



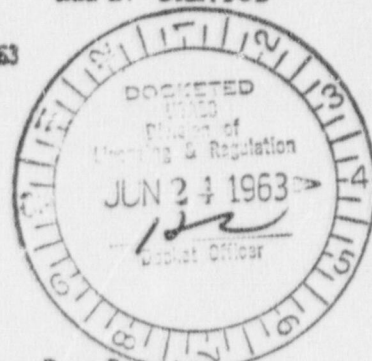
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

WASHINGTON 25, D. C.

BUREAU OF STATE SERVICES

Refer to: DRH:TOB

JUN 20 1963



Mr. Robert Lowenstein, Director
Division of Licensing and Regulation
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Mr. Lowenstein:

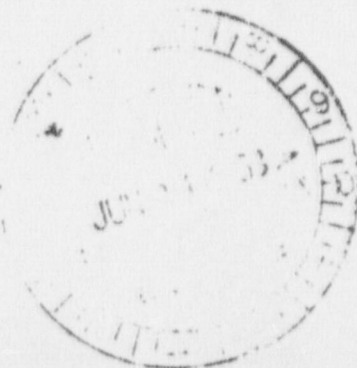
Once a construction permit hearing is scheduled on the Bodega Bay Reactor, we will forward to you a report containing all of our comments, including a summary of background levels and a report from our Division of Water Supply and Pollution Control. Since there has been some interest in the seismological aspect of this site, I am enclosing a copy of our staff's comments on seismology. It is our intention to include these comments in the report to be forwarded to you after a hearing is scheduled. These comments are being transmitted to Mr. Alexander Grendon, California Coordinator of Atomic Energy Development and Radiation Protection.

We hope that the information contained herein will be of some assistance to you and your staff.

Sincerely yours,

for
James G. Terrill, Jr.
Deputy Chief
Division of Radiological Health

Enclosure



PRELIMINARY DRAFT

For Administrative Use Only

A Review of the Seismic Factors Pertaining to the Bodega Bay Atomic Power Unit - Number 1 based upon the following information from the Preliminary Hazard Summary Report by the Pacific Gas and Electric Company:

1. Plant Site and Environment
2. Appendix 4
3. Appendix 5
4. Amendment number 1
5. Amendment number 2



This report was prepared at the request of the Nuclear Facilities Environmental Analysis Section, Technical Operations Branch, Division of Radiological Health, USPHS and is submitted to the Section for review and is to be considered as only a portion of the over-all review being conducted by the Section. (After the Section's review the notation PRELIMINARY DRAFT shall be removed and this review may be issued as a separate report.)

Submitted by: Bruce W. Maxwell
Name

Norman S. Farha
Name

Geologist
Title

Geologist
Title

Technical Operations Branch, DRH
Organization

Technical Operations Branch, DRH
Organization

Date Submitted: May 16, 1963

Pages 8 and 9 revised May 20, 1963
Page 9 revised May 28, 1963.
Addendum - 6/13/63

4521:

In section V of the Preliminary Hazard Summary Report there is this statement:
"A preliminary Geological reconnaissance of Bodega Head was conducted by Mr. Clark E. Melluron, Consulting Engineering Geologist, in 1958, for the company to recommend suitable power plant sites on Bodega Head. When the company had acquired the property at the South end of the Head, it retained Dames and Moore, Soil Mechanics Engineers, to conduct a geophysical and seismic survey of the selected site and a preliminary subsurface exploration. In 1960, Drs. Don Tocher, Seismologist, and William Quaide, Geologist, both at that time with the University of California, were retained to make a detailed study of the selected site from the standpoint of seismology and geology. Professor George Housner, of the California Institute of Technology, was retained to interpret the studies of Tocher and Quaide and to recommend structural design criteria for the plant".

