12.8	7.6
APR------	4.2	2.7	2.1	1.4	1.2	1.3	1.6	2.6	4.8	7.0	11.9	13.4	14.8	12.2	11.3	7.6
MAY------	4.4	2.2	1.6	1.0	1.0	1.6	3.0	3.9	6.9	8.6	13.6	15.0	13.0	10.1	7.7	6.0
JUNE-----	3.7	2.8	2.3	1.7	1.4	1.5	1.7	2.8	6.0	9.0	13.9	14.9	13.4	10.0	8.6	6.2
JULY-----	3.1	1.9	1.4	1.0	.9	.9	1.1	2.2	4.0	8.6	18.9	19.8	13.8	9.4	7.5	5.7
AUG------	3.1	2,3	1.5	1.0	1.0	1.2	1.6	2.6	5.1	9.0	15.8	17.6	14.7	10.0	8.1	5.4
SEPT-----	5.3	2.4	1.6	1.1	1.2	.8	1.2	2.2	3.2	7.9	12.2	12.7	14.7	14.7	11.3	7.7
OCT------	2.2	1.4	.7	.4	.2	.2	.5	1.1	3.8	8.7	16.6	19.9	19.2	12.5	7.8	4.6
NOV------	3.3	1.4	.5	.2	.4	.4	.8	1.7	3.5	8.1	13.9	17.0	20.2	14.0	11.3	5.1
DEC------	3.1	1.2	.4	.3	.3	.3	.5	.9	3.2	8.8	14.4	17.4	18.5	14.4	10.5	6.0
AVERAGE--	3.7	2.0	1.3	0.8	0.8	0.9	1.3	2.0	4.3	8.1	13.9	16.1	16.1	12.5	10.1	6.4

From: Crandell, D.R and D.R. Mullineaux, 1976, Potential Hazards from Future Eruptions of Mount St. Helens Volcano, Washington, U.S. Geological Survey Open File Report 76-491

REVISED ______ DATE ______ APPROVED ______ DATE ______

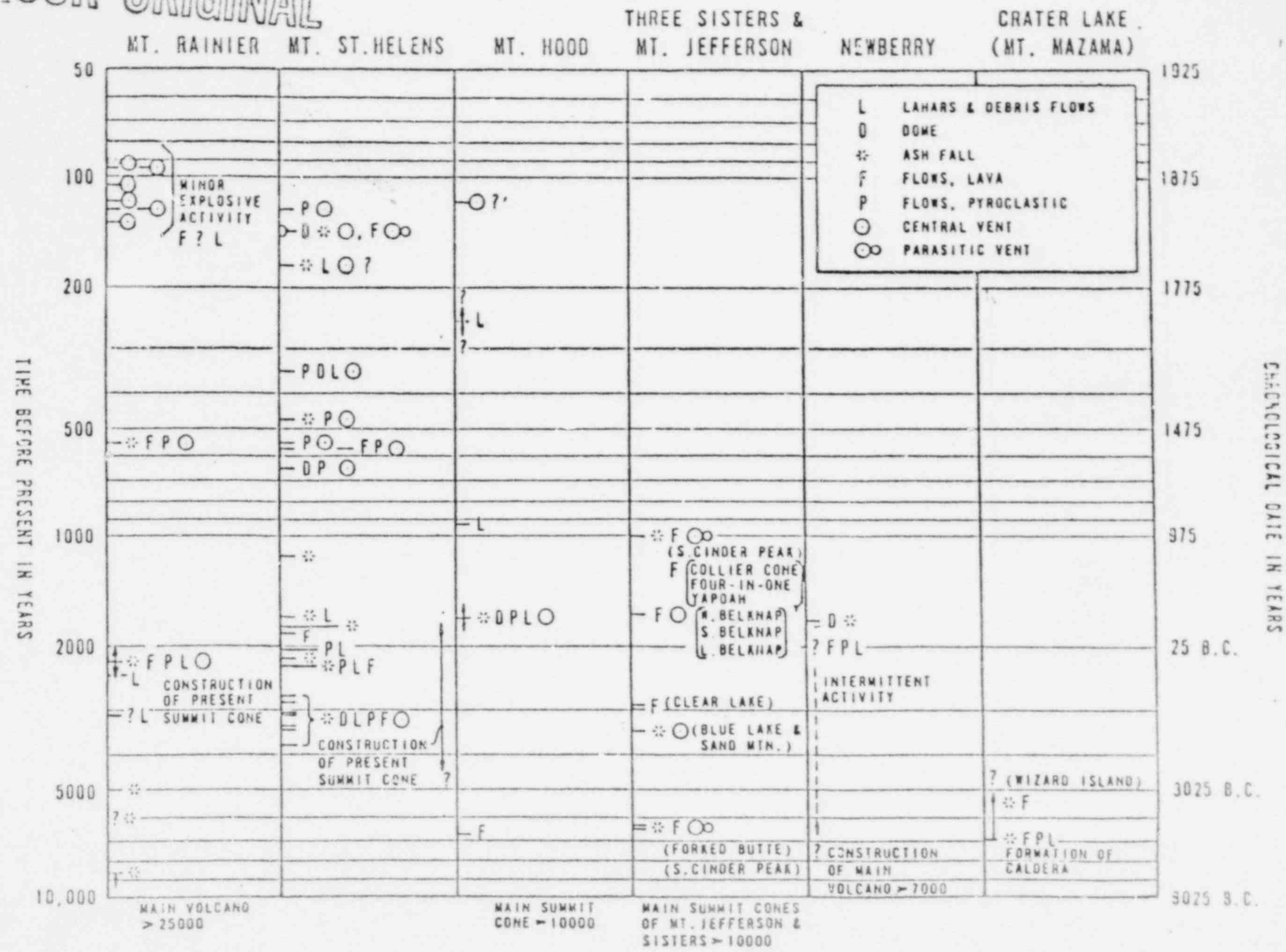

FIG. 6 SUMMARY OF POSTGLACIAL VOLCANIC ACTIVITY

From: Shannon and Wilson, Inc., 1976, Volcanic Hazard Study Potential for Volcanic Ash Fall Pebble Springs Nuclear Plant Site, Gilliam Co., Oregon, No. 1, May 17, [illegible] Report to PG[illegible] Co.