March 3, 1999

Mr. T. A. Green, Sr. Project Manager
BWR Owners' Group Projects
General Electric Company
175 Curtner Avenue
San Jose, CA 95125

SUBJECT: SAFETY EVALUATION OF GE TOPICAL REPORT, NEDC-31858P, REVISION 2, "BWROG REPORT FOR INCREASING MSIV LEAKAGE LIMITS AND ELIMINATION OF LEAKAGE CONTROL SYSTEMS," SEPTEMBER 1993

Dear Mr. Green:

The NRC staff has reviewed the subject topical report submitted by the Boiling Water Reactor Owners' Group (BWROG). The staff considers the BWROG report acceptable for direct reference in future individual plant submittals on the MSIV leakage issue, subject to the conditions and limitations described in the enclosed safety evaluation (SE).

As specified in the enclosed SE, BWROG is requested to incorporate the staff's SE in the version of NEDC-31858P provided for use by member utilities. Specifically, BWROG is instructed that the use of NEDC-31858P by member utilities is subject to the conditions and limitations stated in the staff's SE, and that the earthquake ground motion estimates, shown in Figures 1 through 13 of the SE, represent the only ground motion estimates acceptable to the staff for reference in plant-specific amendment requests involving the use of this topical report. We request that you submit to the NRC the revised version of the topical report that incorporates the staff's SE.

If the NRC's criteria or regulations change so that its conclusion that the topical report is acceptable are invalidated, BWROG and/or the member utilities referencing the topical report will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the topical report without revision of the respective documentation.

Please advise us within 30 days if any material in the enclosed SE is considered proprietary. Without such notification, the staff will place the SE in the NRC Public Document Room.

Sincerely: Original Signed By:
Frank M. Akstulewicz, Acting Chief
Generic Issues and
Environmental Projects Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Enclosure: Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
BWROG GENERIC RESOLUTION
FOR THE BWR MAIN STEAM ISOLATION VALVE LEAKAGE

1.0 INTRODUCTION

The main steam lines in boiling water reactor (BWR) plants contain dual quick-closing main steam isolation valves (MSIVs). These valves function to isolate the reactor system in the event of a break in a steam line outside the primary containment, a design basis loss-of-coolant accident (LOCA), or other events requiring containment isolation. Although the MSIVs are designed to provide a leak-tight barrier, it is recognized that some leakage through the valves will occur. The current Technical Specification (TS) limit for MSIV leakage is typically 11.5 standard cubic feet per hour (scfh). Operating experience indicates that degradation occasionally occurs in the leak-tight MSIVs, and the specified low leakage is difficult to maintain.

Because of recurring problems with excessive leakage of MSIVs, NRC Regulatory Guide (RG) 1.96, "Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants," recommends the installation of a supplemental leakage control system (LCS) to ensure that the isolation function of the MSIVs complies with the specified limits. To meet this RG, many licensees installed a safety-related MSIV LCS that is designed to eliminate or minimize the direct release of fission products through the MSIVs following a design basis LOCA. This is usually accomplished by developing a negative pressure in sections of the main steam lines (MSLs) between the MSIVs. In general, this is accomplished by a series of blowers that discharge the MSIV leakage to the standby gas treatment system (SGTS) where it is released. A few plants may have a positive pressure LCS in the MSLs between the MSIVs. At these plants, MSIV leakage (usually compressed air) is directed back into the containment such that there is no containment bypass leakage through the MSIVs. However, these positive pressure systems tend to increase post-LOCA containment pressure, thereby affecting other bypass leakage paths. Since most plants use the negative pressure type of LCS, this is the type primarily addressed in this evaluation. However, the basic principles could be used to justify the elimination of the positive pressure type of LCS.

Due to design limitations, the LCS would be unavailable if the MSIV leak rate were greatly in excess of the allowable limits specified in the plant technical specifications. Hence, Generic Issue (GI) C-8 was initiated in 1983 to assess: (1) the causes of MSIV failures, (2) the effectiveness of the LCS and alternative leakage paths, and (3) the need for regulatory action to limit public risk. The resolution of GI C-8 (see NUREG-1732, Regulatory Analysis for the Resolution of GI C-8, "Main Steam Isolation Valve Leakage and LCS Failure," dated June 1990) concluded that no backfit requirements to reduce public risk were warranted and that no action should be taken. However, one of the alternative resolutions of GI C-8 showed that several non-seismic Category I alternate MSIV leakage (alternate to the LCS) paths resulted in lower doses than the LCS and could handle larger MSIV leakage rates.

In a parallel effort, the BWR Owners Group (BWROG) formed an MSIV Leakage Committee in 1982 to identify and resolve the causes of high MSIV leakage rates. BWROG then formed a follow-on MSIV Leakage Closure Committee to address alternate actions to resolve ongoing but less severe, MSIV leakage problems and to address the limited capability of the LCS. The

ATTACHMENT

results of these committee activities were submitted to NRC in several General Electric (GE) proprietary reports, the latest of which is NEDC-31858P, Revision 2, dated September 1993 (Reference 1, herein referred to as the BWROG report). In this report, BWROG concludes that the proposed increase in the MSIV leakage limits (up to a maximum of 200 standard cubic feet per hour [scfh]) will reduce radiation exposures to maintenance personnel, reduce outage durations, and extend the effective service lives of the MSIVs. BWROG also concludes that the proposed elimination of the LCS will similarly reduce exposure to maintenance personnel, reduce outage durations, and that the LCS can be replaced with an alternate method for MSIV leakage treatment using the MSLs and the main condenser.

The proposed alternate treatment method recommended in the BWROG report takes advantage of the large volume in the main steam lines and main condenser to provide holdup and plate-out of fission products that may leak through closed MSIVs. This method uses the main steam drain lines (herein referred to as the bypass/drain piping) to direct the leakage to the main condenser. In this approach, the main steam piping, the bypass/drain piping, and the main condenser are used to mitigate the consequences of an accident which could result in potential offsite exposures comparable to the 10 CFR Part 100 limits.

The primary issue of concern is the ability of the main steam piping downstream of the outboard MSIV, including the bypass/drain piping, and the main condenser to remain structurally intact and act as a holdup volume for fission products during and after a Safe Shutdown Earthquake (SSE). The BWROG approach of verifying the seismic adequacy of the alternate leakage treatment (ALT) piping was based on utilizing the earthquake experience-based methodology, supplemented by a plant-specific walkdown and analytical evaluation.

2.0 BACKGROUND

BWROG retained EQE International (EQE) as a consultant to conduct a review of the earthquake experience data on the performance of nuclear power plant facility piping and condensers. The results were summarized in Reference 1, which provides the data on the performance of main steam system piping and condensers in primarily non-nuclear facilities which experienced strong earthquake motions. These data were also compared with the piping and condensers typically used in GE BWRs in the United States. According to EQE, based on past earthquake experience, welded steel piping and condensers designed and constructed to normal industrial practices (e.g., ANSI B31.1 and Heat Exchange Institute (HEI) Standard, respectively) have been found to be seismically rugged and not susceptible to a primary collapse mode of failure as a result of the seismic vibratory motions experienced at sites examined in the earthquake database. Such earthquake experience was derived from a database that includes the seismic performance of power plants and industrial facilities in actual earthquakes (see Section 5.4 of this evaluation). The BWROG report notes that only a relatively small number of seismically-induced piping failures have occurred in the database facilities; these failures were due primarily to excessive relative support movements or seismic interactions.

The primary components to be relied upon for the proposed ALT system are the main turbine condenser and the primary drain pathway piping which consists of the bypass/drain lines that originate from the steam lines just downstream of the outboard MSIVs and terminate at the high pressure (HP) condenser. The condenser forms the ultimate boundary of the ALT system.

Boundaries upstream of the condenser were established by utilizing existing valves, and were used to limit the extent of the plant-specific seismic verification walkdown.

In the past, a limited number of license amendment requests on the MSIV leakage issue have referenced the BWROG report. In view of certain generic deficiencies identified in those individual amendment requests, and to support a more effective review of future MSIV leakage submittals, the staff performed a generic review of the BWROG report.

3.0 REGULATORY POSITION ON SEISMIC EXPERIENCE DATABASE APPROACH

The proposed BWROG resolution approach as described in the BWROG report would allow higher leakage limits and would take credit for the main steam piping downstream of the outermost MSIV and the condenser to plate-out fission products. Leakage would be directed to the condenser via the main steam drain lines. In other words, the main steam piping, the bypass/drain piping, and the condenser are relied upon to mitigate the consequences of an accident which could result in potential offsite exposures comparable to the guideline exposures of 10 CFR Part 100. Appendix A to 10 CFR Part 100 further requires that structures, systems, and components necessary to assure the capability of the plant to mitigate the consequences of accidents, which could result in exposures comparable to the guideline exposures, be designed to remain functional during and after an SSE. Therefore, the proposed ALT path piping and the main condenser are required to remain functional if the SSE occurs. Furthermore, Appendix A to 10 CFR 100 requires that the engineering method used to ensure that the safety functions of the components are maintained during and after an SSE involves the use of either a suitable dynamic analysis or suitable qualification test, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism.

It is noted that there are no provisions in plants' Final Safety Analysis Reports (FSARs) and the staff's safety evaluations associated with facilities operating licenses that would permit the use of experience data as a means of seismic qualification for piping systems and components. However, requiring the non-seismically analyzed portions of the main steam system piping and components to meet Seismic Category I requirements would not be practical because modifications required to upgrade the system to Seismic Category I requirements cannot be justified from a cost-benefit standpoint. Therefore, the staff determined that BWROG's proposed approach of utilizing the earthquake experience-based methodology, supplemented by plant-specific seismic walkdowns and analytical evaluations, provides a viable alternative for demonstrating the seismic ruggedness of non-seismically analyzed main steam system piping, related components and supports, and condensers.

4.0 PAST REVIEWS FOR INDIVIDUAL PLANT SUBMITTALS

The licensees of Hatch 2, Duane Arnold, Limerick, LaSalle, Susquehanna, and Monticello have previously submitted their amendment requests for increasing the MSIV leakage limits and removal of the LCS for staff review and approval. With the exception of the LaSalle submittal, which proposed a resolution based solely on the use of plant-specific analytical methodologies, all the other requests utilized BWROG's approach for resolution, supplemented by plant-specific seismic walkdowns and analytical evaluations. It was found during the course of staff review, that the earthquake experience database originally compiled by EQE for piping was not broad enough to cover portions of the plant-specific data. Specifically, the data was found to be deficient for piping in the range of one inch to 10 inches in diameter, which are typically the sizes of pipes associated with the bypass/drain lines in operating BWRs. The affected licensees, who submitted the amendment requests, were asked to provide additional piping data. As a result, the validation of the vibratory ground motions experienced at the database facilities with piping and equipment being used as surrogates for those at the respective plants, were also subject to staff review. This is to ensure the validity of the database ground motions and hence the validity of the representation of the piping database, which form the cornerstone for BWROG's approach of using the earthquake experience methodology. Other questions which were also raised during the plant-specific reviews included those related to the reliability of the entire ALT path, as well as the support and anchorage evaluations for piping and condensers. In all cases, licensees were able to provide the responses to the staff's requests for additional information, and the amendment requests were subsequently approved.

5.0 EVALUATION OF THE BWROG GENERIC APPROACH

5.1 Functional Design

BWROG's justification for increasing the allowable MSIV leakage rate and eliminating the LCS relies on an alternative (alternate to the LCS) leakage treatment path which results in post-LOCA radiological releases that are within regulatory requirement limits. Regulatory requirements also dictate that the alternative MSIV leakage treatment path must be capable of performing its post-LOCA function during and following an SSE.

