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SUBJECT: Forwards response to request for addl info re floor response Spectra for seismic qualification of batteries at plant. Study 13-CS-102 prepared by Bechtel Power Corp provided in Encl 2.Calculation CTRL-01 encl also.

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102-03191-WLS/AKK/DRL
November 21, 1994

U. S. Nuclear Regulatory Commission
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Dear Sirs,

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. 50-528/529/530
Response to Request for Additional Information
Concerning Floor Response Spectra For Seismic Qualification of Batteries at PVNGS - TAC No. M86200
File: 94-010-026

Arizona Public Service Company (APS) is responding to a request for additional information received through Brian Holian, Senior Project Manager - PVNGS, USNRC, regarding the seismic qualification of the station batteries at PVNGS. Enclosure 1 to this letter contains APS' response to these questions. A copy of Study No. 13-CS-102 prepared by the Bechtel Power Corporation is provided in Enclosure 2.

Should you have any questions, please contact A. Krainik at (602) 393-5421.

Sincerely,

W.L. Stewart

WLS/AKK/DRL/rv

Enclosures:
1. APS' Response
2. Bechtel Power Corporation Study No. 13-CS-102

cc: L. J. Callan
K. E. Perkins
B. E. Holian
K. E. Johnston

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ENCLOSURE 1

APS RESPONSE TO

REQUEST FOR ADDITIONAL INFORMATION

CONCERNING FLOOR RESPONSE SPECTRA FOR

SEISMIC QUALIFICATION OF BATTERIES AT

PALO VERDE NUCLEAR GENERATING STATION

TAC NO. M86200

9412050335

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200

REFERENCES:

1. PVNGS Study No. 13-CS-102, Finite Element Soil Structure Interaction Seismic Analysis, April 4, 1977.

2. NUREG-0800, Standard Review Plan (SRP) 3.7.2, Seismic System Analysis, Revision 2, August 1989.

3. ABB Impell Corporation Calculation No. SOIL-1, Site Analysis of PVNGS, February 23, 1993 (PVNGS SDR #A11401).

4. ABB Impell Corporation Calculation No. STR-01, SSI Methodology, February 17, 1993 (PVNGS SDR #A11401).

5. ABB Impell Corporation Calculation No. CTRL-01, Structural Model and SSI Analysis of Control Building, February 22, 1993 (PVNGS SDR #A11401).

6. ABB Impell Standard Program SASSI, A Computer Program for Soil-Structure Interaction Analysis, Version 4.0, User's Manual, Revision 1, June 1989.

7. APS Letter No. 102-02640-WFC/TRB/SAB, APS Responses to NRC Questions on Seismic Qualification of Station Batteries, September 10, 1993.

8. Regulatory Guide 1.60, Design Response Spectra for Seismic Design of Nuclear Power Plants, Revision 1, December 1973.

9. NUREG-0781, Safety Evaluation Report for South Texas Project, Units 1 and 2, April 1986.

RESPONSE:

Request 1:

A summary report indicating the extent of compliance with SRP 3.7.2 (Revision 2, August 1989) provisions regarding the SSI analysis.

Response to Request 1:

Bechtel Power Corporation Analysis:

The PVNGS finite-element soil-structure interaction analysis was performed by Bechtel Power Corporation (hereafter referred to as Bechtel) and documented in Study No. 13-CS-102 (Reference 1). This analysis was performed in 1977, prior to the issuance of Revision 2 to SRP

3.7.2 (Reference 2). This study is included in Enclosure 2.

To evaluate the extent of compliance of the PVNGS finite-element soil-structure interaction analysis with SRP 3.7.2 (Revision 2), a comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 was made. This comparison is included in Table 1 of Attachment A. It is concluded that the methodology used for the PVNGS finite-element soil-structure interaction analysis, in comparison to the requirements of SRP 3.7.2 (Revision 2), gives reasonable results.

VECTRA Technologies Incorporated (formerly ABB Impell Corporation) Analysis:

In 1993, VECTRA Technologies Incorporated (hereafter referred to as VECTRA) performed soil-structure interaction analysis for the Control Building at PVNGS (References 3, 4 and 5). VECTRA's analysis for the Control Building was presented in two parts. Part 1 was an update of the existing PVNGS design basis for the Safe Shutdown Earthquake (SSE). A Peak Ground Acceleration (PGA) of 0.2g (licensing basis) for the SSE condition was used in the analysis. Part 2 was the evaluation of the building for Review Level Earthquake (RLE) for a PGA of 0.3g as part of the requirements for Individual Plant Examination of External Events (IPEEE).

VECTRA's soil-structure interaction analysis utilized computer program SASSI (Reference 6). SASSI uses finite-element techniques and a complex response method in the frequency domain to solve dynamic soil-structure interaction problems in two or three dimensions. VECTRA's analysis was performed to the requirements of SRP 3.7.2 (Revision 2).

A review of VECTRA's analysis of the Control Building reveals that PVNGS design basis response spectra for elevation 100' are very conservative. VECTRA's analysis also reveals that vertical SSE (increased by 20% for a PGA of 0.25g) and RLE response spectra for elevation 100' of the Control Building, at the batteries' locations, are enveloped by the vertical Test Response Spectrum (TRS) for the batteries. This is shown in Attachment B.

Request 2:

Synthetic time-history (vertical) at the grade level.

Response to Request 2:

Synthetic time-histories (vertical) at the grade level from analyses that were performed by Bechtel and VECTRA are provided in Attachment C.

Request 3:

Vertical response spectra at the foundation level and 60% of the design ground response spectrum.

Response to Request 3:

The vertical response spectra at the foundation level and 60% of the design ground response spectrum from analyses that were performed by Bechtel and VECTRA are provided in Attachment D.

Request 4:

Vertical floor response spectrum (2% damping) at the batteries' locations of the structure which can be utilized for comparison with the TRS in Figure IIa (Reference 7).

Response to Request 4:

Vertical floor response spectra (2% damping) at the batteries' locations from analysis that was performed by VECTRA are provided in Attachment E. Vertical floor response spectrum (2% damping) at the batteries' locations was not generated in Bechtel's Study No. 13-CS-102.

