December 27, 1974

Mr. Olan D. Parr, Chief
Light Water Reactors Project
Branch 1-3
Directorate of Licensing
Office of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

Re: Dockets 50-275-OL
50-323-OL

Dear Mr. Parr:

In response to your request for additional information dated December 6, 1974, the seismic response of typical Design Class I structures, systems, and components at Diablo Canyon has been determined using the modified input response spectra specified in your letter and damping values given in AEC Regulatory Guide 1.61.

The modified input spectra were derived from the acceleration time histories for the Parkfield - 5, 1966, N85E component and the Castaic, 1971, S69E component, each normalized to a peak ground acceleration of 0.5g. The spectral content of these records is considered representative of the vibratory ground motion expected at a site with foundation material similar to Diablo Canyon and generated from a nearby source.

A comparison of these modified spectra with the spectra and damping used in the Diablo Canyon design confirms the seismic design adequacy of typical Class I structures, systems and components at Diablo Canyon. The detailed results of this work are included in the attachment to this letter.

Very truly yours,

F. T. Searls

Attachment (15)
CC w/attachment: See Page 2

JBHoch/PAC:TC

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DIABLO CANYON UNITS 1 AND 2

INVESTIGATION OF EFFECT ON SEISMIC DESIGN USING PARKFIELD-5, 1966, N85E AND CASTAIC, 1971, S69E RECORDS (SCALED TO 0.5G PEAK ACCELERATION) AS INPUT

1. INTRODUCTION

The time-histories of the Parkfield-5, 1966, N85E component and the Castaic, 1971, S69E component are plotted in Figures 1 and 2. The time-histories are scaled to have a peak acceleration of 0.5g. These components (normalized to 0.5g) will hereafter be referred to as simply Parkfield-5 and Castaic. The Double Design Earthquake (DDE, as defined in the FSAR) response spectra for 5% damping is compared with 7% damping response spectra for the Parkfield-5 and Castaic records in Figure 3. The particular choice of damping values for spectral comparison is based on the damping value used in the DDE analysis (5%) and that recommended by AEC Regulatory Guide 1.61 (7%) for reinforced concrete structures such as the containment structure.

Table 1 provides information on the period ranges where the various spectra envelope the others. It is apparent from Table 1 that for structures, systems, and equipment having significant natural modes with periods in the ranges: $T < 0.08$ sec and $0.34 < T < 1.0$ sec, the Parkfield-5 or Castaic ground motions may induce a greater response than the DDE. All of the Category I concrete structures, viz., the entire containment structure, including the interior structure, and the auxiliary building, have significant periods in the range $0.08 < T < 0.34$ sec and thus their seismic design is not likely to be governed by Parkfield-5 or Castaic ground motions. The steel structure above the fuel handling area in the auxiliary building has periods in the range of 0.35 sec to 0.52 sec and its seismic response could possibly be governed by Parkfield-5 or Castaic ground motions. However, as discussed in Section 5, 2% damping was used for bolted steel structures in the DDE analysis whereas Regulatory Guide 1.61 recommends 7%.

In the next section, the results of a dynamic analysis of the containment structure with Parkfield-5 as input ground motion are compared with those from the DDE analysis. Section 3 gives a comparison of floor response spectra for selected points in the containment structure. Section 4 discusses the

effects on NSSS components. Section 5 compares analysis results from Parkfield-5 and DDE on the auxiliary building. Section 6 discusses Design Class I tanks located at grade elevation.

2. CONTAINMENT STRUCTURE

The same analysis procedure as described in Section 3.7 of the FSAR was used. The axisymmetric finite element model of the containment structure and the foundation rock mass is shown in Figure 3.7-5 of the FSAR. The input boundary motions corresponding to Parkfield-5 free field ground motion are derived by the same deconvolution procedure described in Section 3.7 of the FSAR. The comparison of the response spectrum of the original free field motion and that of the recomputed surface motion is made in Figure 4.

Natural mode periods and mode shapes were found to be identical as in the previous DDE analysis. These are given, respectively, in Table 3.7-1 and Figure 3.7-6 of the FSAR. In computing the responses for Parkfield-5, damping of 7% of critical was used for the concrete structure vs. the 5% used in the DDE response computations.

Table 2 through 5 compare the analysis results using the Parkfield-5 motion with corresponding responses obtained using the DDE motion. The responses compared are maximum absolute accelerations, displacements, total shears and total overturning moments. Except for the acceleration at the base slab, the Parkfield-5 responses of the containment structure are much less, or in the case of nodal point 38, only very slightly greater than the corresponding DDE responses. The higher acceleration response at the base slab for Parkfield-5 is to be expected since the peak acceleration in ground adjacent to the slab is specified as 0.5g for Parkfield-5 compared to 0.4g for DDE. The natural periods of the containment structure are all less than 0.25 sec. Noting from Figure 3 that for $T < 0.30$ sec the Parkfield-5 and Castaic response spectra are in approximately similar relation to the DDE spectrum, and that the natural mode periods of the containment structure are all less than 0.30 sec, one may also conclude that the Castaic responses of the containment structure would be generally in the same proportion to the DDE responses as are the Parkfield-5 responses.

3. FLOOR RESPONSE SPECTRA - CONTAINMENT STRUCTURE

Acceleration time-histories at several nodal points of the containment structure model were derived. Acceleration response spectra for Parkfield-5 using 3%, and in some cases 4% damping were calculated at the following nodal points (see Figure 3.7-5 of the FSAR for the location of nodal points).

Nodal Point	Elevation	Remarks
14	231.0'	Dome spring line
19	140.0'	Top of interior structure
32	111.0'	Interior structure
34	120.5'	Exterior structure
47	88.5'	Base slab

Figures 5 through 11 compare these response spectra with DDE floor response spectra for 1/2% and 1% damping, respectively, at corresponding nodal points. Damping of 1/2% was used in seismic (DDE) analysis of piping systems vs. the 3% damping value suggested by AEC Regulatory Guide 1.61 for large piping systems under SSE. Similarly, 1% damping was used in seismic (DDE) analysis of NSSS components vs. 4% damping now accepted by AEC-DRL for the Westinghouse NSSS. The DDE floor response spectra given in FSAR section 3.7 are smoothed versions of the corresponding computer generated plots used in Figure 5 through 11.

It is immediately apparent from Figures 5 through 11 that except for $T < 0.075$ sec at NP 47, the Parkfield-5 floor response spectra are always much lower than the DDE floor response spectra. Making the same argument as made at the end of previous section, the above conclusion can be assumed to be valid for the Castaic component also.

4. NSSS COMPONENTS

The nuclear steam supply system is supported in the containment (interior) structure and applicable response spectra are those at NP 47 and NP 19 for the steam generators and reactor coolant-pumps (Figure 3.7-5, FSAR). The following are the fundamental period ranges of some of the important components of NSSS.

Component	Period Range, sec
Steam Generator	0.11 - 0.12
Reactor Coolant Pump	0.13 - 0.14
Reactor Vessel	0.06

1% damping was used in the NSSS seismic analysis for DDE. However, 4% damp-in the SSE seismic analysis has been accepted by AEC-DRL for the Westinghouse NSSS. Thus, using the spectra in Figures 10 and 11, it may be concluded that the Steam Generators and Reactor Coolant Pumps are likely to see smaller seismic forces under Parkfield-5 motion than under the DDE motion. The reactor vessel is supported on the interior concrete structure at elevation 102. Comparing maximum absolute accelerations for Parkfield-5 and the DDE (see Table 2, NP 38) indicates that seismic forces on the reactor vessel are essentially the same for either seismic input. Similar conclusions may also be made for the Castaic component on the same basis as the conclusion made in the previous sections.

5. AUXILIARY BUILDING

The same analysis procedure as described in Section 3.7 of the FSAR was used. The model for the auxiliary structure is shown in Figure 3.7-13 of the FSAR. The natural mode periods and mode shapes of the structure were found to be identical to those obtained for the DDE analysis. The natural periods are given in Table 3.7-8. In the DDE analysis, 2% damping was used in the steel portion of the structure (Mass No. 6 in Figure 3.7-13 of FSAR) and 5% damping in the concrete portion of the structure. In the present analysis, Parkfield-5 ground motion is used as input and 7% damping is used for both the concrete and steel portions of the structure (the steel structure has bolted connections) in accordance with AEC Regulatory Guide 1.61.

