UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 5 1985

Docket No.: 50-412

APPLICANT: Duquesne Light Company (DLC)

FACILITY: Beaver Valley Power Station, Unit 2

SUBJECT: GEOSCIENCE BRANCH (GSB) MEETING SUMMARY

On December 7, 1984, NRC and applicant representatives met in Bethesda, Maryland to discuss Geoscience Branch's unresolved issues. A meeting notice and attendance roster are enclosed (Enclosures 1 and 2 respectively).

The applicant had provided a report prior to the meeting in response to a GSB question on the adequacy of the BVPS seismic design. A summary of the applicant's presentation is provided in Enclosure 3. The applicant presented a statistical analysis of the historic earthquake record to justify the use of the mean spectra rather than the 84th percentile spectra. The arguments were not accepted by the NRC staff.

In developing representative site specific spectrum the applicant investigated several options.

a. Use California records from stations with soil profiles similar to the BVPS site.

b. Use world wide rock records which match the magnitude of the BVPS safe shutdown earthquake (SSE) and amplify the motion through a soil profile identical to that of the BVPS site.

The results show that the site specific spectrum (SSS) obtained for an expanded suite of rock records amplified through a soil profile (SHAKE) exhibits significantly higher acceleration values than a site matched SSS for a site of soil based sections even when this spectrum is boosted by 10% to allow for the higher velocity contrast at rock interface (3000 ft/sec r.s. 5000 ft/sec).

The 84th percentile of the "soil response" SSS is definitely going to exceed the BVPS design spectrum. However the NRC staff insisted on the applicant showing the 84th percentile SSS since that has become the accepted procedure in the use of SSS.

The following suggestion were presented by the staff:

1. Calculate the SSS at the foundation of the critical structures by using a statistical rock spectra amplified through a BVPS site soil column up to the same elevation as the foundations of the structures.

2. Calculate both the site matched and soil amplified 84th percentile SSS.

3. Do an analysis of the "C" shelter record from the Franklin - Falls Dam (New Hampshire earthquake record) and compare it to the site matched site specific spectrum.

4. Use the Alexander Building record to verify the SHAKE analysis which resulted in a 10% difference between 3000 ft/sec and 5000 ft/sec rock velocity at interface with soil column.

The arguments on the vertical acceleration design (i.e. 2/3 of horizontal) and the arguments for considering shallow earthquakes to be of no significance influence to the seismic design were accepted.

The schedule for submittal of the report was discussed at the conclusion of the meeting. The applicant will submit the report by the end of January 1985.

ORIGINAL SIGNED BY

B. K. Singh, Project Manager
Licensing Branch No. 3
Division of Licensing

Enclosures:
As stated

cc: See next page

DL:LB#3
BKSingh/yt
1/30/85

DL:LB#3
GWKnighton
1/ /85

FEB 5 1985

MEETING SUMMARY DISTRIBUTION

Docket No(s): 50-412
NRC PDR
Local PDR
NSIC
PRC System
LB3 Reading
Attorney, OELD
GWKnighton
Project Manager B. K. Singh
JLee

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D. McMullen
G. Giese-Koch
L. Reiter
K. C. Leu
G. Lear

bcc: Applicant & Service List

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Enclosure 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NOV 27 1984

Docket No. 50-412

MEMORANDUM FOR: George W. Knighton, Chief
Licensing Branch No. 3
Division of Licensing

FROM: B. K. Singh, Project Manager
Licensing Branch No. 3,
Division of Licensing

SUBJECT: FORTHCOMING MEETING BETWEEN THE NRC AND DUQUESNE LIGHT COMPANY

DATE & TIME: December 7, 1984
9:00 AM

LOCATION: Room P-114
Phillips Building
Bethesda, Maryland

PURPOSE: To discuss unresolved issues concerning Geosciences Branch SER.

PARTICIPANTS*: NRC

B. Singh
L. Reiter
G. Giese-Koch
et. al.

Duquesne Light Company

J. O'Neil,
et. al.

B. K. Singh, Project Manager
Licensing Branch No. 3
Division of Licensing

cc: See next page

*Meetings between NRC technical staff and applicants for licenses are open for interested members of the public, petitioners, intervenors, or other parties to attend as observers pursuant to "Open Meeting Statement of NRC Staff Policy", 43 Federal Register 28058, 6/28/78. Those interested in attending this meeting should make their intentions known to the Project Manager, B. K. Singh, at (301) 492-8423, by no later than December 6, 1984.

8412070456

Site Dependent Response Spectra

Beaver Valley Power Station - Unit No. 2

AGENDA

!. Introduction	J. D. O'Neil
2. Response to NRC Action Items	D. D. Hunt
a. Approach	D. D. Hunt
b. Probability	J. T. Christian
c. Horizontal Spectra	D. D. Hunt
d. Vertical Response Spectra	D. D. Hunt
e. Shallow Earthquakes	H. Archaya
3. Discussion	All
4. Summation	J. D. O'Neil

Enclosure 2

Attendance List

12/7/84

Beaver Valley, Unit 2
Meeting with Geoscience Branch

B. K. Singh	NRC/NRR/DL/LB#3	Project Manager
Lyman Heller	NRC/DE/SGEB	Geotechnical S.L.
A. Stanley Lucho	S&W	Chief Geotech. Engr.
J. D. O'Neil	DLC	Project Engineer
J. D. Sutton	SWEC	~~Asst. Project Eng.~~
C-W. Lin	W	Advisory Engineer
G. R. Tilton	SWEC	Principal Structural Engr.
D. L. McMullen	NRC. GSB	Geologist
Gus Giese-Koch	NRC/GSB	Geophysicist
Leon Reiter	NRC/GSB	Section Leader, Seismology
I. M. IDRISS	Woodward-Clyde	Consultant to DLC
V. T. CHRISTIAN	SWEC	CONSULTANT TO DLC
D. HUNT	SWEC	LEAD GEOTECHNICAL ENG
P. A. CADENA	DLC	SR. PROJ. ENG'R.
K. C. LEW	NRC/DE/SGEB	Sr. Struct. Engr
H. K. Achary a	SWEC	Seismologist
D. E. SHAW	CONSULTANT	Consultant to DLC
J. A. JAN	DLC	SR. PROJ. ENGR.
CLEAR	NRC	C/SGEB

SITE DEPENDENT RESPONSE SPECTRA

BEAVER VALLEY POWER STATION - UNIT 2

Enclosure 3

84-41,205

SITE DEPENDENT RESPONSE SPECTRA

- SITE MATCHED ANALYSIS
- SOIL RESPONSE ANALYSIS

NRC ACTION ITEMS

- EXPANDED EARTHQUAKE RECORD DATA BASE FOR SOIL RESPONSE ANALYSIS
- REVISED SCALING LAW
- EFFECT OF VELOCITY CONTRAST ON SITE MATCHED RESPONSE SPECTRA
- RATIO OF VERTICAL TO HORIZONTAL RESPONSE SPECTRA
- SHALLOW EARTHQUAKES

METHODOLOGY

- EARTHQUAKE MAGNITUDE
- SCALING PROCEDURE
- PROBABILISTIC ANALYSIS

DESIGN EARTHQUAKE

I_o = VI (MM)

m_b = 4.75

M_L = 4.95

EARTHQUAKE SCALING

LAW

ATTENUATION RELATIONSHIP

$$\text{LOG } a_h = A + Bm_b - 0.83\,(R^2 + h^2)^{1/2} - CR$$

$$B = 0.5 \qquad \text{FOR } m_b \geq 4.5$$

$$B = 0.25 \qquad \text{FOR } m_b < 4.5$$

SCALING LAW

FOR EASTERN UNITED STATES EARTHQUAKES:

$\text{LOG } a_h = 0.5\,\Delta\, m_b$ FOR $m_b \geq 4.5$

$\text{LOG } a_h = 0.25\,\Delta\, m_b$ FOR $m_b < 4.5$

FOR EQUIVALENT WESTERN UNITED STATES EARTHQUAKES:

$\text{LOG } a_h = 0.54\,\Delta\, M_L$ FOR $M_L \geq 4.7$

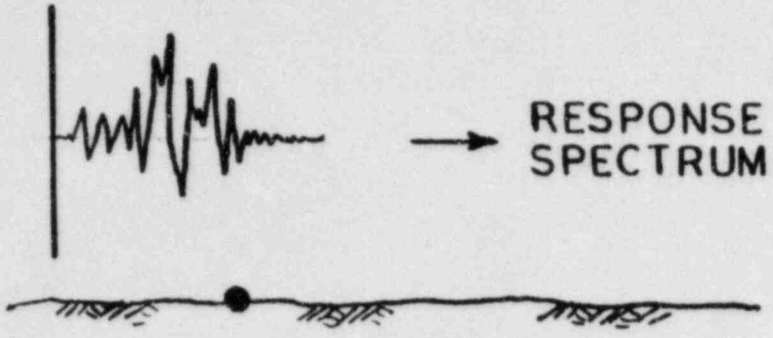
$\text{LOG } a_h = 0.27\,\Delta\, M_L$ FOR $M_L < 4.7$