SUMMARY:

Based on the previous discussions, the following conclusions are made:

1. PVNGS finite-element soil-structure interaction analysis that was performed by Bechtel, in comparison to the requirements of SRP 3.7.2 (Revision 2), gives reasonable results.

2. The soil-structure interaction analysis that was performed by VECTRA meets the requirements of SRP 3.7.2 (Revision 2).

3. A review of VECTRA's analysis of the Control Building reveals that PVNGS design basis response spectra for elevation 100' are very conservative. VECTRA's analysis also reveals that vertical SSE (increased by 20% for a PGA of 0.25g) and RLE response spectra for elevation 100' of the Control Building, at the batteries' locations, are enveloped by the vertical Test Response Spectrum (TRS) for the batteries.

In summary, based on the above discussions and previous APS responses (Reference 7) on the subject, it is concluded that the actual vertical response of the batteries in a SSE event is well enveloped by the vertical Test Response Spectrum (TRS). Therefore, the subject batteries will perform their intended function and maintain their structural integrity during and after a SSE event.

Note: This will also serve as a supplement to the response to Question No. 3 of APS letter 102-02640-WFC/TRB/SAB (Reference 7).

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200

Attachment A

Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200

Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-9	The structure, foundation, and soil are properly modeled to ensure that the results of analyses are within the range of applicability of the particular method employed.	4-1 Section 4.1	The finite-element soil-structure interaction seismic analysis was performed using the computer program LUSH. LUSH was a finite-element program for soil-structure interaction analysis using plane-strain elements to represent structures and a finite region of soil. At the time, LUSH differed from other finite-element programs in that it took into account, in an approximate manner, the non-linear effects which could occur in soil subject to strong earthquake motions. The structures and the soil deposit were mathematically modeled by plane quadrilateral or triangular elements. The soil deposit was assumed to be connected to a rigid base. The model was then excited by a specified acceleration time history at the rigid base.

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200

Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-9	The input motion at the base of a discrete soil model or soil column should produce the specified design spectra at the free surface of the soil profile in the free field (finished grade).	4-1 Section 4.2.A	The LUSH analysis was based on the assumption that earthquake surface motions are primarily the result of upward propagation of shear waves and compression waves from the underlying rock formation. While it would be appropriate to input motions at the rock level, earthquake motions were defined only at the ground surface in Regulatory Guide 1.60. To obtain this rock motion for the analysis, the computer program SHAKE was used to deconvolve the surface motions. Surface motions used in the deconvolution were the Bechtel synthetic time history motions generated by modifying actual records. These synthetic motions enveloped the design spectra of Regulatory Guide 1.60.

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-9	Perform sensitivity studies to identify important parameters (e.g., bonding and debonding of side walls, nonsymmetry of embedment, location of boundaries) and to assist in judging the adequacy of the final results. For the method of modeling soil media with finite boundaries, all boundaries should be properly simulated and the use of types of boundaries should be justified and reviewed on a case-by-case basis.	6-1 Section 6.A 7-1 Section 7.2	The dimensions of the finite-element soil models were sufficiently wide such that effects of wave reflection from boundaries were kept to a minimum. To simulate the existence of horizontal soil layers outside the vertical side boundaries, special boundary conditions were imposed. For the horizontal input motion, the boundary condition was such that all nodal points on the side boundaries could move in the horizontal direction only. Similarly, for the vertical input motion, nodal points on the side boundaries could move in the vertical direction only. Variation in structural frequencies due to variations in parameters such as structural properties, damping, soil properties, and soil-structure interaction were not evaluated. In lieu of this evaluation, the width of response spectra peaks was increased by a minimum of +/- 15 percent.

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-9	Through the use of some appropriate benchmark problems, the user should demonstrate its capability to properly implement any SSI methodologies.	N/A	The finite-element soil-structure interaction analysis was performed by Bechtel. As reported in NUREG-0781, April 1986, Safety Analysis Report related to the operation of South Texas Project, Units 1 and 2, Section 3.7.3, Bechtel as the Architect/Engineer for Houston Lighting and Power Company "has used two-step finite-element analysis to account for the soil-structure interaction (SSI) effects for the major Category I structures" and has therefore demonstrated its capability to properly implement SSI methodology. Note: NUREG-0781 was reviewed to Revision 1 of SRP 3.7.2 (which was the most current revision at the time) rather than to Revision 2.

**Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200**

Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-9	Perform enough parametric studies with the proper variation of parameters (e.g., soil properties) to address the uncertainties (as applicable to the given site) discussed in subsection I.4 of this SRP section.	6-1 Section 6.A	The height (or thickness) of soil elements was predetermined to assure that an ample frequency content could be transmitted from base rock to the soil surface and structures. The maximum element height was calculated based on a maximum cut-off frequency of 15 Hz. Soil layers were identified in the model as either sand or clay. The low strain dependent properties for sand and clay were utilized in the program.
		7-2 Section 7.3.A	A "Column Study" was made to determine the effects of cut-off frequencies. A column of soil in the free-field was modeled by finite-elements in the LUSH program. A rock motion was then used to excite the soil column using various cut-off frequencies. Response spectra at the surface resulting from these cut-off frequencies were then plotted against the free-field response spectrum. The only significant effect from the cut-off frequencies was that the response at frequencies higher

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
cont'd	cont'd	cont'd	than the cut-off frequencies tend to level off to the maximum ground acceleration. This would happen in the soil-structure system due to the "filter effect" even if higher cut-off frequencies were used in the analysis.
		7-1 Section 7.2	Variation in structural frequencies due to variations in parameters such as structural properties, damping, soil properties, and soil-structure interaction were not evaluated. In lieu of this evaluation, the width of response spectra peaks was increased by a minimum of +/- 15 percent.
3.7.2-9	Modeling of Structure: The acceptance criteria given under subsection II.3 of this SRP section are applicable.	6-2 Section 6.B	A comparison between Section 6.B of Study No. 13-CS-102 and subsection II.3 of SRP 3.7.2 (Revision 2) concludes that the structures were properly modeled.