The results of the present analysis are compared with those from the DDE analysis in Tables 6 through 10. The DE analysis results are given in Tables 3.7-9 through 3.7-13 of the FSAR and the DDE responses are simply twice the DE responses.

The results presented in Tables 6 through 10 show that at no point in the structure does the Parkfield-5 ground motion govern the seismic design of the auxiliary building. This is explained by the fact that the dominant

natural mode period of the concrete structure is 0.105 sec where Figure 3 and Table 1 show DDE response spectrum controlling. The steel structure periods are in the range of 0.35-0.52 sec, in which either Parkfield-5 or Castaic spectra controls. However, 2% damping was used in the DDE analysis and if the 2% damping DDE response spectrum is compared with the 7% Parkfield-5 response spectrum, the DDE response spectrum is found to be controlling.

Noting that the steel structure's dominant period in the E-W direction is 0.516 and observing from Figure 3 that the Castaic response spectrum is substantially above the Parkfield-5 response spectrum, it was felt that the steel structure's response in the E-W direction may be controlled by Castaic. An approximate modal analysis, using the intermediate results (periods, mode shapes, and modal participation factors) of the Parkfield-5 computer analysis, was made for the Castaic ground motion. It was found that the Castaic responses were almost equal to (actually 5% smaller) the DDE responses. For example, the absolute acceleration of Mass No. 6 (see Figure 3.7-13 of FSAR) was 1.03g for Castaic compared to 1.10g for DDE.

Thus one may conclude that neither Parkfield-5 nor Castaic governs the seismic design of the auxiliary building.

6. DESIGN CLASS I TANKS

The Design Class I tanks located at grade respond at periods greater than 3 seconds. Therefore their seismic design is governed by the DDE (see Figure 3).

TABLE 1. COMPARISON OF RESPONSE SPECTRA

Period (T) range	Governing Spectrum	$\left\{\frac{S_a(P\text{-}5) \text{ or } S_a(C),\ 7\% \text{ Damping}}{S_a(DDE),\ 5\% \text{ Damping}}\right\}_{max}$
$T < 0.08$ sec	Parkfield-5	1.39
$0.08 < T < 0.34$	DDE	< 1
$0.34 < T < 0.41$	Parkfield-5	1.34
$0.41 < T < 1.0$	Castaic	1.30

TABLE 2. MAXIMUM ABSOLUTE ACCELERATIONS, CONTAINMENT STRUCTURE

Structure	Nodal Point*	Elevation ft	Maximum Absolute Acceleration in g	
			PARKFIELD-5	DDE Analysis
Exterior Structure	2	301.64	1.207	2.083
	8	274.37	1.069	1.736
	10	258.27	0.985	1.567
	14	231.00	0.789	1.177
	17	205.58	0.637	1.358
	23	181.08	0.558	1.369
	26	155.83	0.523	1.292
	34	130.58	0.545	1.080
	37	109.67	0.537	0.793
Interior Structure	19-22	140.00	0.762	1.199
	24	127.00	0.709	0.982
	27-30	114.00	0.657	0.773
	32	110.00	0.645	0.726
	38	102.00	0.608	0.601
Base Slab	47-58	88.58	0.556	0.483

* See Figure 3.7-5 of FSAR

TABLE 3. MAXIMUM DISPLACEMENTS, CONTAINMENT STRUCTURE

Structure	Nodal Point*	Elevation ft	Maximum Displacements in inches	
			PARKFIELD-5	DDE Analysis
Exterior Structure	2	301.64	0.734	1.063
	8	274.37	0.657	0.967
	10	258.27	0.618	0.911
	14	231.00	0.522	0.807
	17	205.58	0.425	0.695
	23	181.08	0.348	0.587
	26	155.83	0.263	0.459
	34	130.58	0.185	0.327
	37	109.67	0.121	0.212
Interior Structure	19-22	140.00	0.124	0.139
	24	127.00	0.109	0.114
	27-30	114.00	0.095	0.090
	32	110.00	0.091	0.084
	38	102.00	0.080	0.068
Base Slab	47-58	88.58	0.063	0.050

* See Figure 3.7-5 of FSAR

TABLE 4. MAXIMUM TOTAL SHEARS, CONTAINMENT STRUCTURE

Structure	Associated Nodal Points*	Elevation ft	Maximum Shears-kipsx10³	
			PARKFIELD-5	DDE Analysis
Exterior Structure	2	301.64	0.19	0.66
	8	274.37	6.04	9.38
	10	258.27	9.01	13.91
	14	231.00	12.97	19.55
	17	205.58	16.92	25.02
	23	181.08	19.74	29.98
	26	155.83	22.28	36.66
	34	130.58	24.24	44.18
	37	109.67	26.67	49.42
	57	88.58	27.49	51.39
Interior Structure	19&22	140.00	8.94	13.23
	27&30	114.00	13.07	16.87
	49&54	88.58	25.71	30.96
Total Base Shear	49,54&57	88.58	37.64	59.99

* See Figure 3.7-5 of FSAR

TABLE 5. MAXIMUM TOTAL OVERTURNING MOMENTS, CONTAINMENT STRUCTURE

Structure	Associated Nodal Points*	Elevation ft	Maximum Overturning Moment - kip-ftx10^6	
			PARKFIELD-5	DDE Analysis
Exterior Structure	2	301.64	0.00	0.00
	8	274.37	0.11	0.18
	10	258.27	0.27	0.41
	14	231.00	0.63	0.97
	17	205.58	1.10	1.67
	23	181.08	1.68	2.50
	26	155.83	2.08	3.08
	34	130.58	2.79	4.07
	37	109.67	3.18	4.58
	57	88.58	3.76	5.48
Interior Structure	19&22	140.00	0.05	0.10
	27&30	114.00	0.19	0.33
	49&54	88.58	0.81	1.24
Total O.T.M. at Base	49,54&57	88.58	3.85	5.62

* See Figure 3.7-5 of FSAR

TABLE 6. MAXIMUM ABSOLUTE ACCELERATIONS, AUXILIARY BUILDING

Mass Point*	Elevation (ft)	Maximum Absolute Accelerations					
		N-S Direction				E-W Direction	
		Horizontal Acceleration (g)		Rotational Acceleration (rad/sec^2)		Horizontal Acceleration (g)	
		1†	2†	1	2	1	2
6	188.00	0.80	1.38	0.010	0.018	0.77	1.10
1	163.00	1.09	1.96	0.074	0.180	1.17	2.40
2	140.00	0.85	1.16	0.063	0.158	0.89	1.60
3	115.00	0.70	0.84	0.045	0.108	0.72	1.08
4	100.00	0.61	0.62	0.034	0.084	0.61	0.74
5	85.00	0.56	0.54	0.018	0.044	0.55	0.54

*See Figure 3.7-13 of FSAR

TABLE 7. MAXIMUM RELATIVE DISPLACEMENTS

Mass Point*	Elevation (ft)	Maximum Relative Displacements					
		N-S Direction				E-W Direction	
		Translation (in.)		Rotation (radians x 10^{-5})		Translation (in.)	
		1	2	1	2	1	2
6	188.00	1.524	2.688	1.551	1.814	1.866	2.756
1	163.00	0.137	0.224	2.105	4.934	0.154	0.276
2	140.00	0.089	0.122	1.835	4.426	0.101	0.172
3	115.00	0.057	0.076	1.282	3.096	0.065	0.104
4	100.00	0.035	0.044	0.977	2.364	0.039	0.060
5	85.00	0.020	0.028	0.464	1.120	0.019	0.028

*See Figure 3.7-13 of FSAR

†Column 1 gives responses to Parkfield-5
Column 2 gives responses to DDE

TABLE 8. MAXIMUM STORY SHEARS, AUXILIARY BUILDING

Member*	Maximum Story Shears (kips x 10^3)			
	N-S Direction		E-W Direction	
	1†	2†	1	2
5	2.08	3.50	2.00	2.78
1	10.65	20.72	13.90	27.06
2	64.05	90.70	61.04	115.18
3	110.37	142.84	111.05	184.82
4	69.62	98.84	62.13	96.56