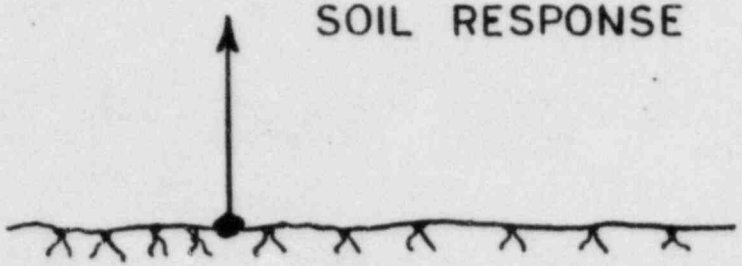
SCALING PROCEDURES

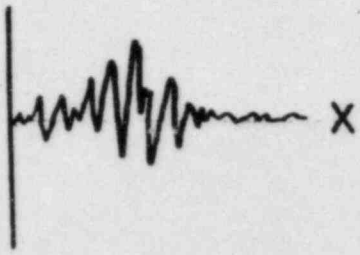
- INPUT SCALING
- OUTPUT SCALING

SCALING PROCEDURES

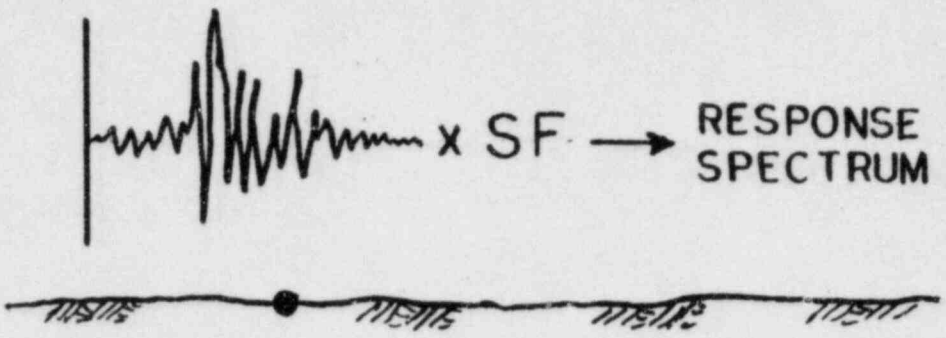
INPUT SCALING

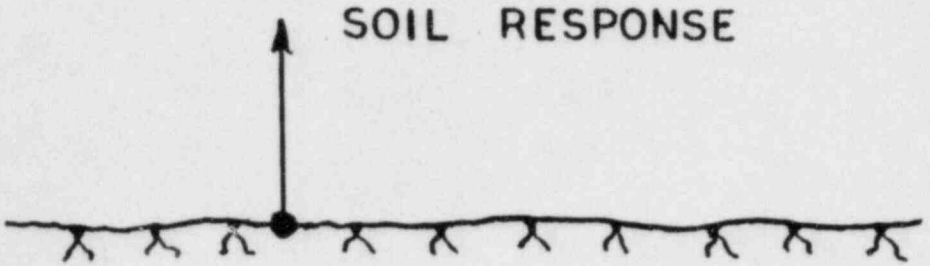


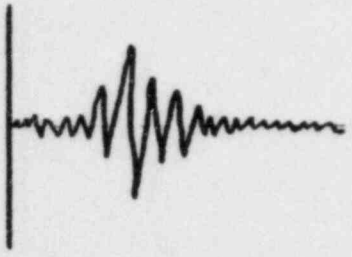




OUTPUT SCALING







SF IS SCALING FACTOR

PROBABILITY ANALYSIS

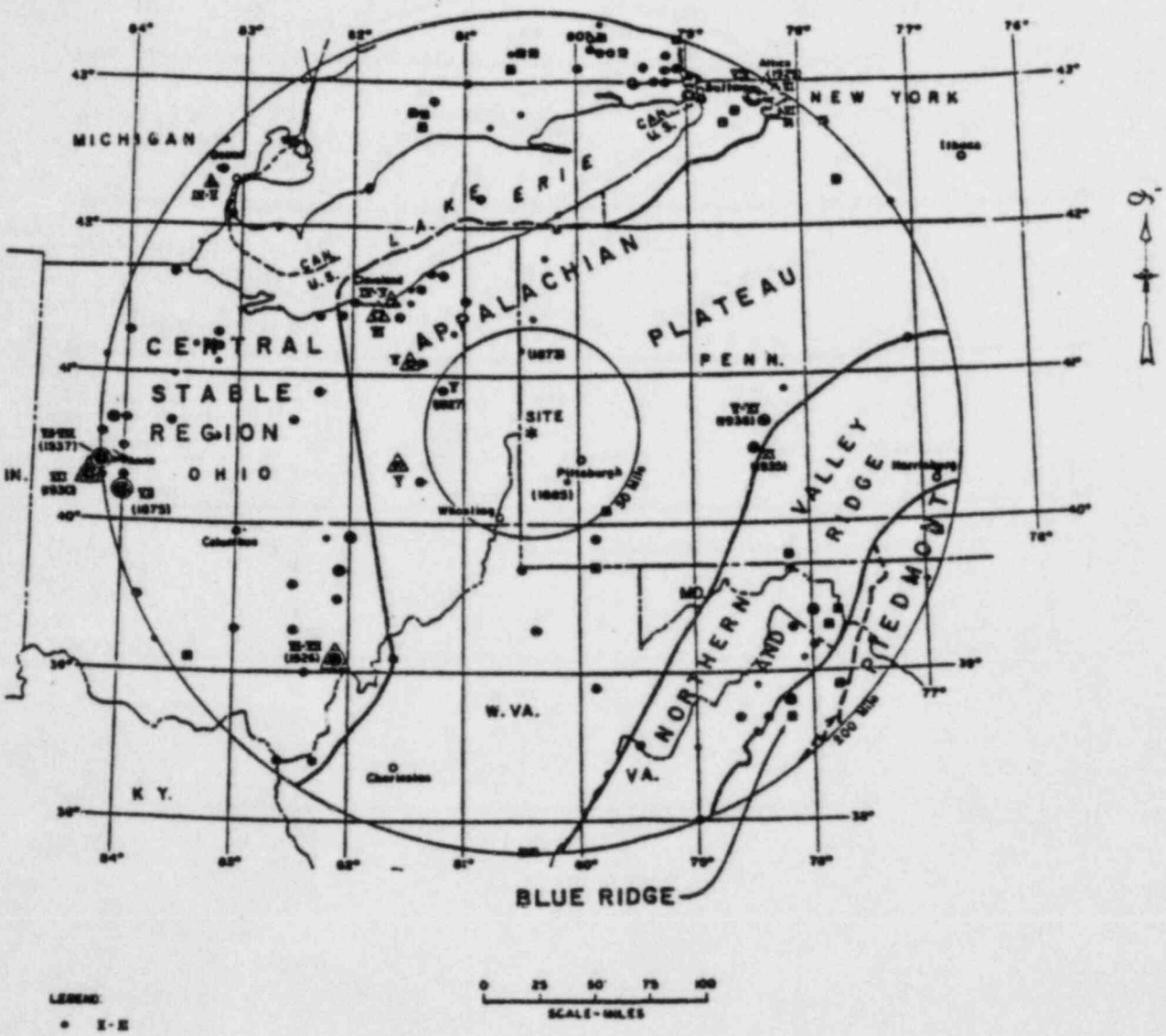
$$P(A_1 \,\&\, A_2 \,\&\, A_3) = P(A_1) \bullet P(A_2 \mid A_1) \bullet P(A_3 \mid A_2 \,\&\, A_1)$$

$$P(A_1) = 0.006 \text{ TO } 0.011$$

$$P(A_2 \mid A_1) = 0.0207$$

$$P(A_3 \mid A_2 \,\&\, A_1) = 10^{-4} / (0.006)(0.0207) = 0.81$$

$$= 10^{-4} / (0.011)(0.0207) = 0.44$$

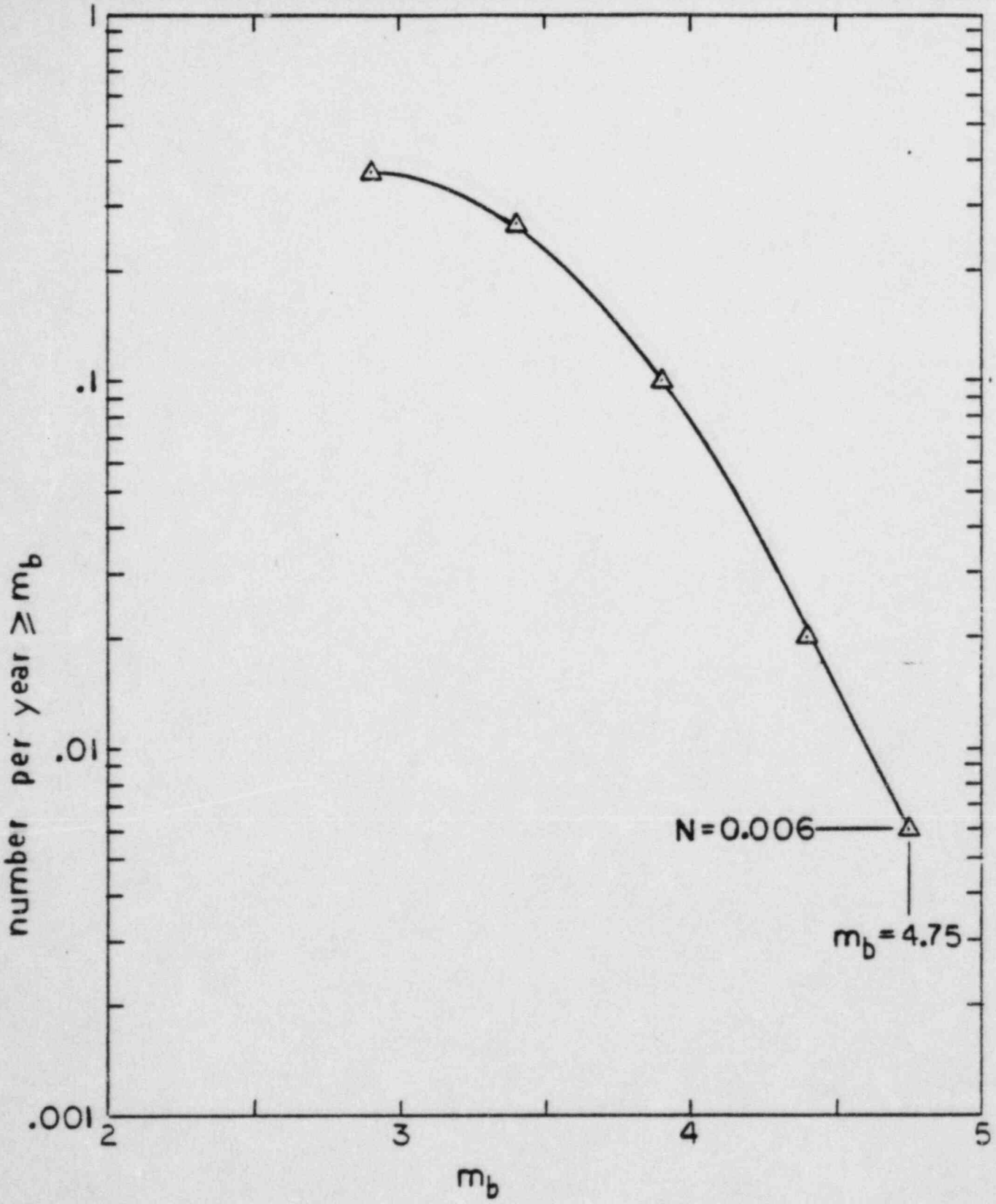


NOTE
INTENSITIES ARE MODIFIED MERCALLI (MM)
FIGURE 2.5.1-5; SWEC (1984a)

FIGURE 2-1

EPICENTERS & TECTONIC PROVINCES WITHIN 200 MILES OF THE SITE

BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION



RECURRENCE RELATION FOR APPALACHIAN PLATEAU PROVINCE WITHIN 200 MILE RADIUS

RECURRENCE RELATION

$$\text{LOG } N = a - bm_b$$

WHERE: N IS THE ANNUAL NUMBER OF EVENTS

FOR $m_b \geq$ A GIVEN VALUE

PROBABILITY ANALYSIS

$$P(A_1 \,\&\, A_2 \,\&\, A_3) = P(A_1) \bullet P(A_2 \mid A_1) \bullet P(A_3 \mid A_2 \,\&\, A_1)$$

$$P(A_1) = 0.006 \text{ TO } 0.0110$$

$$P(A_2 \mid A_1) = 0.0207$$

$$P(A_3 \mid A_2 \,\&\, A_1) = 0.5$$

$$P(A_1 \,\&\, A_2 \,\&\, A_3) = 0.62 \times 10^{-4} \text{ TO } 1.14 \times 10^{-4}$$