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-9	The effect of embedment of structure, ground-water effects, and the layering effect of soil should be accounted for.	1-1 Section 1.2	In-structure floor response spectra were calculated using the finite-element method for all Seismic Category I buildings having embedment more than 15 percent of their least width.
		5-1 Section 5	For purposes of the seismic analysis, PVNGS site was treated as a two-layer system consisting of soil over bedrock. The upper layer (soil) was relatively uniform, both at each unit and between units. The uniformity of the site was indicated by actual soil profiles, velocity values and elastic moduli. A composite soil profile was formed by averaging the depth, thickness, and properties of each layer in the soil profile. The strain dependent relationships for shear moduli and damping ratios for clay and sand were used in the LUSH program for this analysis. An average ground water level of 44 feet below ground surface was used.

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
cont'd	cont'd	4-2 Section 4.2.C	In determining the vertical input motion, for soil above the ground water level, strain-corrected soil properties were found from the horizontal deconvolution. Compression wave velocities for all layers were then calculated and input in place of shear wave velocities. For soil below the ground water level, the field-measured compression wave velocities were input. The synthetic vertical motions scaled to 0.25g for the Safe Shutdown Earthquake (SSE) and 0.13g for the Operating Basis Earthquake (OBE) were used at the ground surface, and vertical rock motions were obtained.

Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-10	The properties used in the SSI analysis should be those corresponding to the low strains that are consistent with the realistic soil strain developed during the design earthquake.	6-1 Section 6.A	The height (or thickness) of soil elements was predetermined to assure that an ample frequency content could be transmitted from base rock to the soil surface and structures. The maximum element height was calculated based on a maximum cut-off frequency of 15 Hz. Soil layers were identified in the model as either sand or clay. The low strain dependent properties for sand and clay, as obtained from the soil reports, were utilized in the program.
		7-3 Section 7.3.C	The equivalent linear method was used in the LUSH analysis. In this method, the shear moduli and damping ratios of soil at the strain level caused by the earthquake motion were determined by iteration. The closer the initial input for the estimated shear moduli and damping ratios of a soil element, the faster a convergence could be obtained. Initial input values were estimated by using the computer program SHAKE. Two SHAKE models were prepared, one for the free-field soil column, and one for the soil column under the building with

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
cont'd	cont'd	cont'd	the building represented by a shear beam which has constant material properties. The two models were then excited by the same earthquake motion. The strain-corrected shear moduli and damping ratios were obtained from both models. These values were then averaged to obtain the input data for estimated shear moduli and damping ratios for soil elements under structures. For soil elements away from the structure, values from the free-field SHAKE models were used.
		4-1 Section 4.2.B	For the deconvolution of horizontal and vertical motions, a SHAKE model was developed using the design soil profile. The synthetic horizontal motions scaled to 0.25g for the Safe Shutdown Earthquake (SSE) and 0.13g for the Operating Basis Earthquake (OBE) were input at the ground surface. The program calculated the strain compatible soil properties by an iterative process and then determined the transfer functions. The motions in the layers were computed based on the transfer functions.

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-10	The control motion should be consistent with the properties of the soil profile...The spectral amplitude of the acceleration response spectra (horizontal component of motion) in the free field at the foundation depth shall not be less than 60 percent of the corresponding design response spectra at the finished grade in the free field (Ref. 5).	8-1 Section 8.2	In order to establish that input motions were in conformance with Regulatory Guide 1.60, free-field response spectra at the ground level were compared to design spectra for all mathematical models. Also, free field response spectra at the base level were compared to the 60 percent design spectra. The rock motions used in the analysis were in conformance with Regulatory Guide 1.60. Also, it was evident that all three mathematical models were adequate representations of the soil-structure system, since free field motions were adequately restored from the deconvolved rock motion through the soil-structure models.

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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-10	The behavior of soil, though recognized to be nonlinear, can often be approximated by linear techniques.	4-1 Section 4.1	The finite-element soil-structure interaction seismic analysis was performed using the computer program LUSH. LUSH was a finite-element program for soil-structure interaction analysis using plane-strain elements to represent structures and a finite region of soil. At the time, LUSH differed from other finite-element programs in that it took into account, in an approximate manner, the non-linear effects which may occur in soil subject to strong earthquake motions.
		7-3 Section 7.3.C	The equivalent linear method was chosen in the LUSH analysis. In this method, the shear moduli and damping ratios of soil at the strain level caused by the earthquake motion were determined by iteration. The closer the initial input for the estimated shear moduli and damping ratios of a soil element, the faster a convergence could be obtained.

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-11	The strain-dependent soil properties (e.g., shear modulus, damping) estimated for analysis of the seismic motion in the free field shall be consistent with the geotechnical information reviewed in SRP Section 2.5.4.	5-1 Section 5	A composite soil profile was formed by averaging the depth, thickness, and properties of each layer in the actual soil profile (PVNGS UFSAR, Figure 3.7-7, Soil Profile) at the three units.
		6-1 Section 6.A	The height (or thickness) of soil elements was predetermined to assure that an ample frequency content could be transmitted from base rock to the soil surface and structures. The maximum element height was calculated based on a maximum cut-off frequency of 15 Hz. Soil layers were identified in the model as either sand or clay. The low-strain dependent properties for sand and clay were utilized in the program.

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
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Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-11	Unless the site is well investigated, the variation in soil properties should be considered by performing SSI analyses using three sets of values (defined in terms of shear moduli and soil hysteretic damping ratio). These three analyses should be performed using the average (or best estimate) value, twice the average value and half the average value of the low strain shear modulus (G_{max} defined at 10^{-4} percent peak shear strain).	5-1 Section 5	For purposes of the seismic analysis, PVNGS site was treated as a two-layer system consisting of soil over bedrock. The upper layer (soil) was relatively uniform, both at each unit and between units. The uniformity of the site was indicated by actual soil profiles and by velocity values and elastic moduli. A composite soil profile was formed by averaging the depth, thickness, and properties of each layer in the soil profile. The strain dependent relationships for shear moduli and damping ratios for clay and sand were used in the LUSH program for this analysis.
		7-1 Section 7.2	Variation in structural frequencies due to variations in parameters such as structural properties, damping, soil properties, and soil-structure interaction were not evaluated. In lieu of this evaluation, the width of response spectra peaks was increased by a minimum of +/- 15 percent.

**Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200**

Table 1: Comparison of Study No. 13-CS-102 to SRP 3.7.2.II.4 (Revision 2)

SRP 3.7.2.II.4 (Revision 2)		Study No. 13-CS-102	
Page No.	**Description**	**Page No. and/or Section No.**	**Description (Note 1)**
3.7.2-12	The following limitations should be observed for deep soil sites: - The model depth, generally, should be at least twice the base dimension below the foundation level, which should be verified by parametric studies. - The fundamental frequency of the soil (or backfill) stratum should be well below the structural frequencies of interest. - All structural modes of significance should be included.	6-1 Section 6.A 7-2 Section 7.3.A	The depth of the model was approximately 2.5 times the effective base width. A "Column Study" was made to determine the effects of cut-off frequencies. A column of soil in the free-field was modeled by finite-elements in the LUSH program. A rock motion was then used to excite the soil column using various cut-off frequencies. Response spectra at the surface resulting from these cut-off frequencies were then plotted against the free-field response spectrum. The only significant effect from the cut-off frequencies was that the response at frequencies higher than the cut-off frequencies tend to level off to the maximum ground acceleration. This would happen in the soil-structure system due to the "filter effect" even if higher cut-off frequencies were used in the analysis.

NOTES:

1. Supporting References, Tables and Figures are included in PVNGS Study No. 13-CS-102.

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
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Attachment B

Test Response Spectrum (TRS) Versus VECTRA's Required Response Spectrum (RRS)

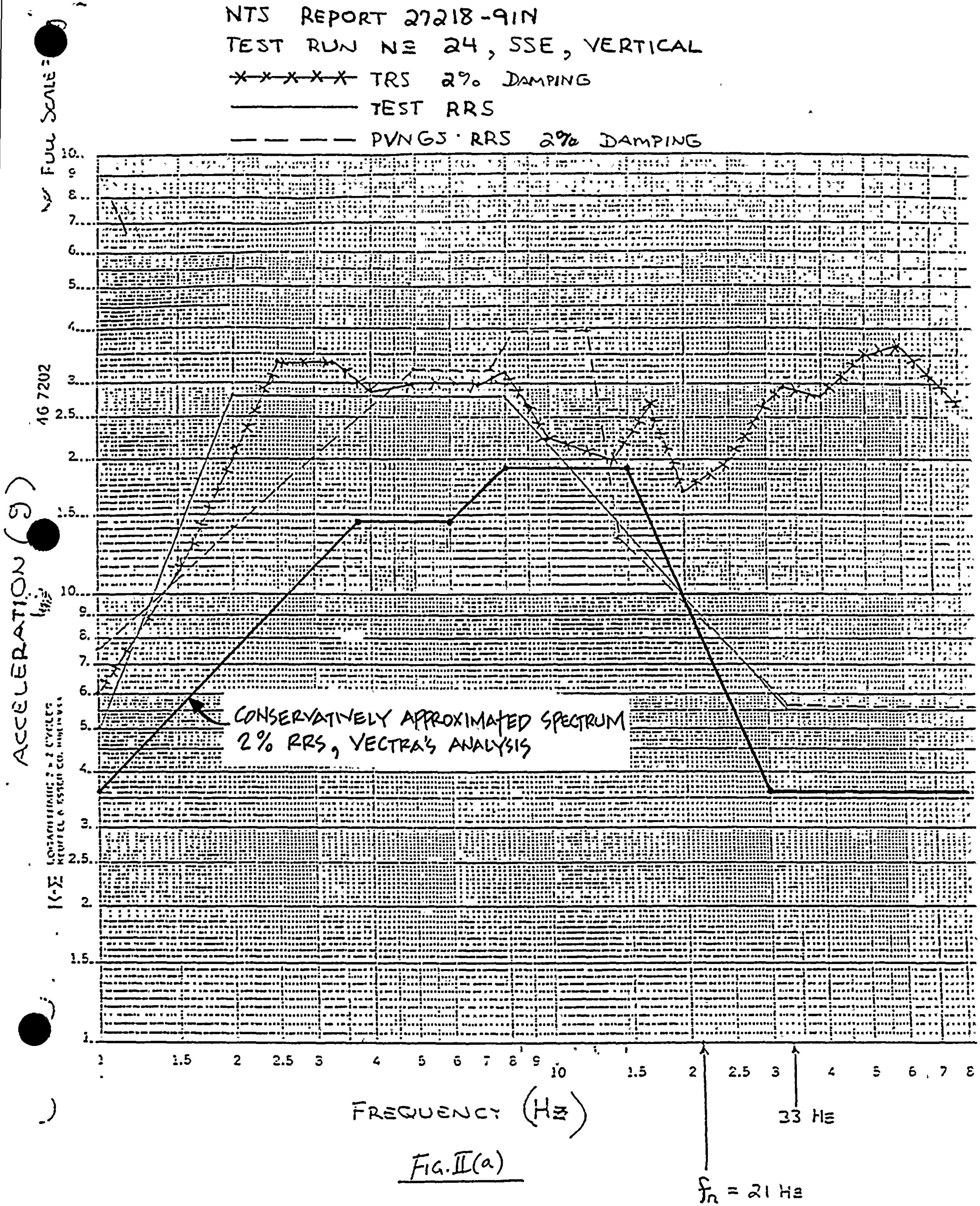

NTS REPORT 27218-91N
TEST RUN NO 24, SSE, VERTICAL
TRS 2% DAMPING
TEST RRS
PVNGS RRS 2% DAMPING
Full Scale
ACCELERATION (g)
CONSERVATIVELY APPROXIMATED SPECTRUM
2% RRS, VECTRA'S ANALYSIS
FREQUENCY (Hz)
33 Hz
f_n = 21 Hz
K·E LOGARITHMIC 2 x 2 CYCLES
KEUFFEL & ESSER CO.
46 7202

FIG. II(a)