*See Figure 3.7-13 of FSAR

TABLE 9. MAXIMUM OVERTURNING MOMENTS

Member*	Maximum O.T. Moments (kip-ft x 10^6)			
	N-S Direction		E-W Direction	
	1	2	1	2
5	0.100	0.168	0.094	0.134
1	0.250	0.486	0.327	0.636
2 (top)	0.237	0.472	0.276	0.646
2 (bottom)	1.818	2.740	1.802	3.526
3	3.444	4.882	3.447	6.298
4	4.488	6.366	4.355	7.746

*See Figure 3.7-13 of FSAR

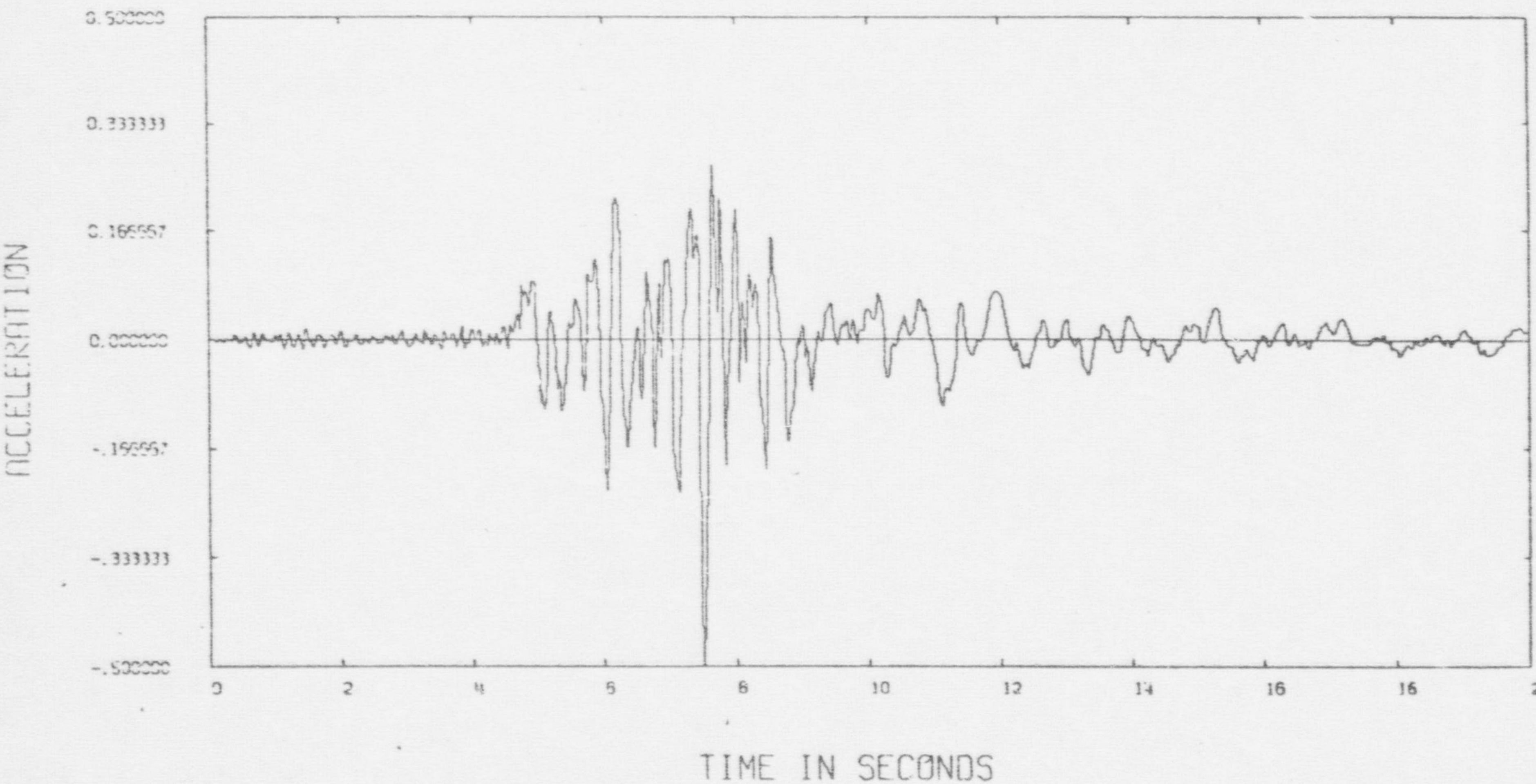
†Column 1 gives responses to Parkfield-5
Column 2 gives responses to DDE

TABLE 10. MAXIMUM TORSIONAL MOMENTS DUE TO EARTHQUAKE IN N-S DIRECTION, AUXILIARY BUILDING

Member*	Maximum Torsional Moments (kip-ft x 10^5)	
	1†	2†
5	0.088	0.172
1	0.804	1.738
2	34.033	81.782
3	52.494	126.034
4	40.333	97.888