It appears that the predictions of Dr. Tocher were used by Professor Housner to provide design criteria for the plant. This seems to be borne out by the statements in Exhibit number 48, "Consultants' Reports of Geologic and Seismic Conditions at the Proposed Bodega Bay Power Plant Site and Summary of Those Reports", presented before the California Public Utilities Commission dated July 6, 1962. This exhibit states that Professor G. W. Housner was retained to interpret the findings of Drs. Tocher and Quaide and derive structural seismic design criteria. There is no indication here that Professor Housner made an independent evaluation of the probability of the maximum earthquake intensity to be expected. It is understood that Dr. Tocher is one of the foremost seismologists in California; however, we do not believe that the safety of the public should rest solely on the analysis of one man as appears to be the case here.

It would seem desirable since each human being is subject to error to have another seismologist make an independent evaluation of the maximum probable intensity at the site. Even if Dr. Housner had made an independent evaluation of the intensity expected it would seem desirable from the standpoint of the company, the state of California, and the public to have an independent evaluation made by a seismologist who is not in the employment of the Pacific Gas and Electric Co. This is particularly important because several more large reactors are contemplated for this site.

The assignment of a probable intensity of eight (MMI) to the Bodega Head Region raises some questions as to the analysis which are not answered in the Hazards Summary Report. The San Francisco earthquake of April 18, 1906 is reported as intensity XI MMI at San Francisco in the Earthquake History of the United States, Part II, "Stronger Earthquakes of California and Western Nevada" by M. O. Wood and N. H. Heck revised by R. A. Eppley, published by the U. S. Department of Commerce in 1961. According to this publication the greatest slip, 21 feet, was in Marin County which includes at least half of Bodega Bay. The report further states that "at Santa Rosa, although 19 miles from the rift, destruction was great and apparent intensity higher than at most other points of comparable distances (from the fault). The district lies directly inland from the region of greatest motion on the San Andreas fault," which would be the Bodega Bay Region.

This is supported by the reports from the book, The California Earthquakes of 1906, edited by David Starr Jordan, 1907, in the following series of excerpts by the authors:

"The Earthquake Rift of April 1906" by David Starr Jordan, President of Stanford University.

- p. 9 "We know that the center is in the sea because where the rift enters the land the motion was more violent and the effects of the shock greater than at any other point along its extent." (This is the Point Arena area.)
- p. 15 "The spreading wave (seismic) displaced or destroyed most of the houses in the villages of Manchester and Point Arena, wrecking the magnificent lighthouse of solid masonry on the Point itself...
.... In Mendocino County the horizontal displacement is about sixteen feet. In Marin County, wherever it is exactly measured, it is sixteen feet seven inches. Southward it becomes less."
- p. 17 "Through this region (Marin County) the shock was very violent, and numerous cracks parallel with the main crack in the bay extended along the shores."
- p. 18 "At Marshall the Humble Hotel was thrown bodily--and upright--into the bay, the boarders unharmed; and at aristocratic Inverness, on Tomales Bay, three summer cottages suffered the same fate."
- p. 19 A train standing at Point Reyes Station was thrown on its side.
- p. 32 "There are distinct traces of great disturbance across Burbanks famous orchard at Sebastopol, but it is not clear that.....the underlying rock is really broken. Here on a slope ^{*}lined with fruit

trees were shifted, a well was moved bodily three or four feet, and a crack about one fourth mile long extended across a neighboring field, its direction paralled with that of the Tomales rift."

p. 59 "It was much less severe in San Francisco than anywhere along the rift in Marin or Mendocino Counties."

Although the Santa Rosa destruction was attributed to poor construction, the same type of construction does not appear to be unique as shown by the following:

"The Destructive Extent of the California Earthquake," by Charles Derleth, Jr., Associate Professor of Structural Engineering, University of California.

p. 114 "Proportionately speaking, Santa Rosa's loss was greater than that of San Francisco..... But it is my judgement that the shock was less serious in the northern city than in San Francisco. How then should the general destruction be explained? The brick buildings of Santa Rosa were carelessly constructed."

p. 131 "The most general destruction by earthquake in San Francisco was observed in ordinary brick buildings. Brick walls were usually thin, of careless bond, and built with lime mortar of little strength."

p. 188 "San Jose, about forty miles to the south and east of San Francisco, is thirteen miles to the east of the fault line..... The earthquake destruction was appalling..... Again we find cheap construction with lime mortar, weak framing and insufficient anchoring for floors and roofs."