Attachment C

Vertical Synthetic Time History

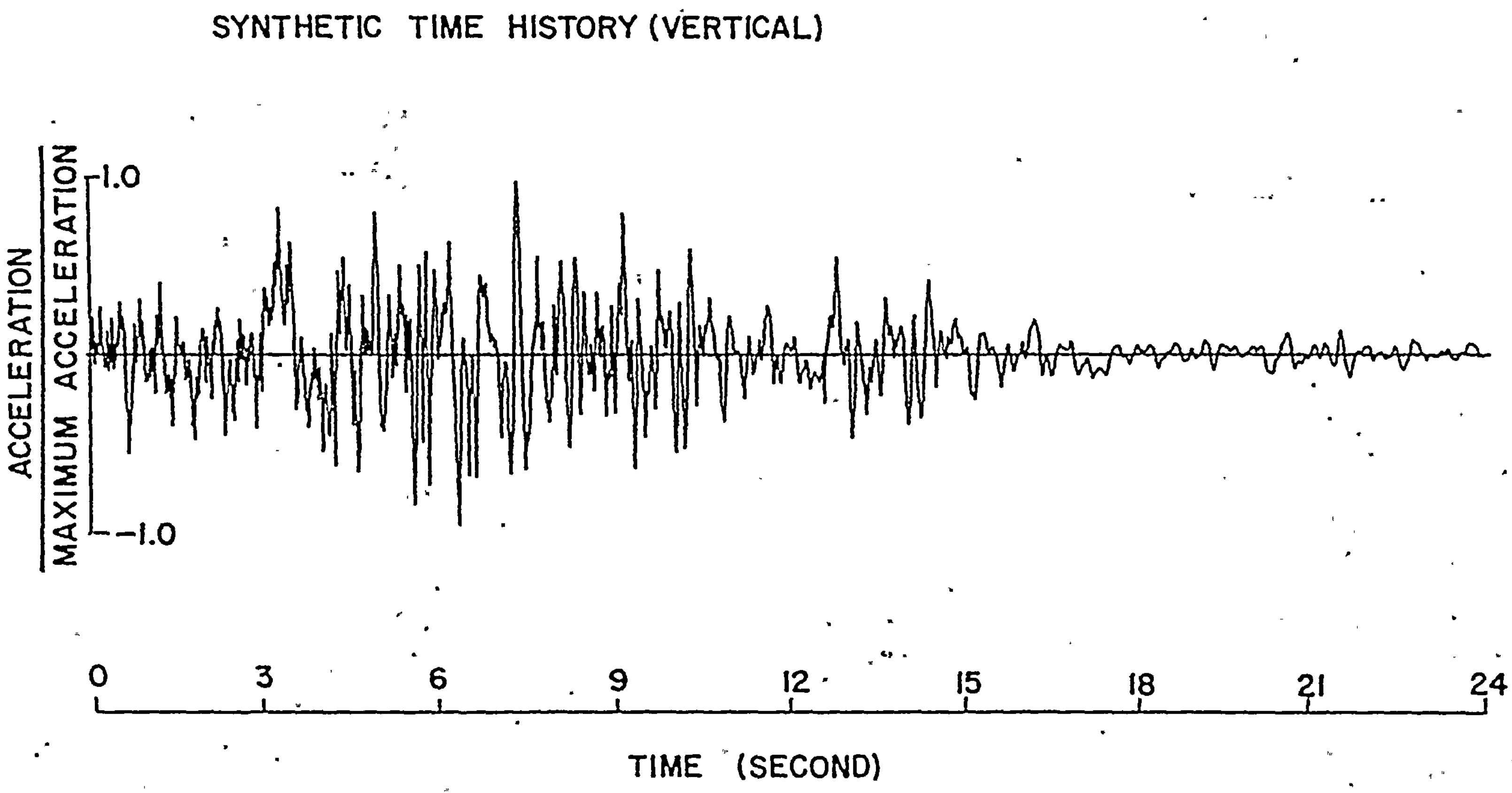
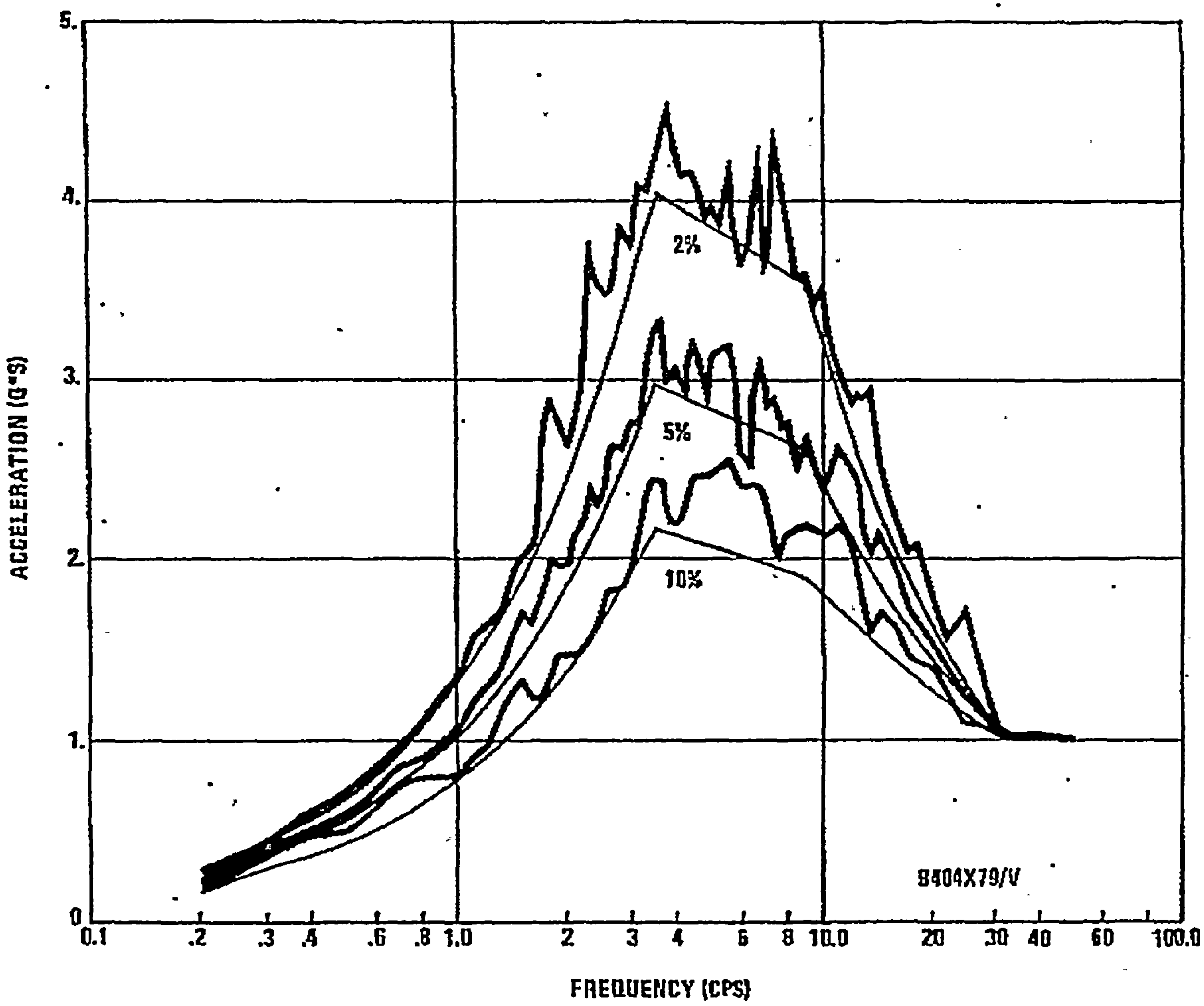