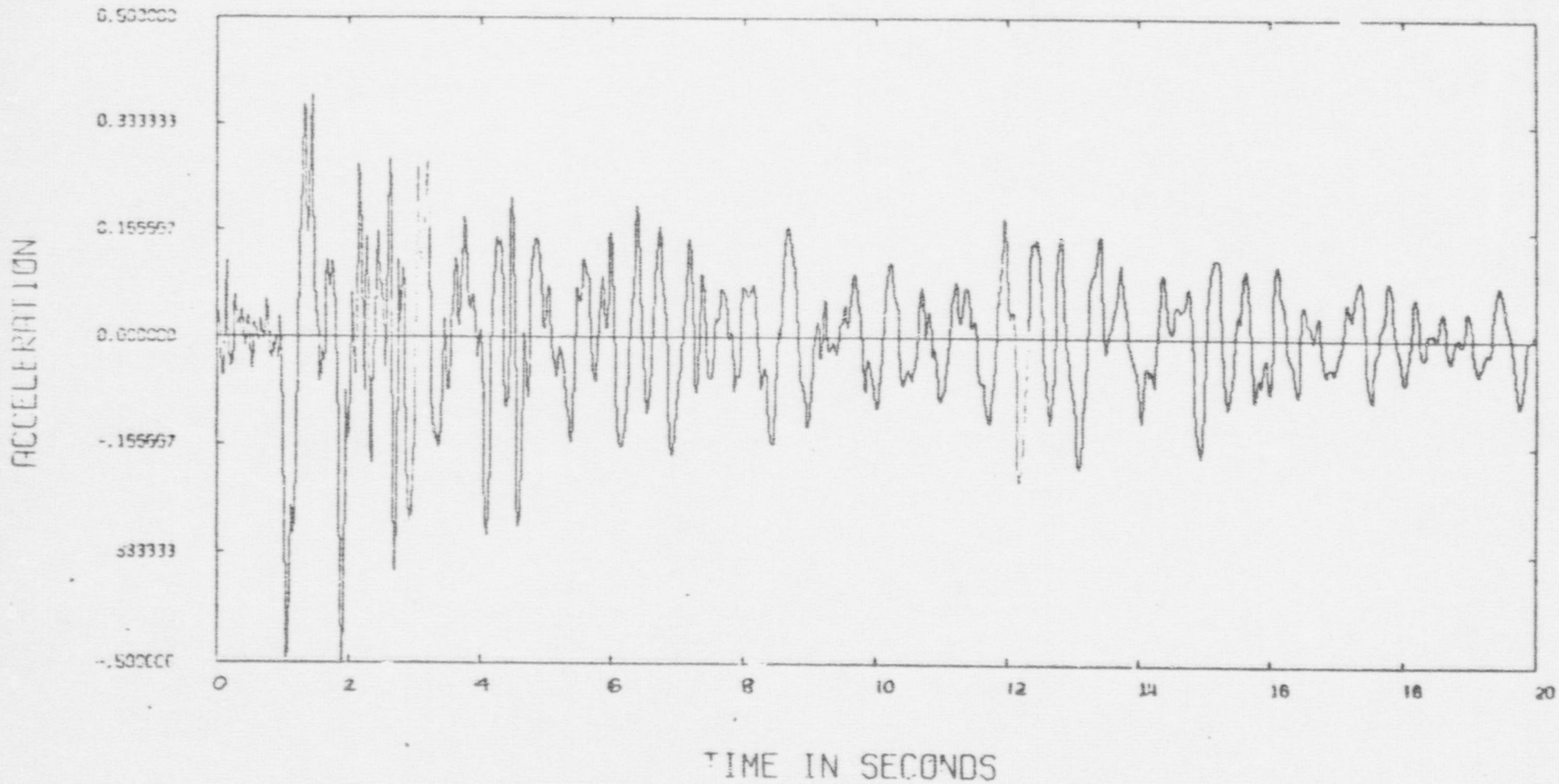
*See Figure 3.7-13 of FSAR

†Column 1 gives responses to Parkfield-5
Column 2 gives responses to DDE



PARKFIELD NORM 0.50G
ACCELERATION TIME HISTORY

FIGURE 1



C A S T A I C   N Ø R M   0 . 5 0 G
ACCELERATIØN TIME HISTØRY

FIGURE 2

JOHN A. BLUME AND ASSOCIATES

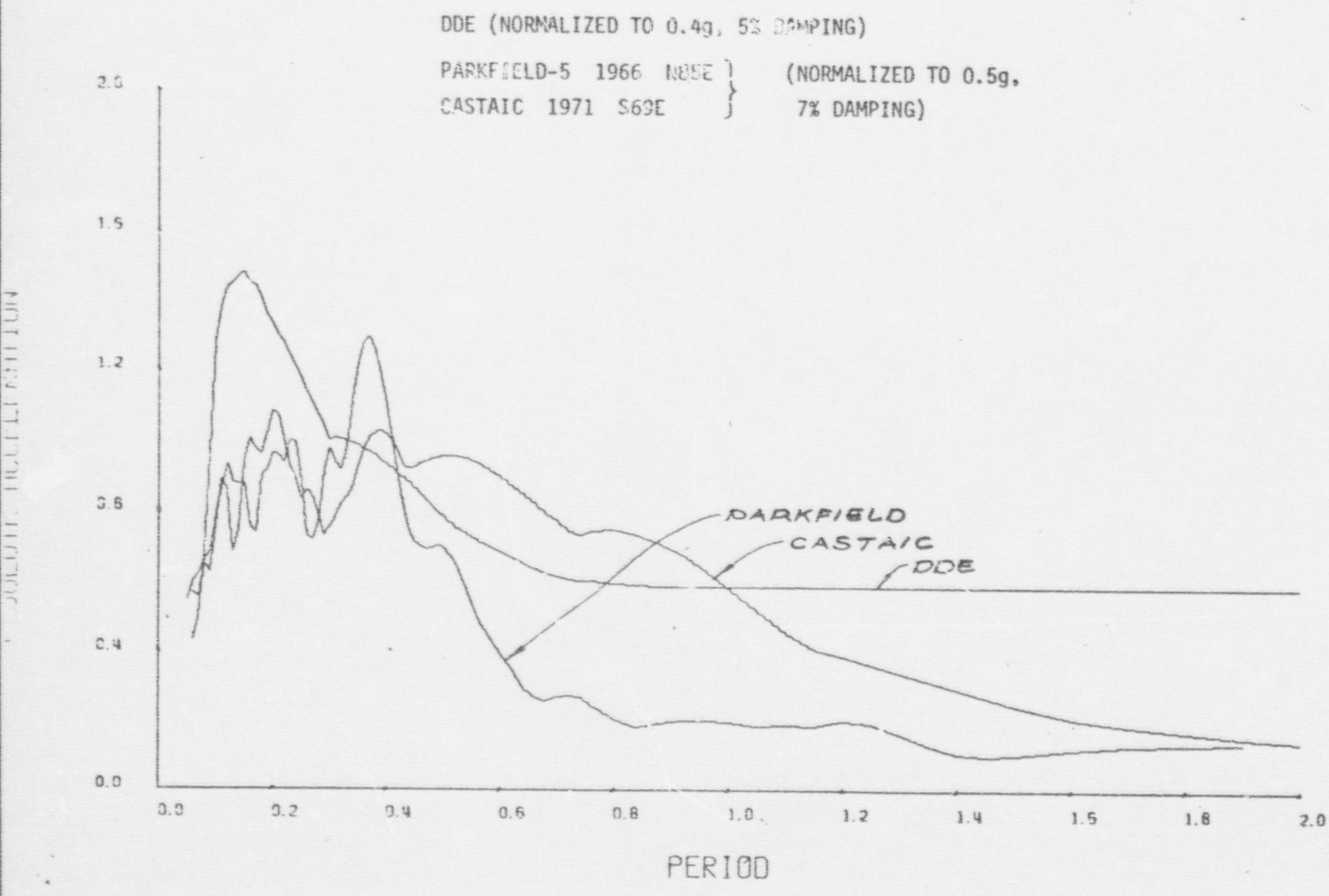


FIGURE 3