SITE MATCHED RESPONSE SPECTRA

- EFFECT OF REVISED SCALING LAW
- EFFECT OF VELOCITY CONTRAST

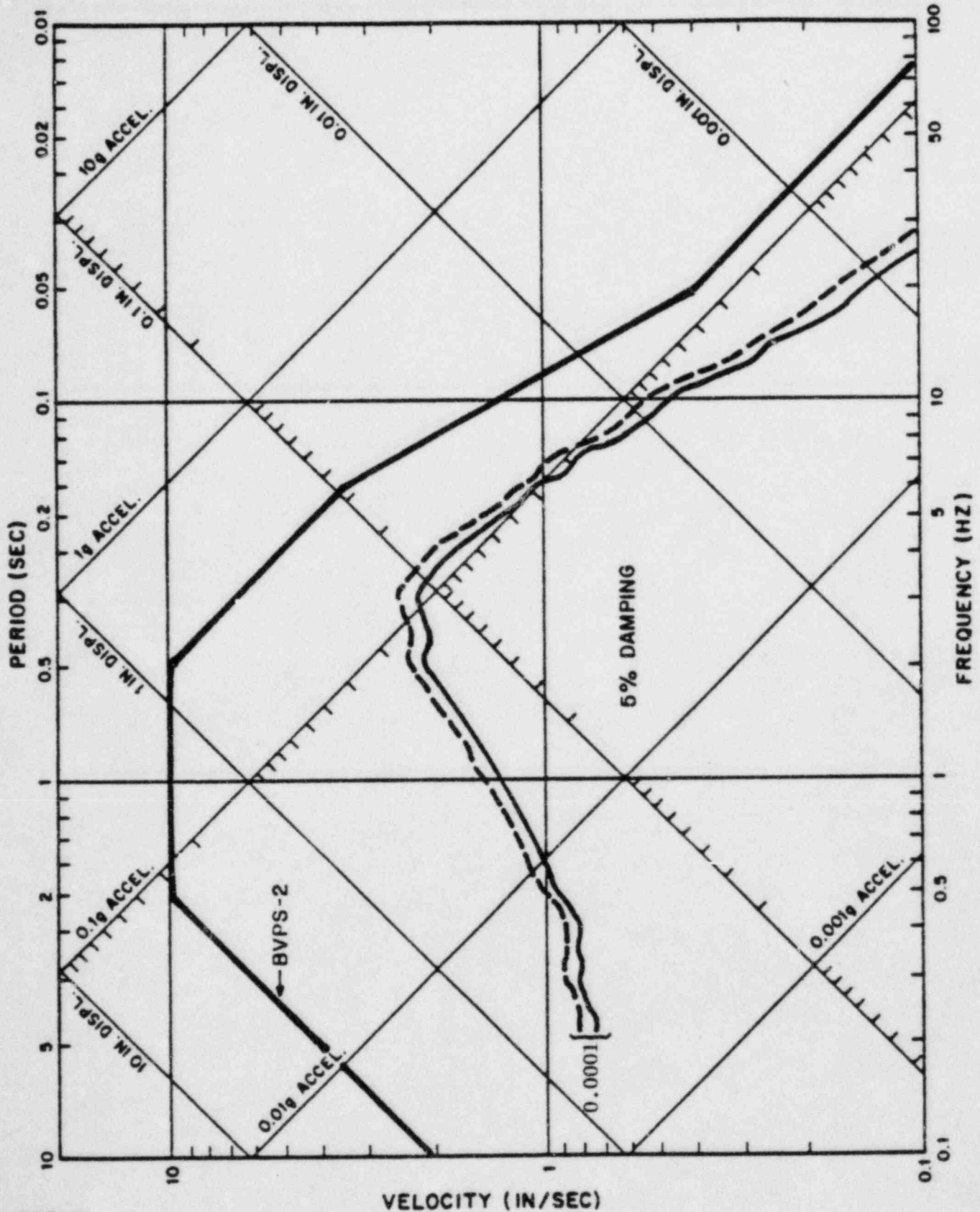
TABLE 3-1

SITE MATCHED GROUND SURFACE EARTHQUAKE RECORDS
SCALED TO AN M_L = 4.95

Year	Date Month	Day	Epicental Location	Magnitude M_L	Recording Station	Epicental Distance (km)	Component	Scaling Factor SWEC (1984)	Scaling Factor EQN. 2-6 a&b	CIT Record No.(1)
1954	12	21	Eureka, CA	6	Federal Bldg., Eureka, CA	6	N79E S11E	0.146	0.146	A-008
1957	03	22	San Francisco, CA	5.3	State Bldg., San Francisco, CA	13	N09E S81W	0.65	0.65	A-016
					Alexander Bldg., San Francisco, CA	14	N09W N81E	0.65	0.65	A-014
1957	03	22	San Francisco, CA	4.4	Alexander Bldg., San Francisco, CA	16	N09W N81E	1.98	1.65	V-323
					City Hall, Oakland, CA	24	N26E S64E	1.98	1.65	A-017
1962	09	04	Northern, CA	5.0	Federal Bldg., Eureka, CA	18	N79E S11E	1.0	0.94	V-330
1965	07	15	Southern, CA	4.0	Old Ridge Rte., Castaic, CA	14	E S	3.26	2.11	V-331
1970	09	12	Lytle Creek, CA	5.4	6074 Park Dr., Wrightwood, CA	14	S65E S25W	0.572	0.572	W-334
1971	02	09	San Fernando, CA	6.4	Old Ridge Rte., Castaic, CA	29	N21E N69W	0.165	0.165	D-056

NOTE:

(1) California Institute of Technology reference number, Trifunac and Lee (1973)



LEGEND:

- OLD SCALING LAW. EQUATION 2-6a FOR ALL MAGNITUDES FIGURE 6-9, SWEC (1984)
- NEW SCALING LAW EQUATIONS 2-6a AND 2-6b

FIGURE 3-2

SITE MATCHED RESPONSE SPECTRA
EFFECT OF REVISED SCALING LAW

BEAVER VALLEY POWER STATION-UNIT 2

STONE & WEBSTER ENGINEERING CORPORATION

TABLE 3-2

ROCK OUTCROP RECORDS SCALED TO AN M_L = 4.95
USED TO EVALUATE EFFECT OF SHEAR WAVE VELOCITY CONTRAST
ON SITE MATCHED RESPONSE SPECTRA

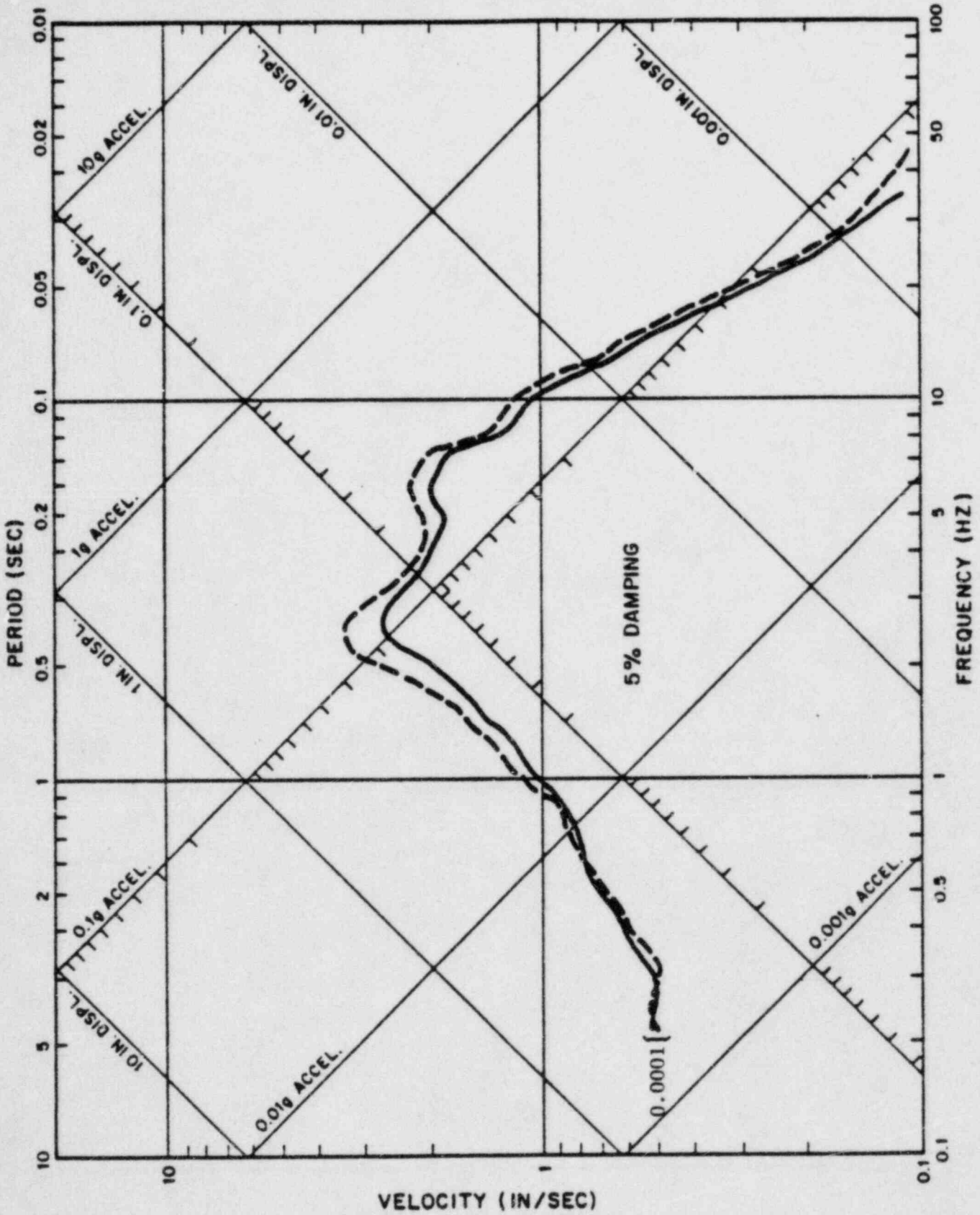
Date			Epicenter	Magnitude	Recording	Epicental Distance		Scaling	CIT Record
Year	Month	Day	Location	M_L	Station	(km)	Component	Factor(2)	No.(3)
1935	10	31	Helena, MT	6.0	Carroll College, Helena, MT	6	EW NS	0.271	B-025
1935	10	31	Helena, MT	4.0(1)	Federal Bldg., Helena, MT	6	NS EW	3.26	U-295
19[illegible]	11	21	Helena, MT	3.8(1)	Federal Bldg., Helena, MT	6	EW NS	4.18	U-296
19[illegible]	11	28	Helena, MT	5.0(1)	Federal Bldg., Helena, MT	6	NS EW	1.0	U-297
1957	03	22	San Francisco, CA	5.3	Golden Gate Pk., San Francisco, CA	11	S80E N10E	0.65	A-015
1970	09	12	Lytle Creek, CA	5.4	Allen Ranch, Cedar Springs, CA	19	S05W S85E	0.572	W-335
1971	02	09	San Fernando, CA	6.4	Array No. 4 Lake Hughes, CA	29	S69E S21W	0.165	J-142
					Array No. 9 Lake Hughes, CA	29	N21E N69W	0.165	J-143
					Array No. 12 Lake Hughes, CA	24	N69W N21E	0.165	J-144

NOTES:

(1) Estimated by Kanomori and Jennings (1978)