BWROG evaluated the effectiveness and availability of leakage treatment methods that use existing BWR plant equipment for reducing the radiological consequences of MSIV leakage. These methods included the isolated condenser, mechanical vacuum pumps, steam jet air ejector/offgas system, and isolated steam lines. As a result of its evaluation, BWROG recommended the use of isolated condenser method, which uses the main steam drain piping to convey MSIV leakage to the condenser, as the preferred treatment method for MSIV leakage. This method provides fission product attenuation in the main condenser such that the radiological consequences of MSIV leakage can be significantly reduced. This method will usually require operator action to open a specific drain valve or valves to initiate the flow path to the condenser.

The isolated condenser treatment path takes advantage of the large volume in the main condenser to provide holdup and plate-out of fission products that may leak through closed MSIVs. Licensees referencing the BWROG report must assure that the identified drain path will remain functional during and following an SSE, assuming offsite power is not available.

The licensees should also address the radiological aspects of MSIV leakage treatment following a LOCA, coincident with a loss of offsite power assuming the worst case single active failure. This is a design basis event for which the radiological consequences must be shown to be less than the regulatory limits for offsite and onsite (control room) doses.

The staff will review the plant-specific functional design of the MSIV ALT path for licensees that submit requests for increasing the MSIV leakage rate and eliminating the LCS based on the BWROG report. The staff will use the failure criteria identified in this evaluation during its review of the ALT path. Licensees referencing the BWROG report should also describe their maintenance and testing program for the active components in the treatment path since they will now be performing a safety-related function and reliability commensurate with safety-related components should be demonstrated.

5.2 Generic Study of Seismic Experience Database

Appendix D to the BWROG report, Revision 2, contains an EQE report entitled, "Performance of Condensers and Main Steam Piping in Past Earthquakes," Report No. 50032.02-R-01 (Revision 0), dated September 1990. This report provides a summary of data on the performance of non-seismically designed main steam piping and condensers in past earthquakes around the world. The database consists mostly of main steam piping and condensers in fossil plants. It was proposed in the EQE report that this earthquake experience data be used to evaluate the ability of main steam piping and condensers in typical GE Mark I, II, and III BWRs in the U.S. to withstand a design basis earthquake.

The EQE report stated that the above stated piping and condensers exhibited substantial seismic ruggedness even though they were not specifically designed for earthquake loading. Specifically, it asserted that no failures of main steam piping were found, and that anchored condensers have also performed well in past earthquakes, with damage limited to minor internal tube leakage.

The staff reviewed the BWROG report, and the associated database, to determine its acceptability as a generic reference for the resolution of the MSIV leakage issue. Consistent with past staff reviews of individual plant submittals, additional generic information was found to be needed for the staff to complete the review. A request for additional information (RAI) on the BWROG report was sent to the BWROG on March 29, 1995 (Reference 2). BWROG's response to the RAI was provided on February 19, 1996 (Reference 3). Subsequently, a further clarification of the staff comments, based on the above February 19, 1996, responses, was provided to BWROG during a May 8, 1996, teleconference. BWROG followed up by providing the staff with supplemental information on January 9, 1997 (Reference 4).

The staff found BWROG's responses provided in Reference 4 to be generally acceptable, with the following exceptions. BWROG has proposed the use of certain analytical procedures for the evaluation of safety-related components and supports, which have not been approved by the staff. Specifically, the analytical procedures described in an EPRI report, EPRI NP-6041, were proposed to be used for demonstrating the seismic margin of selected components and the associated supports. These procedures are typically referred to as the conservative deterministic failure margin (CDFM), seismic margin assessment (SMA), or high-confidence-low-probability-failure (HCLPF) analysis methods. In addition, the validity of some of the earthquake ground motions compiled by EQE to support its experience database for piping and condenser also required further clarification.

It should be noted that the EPRI NP-6041 report and procedures have not been formally reviewed and approved by NRC for the deterministic operability evaluation for safety-related systems, components and the associated supports. Their conservatism and, consequently, the potential impact to the public health and safety are not certain at this time. NRC, therefore, does not endorse the use of the above analytical procedures and the referenced EPRI report, for the seismic analysis of safety-related systems, components and their associated supports. For this reason, BWROG should recommend that individual licensees perform the required analytical evaluations using the plant licensing basis methodology, or approaches which are acceptable to the staff. Use of any other methodologies, not already reviewed and approved by the staff, by individual licensees must be clearly justified, and the analytical results obtained by utilizing these other methodologies will require staff review on a case-by-case basis.

As indicated in the January 9, 1997, letter (Reference 4), BWROG has committed to recommend that the limitations, identified by the staff, regarding the use of BWROG's approach, be incorporated in future plant submittals that elect to utilize the generic approach for resolving the MSIV leakage issue. Therefore, in future submittals, individual licensees should commit to provide plant-specific data and parameters for piping and components to demonstrate that they are indeed enveloped by the corresponding database parameters. Licensees should also commit to perform a plant-specific seismic evaluation for representative supports and anchorages associated with piping and components. In addition, licensees of plants whose FSARs, or Updated FSARs (UFSARs), reference Appendix A to 10 CFR Part 100, should commit to perform a bounding seismic analysis for the ALT path piping. The staff found the above BWROG commitments to be acceptable.

5.3 Reliability of ALT Pathway

The ALT pathway consists of the main steam line piping from the reactor pressure vessel to the selected primary drain line pathway; the drain line piping from the main steam lines to the condenser; the condenser itself; and the turbine building from the low pressure turbine seals to the building release point. BWROG's letter of January 9, 1997 (Reference 4), states that the radiological dose methodology employed takes credit for all of these path components except for the turbine building.

In parallel to the plant-specific reviews conducted in the past, the staff determined that all licensees referencing the generic report should provide assurance for the reliability of the entire ALT pathway, including all of its boundary valves. The licensees should also provide assurance that valves required to open the ALT path to the condenser are provided with highly reliable power sources, and that a secondary path to the condenser with orifice flow exists. In addition, valves which are required to open the ALT path to the condenser are to be included in the plant's Inservice Testing (IST) program.

Based on the above, BWROG has committed to recommend that licensees provide a detailed description of the ALT drain path and the basis for its functional reliability as part of their plant-specific submittals. The staff finds this to be acceptable.

5.4 Seismic Ground Motions for Database Plants

The earthquake experience database contained in the BWROG report was compiled by EQE. For 29 earthquake-facility pairs the database provides: (1) the name, date, and magnitude of the earthquake, (2) the facility name, (3) an estimate of the horizontal peak ground acceleration (PGA), and (4) a brief description of the facility piping and condensers. A majority of the PGA estimates were based on the ground motions recorded at the "nearest" seismic instrument.

5.4.1 Background

On March 29, 1995, in a letter to BWROG (Reference 2), the staff requested additional information on the earthquake experience database listed in Table 3-2 of Appendix D of the topical report. This requested information included: (1) the location of the earthquake, (2) a description of the local geology(ies) of the facility and seismic recording site, (3) the distances from the earthquake to the facility and from the facility to the seismic recording instrument, (4) an estimate of the ground motion response spectrum at the facility, and (5) a description of the method used to estimate the facility ground motion response spectrum. In addition, the staff requested that the BWROG create a definitive earthquake experience database since some of the BWR plants had used earthquake-facility pairs that are not listed in Table 3-2 of Appendix D to demonstrate the seismic capability of their piping and condensers. Since the response provided by BWROG, by letter dated February 19, 1996 (Reference 3), did not completely respond to the staff's questions concerning the earthquake experience database, a conference call was held on May 9, 1996. BWROG then provided an updated response to the staff by letter dated January 9, 1997 (Reference 4). This response also did not provide the requested information and on March 6, 1997, the staff had another conference call with representatives of BWROG. The staff and BWROG jointly acknowledged that some of the requested information for the earthquake experience database might not be obtainable and as a result, some facilities should be removed from the database.

By letter dated September 22, 1997 (Reference 5), BWROG provided the staff with an updated earthquake experience database. This database contains 18 facility-earthquake pairs and provides estimates of ground motion response spectra for six facilities. Previously, the staff had accepted four facility ground motion estimates (Valley Steam, Burbank Power, El Centro Steam, and Moss Landing) in plant-specific reviews. Staff review of the six new facility ground motion estimates found errors with three of the estimates. For two facility ground motion estimates, EQE used an incorrect damping value (2% of critical instead of 5%) for the response spectra and the vertical and horizontal components of ground motion were switched for another facility estimate. On May 8, 1998, BWROG submitted a revised earthquake experience database (Reference 6) that contains 18 facility-earthquake (including aftershocks) pairs and corrects the errors found in the September 22, 1997, database (Reference 5). A review of this latest database is presented in the next section.

5.4.2 Evaluation of Seismic Ground Motions

For facilities without on-site seismic recording instruments, estimating the ground motion requires knowledge of: (1) the earthquake source characteristics (magnitude, focal mechanism, rupture area, fault orientation), (2) the distances from the facility and recording site to the fault rupture area, (3) the distance from the facility to the recording site, (4) the propagation path and its geologic properties, and (5) the geology(ies) immediately beneath the facility and recording site. Since the ground motion may vary significantly over small distances, it is important to verify that differences in distance, propagation path, and local geology are minimal between the facility and the recording site.

5.4.2.1 Previously Accepted Facility Ground Motion Estimates

Ground motion estimates at the Valley Steam Plant, the Burbank Power Plant, the El Centro Steam Plant, and the Moss Landing Power Plants have been previously reviewed and accepted by the staff. For the Valley Steam and Burbank Power facilities the staff has accepted the U.S. Geological Survey (USGS) estimates of the ground motion since the nearest recording of the 1971 M6.6 San Fernando earthquake is more than 8 km distant from the two facilities. To make these two estimates, seismologists at the USGS modified the ground motion record of the

1971 San Fernando earthquake made at the Holiday Inn in Van Nuys, CA. The main adjustment made to the Holiday Inn record was to account for differences in ground motion attenuation between the recording site and the Valley Steam and Burbank facilities. USGS estimates for the Valley Steam and Burbank facilities as well as the Holiday Inn response spectrum and ground motion are shown in Figures 1 and 2, respectively.

For the El Centro Steam Plant in El Centro, CA, the closest recording site is less than 2 km from the plant and is underlain by similar soils. In addition, there were several other seismic instruments in the area that also recorded the 1979 M6.6 Imperial Valley earthquake. Variations in the ground motion from this earthquake were extensively studied and reported in the literature. Therefore, the staff was able to conclude that the seismic recording site and the El Centro Steam Plant experienced similar levels of ground motion. The recording site ground motion and response spectra are shown in Figure 3.

The EQE estimate of ground motion at the Moss Landing Power Plant is based on a study performed by Pacific Gas and Electric (PG&E), the owner of the Moss Landing Power Plant. The staff concluded that this estimate of ground motion at the Moss Landing facility from the 1989 M7.1 Loma Prieta earthquake is technically sound and comprehensive. The PG&E estimate, as well as the ground motion and response spectra from the nearest recording site in Watsonville, CA, are shown in Figure 4.

5.4.2.2 <u>On-Site Facility Recordings</u>

On-site recordings of ground motion made at Humboldt Bay Power Plant (HBPP) from the 1975 M5.5 Ferndale earthquake and the 1992 M6.9 Petrolia mainshock and M6.2 aftershock are shown in Figures 5, 6, and 7, respectively. EQE also listed an additional 1992 Petrolia aftershock in the earthquake experience database. However, the response spectrum at HBPP from this aftershock is enveloped by the three other HBPP response spectra. For the 1980 M7.2 Eureka earthquake, listed in the database, only a scratch plate record of the response spectrum at 2% of critical damping was made at HBPP. Since the accuracy of this record is questionable, the staff does not accept this facility-event pair for inclusion in the database.