"The Investigation of the California Earthquake," by Grove Karl Gilbert, of the U. S. Geological Survey.

p. 245 "The natural foundation of Oakland is similar to that of San Jose, and its distance from the earthquake origin is about the same, but the injury to its buildings was decidedly less; and Santa Rosa standing on ground apparently firmer than that at Oakland or San Jose and having a some what greater distance from the fault, was nevertheless shaken with extreme violence."

It appears, therefore, the destruction at Santa Rosa is valid evidence of the greater intensity along the segment of the fault in Marin County.

Preliminary Hazards Summary Report Appendix 4 by Drs. Tocher and Quaide states: "The following description of effects of the shock (other than fault trace phenomena) was made by Professor J. N. LeConte and Mr. A. S. Wright (Lawson, 1908, page 191). 'Near Bodega Head the bridge over Salmon Creek was somewhat twisted. Just beyond this a good sized hotel previously used as a summer resort was badly wrecked by the earthquake. It was moved on its foundation and rendered unfit for habitation. The building was close to the sand dunes and probably rested on sandy deposits. The barn was completely wrecked!" Although this destruction may have been due to soft ground, it should occasion some concern as to the maximum intensity expected in the Bodega Head Region. The destruction is typical of Modified Mercalli Intensity IX not VIII as is reported by Tocher and Quaide to be the maximum probable intensity at the site.

Drs. Tocher and Quaide also state, "At least one and perhaps two or more major earthquakes can be expected near the site within the next century. These may be as strong, or even somewhat stronger than the California earthquake of April 18, 1906".

It would seem appropriate therefore to design for an intensity of X MMI or greater. When the unit is designed to withstand the appropriate intensity, particular attention should be given to items whose failure could result in the release of activity. These include reactor core, fuel elements, control safety rods, supporting positioning members, reactor pressure vessels, primary coolant loop, piping systems, the heat exchangers, instrumentation safety devices, emergency water system, containment building structures. Particular attention should be given to out of phase movement between adjacent structures

or machinery and particularly to piping. We believe that this should not place a great burden on the company since, according to their own consultant Dr. G. W. Housner in an article titled "Design of Nuclear Power Reactors Against Earthquakes" published in the Proceedings of the Second World Conference on Earthquake Engineering, Vol. I, page 141, he says "It should be noted that in many instances the structures of a nuclear generator are well suited to resist earthquake forces and can withstand horizontal accelerations of 0.5g or even 1.0g without requiring any appreciable strengthening over ordinary operating design. Thus the relatively large design accelerations mentioned above are in general not difficult to meet and do not usually require any appreciable additional cost to meet the earthquake requirements. This can be expected, however, only if earthquake considerations are kept in mind from the beginning of the design. If careful thought is not given from the beginning of the design the cost of earthquake protection may be appreciably increased." He further says on page 143 "pipes connecting two pieces of equipment must be designed so as not to be pulled apart when the equipment begins vibrating. In fact, all piping, whether for steam or water, must be designed and supported so as to resist seismic forces. More careful attention must be given to details in piping than is the usual practice when designing industrial installations. This problem is particularly severe in the case of nuclear reactors because of their very extensive piping systems". On page 144 he says "In the present state of knowledge, the design of the nuclear reactor must be made for the worst possible conditions and it would not seem advisable to reduce the design criteria on the basis of assessed geological merits of the site".

It should be reiterated that barring proof as to the characteristics of the pressure suppression system under all conditions including earthquakes, baffles should be included as they are in Humbolt Bay Reactor pressure suppression system.

