

A REVIEW OF GEOLOGIC CONDITIONS
AT THE PEBBLE SPRINGS NUCLEAR PLANT SITE

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and N. V. Peterson
Oregon Department of Geology and Mineral Industries

Open-file report prepared for
Nuclear and Thermal Energy Council

0-75-1

February 1975

A REVIEW OF GEOLOGIC CONDITIONS AT THE PEBBLE SPRINGS
NUCLEAR PLANT SITE

Summary

The Department's staff and its consultants have reviewed the geologic and seismic investigation reports made by PGE for the Pebble Springs nuclear site and find that they accurately and comprehensively define geologic conditions in the region. There are points of contention with some of the interpretations regarding regional geologic history, basalt stratigraphy, and origin of certain volcanic rocks but these disagreements do not change the main conclusions regarding safety of the site. We concur with the general conclusions of PGE consultants and commend PGE for the detail and quality of its investigations. The Pebble Springs site appears to be geologically acceptable for construction of a nuclear power plant.

The ground acceleration value to be used in seismic design should be determined by the Nuclear & Thermal Energy Council before a construction permit is issued. Two values were cited in the PGE report; 0.20g and 0.15g. Also, the recommendation by J. R. Bell, Soil Mechanics and Foundation Consultant, should be acknowledged before final approval is given regarding geologic conditions at the site. The Department expects to be notified when additional trenching is completed so that its representatives can view the exposed bedrock.

Scope of the Review

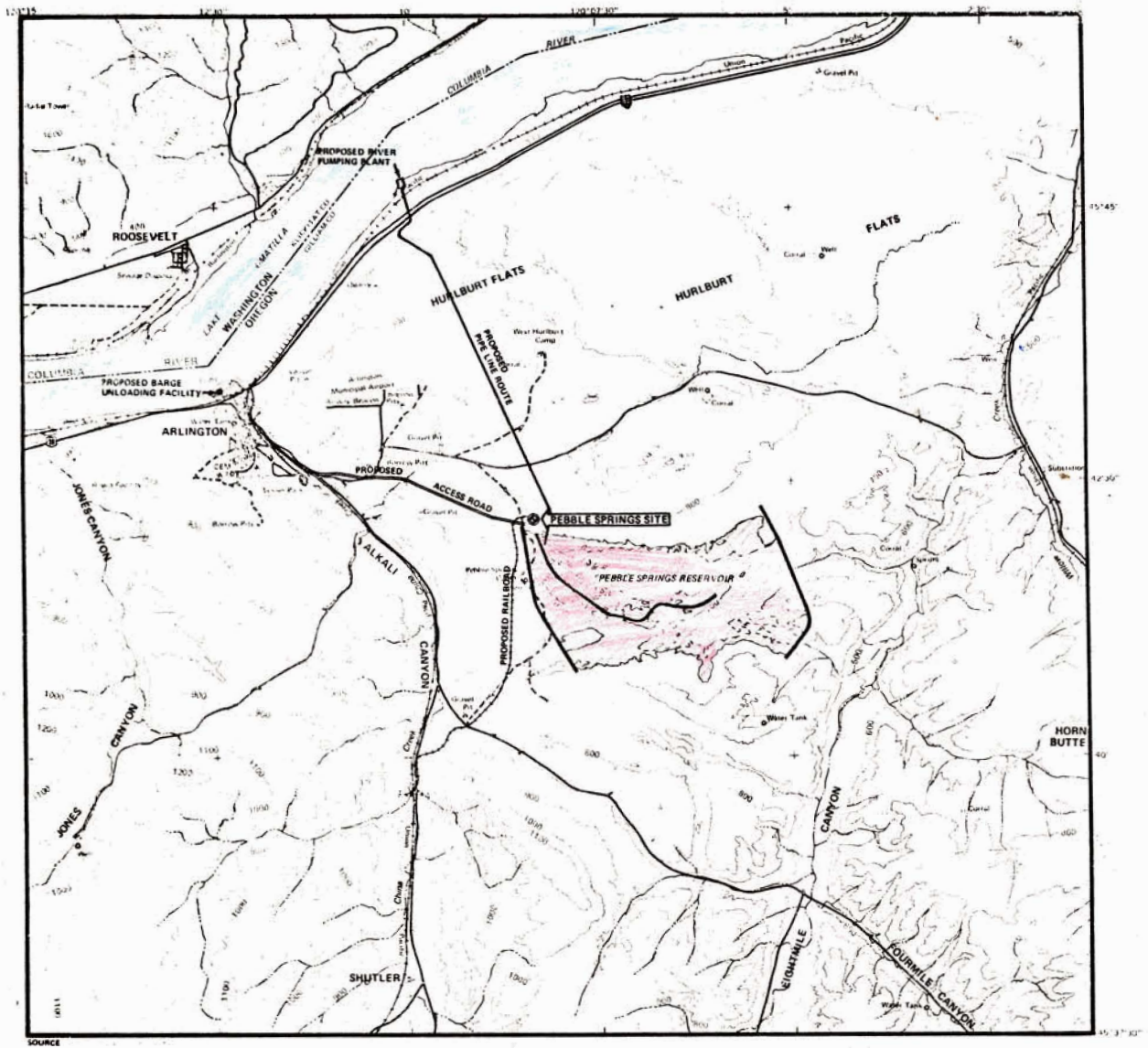
We have reviewed all of the reports made by PGE concerning geology and seismicity as well as other published geologic investigations made in the Columbia Plateau region. We also attended several meetings with PGE consultants to discuss various phases of their investigations and later conducted our own field investigations to confirm the work done by PGE.

J. R. Bell, Professor of Civil Engineering at OSU, was contracted by the Department to examine foundation test data and laboratory reports to determine if conclusions regarding this material were consistent with the data presented. R. D. Bentley, Professor of Geology at Central Washington State College, was employed to review regional tectonic reports and to comment on stratigraphic correlations. A summary of comments by Bentley are contained in the appendix at the end of this report. J. R. Bell's recommendations will be submitted at a later date as the reports he is to comment on were not issued until the latter part of February 1975. Memorandum reports on field investigations by N. V. Peterson and V. C. Newton are included in the appendix.

Location of the Plant Site.

The proposed Pebble Springs nuclear site is situated 2 miles southeast of Arlington, a port city on the Columbia River in north-central Oregon (see Figure 1). Pebble Springs served as a watering place and sheepherder's camp many years ago. The plant site and reservoir will be constructed on a plateau approximately 500' above river level. At present, the land is used mainly for grazing of cattle and is poorly suited for other agricultural use.

Figure 1



SOURCE



Geologic Summary

The Pebble Springs site lies in a region underlain by the Columbia River Group, a thick series of late Miocene flood basalts that covers a large part of northeastern Oregon and southeastern Washington. The upper flow units interfinger with gravels and lake-bed sediments of the Ellensburg Formation. Overlying the Columbia River Group are Pliocene gravels of the Dalles Formation and Pleistocene gravels and wind-blown silt.

In the Pebble Springs area, the Pomona flow, which is one of the upper units of the Columbia River Group, forms the surface of the plateau. The younger sediments have been scoured off by the ancestral Columbia River and only a few remnant ridges of Ellensburg and Dalles gravels remain on the Pomona surface.

Structural Summary

The Pomona flow and underlying units of the Columbia River Group are warped into folds and in some places broken by faults. The general regional trend of the folds is east-west and that of the faults is northwest-southeast (see Figure 2). Several folds and one fault are present in the vicinity of the Pebble Springs site. As shown on Figure 2, the axis of the Dalles-Umatilla syncline passes just north of the proposed nuclear power facility. A small, unnamed anticline trending parallel to the large synclinal structure passes through the south half of the reservoir. The high ridges forming the north bank of the Columbia River across from Arlington are part of a large fold called the Columbia Hills anticline which extends from The Dalles 70 miles east to Wallula Gap.