On-site recordings made at Las Ventanas Units 1 & 2 in Quintero Bay, Chile, from the 1985 M7.8 Valparaiso earthquake, shown in Figure 8, have been reviewed and accepted by the staff. Also, the staff has reviewed and accepted the on-site recording made at Coolwater Power Plant in Dagget, CA, of the 1992 M7.3 Landers earthquake, shown in Figure 9. The staff has not reviewed the Coolwater recording of the 1992 M6.5 Big Bear earthquake. However, the ground motion response spectrum from this event is most likely enveloped by the Coolwater spectrum of the Landers earthquake.

Recordings of the Miyagi-ken-Oki earthquake in Japan made on-site at the New Sendai Power Plant and the Fukushima Nuclear Power Plant have not been made available to the staff and as such, should not be included in the earthquake experience database.

5.4.2.3 <u>Additional Facility Ground Motion Estimates</u>

The most recent EQE earthquake experience database includes ground motion estimates at four additional facilities, which were found acceptable to the staff:

Commerce Refuse to Energy Plant in Commerce, CA
Grayson Power Plant in Glendale, CA
Ormond Beach Power Plant in Port Hueneme, CA
PALCO Cogeneration Plant in Scotia, CA.

The Commerce Refuse to Energy Plant is located about 1 km from a site that recorded the 1987 M5.9 Whittier Narrows earthquake. Both the facility and recording sites are located on thick alluvium deposits. The seismic recording made at the Bulk Mail Facility in Bell, CA, is an acceptable estimate of the ground motion at the Commerce Refuse to Energy Plant. Figure 10 shows the response spectra and ground motion for the two horizontal components at the recording site in Bell, CA.

The Grayson Power Plant in Glendale, CA, is located about 2 km from the Glendale City Hall. The latest EQE earthquake experience database (Reference 6) incorrectly gives a facility-to-recording site distance of 16 km. Both the facility and recording site are located on similar thicknesses of alluvium and therefore, the recording of the 1971 M6.6 San Fernando earthquake made at Glendale City Hall is an acceptable estimate of the ground motion at the Grayson Power Plant (Figure 11). Similarly, the Port Hueneme Naval Laboratory recording of the 1973 M5.6 Point Mugu earthquake, shown in Figure 12, is an acceptable estimate of the ground motion at the Ormond Beach Power Plant in Port Hueneme, CA.

The estimate of ground motion for the PALCO Cogeneration Plant in Scotia, CA, located 2.3 km to the south of the recording site in Rio Dell, from the 1992 M6.9 Petrolia earthquake is shown in Figure 13. Since the response spectra for the two horizontal components vary quite significantly and we have no explanation for this difference, the average of the two components should be used as the estimate of the ground motion at the PALCO plant.

5.4.3 Conclusion on Seismic Ground Motions

The facility ground motion estimates shown in Figures 1 through 13 of this attachment have been reviewed and accepted by the staff for inclusion in BWROG's earthquake experience database. These 13 facility ground motion estimates may be used to verify the seismic adequacy of equipment in the alternative MSIV leakage pathway for plants referencing BWROG's Topical Report, NEDC-31858P, Revision 2. With the exception of the facility estimates for the Valley Steam Plant, the Burbank Power Plant, and the Moss Landing Power Plant, the nearby recording site or on-site response spectra, shown in the attached figures, should be used to estimate the facility ground motion. USGS estimated response spectra should be used for the Valley Steam Plant and the Burbank Power Plant and the PG&E estimated response spectrum should be used for the Moss Landing Power Plant.

It should be emphasized that, at the present time, there is no standard, endorsed by NRC, that provides guidance for determining what constitutes an acceptable number of earthquake recordings and their magnitudes, to be referenced for particular applications of this methodology. Therefore, individual licensees are responsible for ensuring the sufficiency of the data, in concert with above staff evaluation of the BWROG report and the past staff reviews for individual plant submittals discussed in Section 4.0.

5.5 Seismic Verification Walkdowns and Assessments

The staff recognizes that properly designed welded systems may exhibit seismic ruggedness even under loadings greater than a design basis earthquake loading. In the past, NRC has also investigated the actual failure modes of piping due to earthquake loadings. Based on NUREG-1061, Volume 2 Addendum, "Summary and Evaluation of Historical Strong-Motion Earthquake Seismic Response and Damage to Above-Ground Industrial Piping," dated April 1985, the staff found that the piping failures which have been observed in past earthquakes and failures that could potentially occur in the future can be divided into the following four primary categories:

(1) failure of pipe due to excessive displacement of attached equipment;
(2) failure of branch piping due to excessive displacement of attached piping mains;
(3) failure of piping associated with loss of pipe supports; and
(4) failure of piping due to failure of enclosing building and its internals.

The staff considered the above to be also the credible failure modes that need to be addressed during the plant-specific walkdowns, when the earthquake experience-based methodology is used for the verification of seismic adequacy of BWR main steam system piping and condenser. Section 6.7 of the BWROG report describes plant-specific reviews and evaluations which the BWROG recommends individual licensees perform, in order to provide reasonable assurance that the main steam line, the bypass/drain piping, and the main condenser will maintain structural integrity and operability during and following an SSE. Consistent with NUREG-1061, Section 6.7.1 of the BWROG report identifies the primary seismic failure modes to be evaluated. These failure modes include interactions between non-seismically designed plant features and seismically designed plant features (seismic II/I situations), and differential seismic anchor motions on piping systems.

In order to identify and resolve potential seismic II/I situations, Section 6.7.1.1 of the BWROG report dictates that individual licensees perform plant-specific reviews to assess potential failures of non-seismically designed equipment overhead and adjacent to the main steam piping, bypass/drain piping, and condenser. The report states that these reviews may include a review of existing non-safety design programs, plant walk-through, and/or analysis. The report requires that existing non-safety design programs (e.g., seismic design to Uniform Building Code, wind design bases for turbine buildings) are reviewed to identify structures and components which have been evaluated for position retention integrity under earthquake loadings. The report also states that the earthquake experience database may be used to assess component structural integrity in direct field walkdown assessments for seismic II/I types of effect. Potential seismic interactions will be evaluated for piping components such as valve operators, vents, drains, instrumentation, and fragile appurtenances.

Piping and equipment items identified to be potentially vulnerable during the walkdown assessments will be considered outliers. These outliers should be resolved according to each individual licensee's action plan. The approach for the outlier resolution, including analytical methodology used, should be one that is acceptable to the staff.

In order to identify and resolve potential problems due to differential seismic anchor motion, Section 6.7.1.2 of the BWROG report requires that piping be evaluated to ensure that adequate piping flexibility exists to preclude loss of integrity. More specifically, piping systems should be reviewed to identify the potential for: (1) excessive movement of terminal end equipment, (2) excessive differential movement between pipe supports in adjacent, uncoupled buildings, and (3) excessive movements imposed on small branch lines by flexible headers.

The staff found the above BWROG recommendations allow the plant-specific reviews to be focused on identification and resolution of the stated potential failure modes, and are, therefore, acceptable.

5.6 Existing Seismic Analyses for ALT Pathway

The staff has found that most of the early BWRs have seismically analyzed main steam piping up to the outermost MSIV, whereas later BWRs have extended the seismic analysis from the outermost MSIV up to the turbine stop valve (in some plants, the bypass piping was also analyzed). In addition, some BWRs have a third shutoff valve and a seismic restraint inside the auxiliary building steam tunnel. For these plants, the third shutoff valve can be partially credited with providing a means of isolating the MSIV leakage and, therefore, the piping downstream of the third shutoff valve will not be needed as part of the ALT path. Because of these differences in the plant's physical configuration and differences in the amount of existing seismic analysis, the level of effort required to verify the seismic adequacy of the specific MSIV ALT path varies from plant to plant.

Individual licensees should ensure that for all portions of piping credited toward the MSIV ALT method (i.e., main steam piping up to and including the turbine stop valve, and bypass/drain piping to the condenser; or, for plants with a third shutoff valve, main steam piping up to the third shutoff valve and main steam drain piping to the condenser), which have not been seismically analyzed, a seismic verification walkdown should be performed to evaluate the seismic ruggedness and potential failure modes of piping systems.

5.7 Plant-Specific Verification for the adequacy of ALT Path Piping and Condenser

Section 6.7.2 of the BWROG report describes the scope of the plant-specific reviews. The report states that the individual plant condenser design will be reviewed to demonstrate that it falls within the bounds of design characteristics found in the earthquake experience database. This will also include a review of as-built design documents and/or a walkdown to verify that the condenser has adequate anchorage.

Based on its review of the BWROG report, the staff has determined that the generic methodology presented, coupled with the plant-specific analytical evaluations for the condenser structural members and their associated anchorages, would provide an acceptable method to verify the seismic adequacy of the condenser design. Individual licensees must, however, confirm that the condenser will not fail due to seismic II/I types of interaction (e.g., structural failure of the turbine building and its internals). Based on the generic data reviewed, the staff has found that the application of an earthquake experience database to BWR condensers in the U.S. is generally appropriate, since condensers in nuclear plants are typically similar to condensers in non-nuclear plants. The staff will evaluate plant-specific submittals which verify the applicability of the generic condenser database to the plant-specific condensers for those facilities seeking to use the condensers as part of an ALT path.

As part of a plant-specific approval, all portions of the main steam and bypass/drain piping which have not been seismically analyzed will be reviewed to demonstrate that piping and supports fall within the bounds of the database. As stated in the BWROG report, this will include a review of design codes and standards used to ensure adequate dead load support margin and ductile support behavior when subject to lateral loads. It will also include a walkdown to verify that small diameter piping and instrumentation are free from impact interactions, from falling objects, and from differential motion hazards. Interconnected piping systems to the main steam lines, bypass/drain piping, and condenser will be reviewed to ensure adequate piping design, freedom from adverse interactions, and adequate anchorage up to major system equipment.

The staff has determined that the plant-specific reviews described above generally address the four primary categories of piping failures identified in Section 5.5 of this evaluation. If properly implemented, the recommended review methods should be adequate in addressing all the potential piping concerns. In submitting their amendment requests, licensees should incorporate all of BWROG's recommendations and commitments, as previously discussed. In addition, licensees should address plant-specific information for piping design parameters (e.g., uniqueness of piping configurations, pipe span between supports, and diameter-to-thickness ratios for each pipe size) to demonstrate that they are bounded by those associated with the earthquake experience database.

In addition to the above, representative supports and anchors associated with ALT path piping should also be analytically evaluated for their seismic adequacy. Consistent with Section 5.2, the methodology and criteria used for such evaluations should be those which are in compliance with the design basis methodology and criteria, or those which are acceptable to the staff.

It should be noted that, at the present time, there is no standard that provides guidance for determining what constitutes an adequate number of piping and equipment items in the earthquake experience database, to be referenced for particular applications of this methodology. The American Society of Mechanical Engineers (ASME) is currently proceeding with a revision to the QME Standard, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," to provide some criteria for the use of earthquake experience data in the seismic qualification of mechanical equipment (not including piping). Until such revision is finalized and endorsed by NRC, individual licensees are responsible for ensuring the sufficiency of the experience data submitted for staff review of MSIV leakage applications.

5.8 <u>Bounding Seismic Analyses</u>

As stated previously, Appendix A to 10 CFR Part 100 requires that the engineering method used to ensure that the safety functions of ALT pathways are maintained during and after an SSE involves the use of either a suitable dynamic analysis or suitable qualification test, except where it can be demonstrated that the use an equivalent static load method provides adequate conservatism.