Also in the above book edited by David Starr Jordan was the following comment:

"Local Effects of the California Earthquake of 1906", Stephen Taber, Stanford University.

p. 274 "It was the first motion that snapped off branches, overturned oak trees and wrecked buildings in the immediate vicinity of the fault line; and although this motion extended for a considerable distance, the damage it caused was limited to a belt not over a mile distant from the fracture".

These findings of Stephen Taber agree with the statement found in the Proceedings of the Second World Conference on Earthquake Engineering, Vol. I, "On the Damage of Fukui Earthquake and the Destructive Power of Earthquake of Such A Kind", by Professor Y. Sakabe:

p. 546 "I feel it absolutely undeniable that the shock motion plays the main part on the destruction near the epicenter".

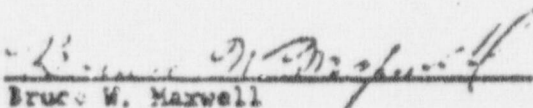
Because of the possibility of earth shock as described above, and since the Bodega reactor site is approximately 1500 feet from the western limit of the fault zone, we would like to know if this factor has been considered by Drs. Tocher, Quaide, and Housner in the formulation of the seismic evaluation of the plant site and design criteria.

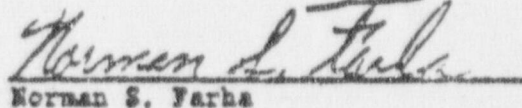
CONCLUSIONS

Primary only one seismologist has made an analysis of the site for the maximum probable earthquake intensity. It would be desirable to have a seismologist not employed by the Pacific Gas and Electric Company make an independent evaluation.

The anticipated maximum intensity of Modified Mercalli Intensity VIII and design criteria based on MMI IX is open to some question. Further investigation into the probability of a MMI of X or greater at the site is advisable.

3. Earth shock motion as well as wave motion has contributed significantly to the destruction in the area near the active portion of the fault. In the 1906 earthquake, it played the main part in the destruction at distances of one mile on either side of the active area of the fault. The magnitude of destructive forces should be investigated because the Bodega reactor site is approximately 1500 feet from the western limit of the fault zone.
4. Particular attention during design and construction should be given to the seismic qualities of the piping systems.
5. The characteristics of surging, standing waves, etc. under all conditions including earthquakes should be investigated before baffles are deleted from the pressure suppression system.


Bruce W. Maxwell
Geologist


Norman S. Farba
Geologist

ADDENDUM TO "REVIEW OF THE SEISMIC FACTORS PERTAINING TO THE BODEGA BAY
ATOMIC POWER UNIT - NUMBER 1" DATED MAY 16, 1963 REVISED MAY 28, 1963

The maximum intensity at the site can not be predicted with any degree of certainty. The design criteria should be based on at least the maximum intensity known or thought to have occurred at Bodega. If a safety factor is desired the design should, of course, be for a higher intensity.

The April 18, 1906 earthquake intensity at Bodega Head is reported by the State Earthquake Investigation Committee Upon the California Earthquake of April 18, 1906 to be 10 Rossi-Forel, equivalent to 10 or greater on the Modified Mercalli scale. Thus design for 10 MMI would be in line with reported facts. In light of this, construction of plant etc. for any less than 10 MMI would imply sanction of failure of reactor components. Horizontal forces on the order of 1 g are to be expected from the earth shock of initial movement along the fault.

Numerous slickensides, planes of slippage in the rock, are present in the sea cliff west of the site. These are evidence of movement at the site but the age could not be determined and the presence of dirt dumped over the cliff during recent construction prevented examination of a critical area for evidence of a fault through the saddle in which the reactor will be situated. Engineering geologists of the U. S. Geological Survey (Messrs. Schlocker, Bonelli, Clebsch) are examining the site for evidence of recent faulting and will prepare a report for the Department of Interior.

June 13, 1963

DATE


SIGNATURE

Geologist

TITLE