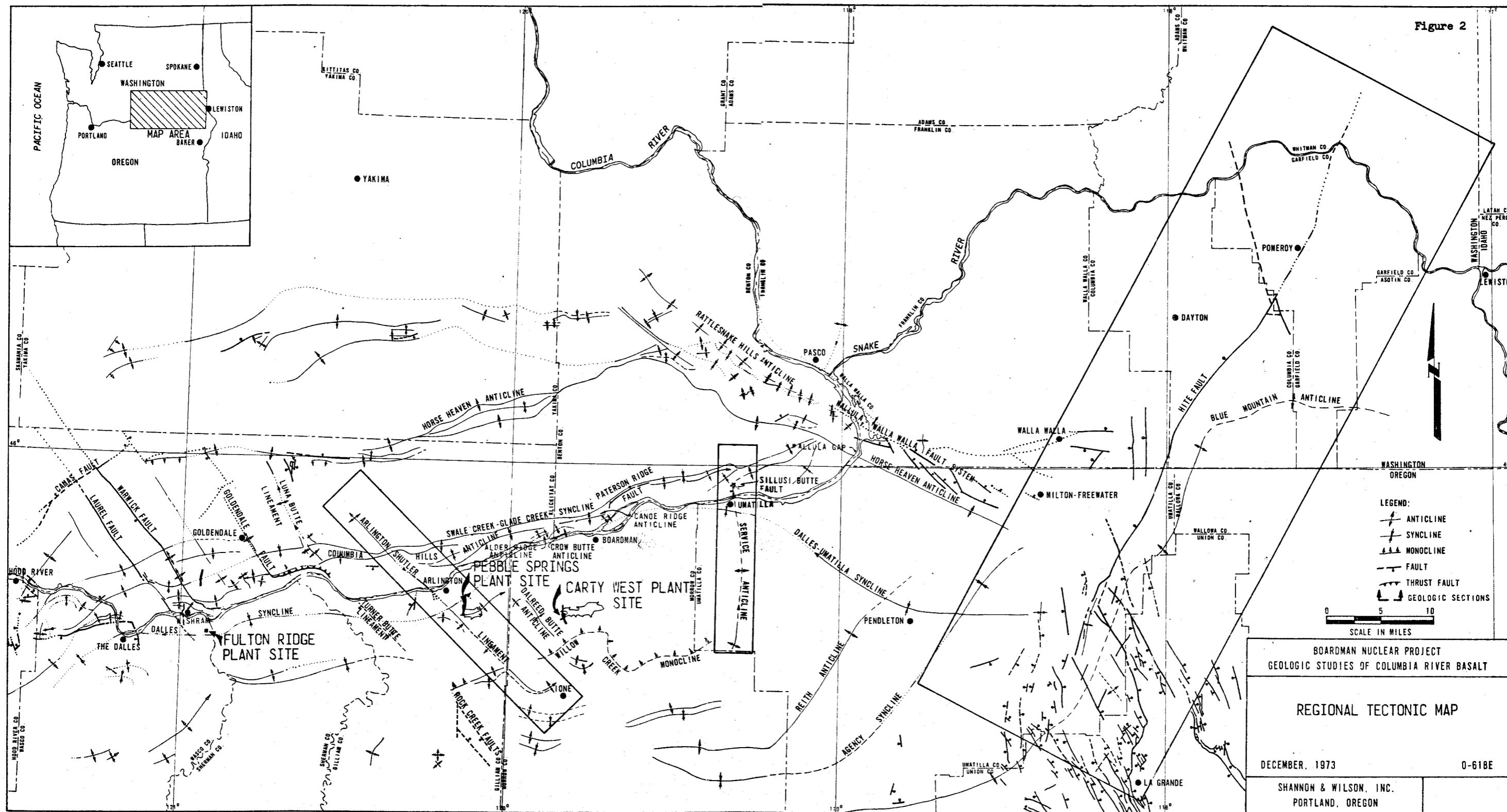
The Arlington-Shutler structure, a northwest-trending lineament, lies 3 miles west of Pebble Springs. It is of particular concern to the proposed

project because a fault is projected by field mapping along its crest for a distance of 9 miles. Because this fault is quite close to the site, investigators deemed it imperative to date the age of latest movement. The evidence for late fault movement described later in the review showed that the last movement occurred more than 700,000 years ago. Geologists who have studied the Columbia Plateau indicate that the last major tectonism in this region occurred near the end of the Pliocene epoch and in the early part of the Pleistocene epoch and that regional deformation had subsided by middle Pleistocene time. No evidence was uncovered in the site studies to suggest that tectonic activity had affected rocks of late Pleistocene age or younger.

Major faults and folds reflect past stress patterns in the earth's crust and the most recent trends can be used to estimate where future movements will occur. The work by Shannon & Wilson and others show that north to northwest trending structures are cut by generally east-west trending folds indicating that crustal stress changed in the last few million years. The east-west folds are believed to be the youngest structures. Several of these major structures were described by Shannon & Wilson to obtain an estimate of latest movement in the Pebble Springs region.

The Columbia Hills anticline is a large east-west trending fold system that plunges from 1,800' elevation near Wishram, Washington to 100' at Wallula Gap where it terminates against the Wallula-Walla Walla Fault system. This fault system was found to be the most probable earthquake producing structure in the region.

Three large northwest trending faults, the Laurel, Warwick and Goldendale, cross the west end of the Columbia Hills anticline. Lesser faults have been mapped along the crest of the Columbia Hills northeast of Boardman (Paterson Ridge Fault) and along the axis of the Arlington-Shutler lineament a few



miles northwest of the Pebble Spring site. The magnitude of folding and faulting can be seen to increase going westward toward the Cascade Range.

Evidence for Latest Fault Movement

What appears to the writers to be the latest fault movement in the region is seen at the south end of the Warwick fault, another major fault 25 miles west of Arlington, where it crosses the Columbia Hills. Basaltic lavas approximately 0.9 million years old by K Ar dating issued from a vent at Haystack Butte and flowed down the south slope of the Columbia Hills near the town of Wishram, Washington and covered the fault. This relationship is visible in a small canyon just east of Highway 14 on the hillside above Miller Island. The young lava does not appear to have been disturbed by any more recent earth movement.

The age of faulting near Pebble Springs has been inferred from the above cited evidence and from studies of regional tectonism. PGE and its consultants appear to have explored the region thoroughly for information on the latest age of fault movement.

The closest potentially active fault structure, the Wallula-Walla Walla system, lies approximately 55 miles northeast of Pebble Springs. A great deal of recent seismicity is associated with this fault. The Goldendale fault, 15 miles west of the plant site, is the closest known major fault. It has been mapped as a low-angle thrust which developed as folding steepened the south limb of the Columbia Hills anticline. The Goldendale fault presumably continues northwesterly as a strike-slip type but no actual fault surface has been found along the trend, its surface trace is postulated on the basis of topographic expression. Evidence for the latest movement along this structure is inconclusive but is estimated

to be more than 700,000 years ago based upon paleomagnetic studies of the Simcoe Lavas which overlies the projected fault trace north of Goldendale, Washington.

The Paterson Ridge fault was mapped as having a normal-type displacement of approximately 200 feet, down on the north side. The fault is postulated from apparent offset of the basalt flow which forms the ridge. The actual fault plane is not exposed. Younger rock has been eroded from the hill top so it is not possible to estimate the latest age of movement except by inference to regional tectonism.