(2) From SWEC (1984)

(3) California Institute of Technology reference number, Trifunac and Lee (1973)



LEGEND:

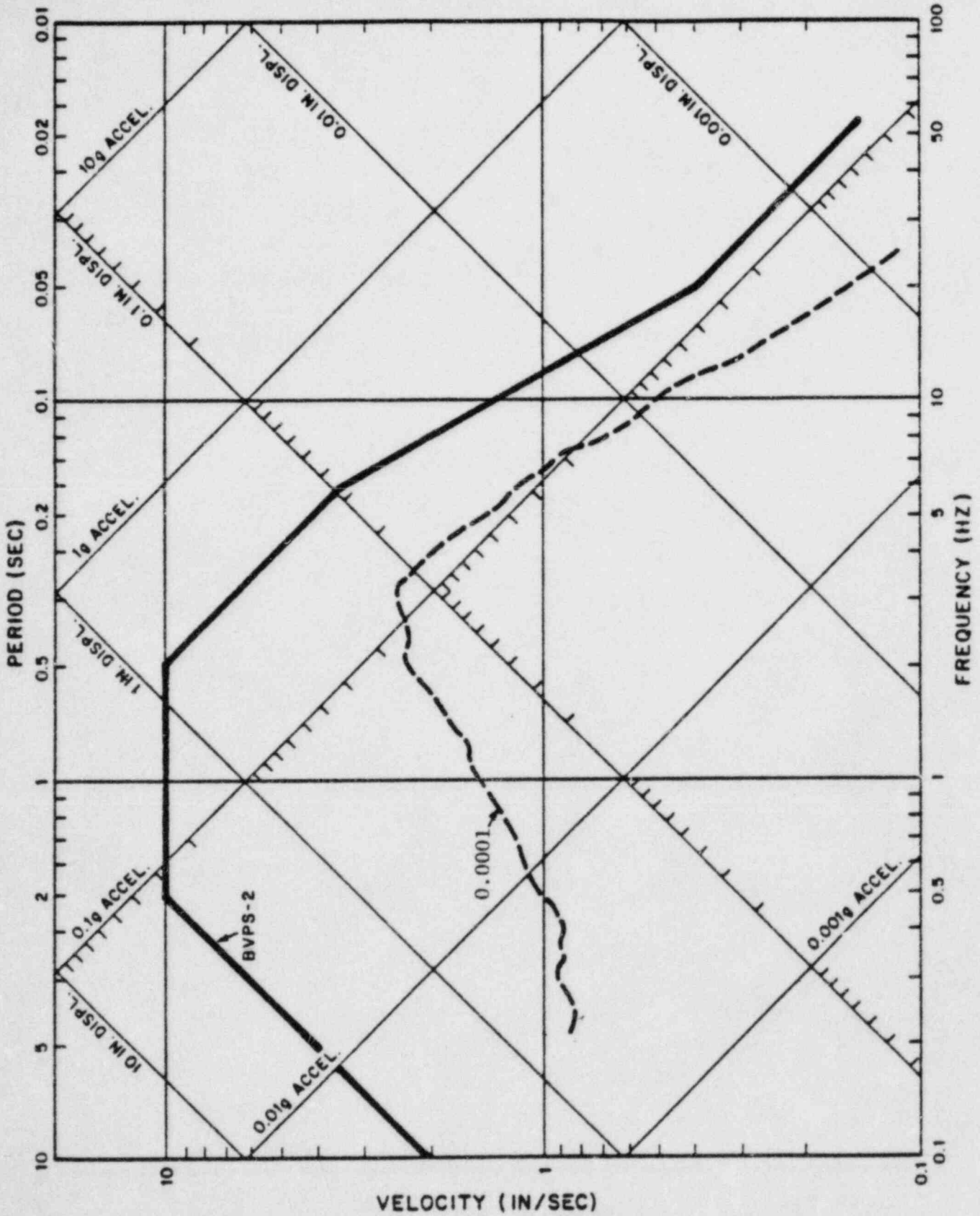
- ROCK SHEAR WAVE VELOCITY OF 5000 ft/sec.
- ROCK SHEAR WAVE VELOCITY OF 3000 ft/sec.

FIGURE 3-3

EFFECT OF SHEAR WAVE VELOCITY OF ROCK ON SOIL RESPONSE ANALYSIS

BEAVER VALLEY POWER STATION-UNIT 2

STONE & WEBSTER ENGINEERING CORPORATION



NOTE
MEAN SPECTRUM INCREASED BY 10%. FROM EVENTS SCALED ACCORDING TO REVISED SCALING LAW - EQ 2-6

FIGURE 3-4
SITE MATCHED RESPONSE SPECTRUM ADJUSTED FOR SHEAR WAVE VELOCITY CONTRAST
BEAVER VALLEY POWER STATION - UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

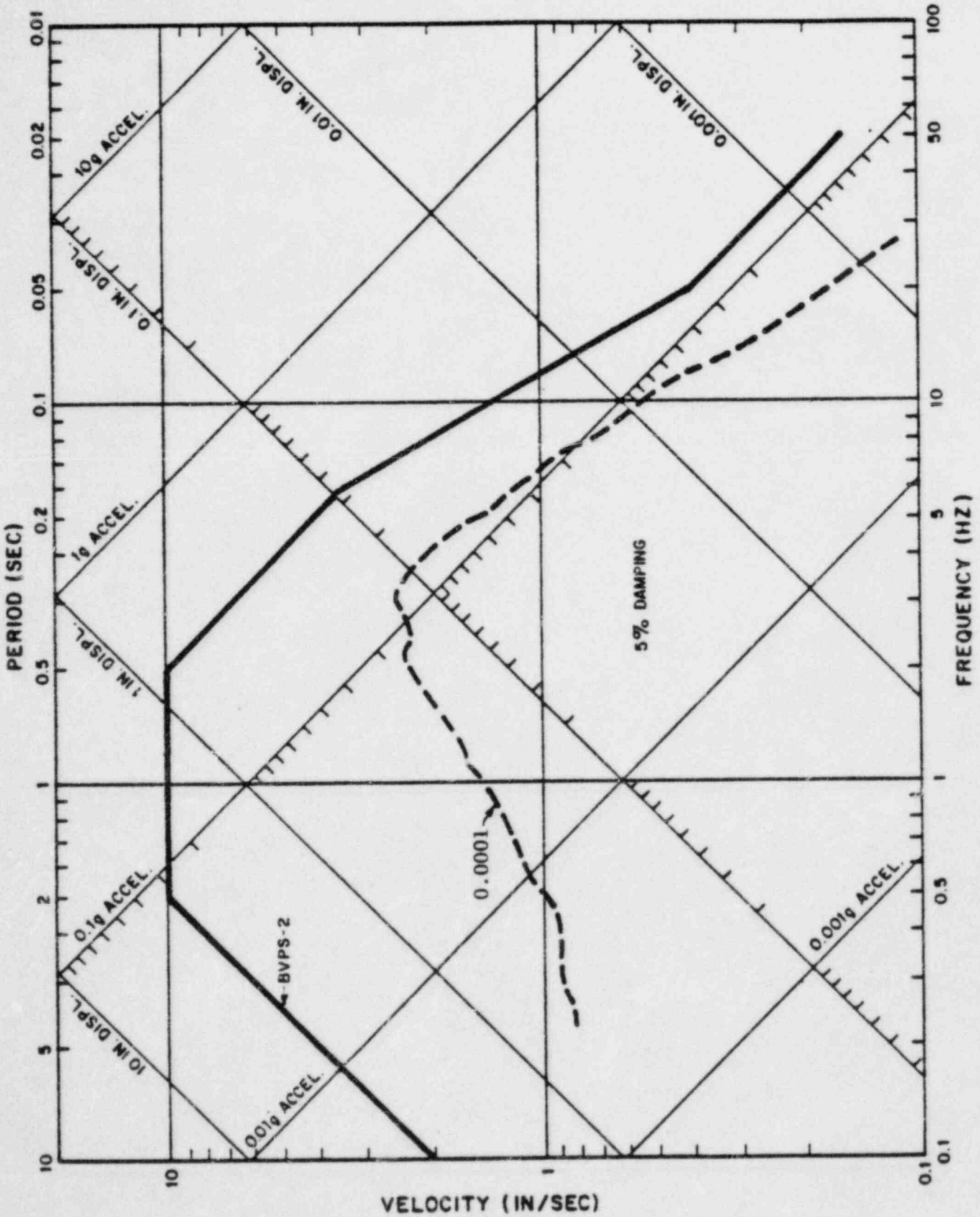


FIGURE 3-1
SITE MATCHED RESPONSE SPECTRUM: SCALED
BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

NOTE:
TAKEN FROM FIGURE 6-9 SWEC (1984)

SOIL RESPONSE ANALYSIS

- SOIL MODEL
- EARTHQUAKE RECORD DATA BASE

TABLE 4-1

EARTHQUAKE DATA BASE
FROM SWEC (1984)

Year	Mo.	Day	Epicenter Location	Magnitude M_L	Epicenter Distance (km)	CIT Record No.(2)	Recording Station
1935	10	31	Helena, MT	6.0	6.6	B-025	Carroll College, Helena, MT
1935	10	31	Helena, MT	4.0(1)	5.8	U-295	Federal Bldg., Helena, MT
1935	11	21	Helena, MT	3.8(1)	5.8	U-296	Federal Bldg., Helena, MT
1935	11	28	Helena, MT	5.0(1)	5.8	U-297	Federal Bldg., Helena, MT
1957	03	22	San Francisco, CA	5.3	11.2	A-015	Golden Gate Pk., San Francisco, CA
1970	09	12	Lytle Creek, CA	5.4	19.2	W-335	Allen Ranch, Cedar Springs, CA
1971	02	09	San Fernando	6.4	28.8	J-142	Array No. 4 Lake Hughes, CA
					28.6	J-143	Array No. 9 Lake Hughes, CA
					24.0	J-144	Array No. 12 Lake Hughes, CA

NOTES:

(1) Estimated by Kanamori and Jennings (1978)

(2) California Institute of Technology reference number, Trifunac and Lee (1973)

(3) From Table 7-2, SWEC (1984)

TABLE 4-2

ROCK SITES

	Date	Station Code and Name	M_L	Dist (km)
1)	10/31/35	U295 - Helena Feder. Bldg.	(5.0)	6
2)	10/31/35	B025 - Helena Carroll Coll.	6.0	7
3)	11/28/35	U297 - Helena Feder. Bldg.	(5.0)	6
4)	6/28/66	B037 - Temblor	5.6	(20)
5)	9/12/70	W335 - Allen Ranch	5.4	19
6)	1/12/76	PC175 - Cape Mendocino	5.2	27
7)	6/7/75	PC675 - Cape Mendocino	5.2	22
8)	8/1/75	OD875 - Oroville Dam	5.7	11
9)	8/1/75	OS875 - Oroville Seis. Stat.	5.7	12
10)	8/6/75	J350 - (Johnson Ranch)	4.7	13
11)	8/8/75	J700 - (Johnson Ranch)	4.9	11
12)	8/8/75	6700 - Oroville #6	4.9	(5)
13)	9/27/75	8234 - (Johnson Ranch)	4.6	(13)
14)	9/27/75	B234 - Oroville #8	4.6	(11)
15)	9/11/76	I142 - Somplago	5.9	6
16)	9/11/76	I139 - San Rocco	5.9	14
17)	9/11/76	I132 - San Rocco	5.5	15
18)	9/11/76	I134 - Somplago	5.5	10
19)	9/15/76	I159 - Somplago	5.0	11
20)	9/15/76	I169 - San Rocco	6.0	19
21)	8/13/78	North Hall (Goleta)	5.1	(4)
22)	8/6/79	San Martin, C.C.	5.9	1
23)	8/6/79	(Gilroy #1)	5.9	8
		Gilroy #6		
	3/31/82	Mitchell Lake, Aftershock New Brunswick	4.8	
	1/18/82	Franklin Falls Dam	4.7	
	1/26/80	Livermore, CA Morgan Territory Park		