In order for the staff to conclude that the proposed ALT piping system will maintain its functionality under the plant design basis SSE, licensees whose plant's FSAR or UFSAR reference 10 CFR Part 100, are required to provide for staff review a summary of the bounding seismic analysis for a representative portion of the ALT bypass/drain piping. Such a bounding seismic analysis should serve to yield the most conservative piping stresses and support loads for the proposed ALT system, to substantiate the earthquake database methodology, and ultimately to verify the overall seismic adequacy of the ALT system piping. The licensee's evaluation should discuss the basis for selecting a particular portion of the bypass/drain line for the bounding analysis. This is to ensure that potentially the most vulnerable pipe routing and support configurations are considered for the analysis.

The methodology and criteria used for the bounding analysis should conform to the plant licensing basis, as described in the plant FSAR or the UFSAR. This pertains to both piping stress calculations and the evaluation for supports and anchorages. For plants where no specific design procedures and criteria, for seismic qualification of equipment and components, are specified in the FSAR or UFSAR, only the methodology and criteria that were found acceptable to the staff in similar MSIV ALT path reviews should be used. Licensees are reminded that the analytical procedures described in the EPRI NP-6041 report are not currently endorsed by the staff for the resolution of the MSIV leakage issue.

For plants whose construction permits were docketed prior to the effective date of 10 CFR Part 100, a bounding seismic analysis as discussed above is not required by the staff. In the absence of specific commitments to the performance of seismic qualification of mechanical equipment and components, licensees of these plants may use the methodology and criteria that were found acceptable to the staff in previous MSIV ALT path reviews for plants of similar vintage, to resolve the MSIV leakage issue at their facilities.

6.0 SUMMARY OF LIMITATIONS ON THE USE OF THE BWROG REPORT

Based on the above evaluation, the staff has identified a number of limitations which individual licensees should address, when electing to utilize the BWROG approach for resolving the MSIV issue in the future. These limitations, which are contained in the body of this SE, are listed below:

1. Individual licensees should provide a detailed description of the ALT drain path and the basis for its functional reliability, commensurate with its intended safety-related function. The licensee should also describe their maintenance and testing program for the active components (such as valves) in the ALT path.

2. Individual licensees should provide plant-specific information for piping design parameters (e.g., uniqueness of piping configurations, pipe span between supports, and diameter-to-thickness ratios for each pipe size), to demonstrate that they are enveloped by those associated with the earthquake experience database.

3. Individual licensees should demonstrate that the plant condenser design falls within the bounds of design characteristics found in the earthquake experience database. This should include a review of as-built design documents and/or a walkdown to verify that the condenser has adequate anchorage.

4. Individual licensees should perform a plant-specific seismic evaluation for representative supports and anchorages associated with affected piping and the condenser.

5. Individual licensees should confirm that the condenser will not fall due to seismic II/I type of interaction (e.g., structural failure of the turbine building and its internals).

6. Individual licensees of plants whose FSARs or UFSARs reference Appendix A to 10 CFR Part 100 should perform a bounding seismic analysis for the ALT path piping. Those licensees committed to Part 100 should discuss the basis for selecting a particular portion of the bypass/drain line for the bounding analysis.

7. The methodology and criteria used for the analytical evaluations should be those which are in compliance with the design basis methodology and criteria, or those which are acceptable to the staff.

8. The facility ground motion estimates shown in Figures 1 through 13 of this attachment have been reviewed and accepted by the staff for inclusion in BWROG's earthquake experience database. These 13 facility ground motion estimates may be used to verify the seismic adequacy of equipment in the alternative MSIV leakage pathway for plants referencing the BWROG's Topical Report, NEDC-31858P, Revision 2.

9. At the present time, there is no standard, endorsed by NRC, that provides guidance for determining what constitutes an acceptable number of earthquake recordings and their magnitudes and for determining the required number of piping and equipment items, that should be referenced in the earthquake experience database when utilizing the BWROG methodology. Therefore, individual licensees are responsible for ensuring the sufficiency of the data to be submitted for staff review and determination. When a revision of the QME Standard that incorporates specific criteria for use of experience data in the qualification of mechanical equipment is endorsed by NRC, such criteria should be followed in future applications involving MSIV ALT pathway evaluations.

7.0 CONCLUSION

Based on the above evaluation, the staff determines that BWROG's proposed approach contained in the GE report, NEDC-31858P, Revision 2, together with the additional information provided in its letters of February 19, 1996 (Reference 3), January 9, 1997 (Reference 4), September 22, 1997 (Reference 5), and May 8, 1998 (Reference 6), constitutes a viable approach for the resolution of the BWR MSIV leakage issue, provided it adheres to the staff limitations contained in this evaluation. Licensees referencing the BWROG report, and demonstrating the plant-specific attributes in accordance with this SER, should be able to justify plant-specific amendments and should be allowed to increase the MSIV leakage rate up to a maximum of 200 scfh and, if applicable, eliminate the LCS. In accordance with the limitations stated in Section 6.0, the staff concludes that when plant-specific evaluations are properly performed, reasonable assurance can be obtained that, for current operating BWRs, the main steam piping from the outermost isolation valve up to the turbine stop valve, the bypass/drain piping to the main condenser, and the main condenser will retain their structural integrity during and following an SSE. The staff determines, therefore, the BWROG report is acceptable for direct reference by future individual plant submittals on the MSIV leakage issue. The final version of the BWROG report should incorporate this safety evaluation, and its use by member utilities is subject to the conditions and limitations stated in this SE. The closure of this issue for each plant will be accomplished through the review and approval of the implementation submittal provided by the respective licensee.

8.0 REFERENCES

(1) NEDC-31858P, BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems, Revision 2, September 1993

(2) Letter from E. H. Trottier (NRC) to T. A. Green (BWROG), "Request for Additional Information - Topical Report NEDC-31858P (Revision 2) BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems," March 29, 1995

(3) Letter from K. P. Donovan (BWROG) to Document Control Desk (NRC), "BWR Owners' Group Response to Request for Additional Information Regarding Topical Report, NEDC-31858P, Revision 2," February 19, 1996

(4) Letter from K. P. Donovan (BWROG) to Document Control Desk (NRC), "BWR Owners' Group Response to Request for Additional Information Regarding Topical Report, NEDC-31858P, Revision 2," January 9, 1997

(5) Letter from T. A. Green (BWROG) to Tilda Liu (NRC), "BWR Owners' Group Response to NRC Comments Regarding Seismic Events Referenced in NEDC-31858P, Revision 2," September 22, 1997

(6) Letter from T. A. Green (BWROG) to Tilda Liu (NRC), "EQE Database Power Plant Site Ground Motion Estimates," May 8, 1998

Principal Reviewers: A. J. Lee
C. Munson

Date: March 1999

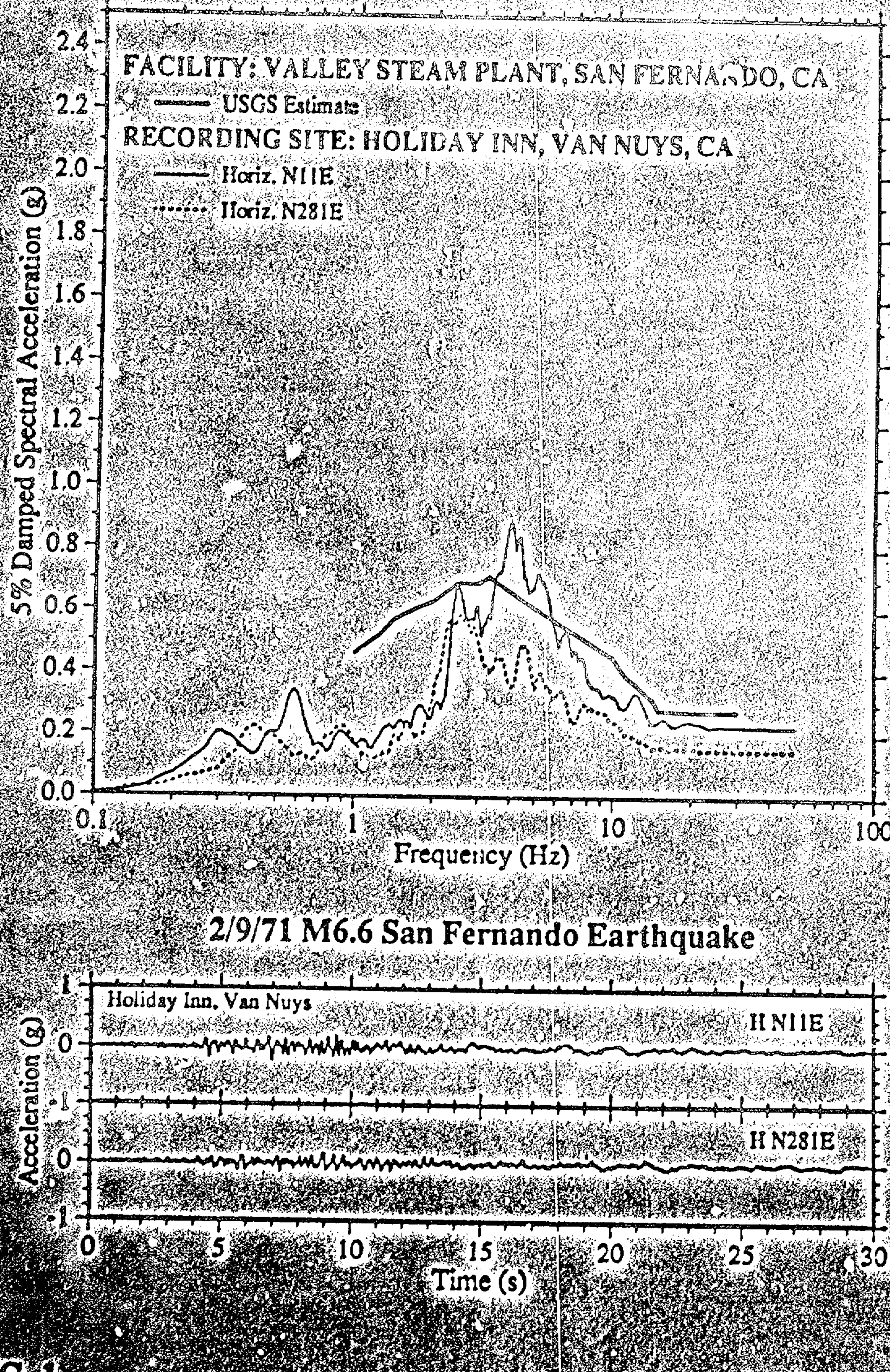
FACILITY: VALLEY STEAM PLANT, SAN FERNANDO, CA
USGS Estimate
RECORDING SITE: HOLIDAY INN, VAN NUYS, CA
Horiz. N11E
Horiz. N281E
5% Damped Spectral Acceleration (g)
Frequency (Hz)
2/9/71 M6.6 San Fernando Earthquake
Holiday Inn, Van Nuys
H N11E
H N281E
Acceleration (g)
Time (s)