There is indication of possible faulting 3 miles west of the Pebble Springs site where a linear depression occurs along the crest of the Arlington-Shutler structure. Although the evidence for fault movement at this location is inconclusive, shear zones can be seen approximately 2 miles to the north where the Arlington-Shutler structure is intersected by Highway 80N. This same structure can be traced northwesterly to the Washington side of the Columbia River where it is characterized by a linear coulee. A railroad fill on the Washington shore obscures any other positive evidence of a fault, if it does occur here. The fault is given a probable length of 9 miles based upon topographic features. Because movement along the fault appears to have been less than 100' vertically, this is not a major fault zone but more likely a breaking up of the basalt flows due to folding stress. No other evidence of fault movement has been found along the more than 30-mile length of the Arlington-Shutler lineament. Dating of the latest fault movement is not possible along the structure because the youngest rock units have been removed by erosion.

Earthquakes and Seismic Design

Oregon is only moderately active seismically while portions of adjoining

Figure 3

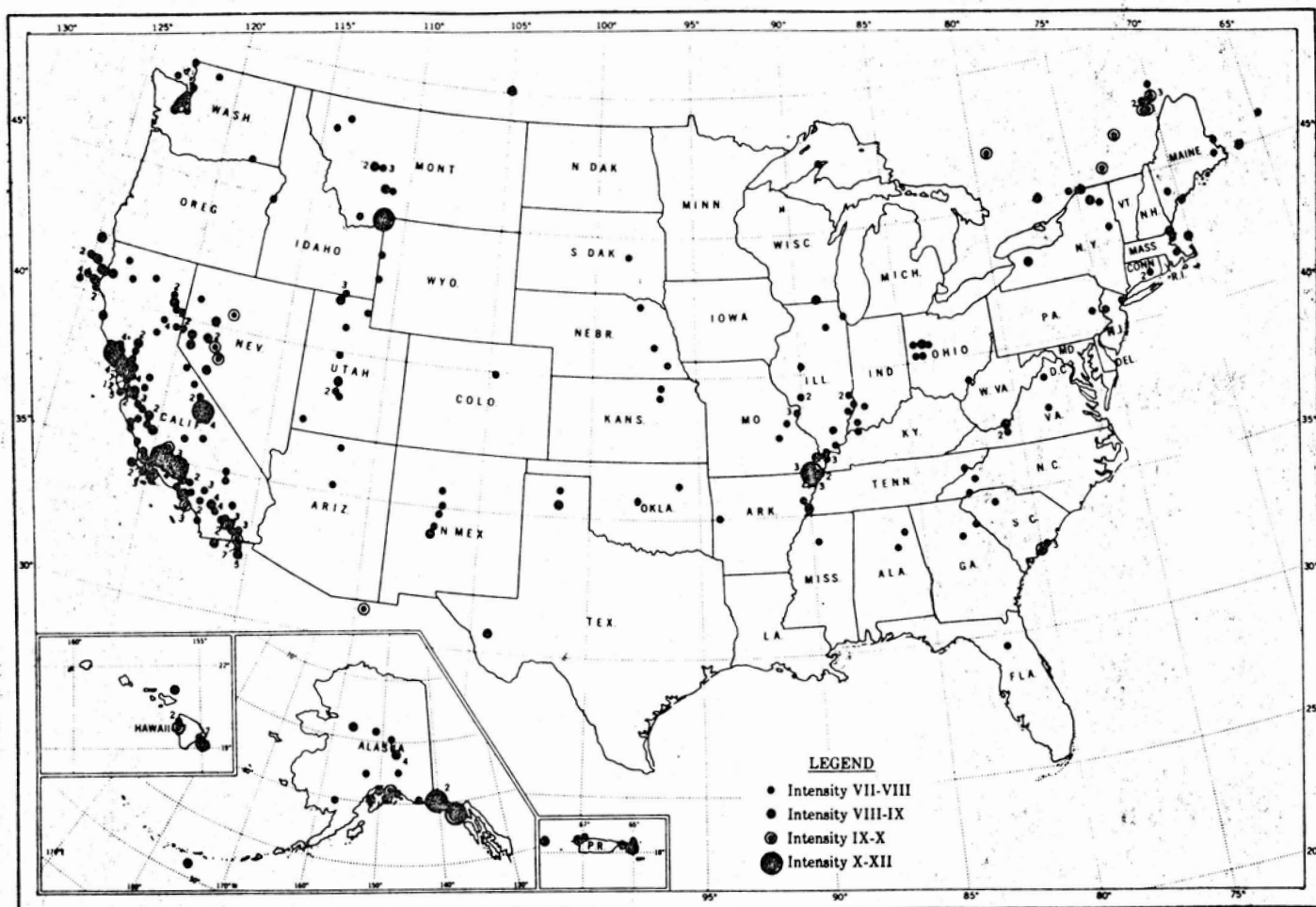


Figure 3 Damaging earthquakes in the United States through 1969 (von Hake and Cloud, 1971).
NOAA 1969

states contain seismically active areas (See Figure 3). Only two historic earthquakes have been recorded within 20 miles of Pebble Springs, both of these were MM Intensity II. The epicenter of one of these was located near Arlington. The proposed nuclear site is approximately equidistant between the seismically active Cascade Range and the Wallula-Walla Walla fault system (a distance of 55 miles) and it is probable that earthquakes of moderate size will continue to occur at both places. Micro-earthquake studies in the Boardman region by Stewart W. Smith & Associates substantiate that the Arlington area is one of low seismicity.

Page 2.5-4 of the May 1974 PGE "Site Characteristics Report," a design basis for vibratory ground motion of 0.15g is recommended. In this same report, on page 2.5-100, a ground acceleration design factor of 0.20g is recommended. The conservative design for ground acceleration is stated to be 0.15g on page 8-52 of the "Site Certificate Application," December 14, 1974. The apparent contradiction should be resolved. The reviewers to not favor the lower design factor. Figure 2.5-30 of the "Site Characteristics Report" shows that an MM Intensity VII earthquake 20 to 40 miles from the site will probably produce a peak acceleration of between 0.20g and 0.09g at the site. The 0.20g design for 55 miles is conservative.

Potential Volcanism

Eruptions of lava and ash have been fairly common events in the Cascade Range up until the last few thousand years. (See Figure 4). In historic time such eruptions have been of minor significance. However, the past activity suggests that eruptions will continue to occur along this north-trending alignment of volcanoes. Detailed studies of Mt. Rainier (Crandell and Waldon, 1973) show there have been more than a dozen eruptions from this