TABLE A-3

EARTHQUAKE RECORDS CONSIDERED

Ref. No.	Date Year	Mo.	Day	Earthquake Name	Magnitude (M_L)	Epicentral Distance (km)	Record No.	Recording Station	Site Conditions at Recording Station
1.	1935	10	31	Helena, MT	6.0	6	B-025	Carroll College, Helena, MT	Limestone
2.**	1935	10	31	Helena, MT	4.0*	6	U-295	Federal Bldg., Helena, MT	Limestone
3.**	1935	11	21	Helena, MT	3.8*	6	U-296	Federal Bldg., Helena, MT	Limestone
4.**	1935	11	28	Helena, MT	5.0*	6	U-297	Federal Bldg., Helena, MT	Limestone
5.**	1957	03	22	San Francisco, CA	5.3	11	A-015	Golden Gate Pk., San Francisco, CA	Chert and Shale
6.	1966	06	28	Parkfield, CA	5.6	39(?)	B-037	Cholame-Shandon Array, Temblor	Serpentine and serpentinized peridotite
7.	1970	09	12	Lytle Creek, CA	5.4	19	W-335	Allen Ranch, Cedar Springs, CA	Granite bedrock
8.	1971	02	09	San Fernando, CA	6.4	29	J-142	Array No. 4, Lake Hughes, CA	Weathered granite bedrock
9.**						29	J-143	Array No. 9, Lake Hughes, CA	9 ft of silty and gravelly sand overlying granite gneiss
10.**						24	J-144	Array No. 12, Lake Hughes, CA	5-10 ft of landslide debris overlying sandstone, conglomerate and shale
11.**	1975	01	12	Cape Mendocino, CA	4.4	16	PC-175	Cape Mendocino, Petrolia, CA	Cretaceous Franciscan volcanic sandstone (graywacke)
12.**	1975	06	07	Cape Mendocino, CA	5.2	30	PC-675	Cape Mendocino, Petrolia, CA	Cretaceous Franciscan volcanic sandstone (graywacke)
13.**	1975	08	01	Oroville, CA	5.7	11	OD-875	Oroville Dam Crest	Earthfill dam
14.						12	OS-875	Oroville Dam Seismograph Sta.	Metavolcanic rock
15.**	1975	08	06	Oroville, CA Aftershock	4.7	8	J-350	Johnson Ranch	10 meters of sediments overlying greenstone
16.**	1975	08	08	Oroville, CA Aftershock	4.9	8	J-700	Johnson Ranch	10 meters of sediments overlying greenstone
17.						6	6-700	Oroville, CA CDMG No. 6	Mesozoic greenstone
18.**	1975	09	27	Oroville, CA Aftershock	4.6	11	J-234	Johnson Ranch	10 meters of sediments overlying greenstone
19.						11	8-234	Oroville, CA CDMG No. 8	Mesozoic greenstone
20.**	1976	09	11	Friuli, Italy Aftershock	5.9	6	I-142	Sampiago (D)	Triassic limestone and dolomite. Installed 260 meters below surface.
21.							I-139	San Rocco	Limestone
22.	1976	09	11	Friuli, Italy Aftershock	5.5	16	I-132	San Rocco	Limestone
23.**						10	I-134	Sampiago (D)	Triassic limestone and dolomite. Installed 260 meters below surface.
24.**	1976	09	15	Friuli, Italy Aftershock	5.0	11	I-159	Sampiago (D)	Triassic limestone and dolomite. Installed 260 meters below surface.
25.	1976	09	15	Friuli, Italy Aftershock	6.0	19	I-169	San Rocco	Limestone
26.**	1978	08	13	Santa Barbara, CA	5.1	13	-	UCSB-North Hall, Goleta, CA	Floor slab on caissons extending through 13 ft of soil and founded in siltstone
27.	1979	08	06	Coyote Lake, CA	5.9	2	SM-879	Coyote Creek, San Martin, CA	Conglomerate, sandstone and shale
28.						16	G1-879	Gilroy No. 1, Gavilan College Water Tower	Sandstone, shale, and chert
29.						10	G6-879	Gilroy No. 6, San Ysidro, CA	Conglomerate, sandstone and shale
30.**	1980	01	26	Livermore, CA	5.2-5.8	11	-	Livermore - Morgan Territory Park	Sandstone and shale (Digitized record not available)
31.	1982	01	18	New Hampshire	4.7 (M_b = 4.4)	8	-	Franklin Falls Dam, Rt. abutment	Rock
32.	1982	03	31	New Brunswick Aftershock	4.8 (M_b = 5.0)	4	-	Mitchell Lake Rd.	Rock

NOTES:

* Magnitude estimate by Kanamori and Jennings (1978)

** Recorded from dam crest base

TABLE 4-4

SCALED ROCK OUTCROP RECORDS

Year	Mo.	Day	Earthquake Name	Magnitude M_L	Scaling Factor	Recording Station	Epicentral Distance (Km)	Component	Record No.
1935	10	31	Helena, MT	6.0	0.271	Carroll College, Helena, MT	6	EW NS	B-025
1966	06	28	Parkfield, CA	5.6	0.446	Cholame-Shandon Array, Temblor	39(7)	N65W S25W	B-037
1970	09	12	Lytle Creek, CA	5.4	0.572	Allen Ranch Cedar Springs, CA	19	S05W S85E	W-335
1971	02	09	San Fernando, CA	6.4	0.165	Array No. 4 Lake Hughes, CA	29	S69E S21W	J-142
1975	08	01	Oroville, CA	5.7	0.394	Oroville Dam Seismograph Station	12	N53W N37E	OS-875
1975	08	08	Oroville, CA Aftershock	4.9	1.064	Oroville, CA CDMG No. 6	6	S55E N35E	6-700
1975	09	27	Oroville, CA Aftershock	4.6	1.452	Oroville, CA CMDG No. 8	11	N90W S00E	8-324
1976	09	11	Friuli, Italy Aftershock	5.9	0.307	San Rocco	14	NS EW	I-139
1976	09	11	Friuli, Italy Aftershock	5.5	0.505	San Rocco	16	NS EW	I-132
1976	09	15	Friuli, Italy Aftershock	6.0	0.271	San Rocco	19	NS EW	I-169
1979	08	06	Coyote Lake, CA	5.9	0.307	Coyote Creek San Martin, CA	2	250° 160°	SM-879
						Gilroy No. 1, Gavilan College Water Tower	16	320° 230°	G1-879
						Gilroy No. 6 San Ysidro, CA	10	320° 230°	G6-879
1982	01	18	New Hampshire	4.7 (m_b= 4.4)	1.413	Franklin Falls Dam Right Abutment	8	315° 45°	FR-182
1982	03	31	Miramichi, New Brunswick	4.8 (m_b= 5.0)	0.750	Mitchell Lake Road	4	118° 28°	ML-382