FIG. 1

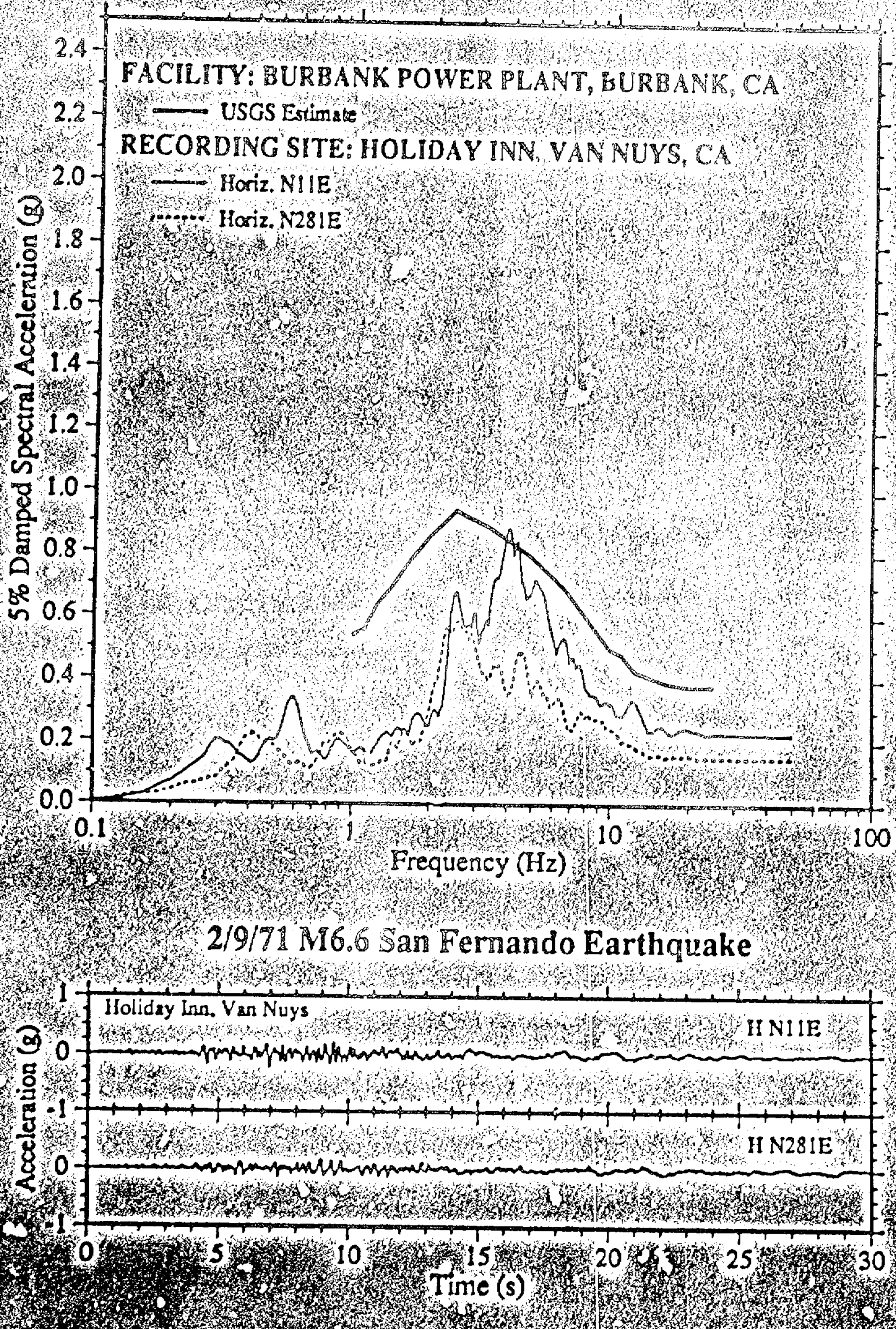
FACILITY: BURBANK POWER PLANT, BURBANK, CA
USGS Estimate
RECORDING SITE: HOLIDAY INN, VAN NUYS, CA
Horiz. N11E
Horiz. N281E
5% Damped Spectral Acceleration (g)
Frequency (Hz)
2/9/71 M6.6 San Fernando Earthquake
Holiday Inn, Van Nuys
H N11E
H N281E
Acceleration (g)
Time (s)

FIG. 2

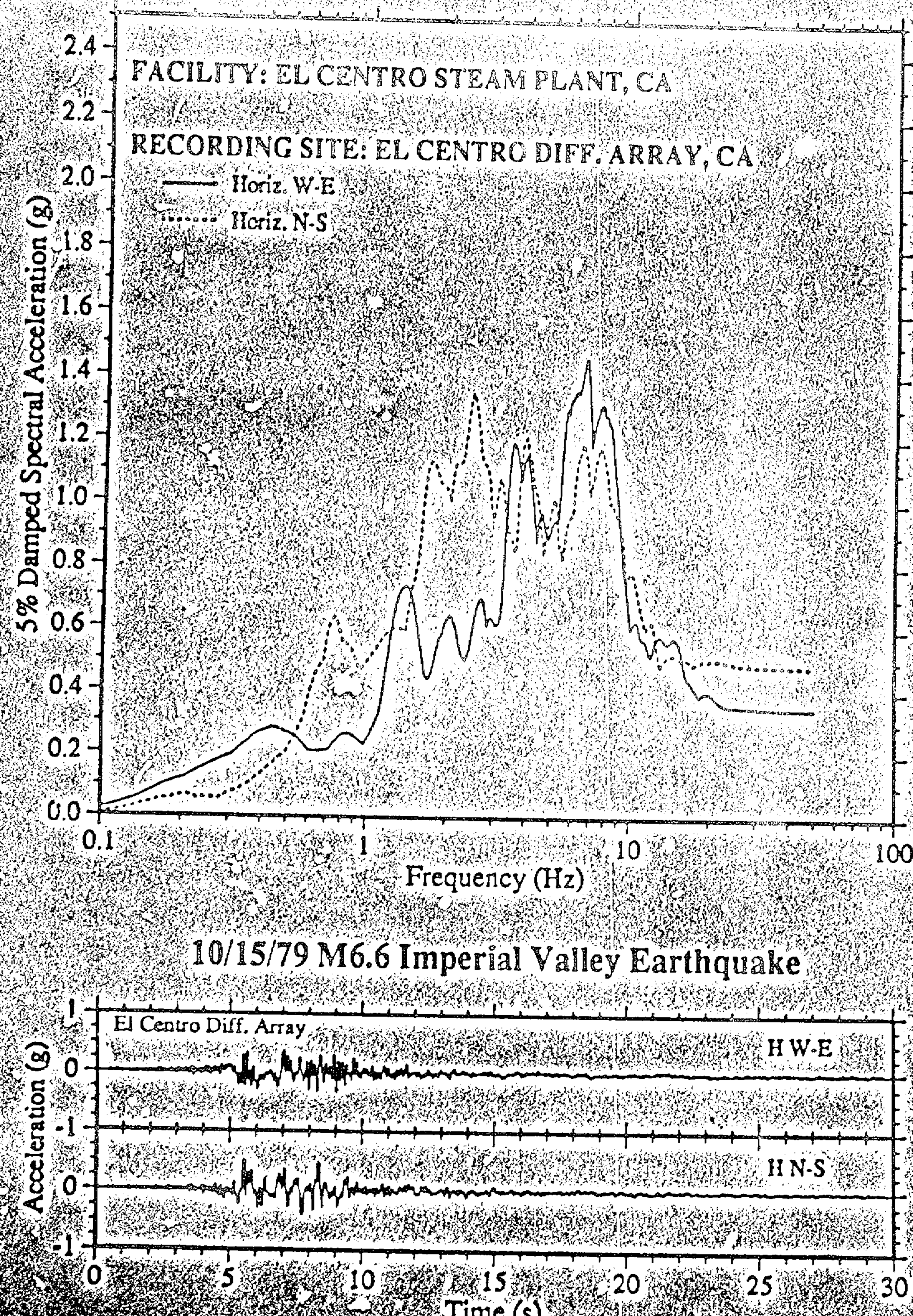
FACILITY: EL CENTRO STEAM PLANT, CA
RECORDING SITE: EL CENTRO DIFF. ARRAY, CA
Horiz. W-E
Horiz. N-S
5% Damped Spectral Acceleration (g)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.1
1
10
100
Frequency (Hz)
10/15/79 M6.6 Imperial Valley Earthquake
El Centro Diff. Array
H W-E
H N-S
Acceleration (g)
1
0
-1
0
-1
0
5
10
15
20
25
30
Time (s)

FIG. 3

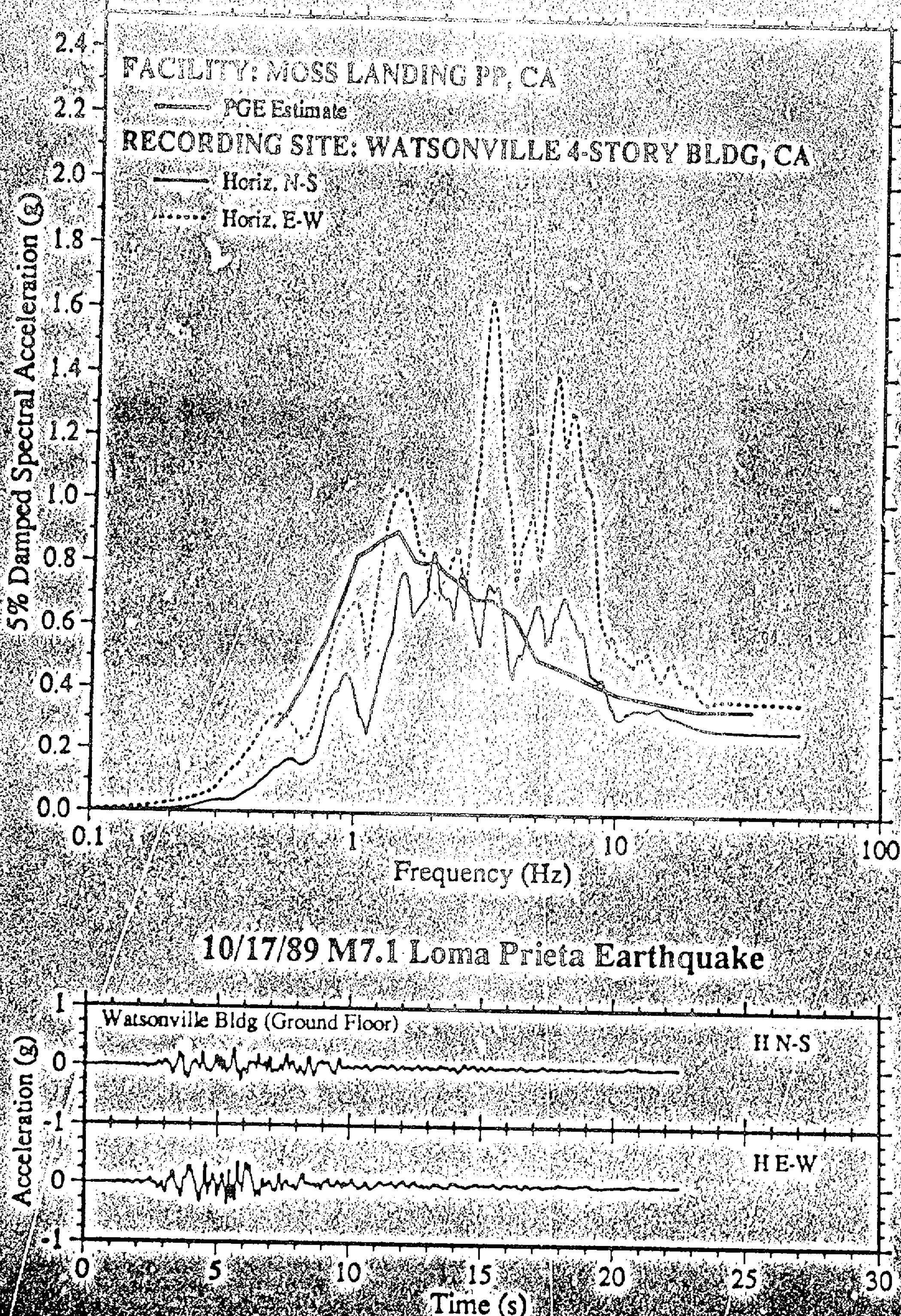
FACILITY: MOSS LANDING PP, CA
PGE Estimate
RECORDING SITE: WATSONVILLE 4-STORY BLDG, CA
Horiz. N-S
Horiz. E-W
5% Damped Spectral Acceleration (g)
Frequency (Hz)
10/17/89 M7.1 Loma Prieta Earthquake
Watsonville Bldg (Ground Floor)
H N-S
H E-W
Acceleration (g)
Time (s)