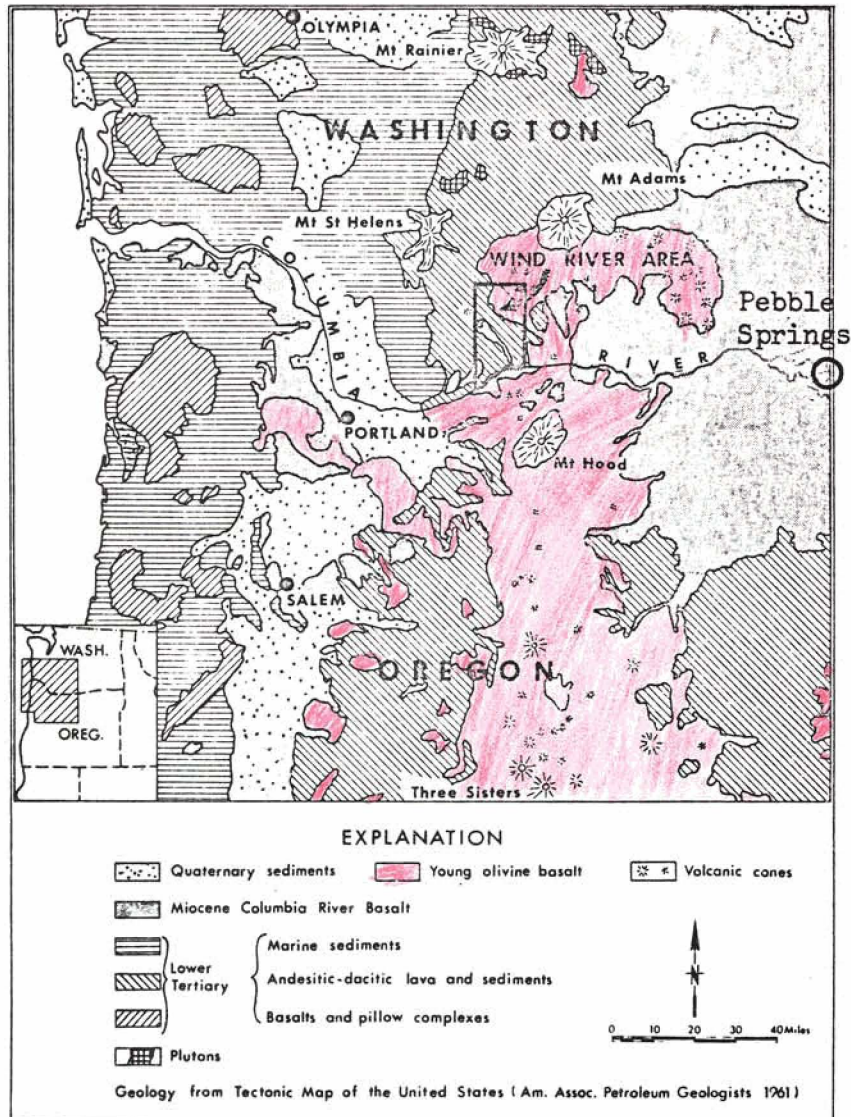


Figure 4 (Wm S. Wise, 1970.)

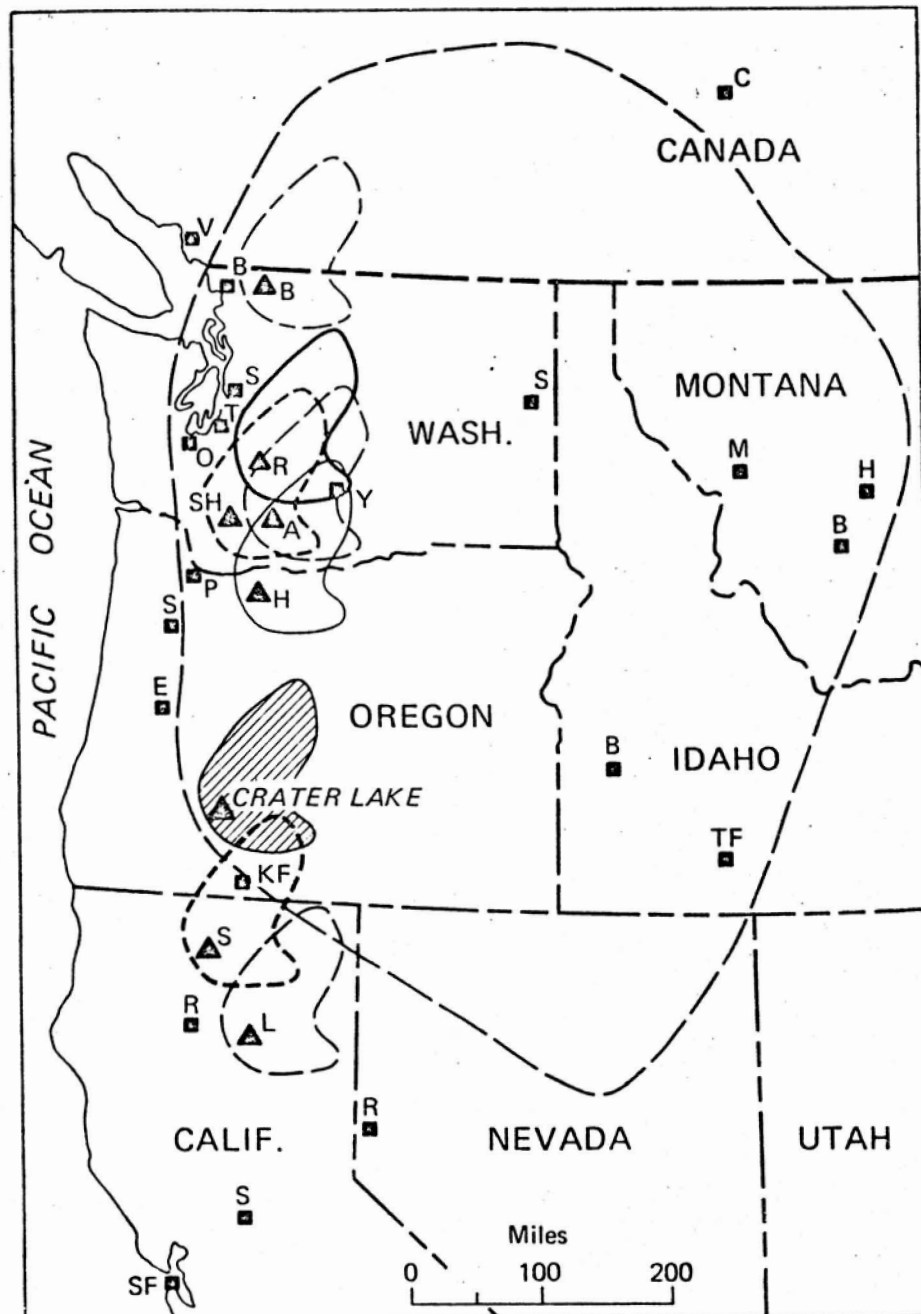


FIG. 5. Map of Cascade Range, showing area covered by pumice eruption at site of Crater Lake about 7,000 years ago. The outer line shows maximum limits of ash fall; inner line (pattern) shows area covered by 6 inches or more of pumice. The same 6-inch thickness line is shown superimposed on the other major volcanoes of the range. Data from reports by Howel Williams and H. A. Powers and R. E. Wilcox.

vent and 55 mud flows within the last 10,000 years. The youngest mudflow occurred 450 years ago and extended 30 miles from the base of the mountain. An ash eruption from Mount St. Helens 3,500 years ago deposited 2 feet of pumice 50 miles from the vent.

Post ice-age lavas issued from near Mt. Adams along the trend of the Warwick fault zone. This event made the Fulton Ridge site a questionable location for a nuclear plant (Shannon & Wilson, Age of Deformation Report, page 52). Lavas 0.9 million years old poured from Haystack Butte and covered part of the Warwick Fault just north of the Fulton Ridge site. The Pebble Springs nuclear site is located 75 airline miles from Mount Adams and 70 miles from Mount Hood and it is 40 miles from the Haystack Butte flows. The site lies at the eastern margin of potential ashfall from Cascade Volcanoes and is outside any probable damaging eruptive activity (see Figure 5).

Foundation Conditions

Detailed geology and topography of the Pebble Springs site Figure 2.5-11 of the "Site Characteristics Report" shows that the plant site is approximately 40 feet above high water level of the reservoir. At this point there is 30' to 40' of sedimentary rock cover consisting of Dalles Formation gravels and Rattlesnake Ridge member silts overlying Pomona basalt.

A total of 11 borings penetrated to the Selah Formation, member of the Ellensburg Formation, below the Pomona basalt at the plant site. These test drillings provide adequate information to define stratigraphy and to show that no significant faulting occurs beneath the proposed plant. Boring B-16 penetrated well into the Columbia River basalt 500' below the surface in the plant area. The subsurface data shows that the Pomona flow is 65' thick

at this location and that it is underlain by 300' of ashy Selah member sediments.