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

PARKFIELD NORM 0.5 G DAMP 0.050
GROUND MOTION FROM FEMODEL DECON

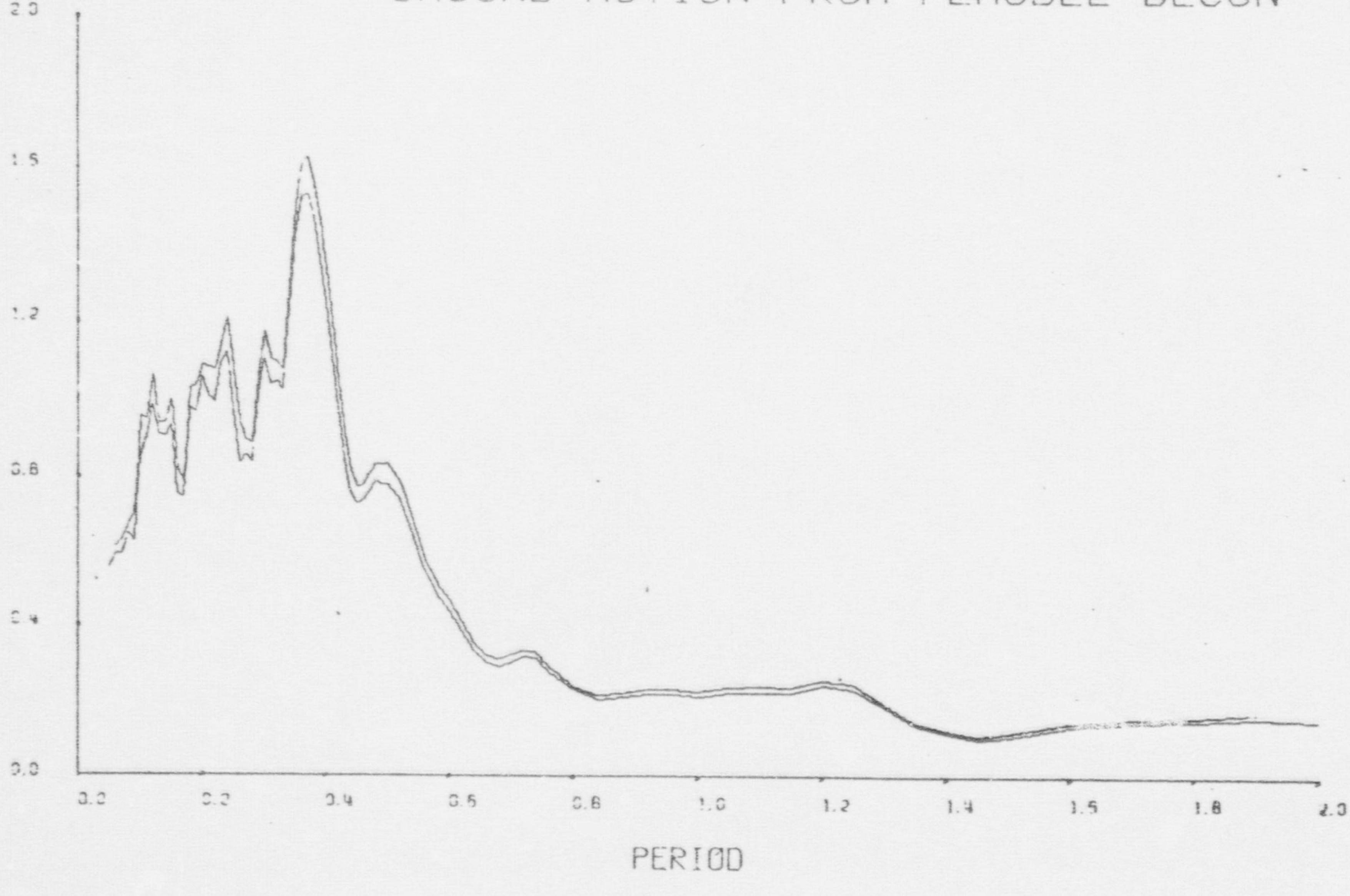


FIGURE 4

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

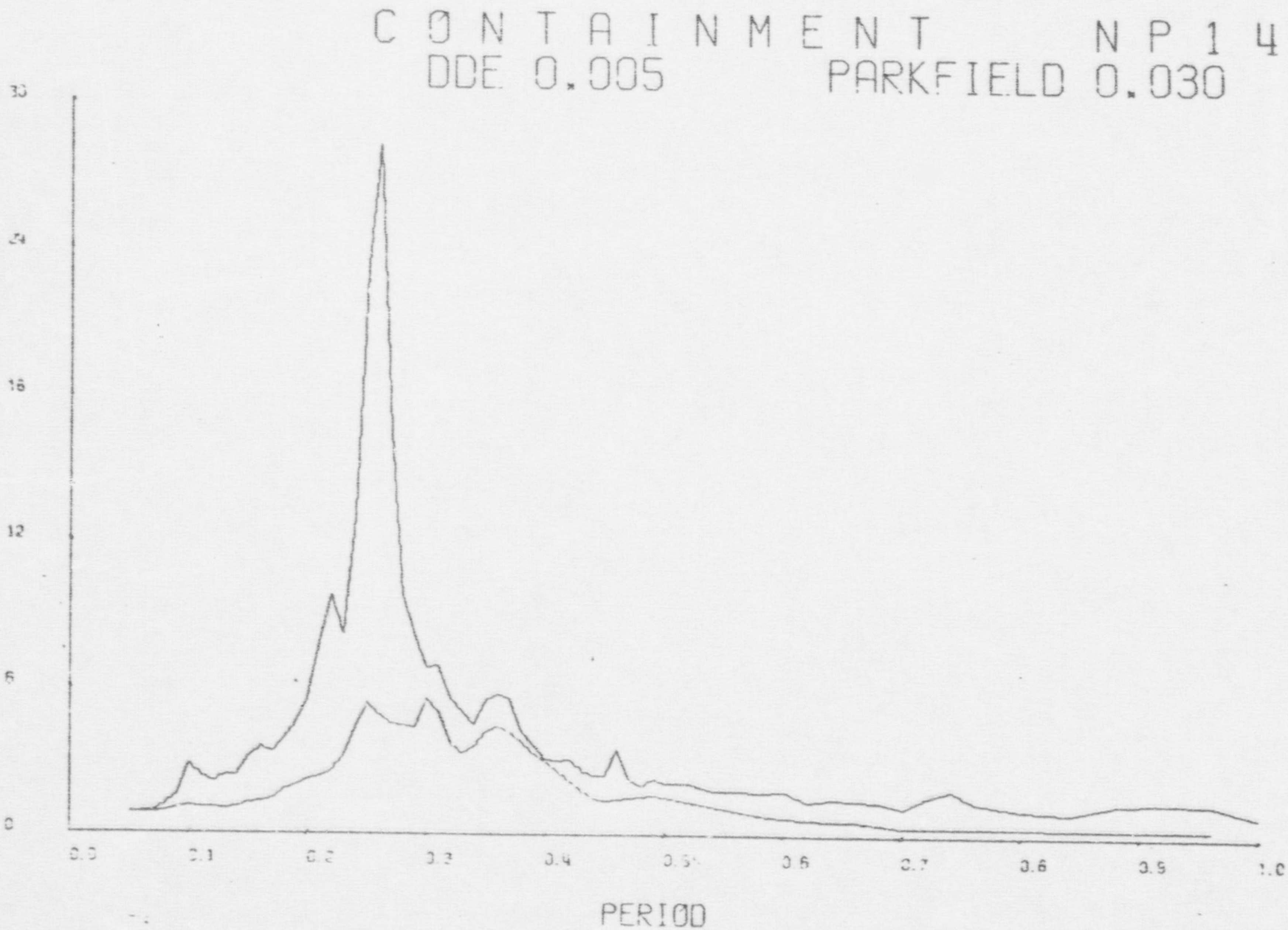


FIGURE 5

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

CONTAINMENT NP19
DDE 0.005 PARKFIELD 0.030

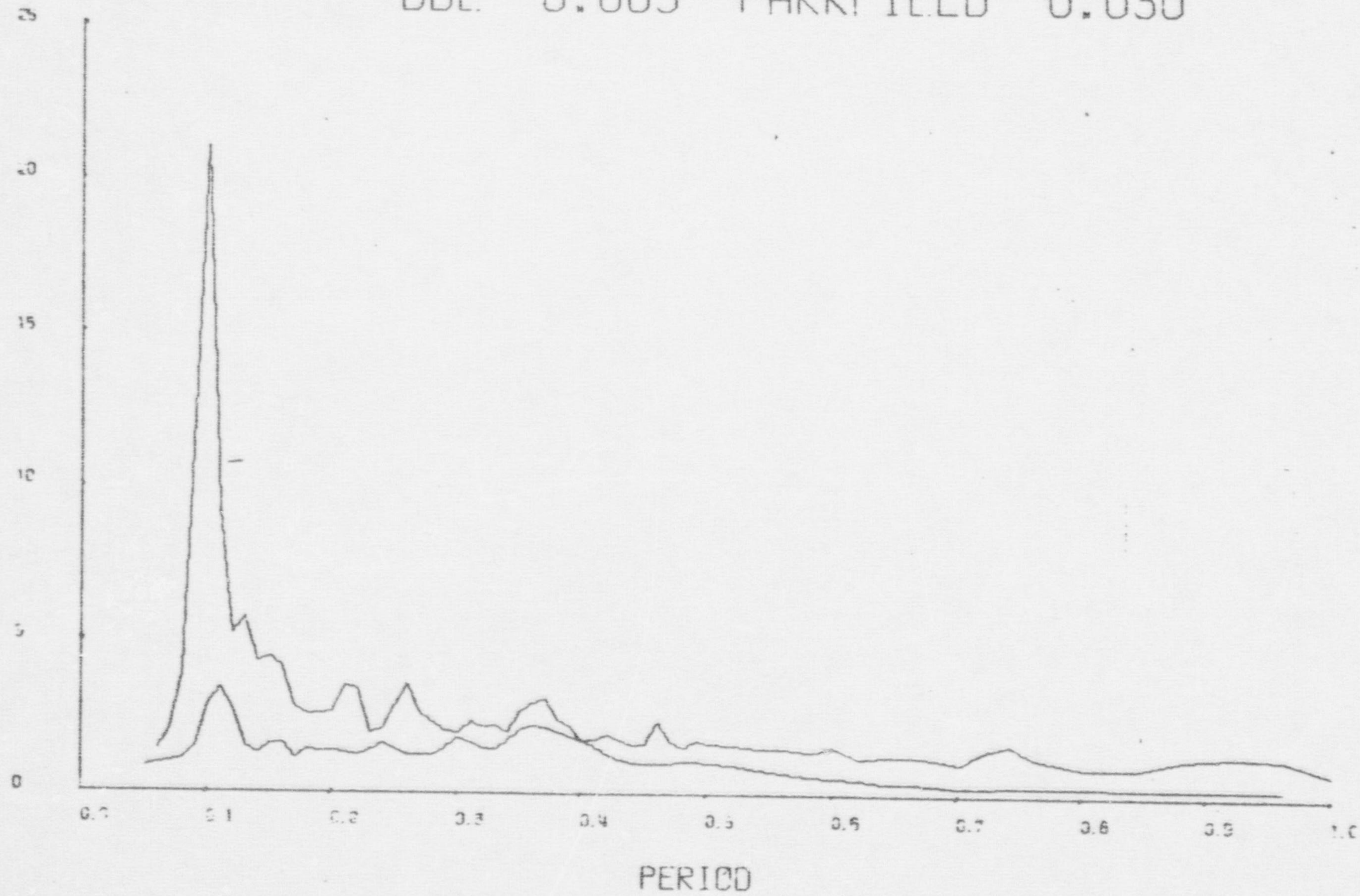