Fig. 2-16 Synthetic Time History Of The Vertical Component Of The Design Earthquake

BECHTEL'S ANALYSIS

FIGURE 2-16. COMPARISON OF THE ACCELERATION RESPONSE SPECTRA OF B404X79/V TIME HISTORY WITH THE VERTICAL DESIGN SPECTRA FOR 2%, 5% AND 10% CRITICAL DAMPING.



BECHTEL'S ANALYSIS

DESIGN VERIFICATION	
CLIENT APS	
JOB NO. 0165-00251	
CALC/PROB NO. SOIL-1	
BY: SMD	DATE: 1/27/93
CHKD: AA	DATE: 1/28/93

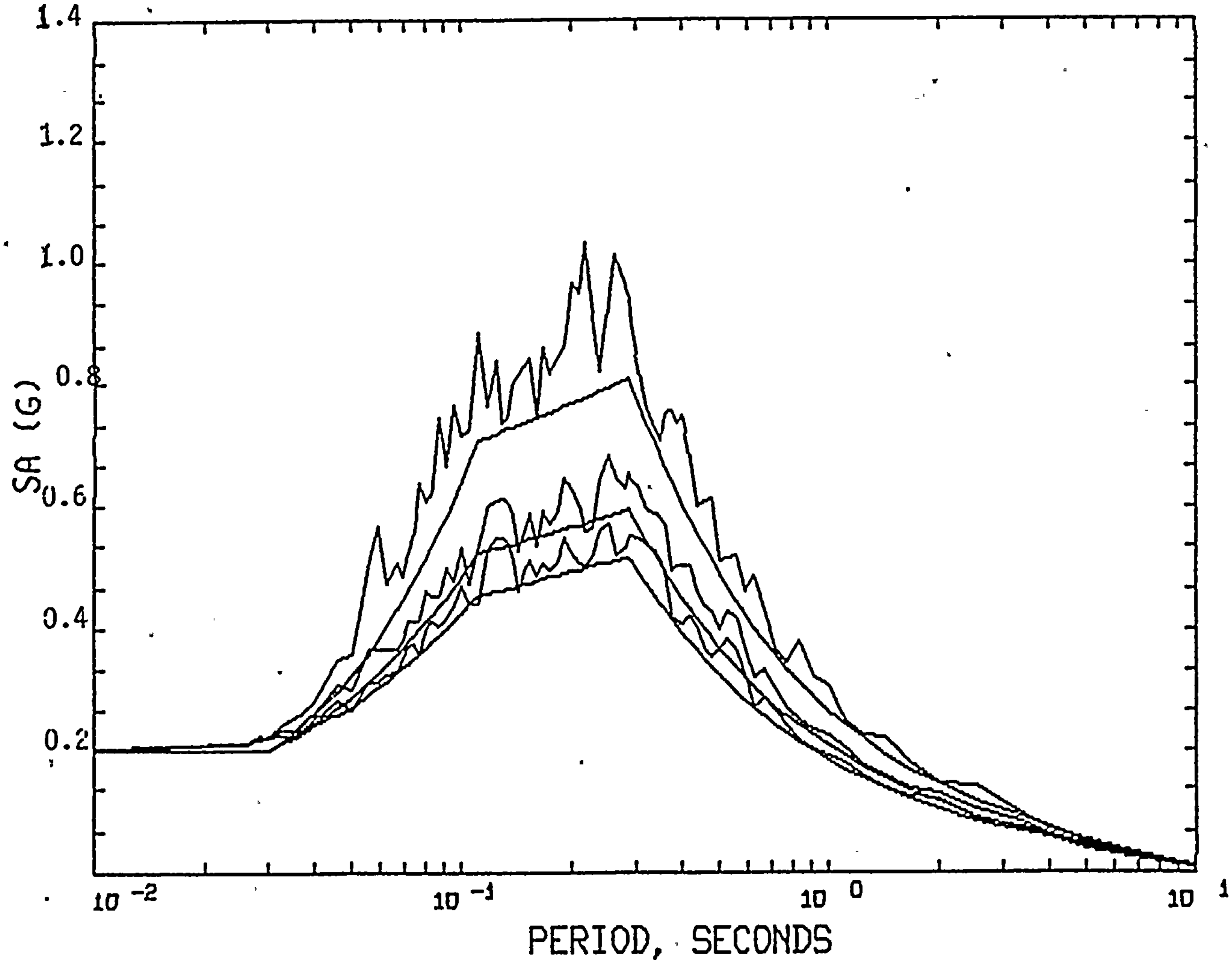


Figure 3.3 - Spectral Matching of Vertical SSE Motion 2, 5, 7% Damping