Foundations for the main buildings are shown in Figure 2.5-20 of the Site Characteristics Report to be in the breccia zone at the top of the Pomona basalt. Our investigations of the Pomona breccia disclosed that it is not a typical flow breccia but that the basalt fragments and blocks are separated by fairly large spaces filled with altered volcanic ash. The rock has the appearance of near vent-type material. Because the breccia will be water-saturated when the reservoir is full, results of bearing tests under saturated conditions should be closely evaluated.

The west dam is located 2 miles directly up stream from the town of Arlington. This structure will be founded in the dense Pomona flow (We will not comment in any detail on these structures as this responsibility lies with the State Engineer).

Nearly everywhere that the Selah member is cut by drainage canyons, slide problems develop and block slumping occurs in the overlying Pomona flow. The proposed west dam structure is approximately 1 mile from Alkali Canyon but 2 or 3 drainages reach to very near the base of the dam. It may be necessary to grout or provide cut-off curtains at these points.

The abutments at the east dam consist of silts and gravels which have potential for excessive leakage if some type of cut-off is not provided. Mammal bones and charred wood were found in excavations at the east dam excavations and dating of these fossils is recommended.

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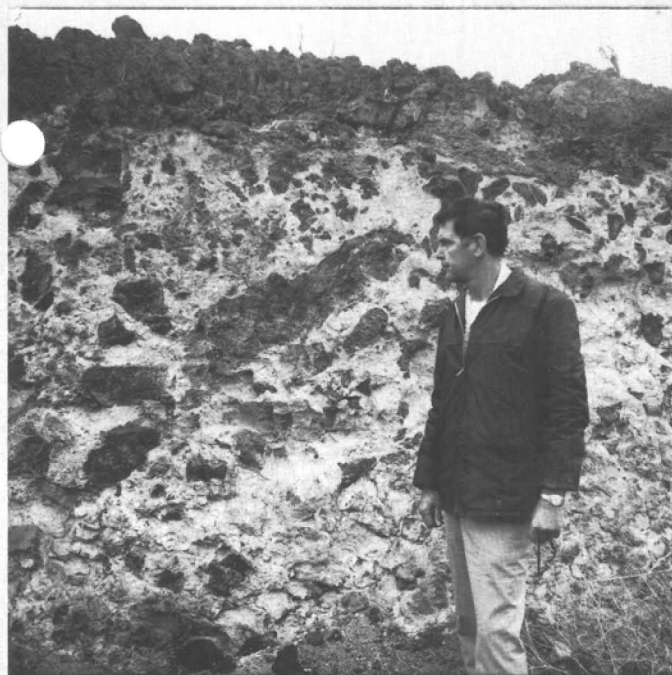


Figure 1. Pomona Basalt breccia zone exposed in excavation west of the west dam area. Dark gray to black angular vesicular basalt fragments and blocks in a white to tan tuffaceous to silty matrix. Near the base of the cut, open and porous areas are common.



Figure 2. Thick lenses of conglomerate loosely consolidated are exposed in bulldozer cuts in east part of reservoir area.

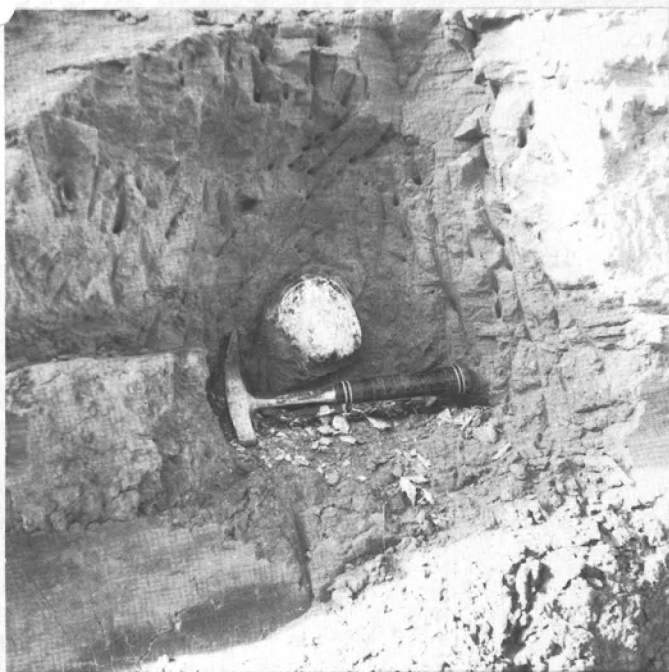


Figure 3. Part of an elephant tusk exposed in west wall of bulldozer cut in southeast reservoir area, Pebble Springs. In sandy silt layer of Dalles fm.

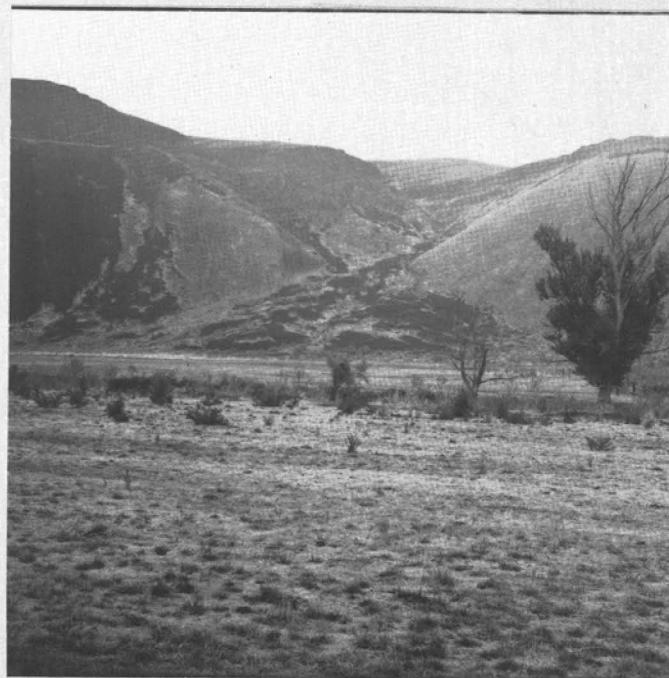


Figure 4. Looking east across Rock Creek at the northwest trending escarpment that probably marks a fault. Large rock slide and debris fan at the mouth of the tributary canyon.



Figure 5. Looking south across I-80 Freeway at 6' wide shear zone along east side of Arlington - Shutler lineament. No displacement is apparent.



Figure 6. Looking across all four lanes of I-80 at 60' wide sheared zone in basalt. This zone appears to strike N-S not quite parallel to the Arlington - Shutler lineament. Again, no displacement is apparent.

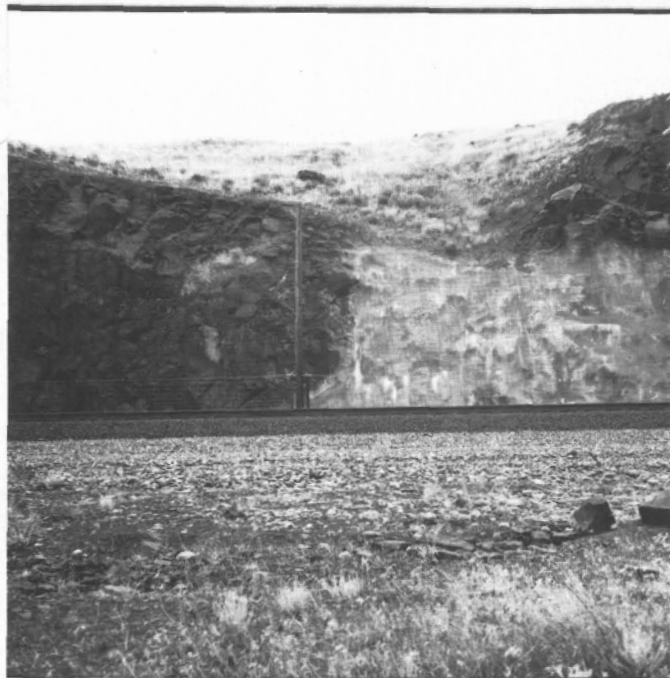


Figure 7. Looking south from Columbia River to Railroad cut about 1 mile west of Arlington. Shear zone associated with Arlington - Shutler lineament has been gunited to prevent rock fall. There is some apparent displacement but can't be sure that this is true.