FIG. 4

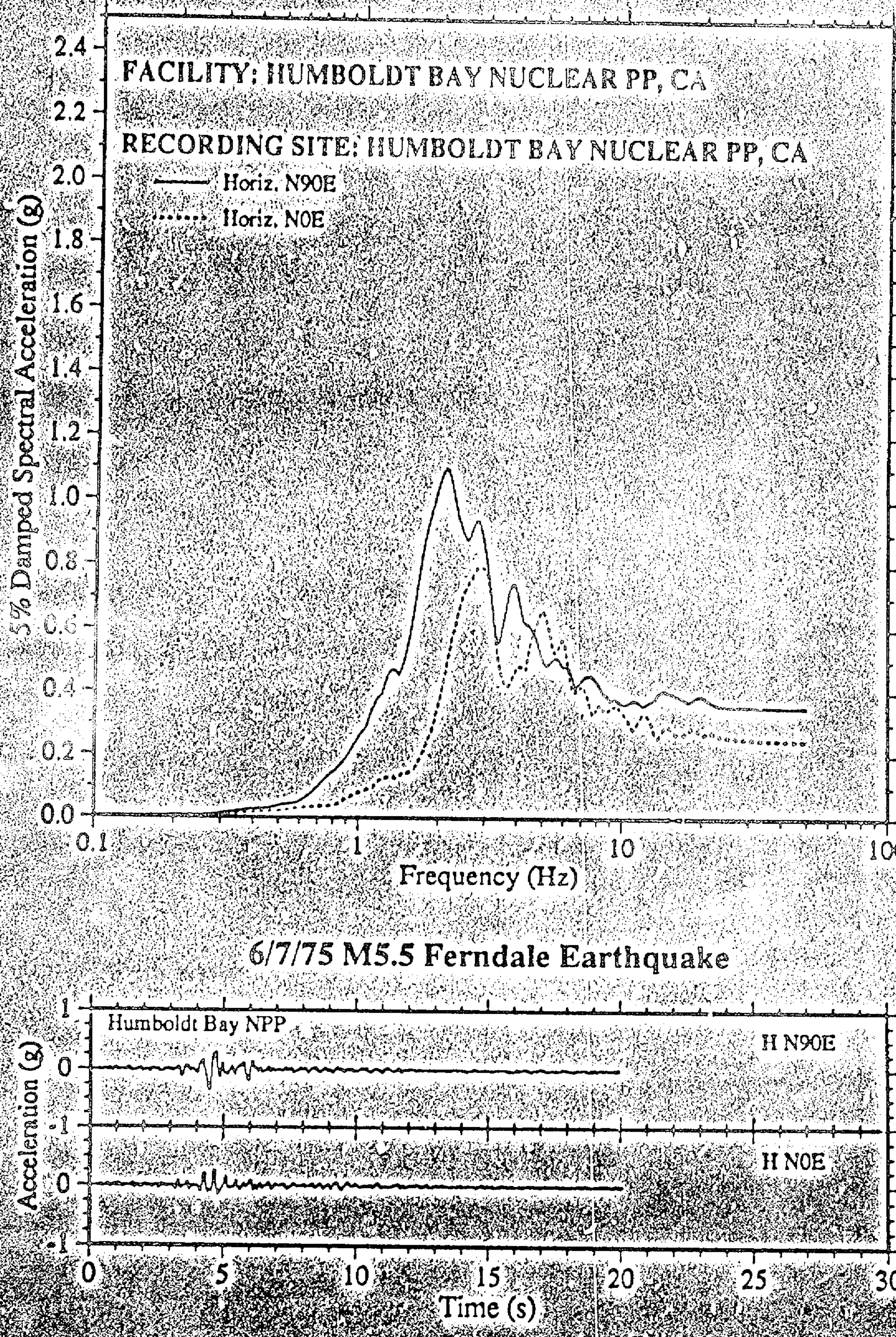
FACILITY: HUMBOLDT BAY NUCLEAR PP, CA
RECORDING SITE: HUMBOLDT BAY NUCLEAR PP, CA
Horiz. N90E
Horiz. N0E
5% Damped Spectral Acceleration (g)
Frequency (Hz)
6/7/75 M5.5 Ferndale Earthquake
Humboldt Bay NPP
H N90E
H N0E
Acceleration (g)
Time (s)

FIG. 5

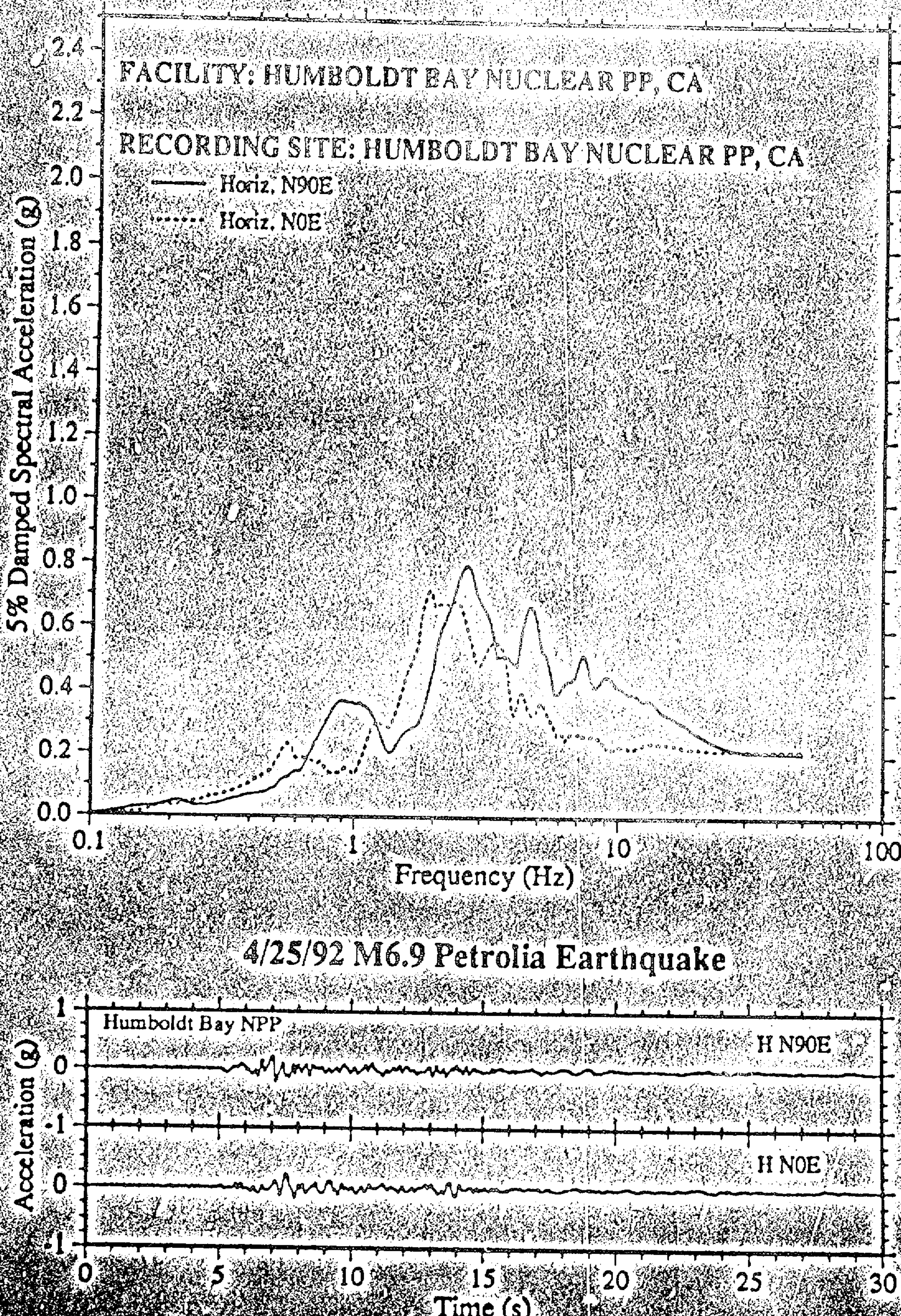
FACILITY: HUMBOLDT BAY NUCLEAR PP, CA
RECORDING SITE: HUMBOLDT BAY NUCLEAR PP, CA
Horiz. N90E
Horiz. N0E
5% Damped Spectral Acceleration (g)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.1
1
10
100
Frequency (Hz)
4/25/92 M6.9 Petrolia Earthquake
Humboldt Bay NPP
H N90E
H N0E
Acceleration (g)
1
0
-1
0
-1
0
5
10
15
20
25
30
Time (s)

FIG. 6

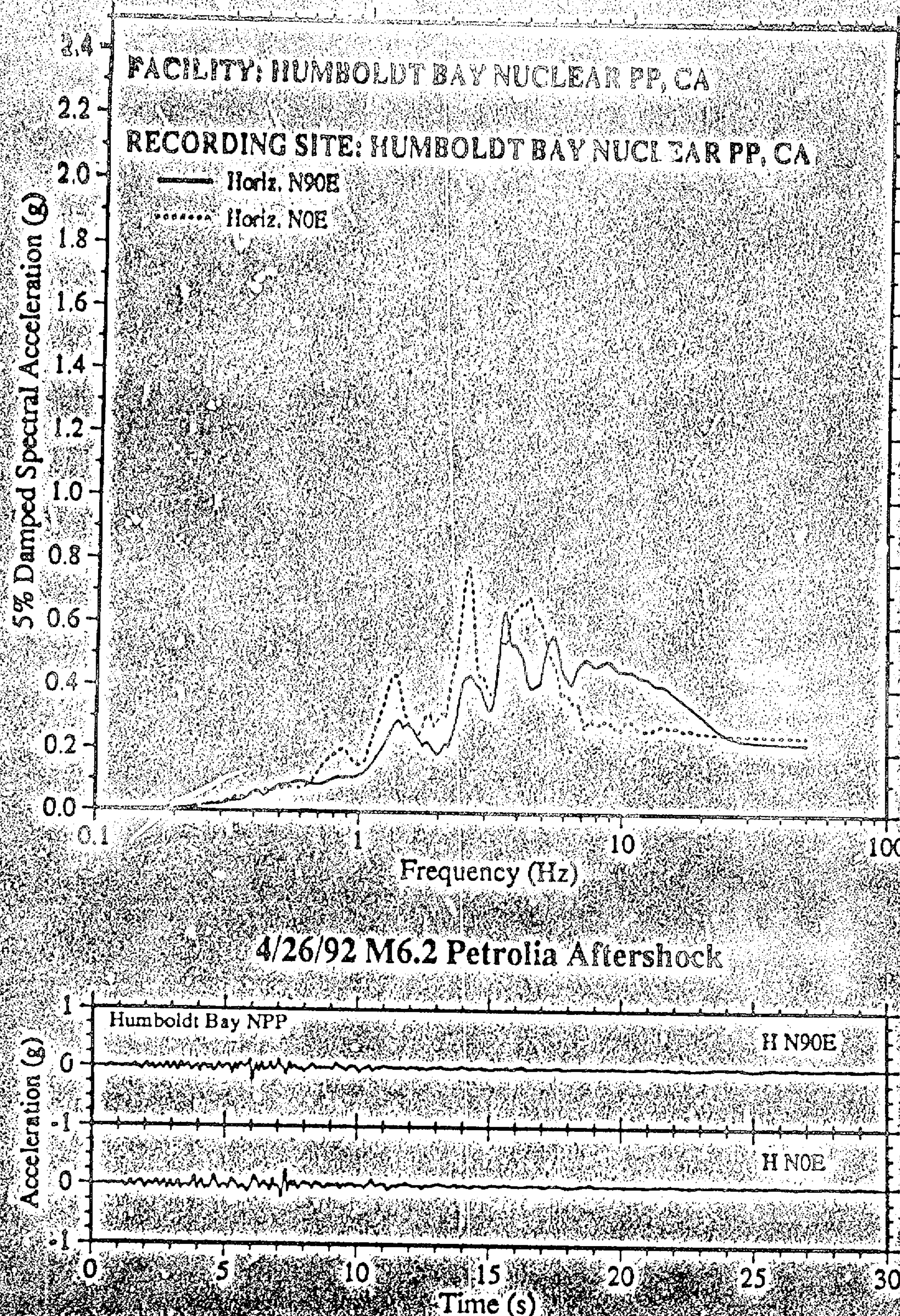
FACILITY: HUMBOLDT BAY NUCLEAR PP, CA
RECORDING SITE: HUMBOLDT BAY NUCLEAR PP, CA
Horiz. N90E
Horiz. N0E
5% Damped Spectral Acceleration (g)
Frequency (Hz)
4/26/92 M6.2 Petrolia Aftershock
Humboldt Bay NPP
H N90E
H N0E
Acceleration (g)
Time (s)