FIGURE 6

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

CONTAINMENT NP32
DDE 0.005 PARKFIELD 0.030

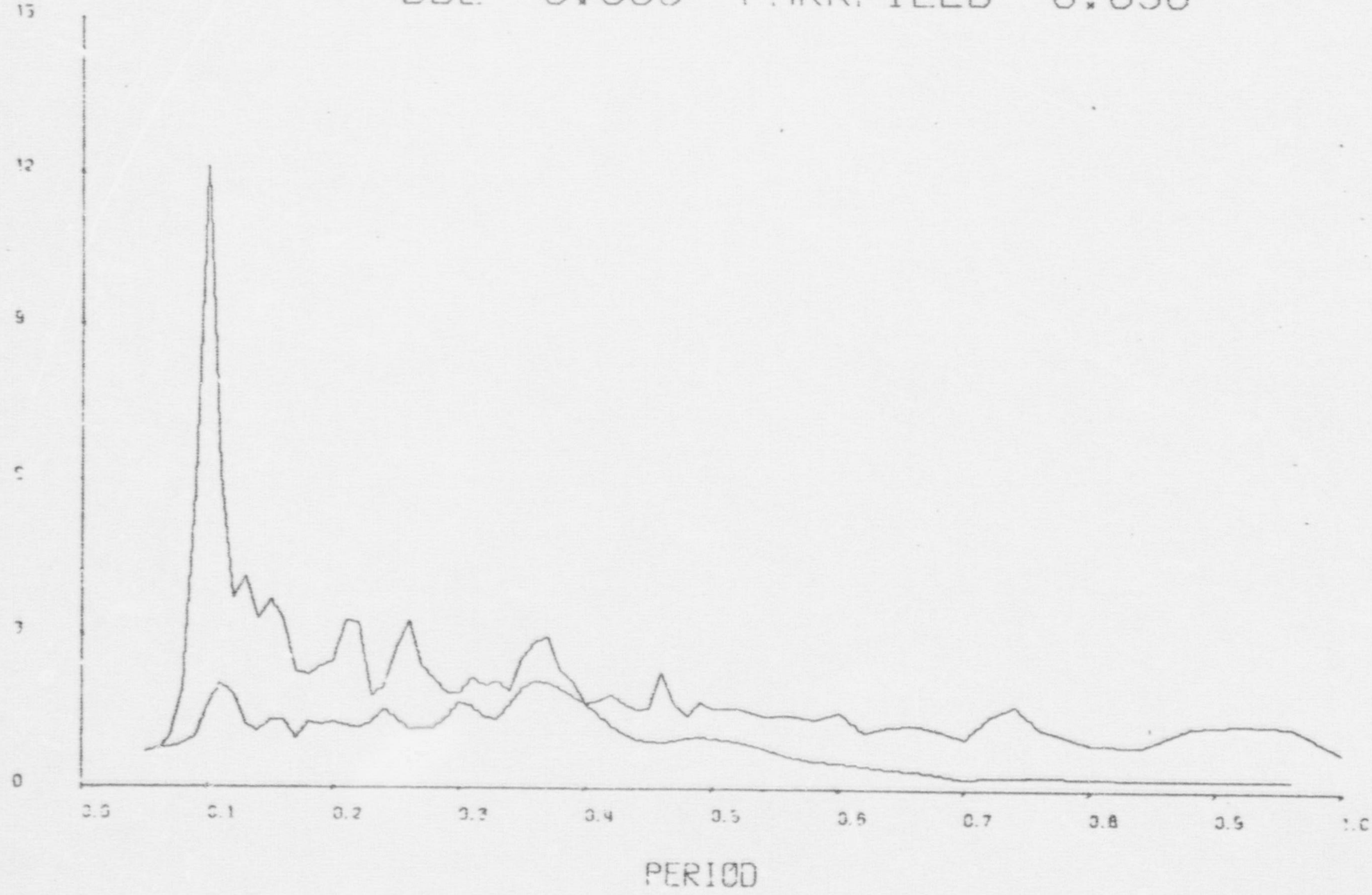


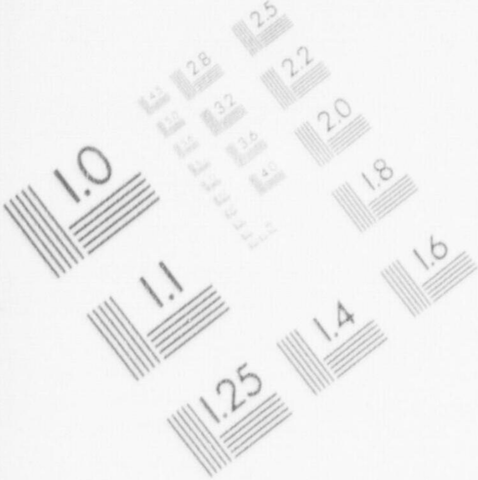
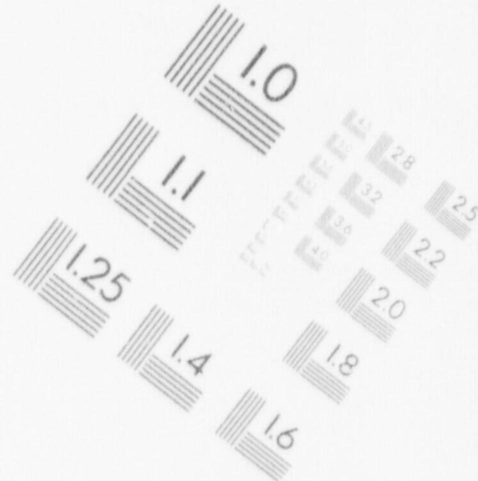
FIGURE 7

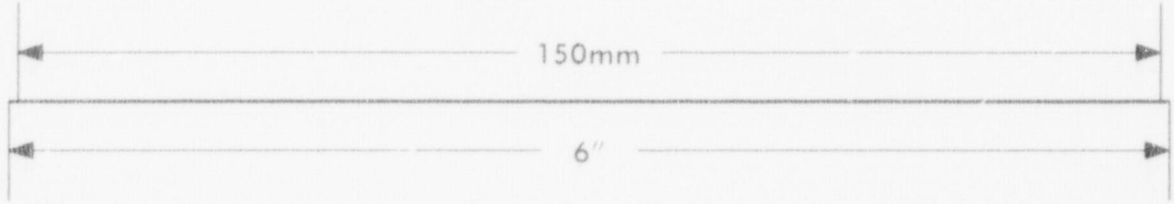
IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

IMAGE EVALUATION
TEST TARGET (MT-3)