Figure 8. Looking west along eastbound lanes of I-80 toward Arlington. Active landslide toe is about 3/4 the way up the slope. Selah Formation.

December 31, 1974

SUMMARY OF R. D. BENTLEY'S REVIEW

1. Geology at Haystack Butte is critical to the study. There may be 1,000' or more of throw on the Warwick Fault in this area.
2. A major, more or less continuous, fault may exist along the steep asymmetric side of the Columbia Hills Anticline between Paterson Ridge westward to the Ortley Anticline. Movement along this fault probably occurred between 13 million years ago to 1 million years ago. Perhaps some movement has occurred more recently.
3. Additional investigation should be done along Alder Ridge to obtain more information on the suspected major fault along the south limb of the Columbia Hills Anticline.
4. Check the Arlington-Shutler structure in more detail. Geologic mapping done for PGE does not show the Roza flow thinning across the top of the Arlington-Shutler structure.
5. Check the Rock Creek faults.
- 6 to 7. Includes a discussion of basalt stratigraphy in the Columbia Plateau region.
8. The Age of Deformation is difficult to pin down, but from his studies Dr. Bentley concluded that regional deformation has occurred periodically from 13 million years ago to 6 million years ago. Most faults in the region show evidence of repeated deformations. Dating the latest fault movement in the Columbia Plateau region is very difficult. Nowhere in the plateau is there any evidence of late Pleistocene deformation.
- 9 to 10. Includes a discussion of Shannon & Wilson's "Age of Deformation" arguments. Dr. Bentley disagrees with some of these. He concludes that it is probably impossible to prove that no deformation has occurred in the plateau region in the last 0.5 million years for two reasons: (a) There are no correlateable units with ages between 30,000 B.P. and 3.5 mya. (b) K Ar dates are very unreliable over this range of time.



PORTLAND GENERAL ELECTRIC COMPANY

Viper
ELECTRIC BUILDING
621 S.W. ALDER STREET
PORTLAND, OREGON 97205

November 21, 1974
SRC-1001-74

Mr. R. E. Corcoran
State Geologist
1400 S. W. 5th
Room 1069
Portland, Oregon

Dear Andy:

PEBBLE SPRINGS NUCLEAR PLANT
Consultant's Report

In support of our application for a site certificate for construction of the Pebble Springs Nuclear Plant I am enclosing for your information, a copy of a report prepared by Dr. G. T. Benson of Portland State University. The report is titled "Revue of Geologic Studies of Columbia River Basalt Structures and Age of Deformation - The Dalles - Umatilla Region, Washington and Oregon."

Dr. Benson was requested as an independent consultant to study the age of deformation of the Columbia Hills anticline and the Arlington Shutler Butte lineament. The report is based on his review of the Shannon & Wilson Age of Deformation Report, and field investigations of the structural geology of the area. Dr. Benson is in agreement with the conclusions presented by Shannon & Wilson.

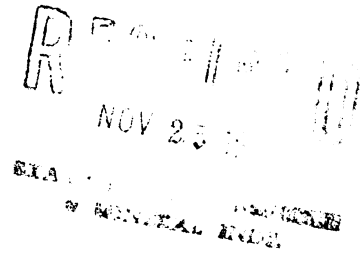
Sincerely,

S. R. Christensen

S. R. Christensen
Manager of Generation Engineering

SRC/RH/br
Enclosures

c: J. L. Williams
J. E. Grund (5)
C. P. Yundt
Nuclear Project File (2)



State Department of Geology and Mineral Industries

1069 State Office Building
Portland 1, Oregon

Grants Pass Office
November 15, 1974

Memo Report - Pebble Springs Nuclear Plant Site

This includes 3 days in the field (Nov. 6, 7, 8) and a review of PGE Report #2004, Site Characteristics, Pebble Springs Nuclear Plant, dated May 1974.

In reviewing the report I didn't spend a great deal of time on the regional geology as it is the same as for the Carty site.

Site Geology

The site geologic map was checked in the field and found to be accurate. I did not have the latest S & W report to locate all the backhoe and bulldozer excavations, however, did examine the excavations. The drilling program and excavations appear to be extensive enough to allow for their engineering interpretations. Also the tests made for the engineering properties of the subsurface materials appear to me to be adequate for building foundation design and reservoir design.

In their description of rock units on p. (2.5 - 64) the description of the structure of the Pomona breccia zone is accurate except for the statement that it does not contain open voids. During our field inspection of excavations at the west dam abutments, we noted several vuggy porous areas in the lower part (Figure 1). This will apparently have no great effect on leakage of the reservoir or cause an unstable condition for structures. The origin of this rock structure is baffling to me as it is widespread under the Pebble Springs site and also at the Carty site. The upper basalt surface appears to be similar to an aa lava flow except that the loose blocks are generally completely surrounded by the ashy tuffaceous material, the size and abundance of rock fragments diminishes upward and in some places grades upward into a light colored loosely consolidated clayey tuff.

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I do have some questions about the possibility of excessive leakage out of the reservoir through the porous sand and gravel zones in eastern part of the reservoir, especially just south of the east dam (Figure 2). We should probably ask about this if it is part of our responsibility. In examining the bulldozer cuts in the east dam area, I noted charred wood and also part of an elephant tusk (Figure 3). I did hear also that bones were found during the time the excavations were being made and wonder if these fossil discoveries may help to more accurately date the Dalles Formation in this area.

Vibratory Ground Motion

This subject is covered in great detail in the report and my only comment is that on page 2.5 - 4 that the design basis for vibrating ground motion (SSE) should be 0.15 g without the need to design for surface faulting. Then on page 2.5 - 100 they recommend a 0.20 g value. Perhaps their later report will take care of this conflict.

Surface Faulting

During our field inspection we made a traverse of Rock Creek and it certainly appears that upper Rock Creek marks a fault. It has a relatively straight steep escarpment with massive talus piles and landslide at the base (Figure 4). Tributary canyons have deposited conspicuous fans of debris over a long period of time. We could see no evidence for recent activity along this fault. We could find no evidence to substantiate a parallel fault to the west.

The Arlington - Shutler lineament was examined in the I-80 Freeway road cuts, railroad cuts, and along the Columbia River banks plus a foot traverse along the segment

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from Alkali Canyon to I-80. The 6' wide sheared zone (Figure 5) at the east end of the highway cut just west of Arlington does not appear to have any recent movement or any appreciable displacement at anytime. At the western edge of this same cut there is a sheared zone 60' wide (Figure 6) that also contains sheared weathered basalt, reddish scoria, and yellowish ash that may indicate proximity to a vent. Neither of these shear zones can be seen in the Railroad cuts just to the north although one area has been gunited (Figure 7) and may mark the trace of the 6' wide east shear. It appears to me that this Arlington - Shutler trend of small topographic highs could be interpreted as being former vents for the Pomona lava flows along a northwest zone of weakness. If this is the case there does not appear to have been any post-Pliocene activity along the zone.