FIG. 7

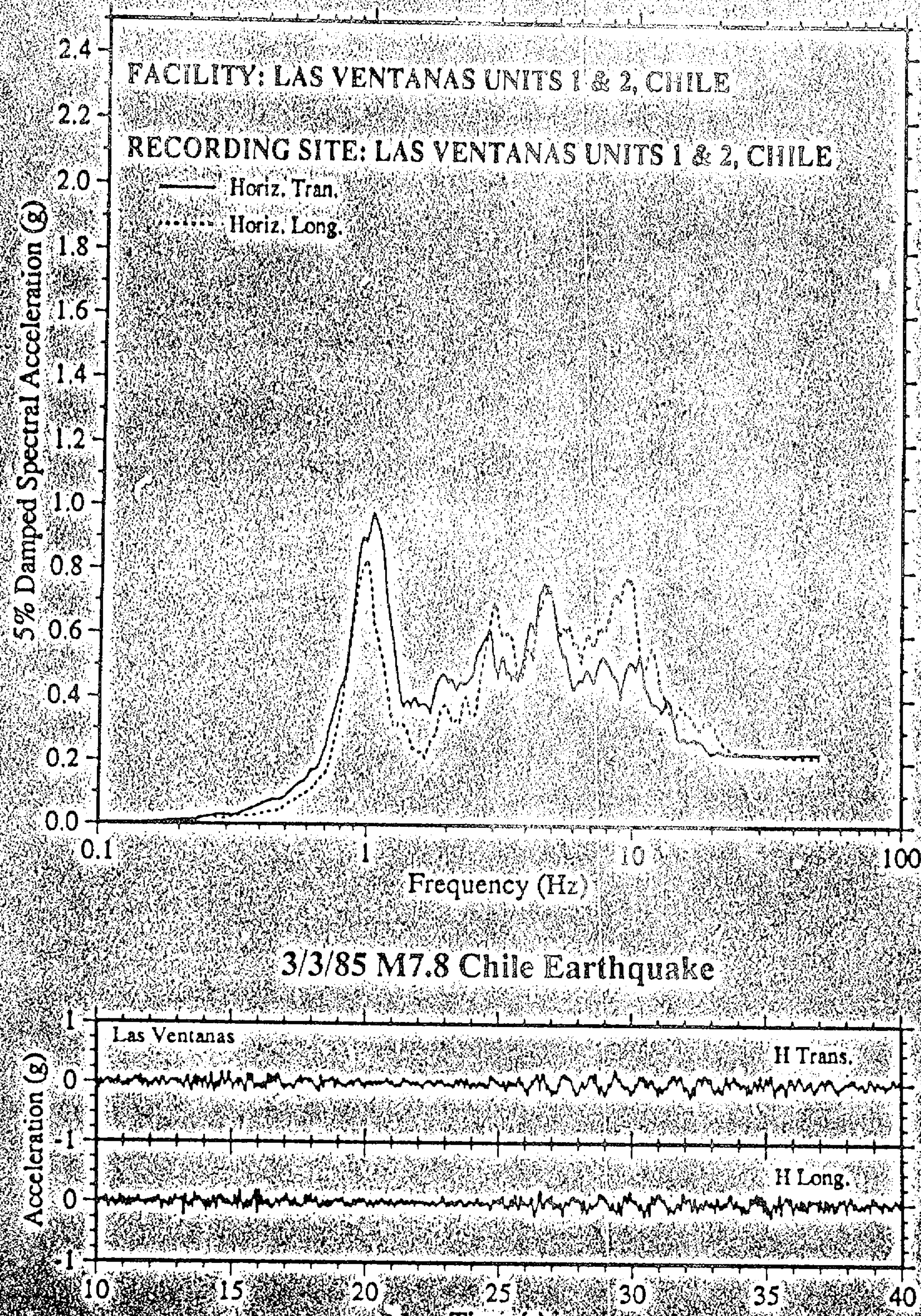
FACILITY: LAS VENTANAS UNITS 1 & 2, CHILE
RECORDING SITE: LAS VENTANAS UNITS 1 & 2, CHILE
Horiz. Tran.
Horiz. Long.
5% Damped Spectral Acceleration (g)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
0.1
1
10
100
Frequency (Hz)
3/3/85 M7.8 Chile Earthquake
Las Ventanas
H Trans.
H Long.
Acceleration (g)
1
0
-1
10
15
20
25
30
35
40
Time (s)

FIG. 8

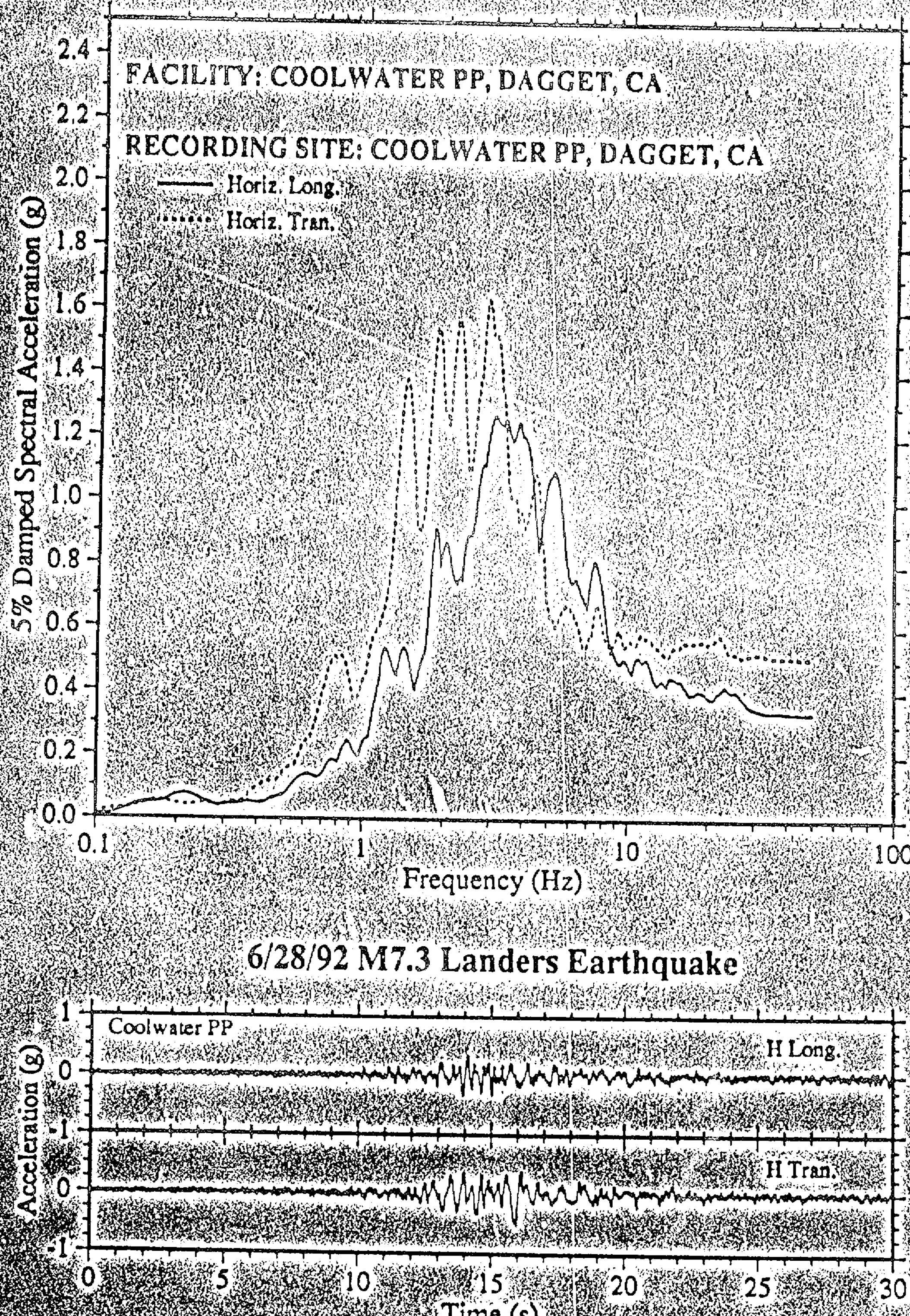
FACILITY: COOLWATER PP, DAGGET, CA
RECORDING SITE: COOLWATER PP, DAGGET, CA
Horiz. Long.
Horiz. Tran.
5% Damped Spectral Acceleration (g)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.1
1
10
100
Frequency (Hz)
6/28/92 M7.3 Landers Earthquake
Coolwater PP
H Long.
H Tran.
Acceleration (g)
1
0
-1
0
5
10
15
20
25
30
Time (s)