VECTRA'S ANALYSIS

Attachment D

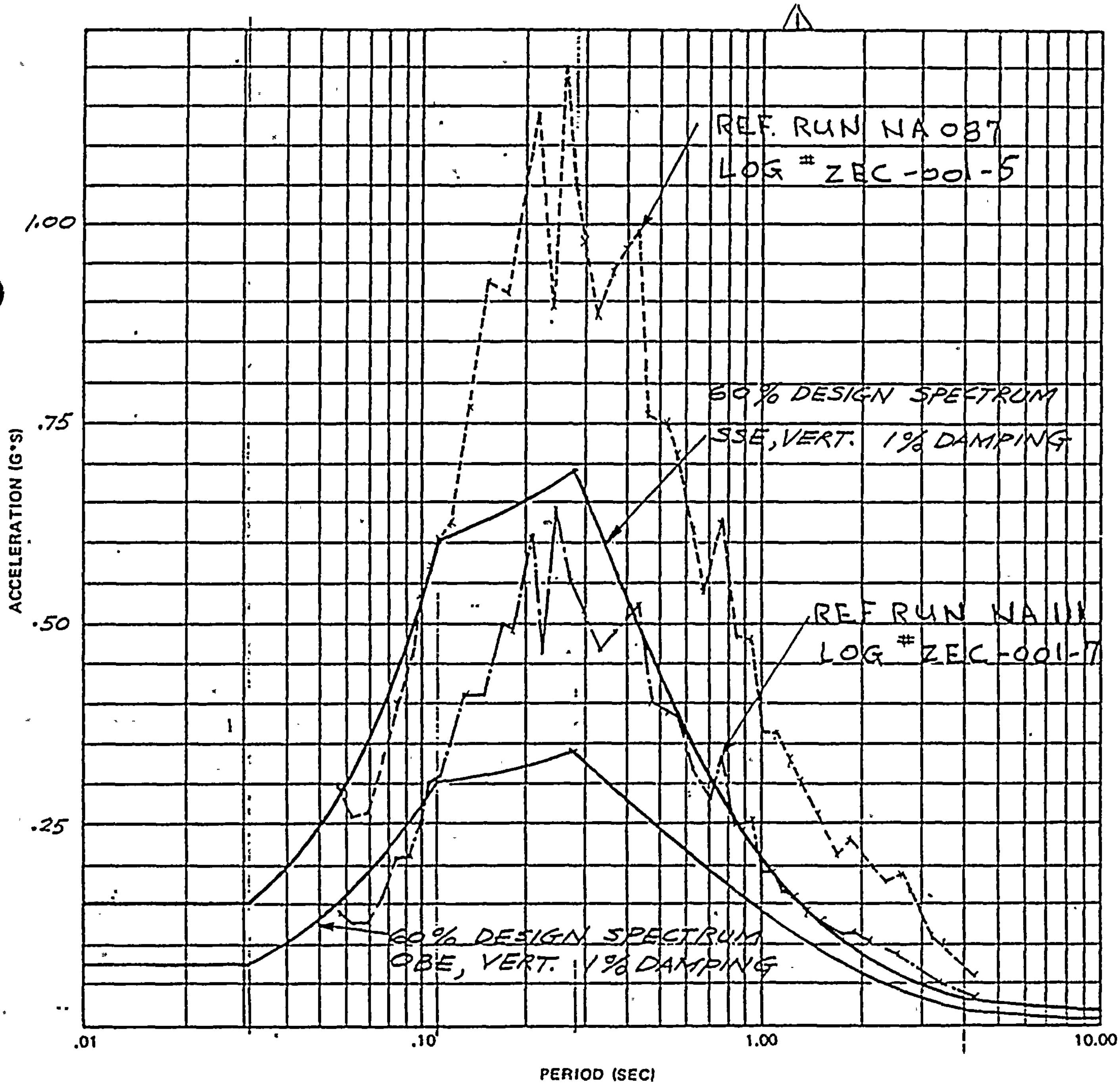
Vertical Response Spectra at the Foundation Level and 60% of the Design Ground Response Spectrum

13-CC-ZE-015

ARIZONA NUCLEAR POWER PROJECT
PALO VERDE NUCLEAR GENERATING STATION
UNITS 1, 2, AND 3

COMPARISON OF MOTIONS AT BASE LEVELS OF STRUCTURES TO 60% FREE-FIELD MOTION, SSEV & OBEV

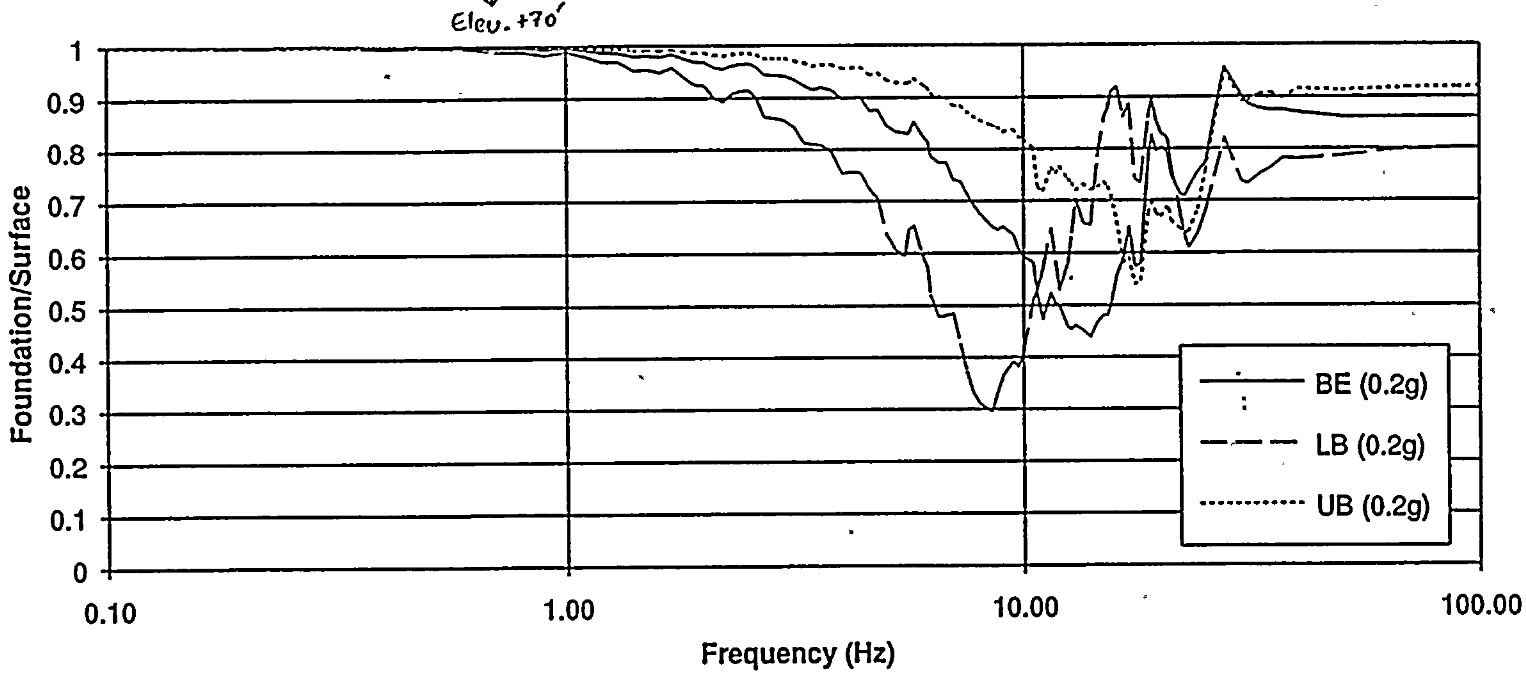
PREPARED:	REVIEWED:	APPROVED:	
S B HINCHMAN	C.Y. WEI	—	
JOB NO. 10407	DRAWING NO.: 7 of 12	REV. —	DATE: 5/28/76