Stability of Subsurface Materials and Slope Stability

As we arrived in Arlington on November 5 we noted that there was an active landslide about 3/4 mile east of town. We looked at the slide with Roland Van Cleave of the Highway Dep't. on Nov. 7. The slide involves about 200,000 yds³ of colluvium and Selah member tuffs (Figures 4 and 5). Drill information shows the slip plane to be in a greenish clay zone in the Selah about 50 to 60 feet below the upper surface. This should be the driest time of the year, why is it sliding now?

This will cause some concern for the Pebble Springs project as their water intake from the Columbia River is about a mile beyond and they have projected the pipeline to angle up and across materials like the ones that are involved in this active slide.

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SUMMARY

If we can establish the basis for vibratory ground motion (SSE) at 0.20 and if we can pretty well establish the age for the last deformation as reported by Shannon and Wilson, the site appears to be geologically all right for the proposed power plants.

Report by: N.V. Peterson November 15, 1974



STATE OF OREGON

INTEROFFICE MEMO

TO: R. E. Corcoran

DATE: November 15, 1974

FROM: V. C. Newton

SUBJECT: Field Check on Age of Deformation, Columbia Plateau

Norm Peterson and I met Clive Kienle, geologist for Shannon & Wilson, Engineers, Inc. at Biggs Junction on November 19, 1974. The purpose of our field investigation was to have Clive show us his evidence for dating the latest fault movement in the region relative to the Pebble Springs nuclear site. All the evidence for dating the latest tectonism is located north of the Columbia River, in Washington state.

The first field check was made at Haystack Butte across the Columbia River from the Fulton Ridge site. Here Quaternary lava poured down the south slope of the Columbia Hills anticline probably causing the damming of the Columbia River as Miller Island consists of this lava. The lava from Haystack Butte can be seen overlying basalt talus which developed on the older underlying lavas of the Columbia River Group (Plio-Miocene age). At one point this young lava (radio-isotope age of 0.9 million years) covers the southern end of the Warwick fault. This is the only place where young rock can be seen overlying a major fault in the region around north-central Oregon and south-central Washington. We confirmed the geologic conditions mapped by Kienle.

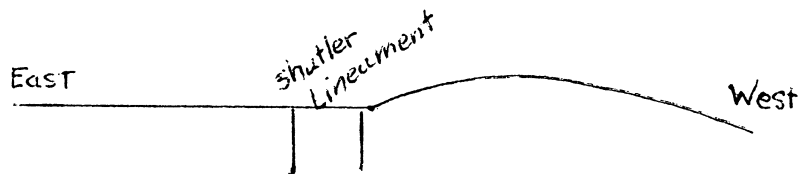
We next travelled east to where the Goldendale fault crosses the Columbia Hills structure. Here the fault changes from a strike slip type fault to a thrust fault as it crosses the Columbia Hills. Clive showed us evidence of major faulting along the south slope of the Columbia Hills

which consisted of large zones of brecciation and fracturing in the Columbia River lavas. Going north to Goldendale, Kienle pointed to an outcrop of Rona flow east of the Goldendale Fault and told us that at this point Rona basalt was against Ramona basalt indicating a vertical offset with the east side having moved up relative to the west side. Except for this evidence, the steep slope in Quaternary basalt conservatively interpreted to be a fault scarp north of Goldendale and the general northwest-southeast alignment of Quaternary volcanic cones, there was little other evidence to substantiate the extension of the Goldendale Fault north of the Columbia Hills. Additional evidence cited for faulting near Goldendale was an radio-isotope date of 4.5 million years in basalt north of the town of Goldendale and a 1.95 million year age date on basalt in a quarry west of the town. If there is a fault as suggested, then lavas 4.5 million years old have been offset by movement on the fault. Further north at Jackknife Butte lavas dated as 0.7 million years old or older cover the proposed fault. Therefore, the inference along this postulated fault is that the latest movement occurred prior to 0.7 million years ago. Quaternary lava at Pothole Lake near Jackknife Butte was dated by the radio-isotope method at 3-6 million years, thus movement along this postulated fault probably occurred between 3.6 million years ago and 4.5 million years ago and probably before 3.6 million years ago.

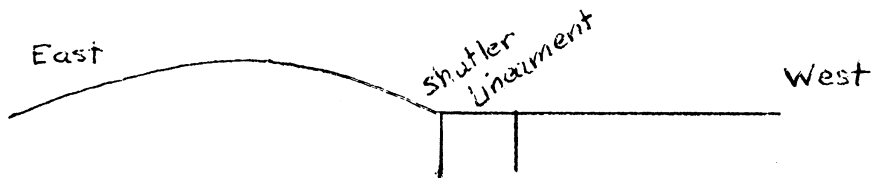
The Luna Butte structure is postulated on alignment of two cinder cones, a small anticlinal warp near the Columbia Hill, and inferred faulting mapped by Sheppard, 1967. Structural evidence is limited and no outcrops of fault planes have been found along the hypothetical structure.

Norm Peterson and I visited the Arlington-Shutler lineament on the north side of the Columbia River on the following day. The lineament was

characterized by an undrained, flat-bottomed canyon on this side of the Columbia River similar to the depression along the crest of the structure 2 miles south of Arlington and $2\frac{1}{2}$ miles west of the Pebble Springs site. The lower end of the canyon on the Washington side was bridged with slide material (?). We checked the railroad cuts near the river and walked the river bank looking for evidence of faulting. None could be found, but a 100-yard stretch between the railroad cuts was filled with rock and this covered the river bank as well. Evidence of faulting could very well have been obscured by the rock fill. Standing on the edge of the gully we could see the Arlington-Shutler structure on the Oregon side of the river and then looking north we could make out the structure near the ridge of the Columbia Hills. The evidence for wrench faulting was quite apparent from this viewpoint (see sketches below).



Oregon side of the Columbia River



Washington side of the Columbia River

State Department of Geology and Mineral Industries

1069 State Office Building
Portland 1, Oregon

Grants Pass Office
December 4, 1974

Memo Report - Pebble Springs Nuclear Plant Site

with special emphasis on "Age of Deformation Boardman Nuclear Project"
contained in Report #0-618E by Shannon and Wilson

This covers Nov. 19 and 20 which were spent in the field with Vern Newton
C. F. Kienle Jr., in the Arlington, Oregon to Goldendale, Washington area reviewing
the geologic evidence for determining the time of last deformation in the Arlington area.

Warwick Fault

We examined the area on the Washington side of the Columbia River in the
vicinity of Haystack Butte where Pleistocene lava flows have entered the river canyon
and make up a part of Miller Island (Figure 1). The Warwick fault is present here and
curves into the Columbia Hills anticline about $1\frac{1}{2}$ miles northeast of Wishram. Outcrops
are not continuous but the Quarternary lavas do appear to cover the Warwick Fault with
no appreciable offset (Figure 2). The KA dating of the lavas here 0.9 million years
would suggest that the Warwick fault has not been active since the lavas were erupted.

The Goldendale Fault

The Goldendale Fault is very similar to the Warwick fault with a northwest trend
that curves around to east-west along the slope of the Maryhill Cliffs on the Washington
side of the Columbia River. The fault northward toward Goldendale was examined and
although soil and debris covers most surface outcrops, Quaternary lavas again overlie
the fault trace with no apparent offset. Again, KA dates indicate no recent movement
on this large fault.

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Arlington - Shutler Butte Lineament

The trace of the Arlington Shutler Butte lineament north of the Columbia River was examined in detail just west of Roosevelt (Figure 3) and on a traverse to the north up Old Lady Canyon we looked at some discontinuous topographic highs that would be its extension to the north. This confirms the small size and discontinuous nature of the parts of this lineament, if in fact the features have all been formed by the same tectonic event.