FIG. 9

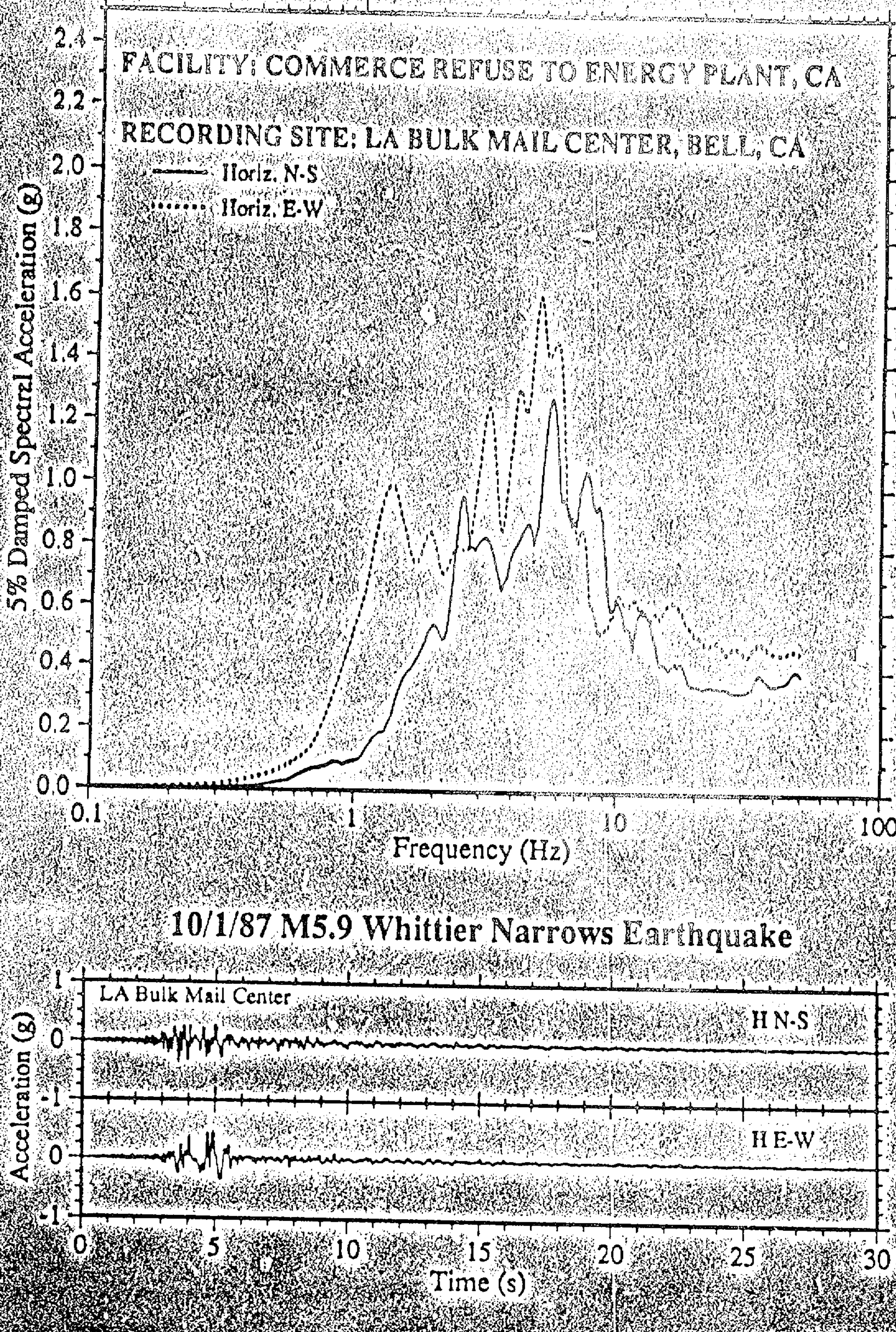
FACILITY: COMMERCE REFUSE TO ENERGY PLANT, CA
RECORDING SITE: LA BULK MAIL CENTER, BELL, CA
Horiz. N-S
Horiz. E-W
5% Damped Spectral Acceleration (g)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.1
1
10
100
Frequency (Hz)
10/1/87 M5.9 Whittier Narrows Earthquake
LA Bulk Mail Center
H N-S
H E-W
Acceleration (g)
1
0
-1
0
5
10
15
20
25
30
Time (s)

FIG. 10

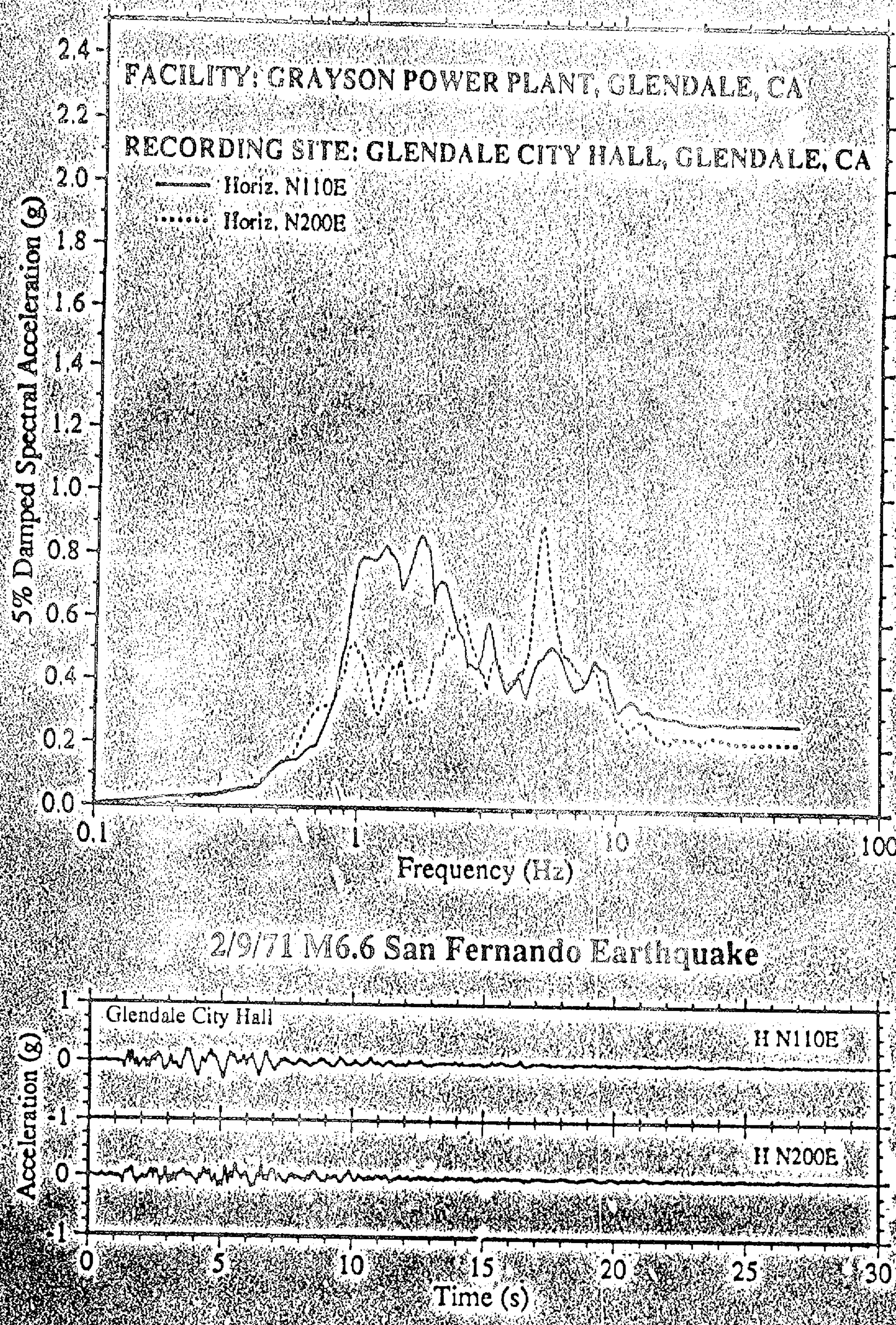
FACILITY: GRAYSON POWER PLANT, GLENDALE, CA
RECORDING SITE: GLENDALE CITY HALL, GLENDALE, CA
Horiz. N110E
Horiz. N200E
5% Damped Spectral Acceleration (g)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.1
1
10
100
Frequency (Hz)
2/9/71 M6.6 San Fernando Earthquake
Glendale City Hall
H N110E
H N200E
Acceleration (g)
1
0
-1
0
5
10
15
20
25
30
Time (s)

FIG. 11

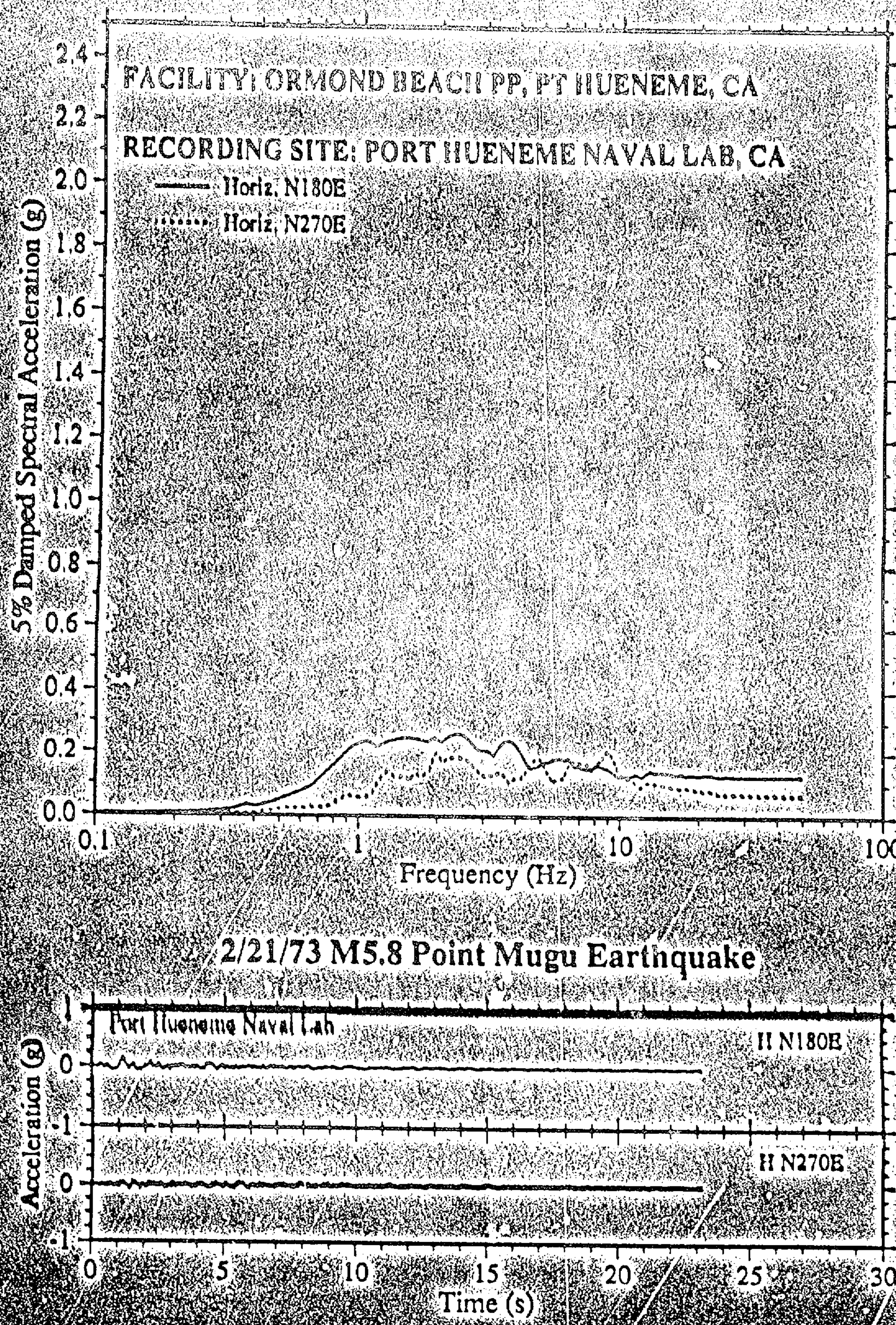
FACILITY: ORMOND BEACH PP, PT HUENEME, CA
RECORDING SITE: PORT HUENEME NAVAL LAB, CA
Horiz. N180E
Horiz. N270E
5% Damped Spectral Acceleration (g)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
0.1
1
10
100
Frequency (Hz)
2/21/73 M5.8 Point Mugu Earthquake
Port Hueneme Naval Lab
H N180E
H N270E
Acceleration (g)
1
0
-1
0
5
10
15
20
25
30
Time (s)

FIG. 12