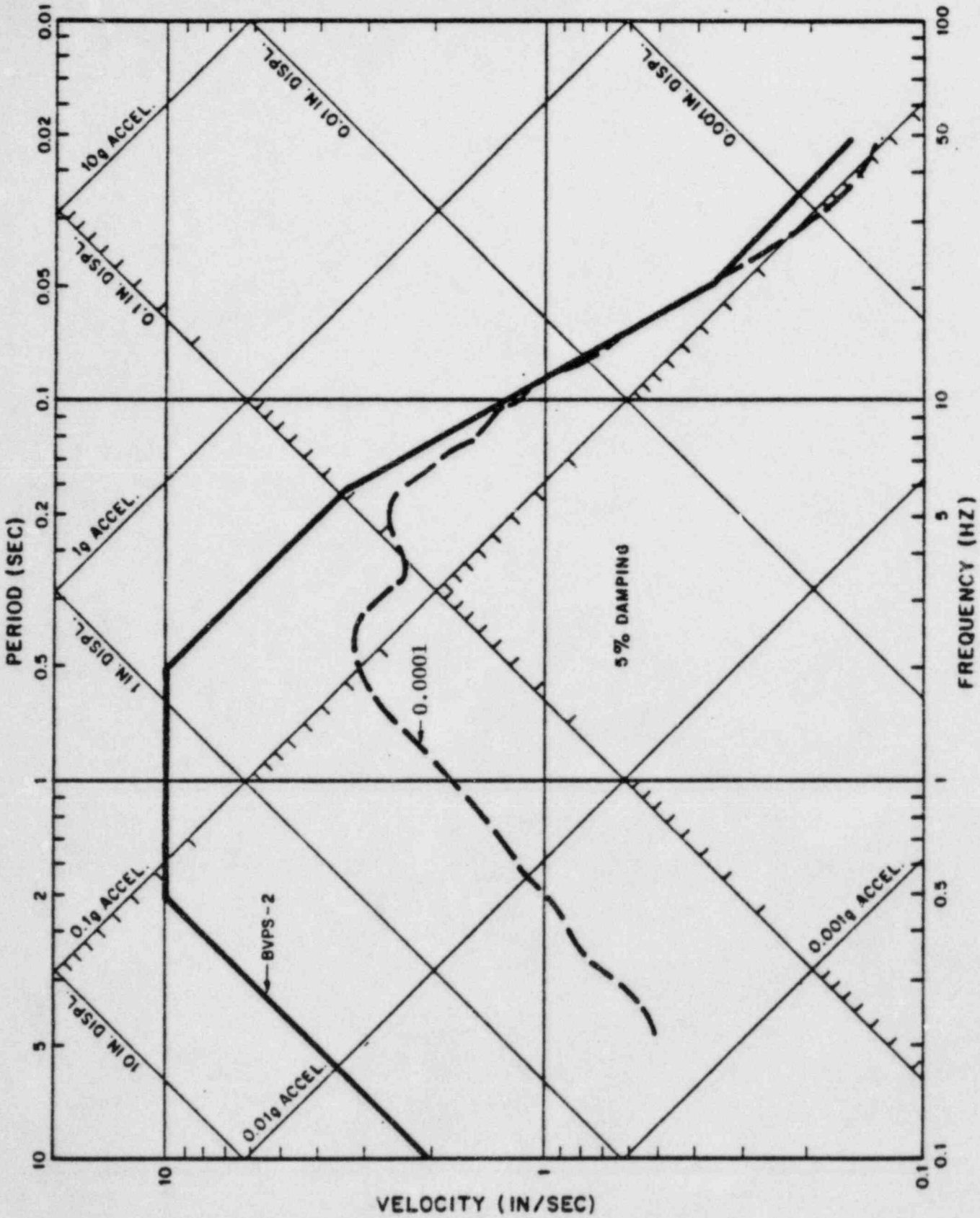
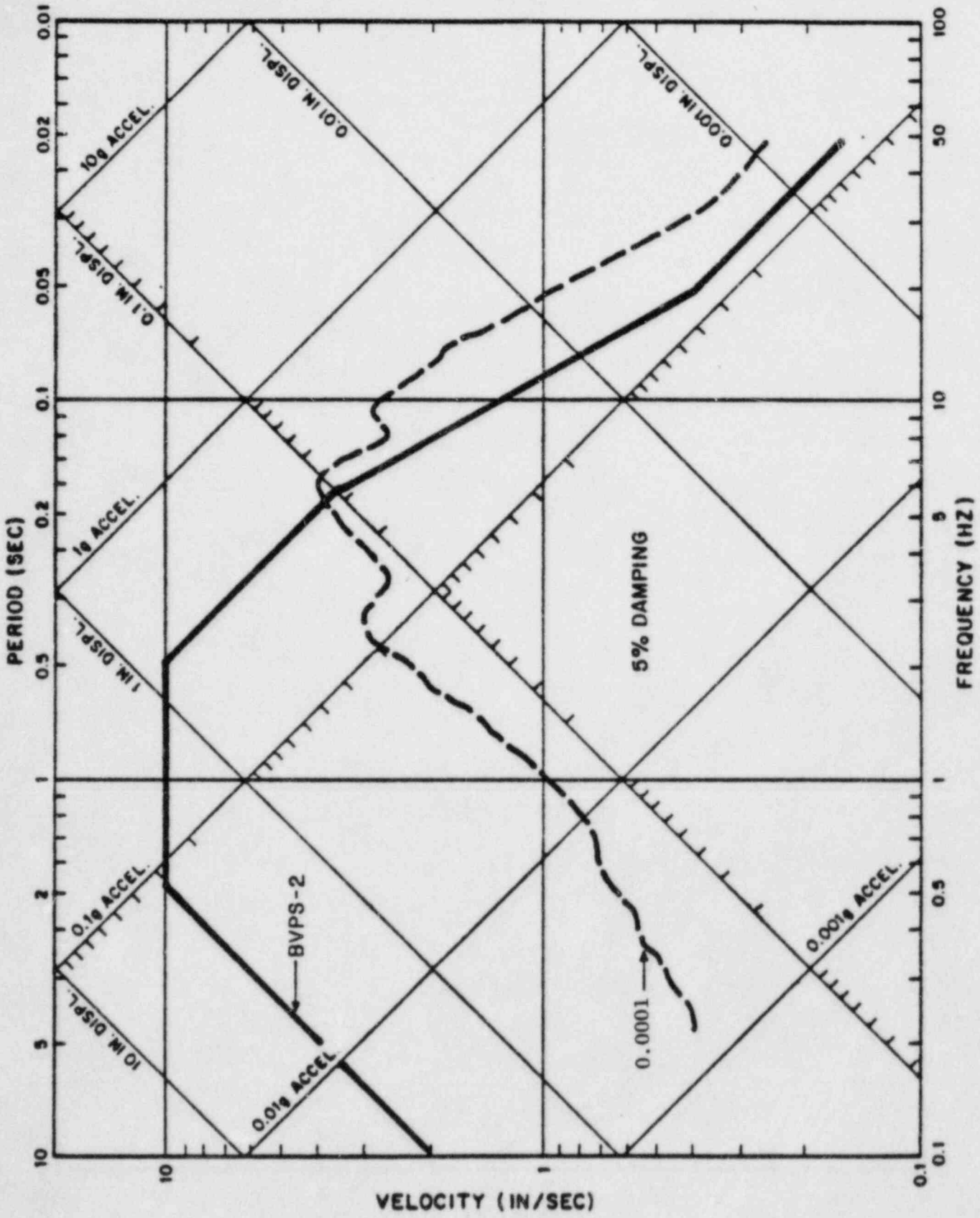


FIGURE 4-3
HORIZONTAL RESPONSE SPECTRUM
FROM SOIL RESPONSE
ANALYSIS: OUTPUT SCALED
BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

TABLE 4-5

UNSCALED ROCK OUTCROP RECORDS

Year	Mo.	Day	Earthquake Name	Magnitude M_L	Epicentral Distance (km)	Record No.	Component	Recording Station
1970	09	12	Lytle Creek, CA	5.4	19	W-334	S05W S85E	Allen Ranch Cedar Springs, CA
1975	08	08	Oroville, CA Aftershock	4.9	6	6-700	S55E N35E	Oroville, CA CDMG No. 6
1975	09	27	Oroville, CA Aftershock	4.6	11	8-324	N90W S00E	Oroville, CA CDMG No. 8
1976	09	11	Friuli, Italy Aftershock	5.5	16	[illegible]-132	NS EW	San Rocco
1982	01	18	New Hampshire	4.7 (m_b = 4.4)	8	FR-182	315° 45°	Franklin Falls Dam Right abutment
1982	03	31	Miramichi, New Brunswick	4.8 (m_b = 5.0)	4	ML-382	118° 28°	Mitchell Lake Road



NOTE:

MEAN RESPONSE SPECTRUM FROM RECORDS LISTED IN TABLE 4-5

FIGURE 4-4

SOIL RESPONSE ANALYSIS
RESPONSE SPECTRUM: UNSCALED
BEAVER VALLEY POWER STATION - UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

WHY UNSCALED PROCEDURE IS INADEQUATE

- FRANKLIN FALLS RECORDING UNLIKELY TO BE ON ROCK AND LIKELY TO BE AFFECTED BY GEOMETRY.
- REMOVING FRANKLIN FALLS MAKES NUMBER OF RECORDS = 10 – INAPPROPRIATE FOR ANALYSIS.
- MEAN M_L = 5.1 (WESTERN EVENTS), WHICH RESULTS IN 21% INCREASE IN AMPLITUDE.
- EASTERN RECORDS HAVE VERY SHORT DURATION, HIGH FREQUENCY PULSE, AND LITTLE ENERGY.
- TOTAL NUMBER OF RECORDS = 12 – BARELY ADEQUATE.

VERTICAL RESPONSE SPECTRA

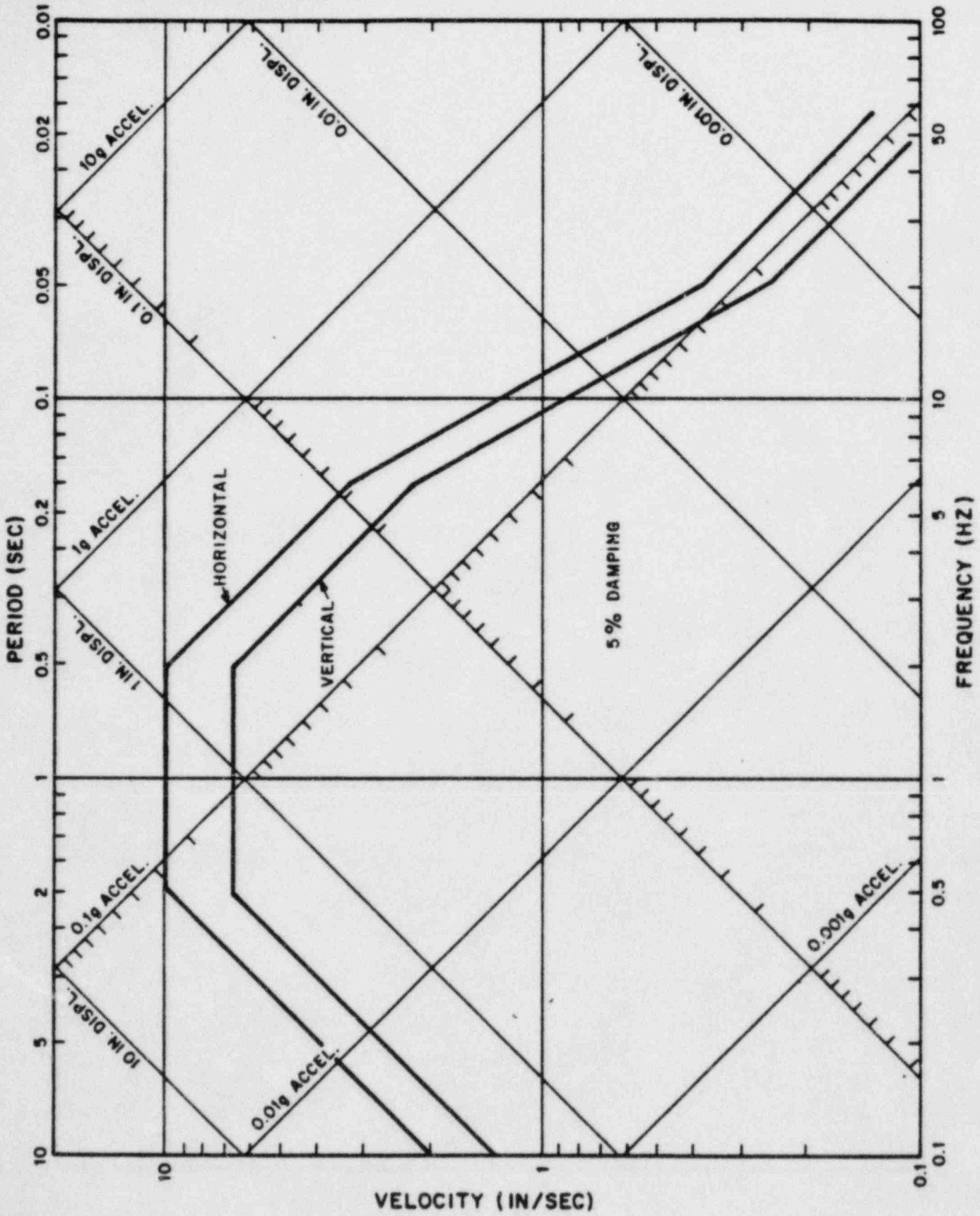


FIGURE 5-1
DESIGN RESPONSE SPECTRA
BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