This should complete our evaluation of the Pebble Springs site and I have assured myself that Shannon and Wilson have studied the geology carefully and made valid interpretations. The evidence available indicates that their determination of the age of deformation is most likely correct.

Report by: N. V. Peterson, December 4, 1974

Memo Report - Pebble Springs Nuclear Plant Site

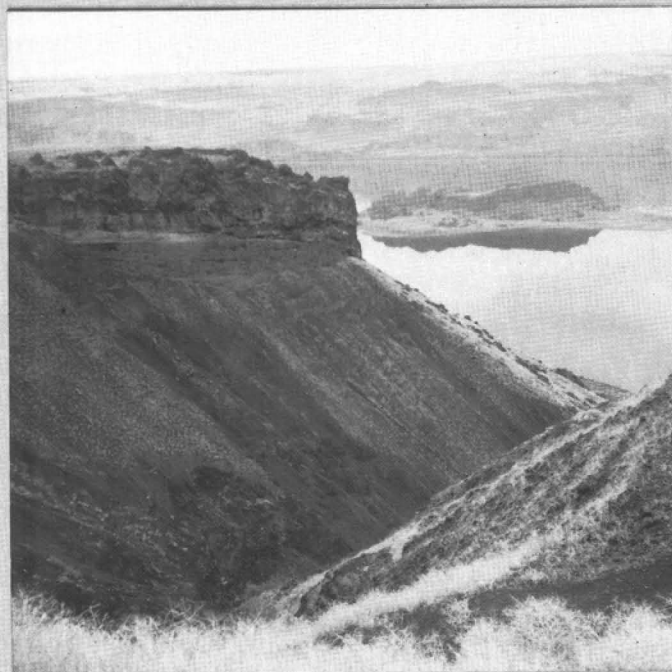


Figure 1. Quaternary basalt flows from Haystack Butte overlying colluvium (?). Eastern part of Miller Island capped by the same lavas in the middle distance. November 20, 1974



Figure 2. Looking across the Warwick Fault zone with a thin lava flow above overlying colluvium. Nov. 20, 1974

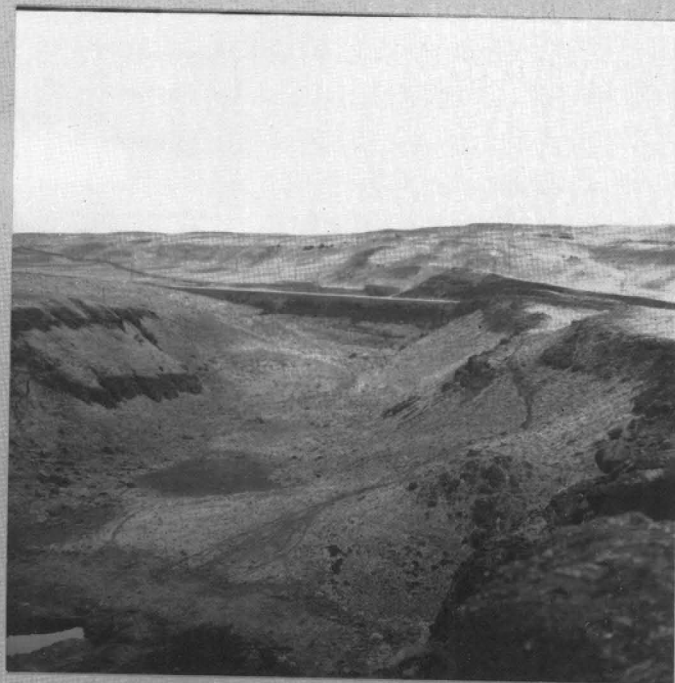


Figure 3. Looking northwest along the trend of the Arlington-Shutler Butte lineament. This small coulee about $1\frac{1}{2}$ miles west of Roosevelt may mark a small fold or fault zone. At river level to the south there are no bedrock outcrops. Nov. 20, 1974



STATE OF OREGON

INTEROFFICE MEMO

TO: H. E. Corcoran

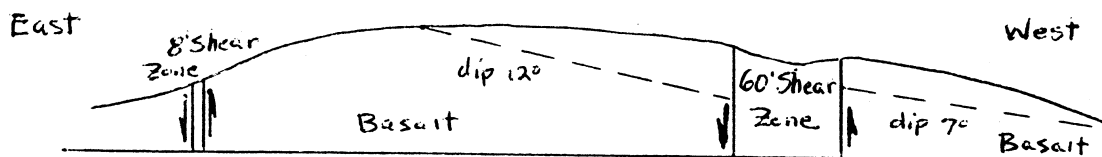
DATE: December 9, 1974

FROM: V. C. Newton

SUBJECT: Status of Pebble Springs Nuclear Site Investigation

Norm Peterson and I investigated mapped faults in the Arlington area early this month and also inspected trenches excavated at the plant site and dams. The Rock Creek faults, 15 miles south of the site, were investigated. The main valley is probably bordered on the north by a fault. However, the fault appears to be pre-Holocene age as the "scarp" is deeply eroded and alluvial fans well developed along the cliff. No offsetting was observed in the fans. No evidence could be found for the other two proposed faults in the Rock Creek area.

The Arlington-Shutler structure was investigated along the entire length. Evidence for a fold structure is meager, although there is undoubtedly linear topographic expression to support some sort of associated structure. Faulting at the northwest end of the Arlington-Shutler lineament was examined in cuts along Highway 80 N. One 8-foot fault zone can be seen which aligns with the lineament. A parallel fault (?) can be seen at the west end of the highway cut where an 60-foot zone of scoria and pyroclastic volcanic material can be seen. This could be a vent. The Arlington-Shutler lineament may be a zone of aligned vents? Another 60-foot shear zone can be seen in the highway cut 2 1/2 miles west of the Arlington-Shutler structure.



Arlington-Shutler structure in Highway Cut

Young rock units have been eroded off the crest of the Arlington-Shutler structure and related faults so that dating the latest fault movement is impossible. The Shannon & Wilson study described this situation and the consultants proceeded to search for evidence along nearby northwest-southeast trending faults. They reportedly found young lavas covering two of the neighboring faults and by dating the lavas by radio isotope methods concluded that faulting in the region occurred before 0.7 mya. The Department has not been able to confirm this situation as yet and finds it desirable to have the PGE consultants assist in confirming this evidence in the field. According to AEC rules, any fault within 5 miles of the site which cannot be dated must be assumed active.

Clastic dikes have been described in the Arlington area and the Department's geologists found some in sedimentary rock in Eight Mile Canyon, where the Arlington-Shutler lineament crosses the canyon. If clastic dikes are found in foundation rocks at Pebble Springs, the Department should be notified. Clastic dikes at this location cannot be described as tension cracks resulting from removal of lateral support. The Department geologists did not see any clastic dikes in the existing trenches.

The Selah Formation, which underlies the site at a depth of 80 or 100 feet, exhibits slope problems where exposed in canyons in the area. However, dam abutments are located in rocks overlying the Selah Formation. There may be leakage problems in the abutments at the east dam as the abutment materials are uncemented sands and gravels.

Fossil bones and elephant tusks have been found in the gravels at the east end of the reservoir. Did the age dating of these confirm geologic mapping?

Seismic design will depend upon the determination of the closest probable active faulting or perhaps the nearest Holocene volcanic activity. In any case, it should be no less than 0.20 g, as recommended on page 2.5.-100, "Site Characteristic Report," May 1974, by FGE.

The following is recommended before deciding on the final design of the Pebble Springs nuclear plant:

- (a) Field check evidence for dating of the latest fault movement.
- (b) Confirm basalt stratigraphy in the vicinity of Arlington - by Department consultants.
- (c) Inspect any new trenching at the site.