F.E. SOIL STRUCTURE ANALYSIS, FF MOTION R.S.

Figure 4.3

Ratio of Foundation Level Spectra to Surface Spectra (5% Damping, Vert.)



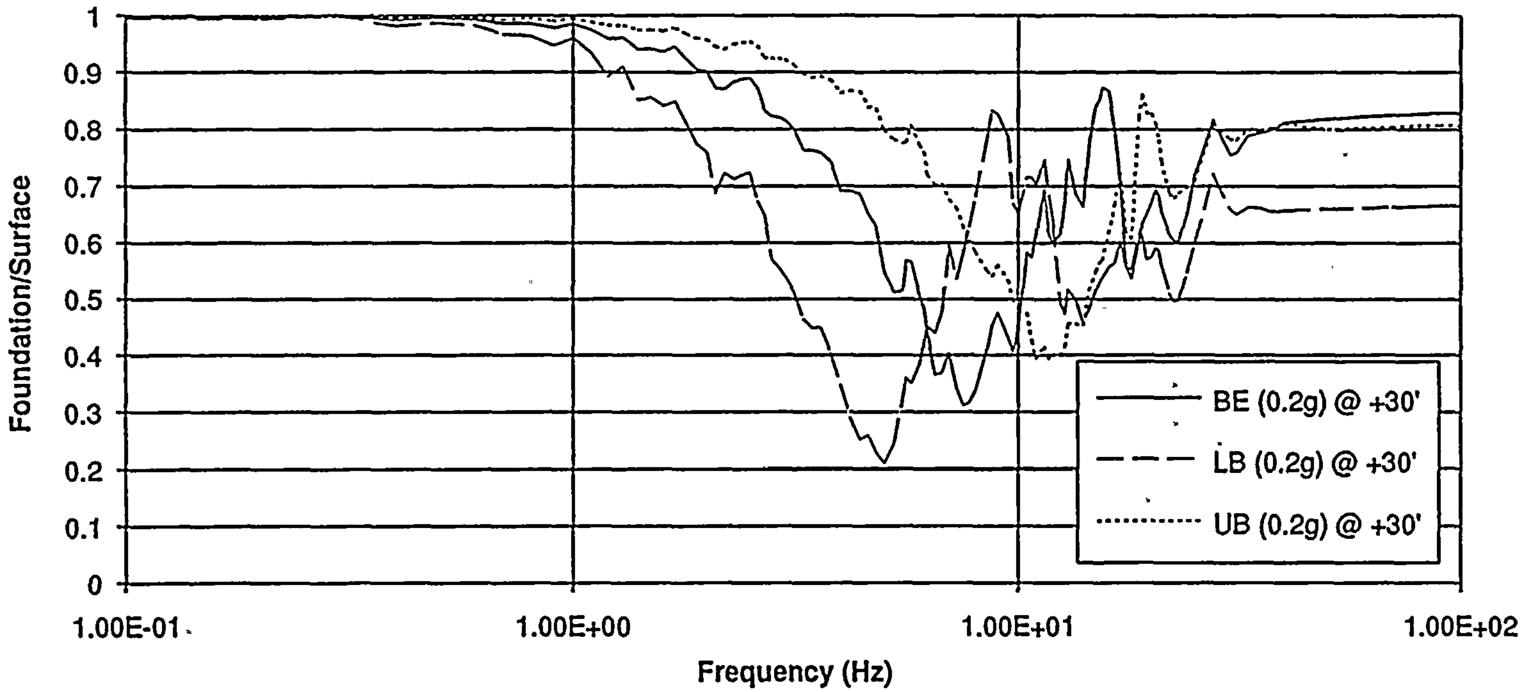
DESIGN VERIFICATION	
CLIENT APS	
JOB NO. 0165-00251	
CALC/PROB NO. SOIL-1	
BY: SAD	DATE: 1-27-93
CHKD: AA	DATE: 1/28/93

VECTRA'S ANALYSIS

4-8

Figure 4.6

Ratio of Foundation Level Spectra to Surface Spectra (5%Damping,Vert.)



DESIGN VERIFICATION	
CLIENT: APS	
JOB NO. 0165-00751	
CALC/PROB NO. Soil-1	
BY: SMD	DATE: 1-27-93
CHKD: AA	DATE: 1/28/93

VECTRA'S ANALYSIS

Floor Response Spectra for Seismic Qualification of AT&T Round Cell Batteries at Palo Verde Nuclear Generating Station (PVNGS)
TAC No. M86200

Attachment E

Vertical Floor Response Spectra (2% Damping) at the Batteries Location