TABLE 5-1

SITE MATCHED GROUND SURFACE RECORDS
USED TO DETERMINE RATIO OF VERTICAL TO HORIZONTAL RESPONSE SPECTRA

Date			Epicenter Location	Magnitude (M)	Recording Station	Epicenter Distance D (km)	Component	Scaling Factor to M = 4.95	Scaled Peak Acceleration (g's)	$\frac{a_v}{a_h}$ (1)	CIT Record No. (2)
Year	Month	Day									
1954	12	21	Eureka, CA	6.5	Federal Building, Eureka, CA	6	N79E S11E VERT	0.146	0.038 0.024 0.012	0.39	A-008
1957	03	22	San Francisco, CA	5.3	State Bldg., San Francisco, CA	13	N09E S81W VERT	0.65	0.056 0.036 0.029	0.062	A-016
					Alexander Bldg., San Francisco, CA	14	N09W N81E VERT	0.65 0.020	0.028 0.030	0.67	A-014
1957	03	22	San Francisco, CA	4.4	Alexander Bldg., San Francisco, CA	16	N09W N81E UP	1.98	0.038 0.032 0.012	0.34	V-323
					City Hall, Oakland, CA	24	N26E S64E VERT	1.98	0.079 0.049 0.031	0.50	A-017
1962	09	04	Northern, CA	5.0	Federal Bldg., Eureka, CA	18	N79E S11E UP	1.0	0.046 0.048 0.013	0.28	V-330
1965	07	15	Southern, CA	4.0	Old Ridge Rte., Castaic, CA	14	E S DOWN	3.26	0.119 0.134 0.087	0.69	V-331
1970	09	12	Lytle Creek, CA	5.4	6074 Park Dr., Wrightwood, CA	14	S65E S25W DOWN	0.572	0.081 0.113 0.031	0.32	W-334
1971	02	09	San Fernando, CA	6.4	Old Ridge Rte., Castaic,	29	N21E N69W DOWN	0.165	0.052 0.045 0.026	0.53	D-056

NOTES:

1. Ratio a_v/a_h determined as the peak vertical acceleration divided by the average peak horizontal acceleration.

2. California Institute of Technology record number in accordance with Trifunac and Lee (1973).

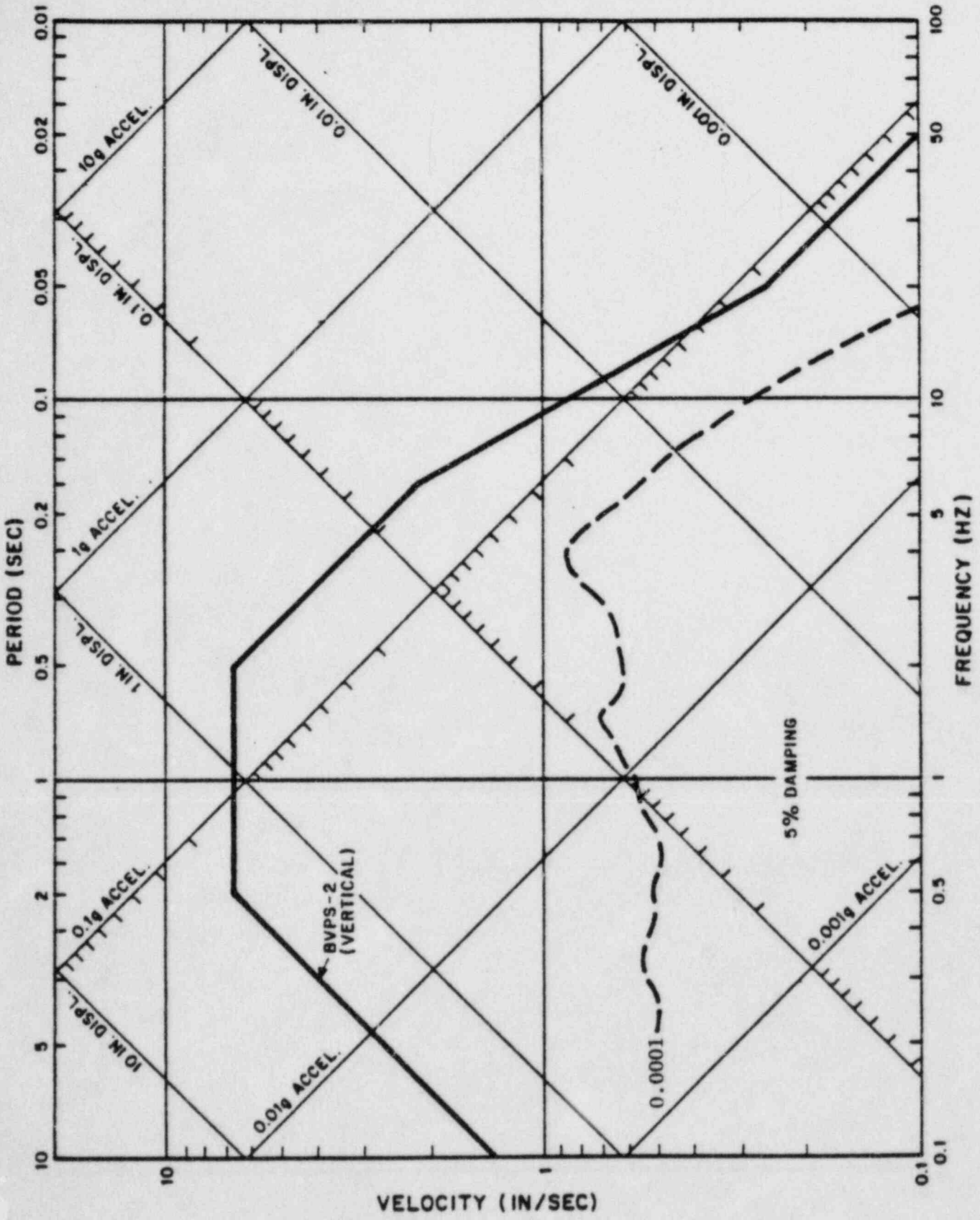


FIGURE 5-2
SITE MATCHED VERTICAL RESPONSE SPECTRUM
BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

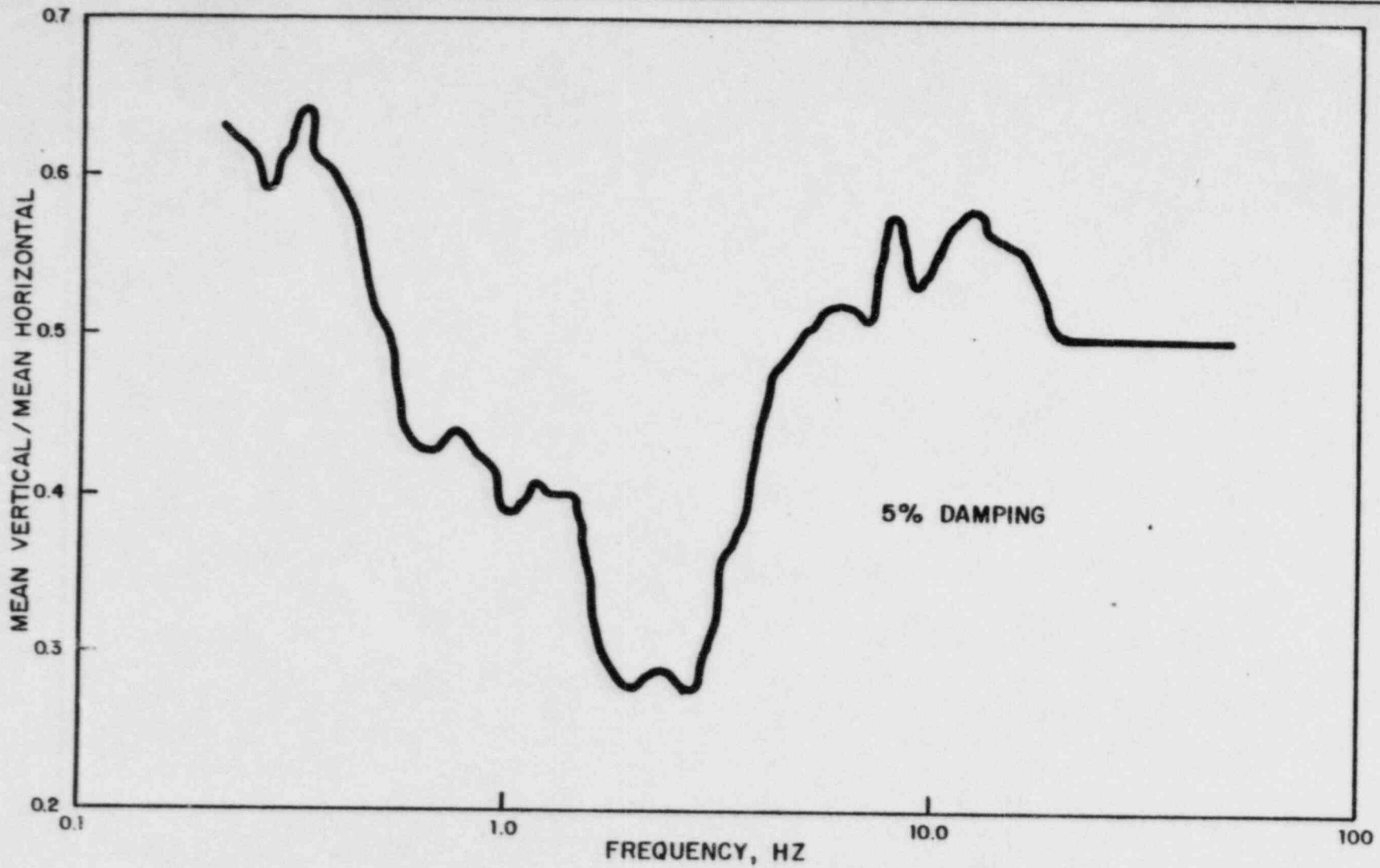
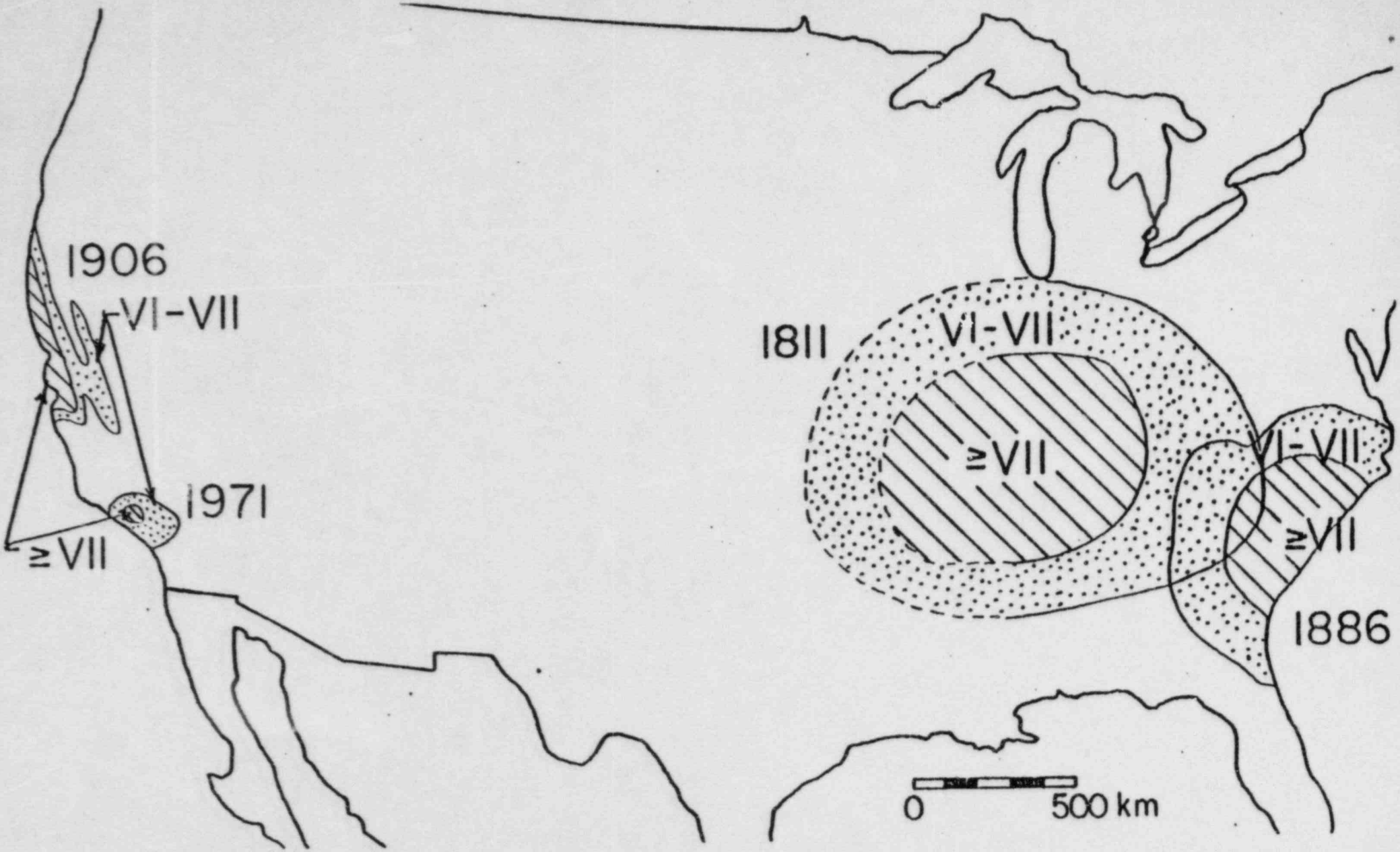
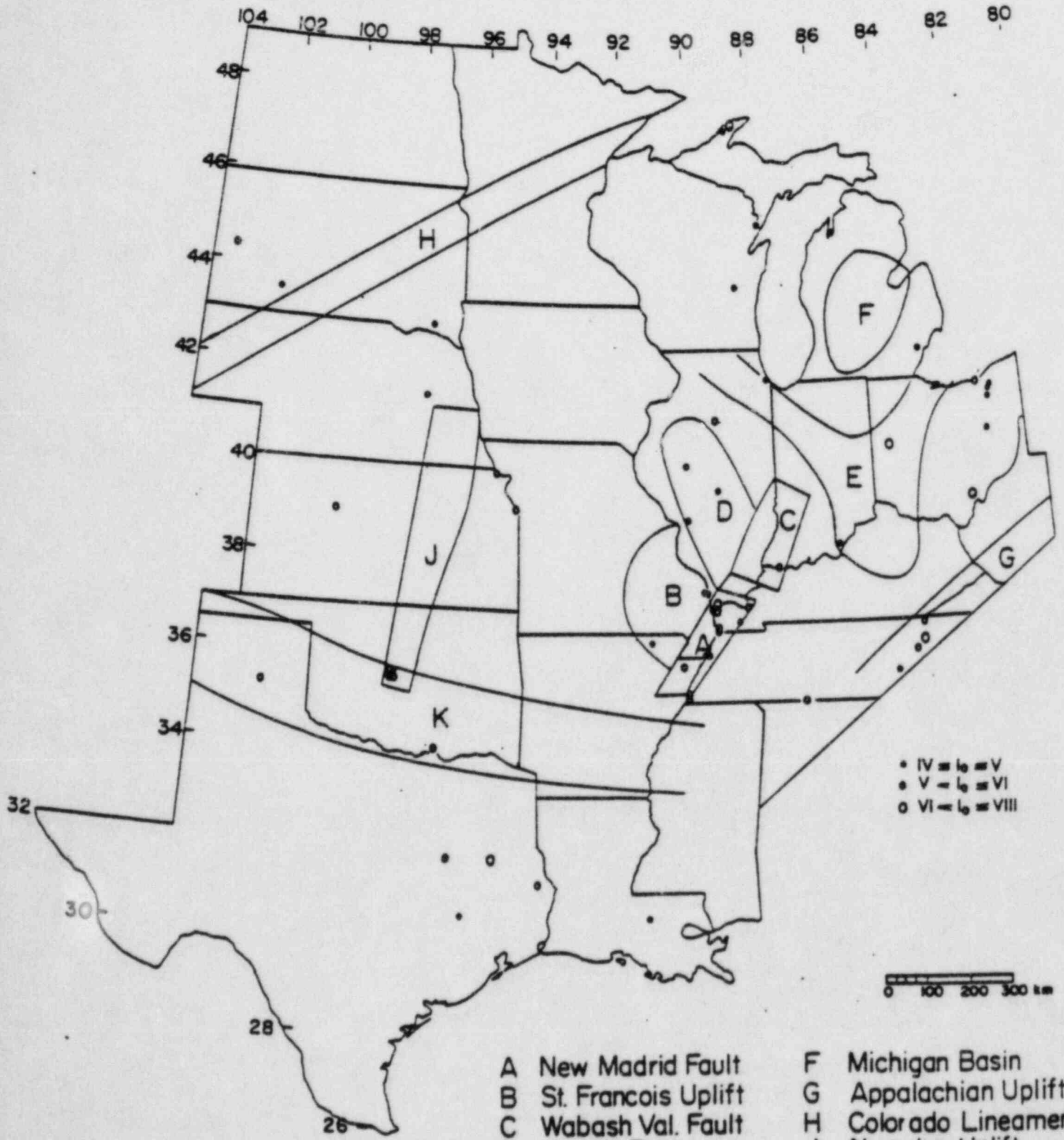
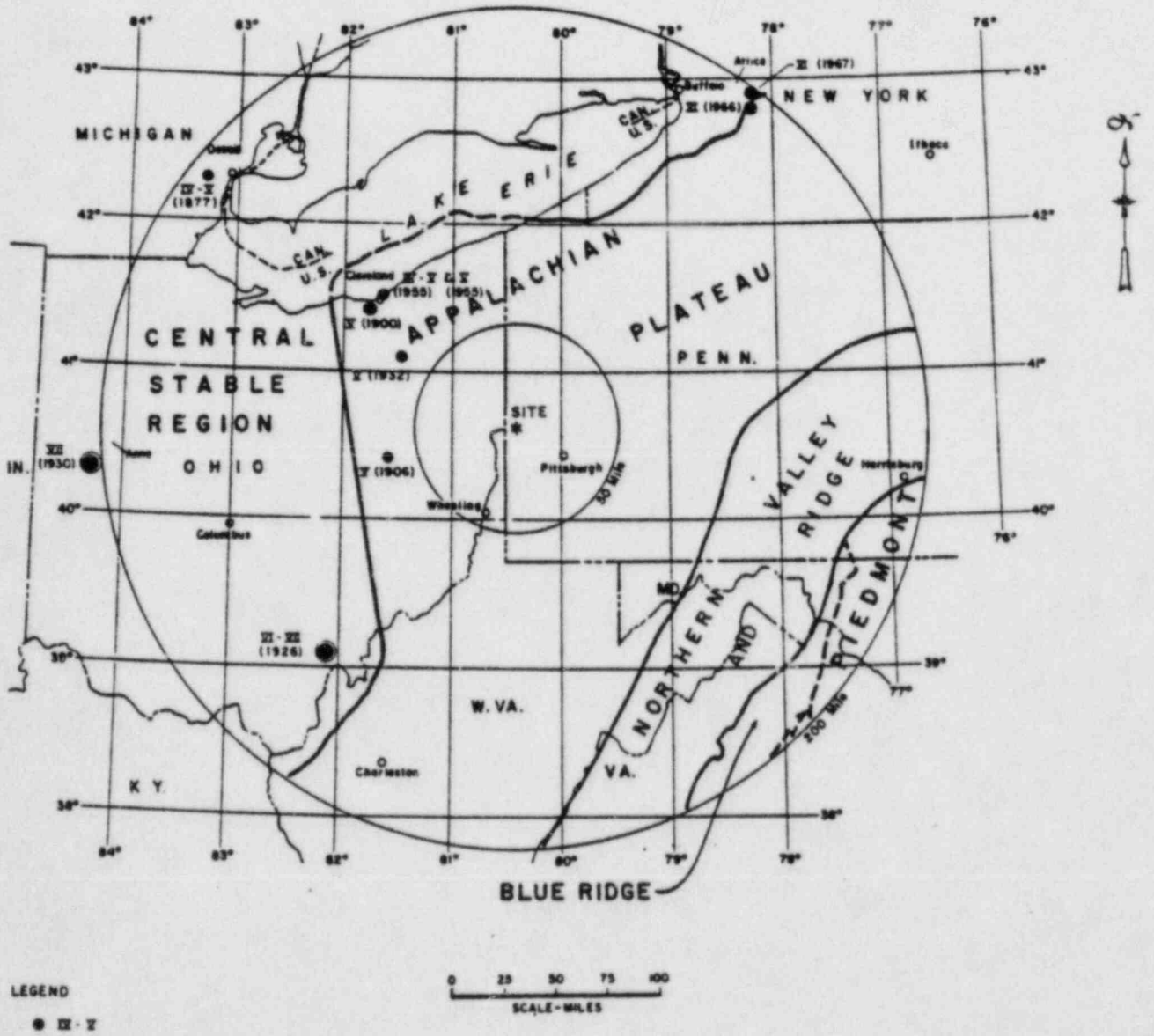


FIGURE 5-4
RATIO OF VERTICAL TO HORIZONTAL SITE MATCHED RESPONSE SPECTRA
BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION


1906
VI-VII
≥VII
1971
1811
VI-VII
≥VII
VI-VII
≥VII
1886
0
500 km



VERY SHALLOW EARTHQUAKES IN THE CENTRAL UNITED STATES AND PRINCIPAL SEISMIC SOURCE ZONES



NOTE:

INTENSITIES ARE MODIFIED MERCALLI (MM)
SEE TABLE A3-1

FIGURE A3-1

SHALLOW EARTHQUAKE EPICENTERS
WITHIN 200 MILES OF THE SITE

BEAVER VALLEY POWER STATION-UNIT 2
STONE & WEBSTER ENGINEERING CORPORATION

Date	Time	Latitude °N	Longitude °W	Io (MM)	m_b	Source
08/17/1877	16:50	42.3	83.3	IV-V	3.2	CSR
04/09/1900	14:00	41.4	81.8	VI	3.8	APP
06/27/1906	12:10	40.4	81.6	V	3.4	APP
11/05/1926	15:53	39.1	82.1	VI-VII	3.4	CSR
09/30/1930	20:40	40.3	84.3	VII	4.2	Anna, Ohio
01/22/1932		41.1	81.5	V	3.6	APP
05/26/1955	18:09	41.5	81.7	IV-V	3.6	APP
06/29/1955	01:16	41.5	81.7	IV	3.6	APP
01/01/1966	13:23	42.8	78.2	VI	4.6	Clarendon Linden
06/13/1967	19:08	42.9	78.2	VI	4.4	Clarendon Linden

CSR - Central Stable Region
APP - Appalachian Plateau Province

SHALLOW EARTHQUAKES WITHIN 200 MILES OF BEAVER VALLEY POWER STATION