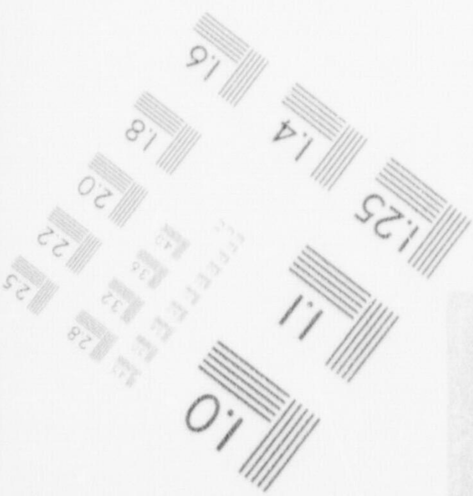
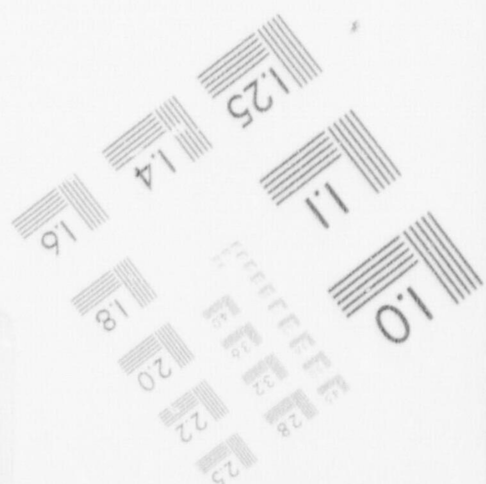
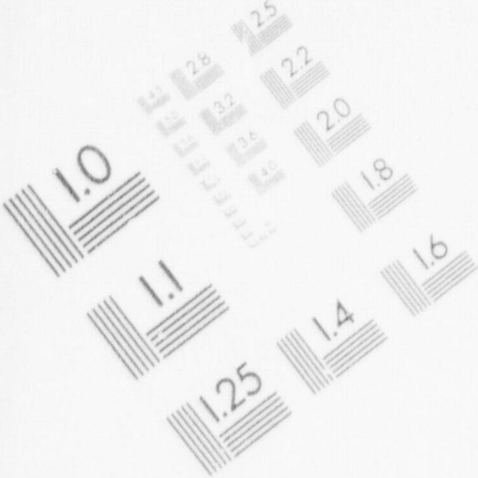
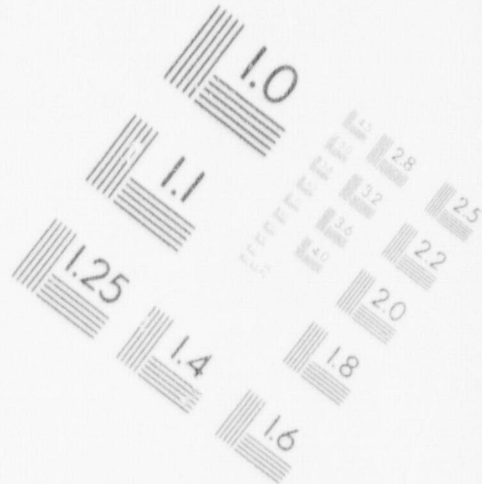
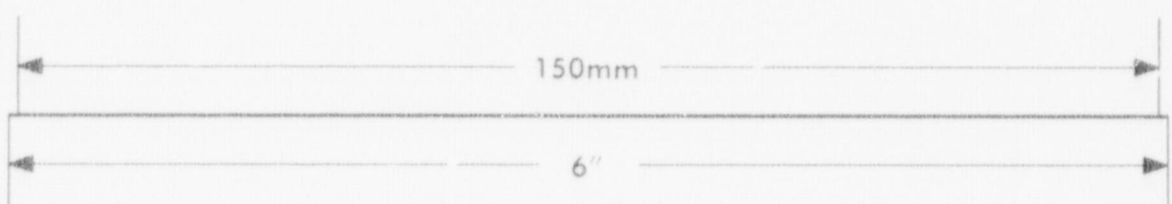



IMAGE EVALUATION
TEST TARGET (MT-3)

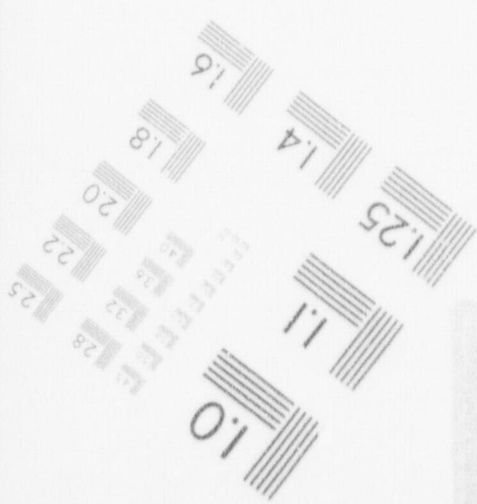
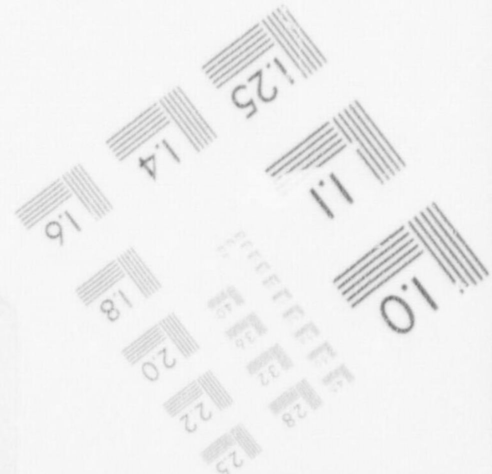



IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

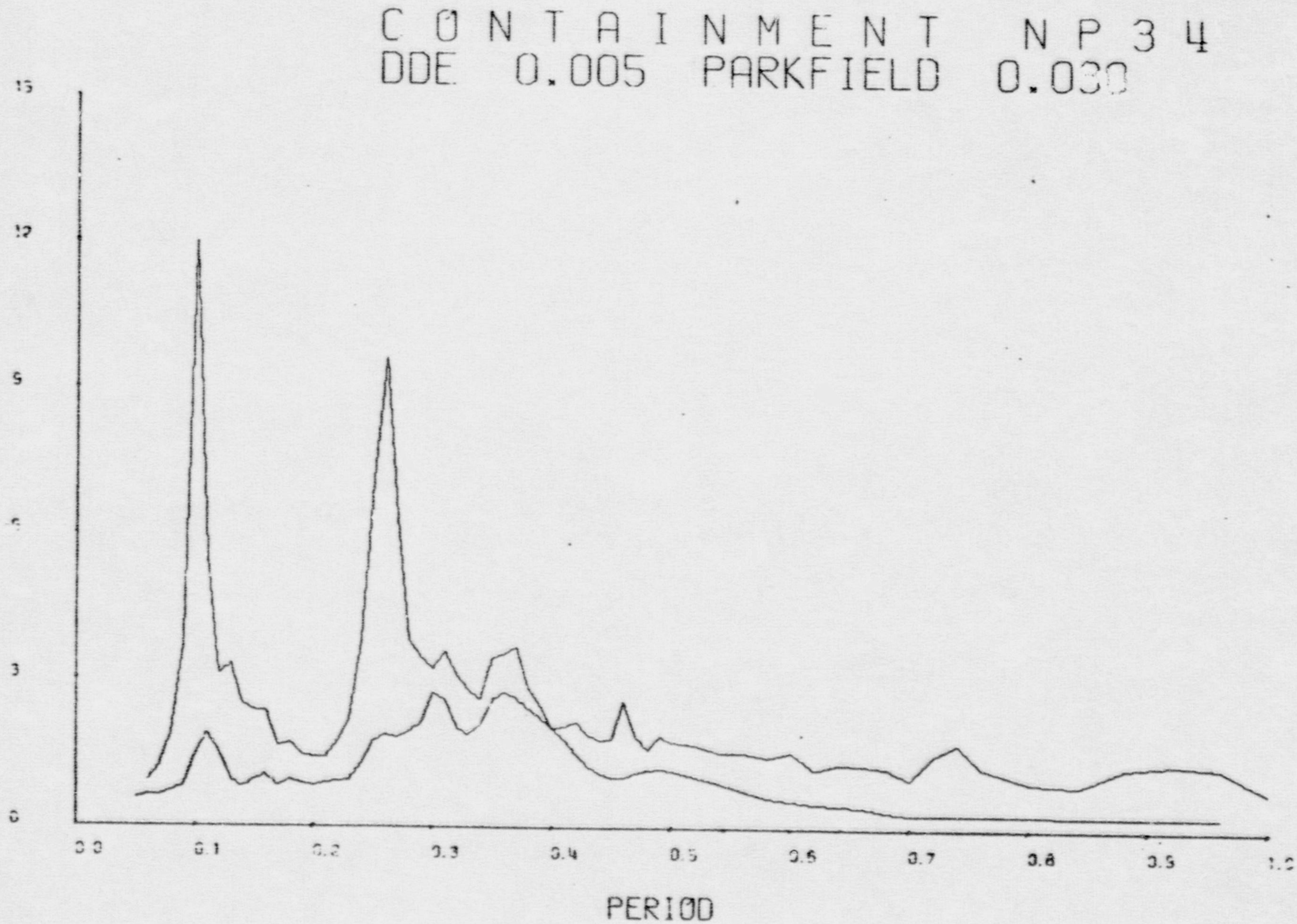
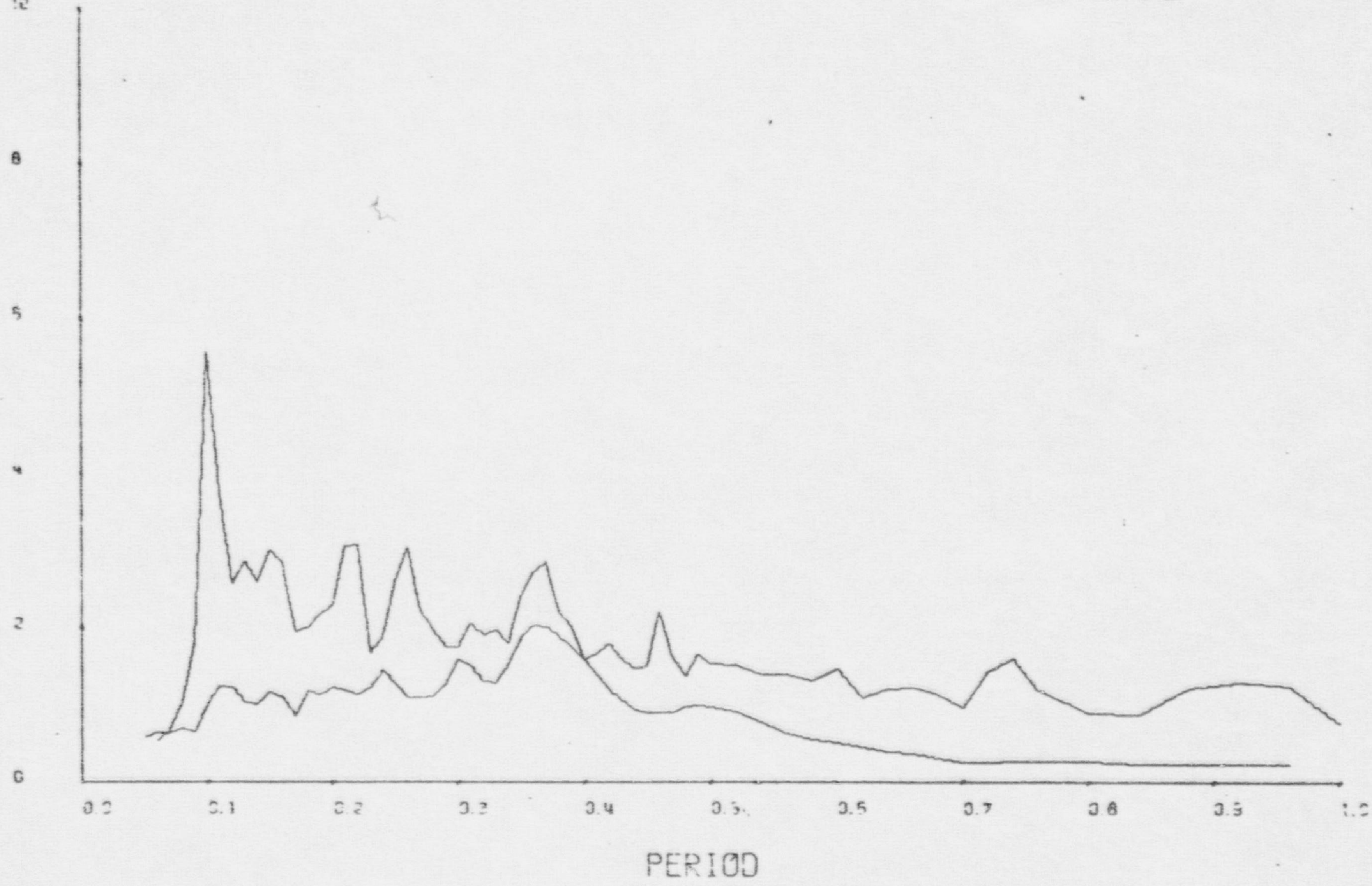


FIGURE 8

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

CONTAINMENT NP47
DDE 0.005 PARKFIELD 0.030



GURE 9

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

CONTAINMENT NP19
DDE 0.010 PARKFIELD 0.040

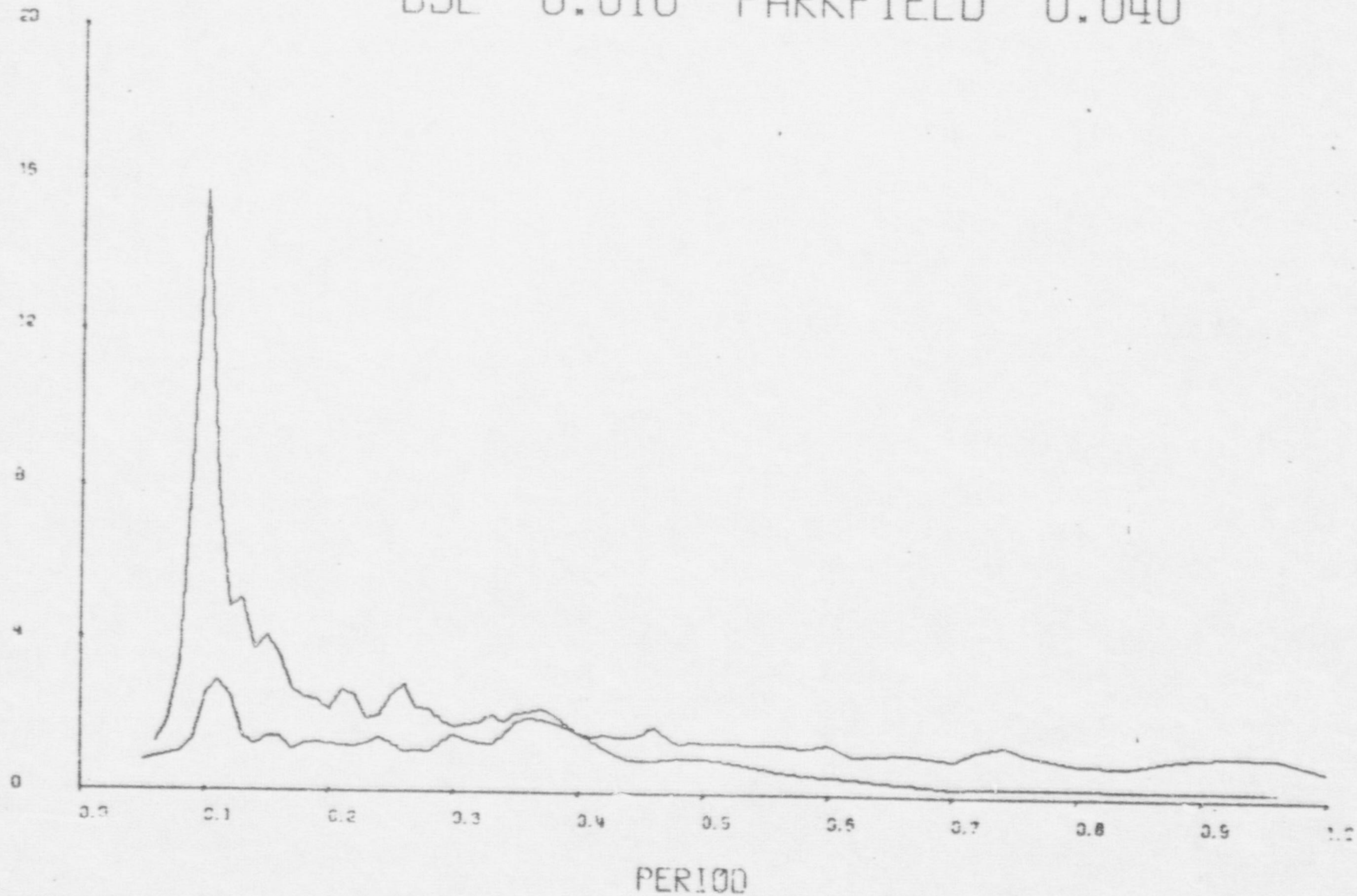


FIGURE 10

JOHN A. BLUME AND ASSOCIATES / RESEARCH DIVISION

CONTAINMENT NP47
DDE 0.010 PARKFIELD 0.040

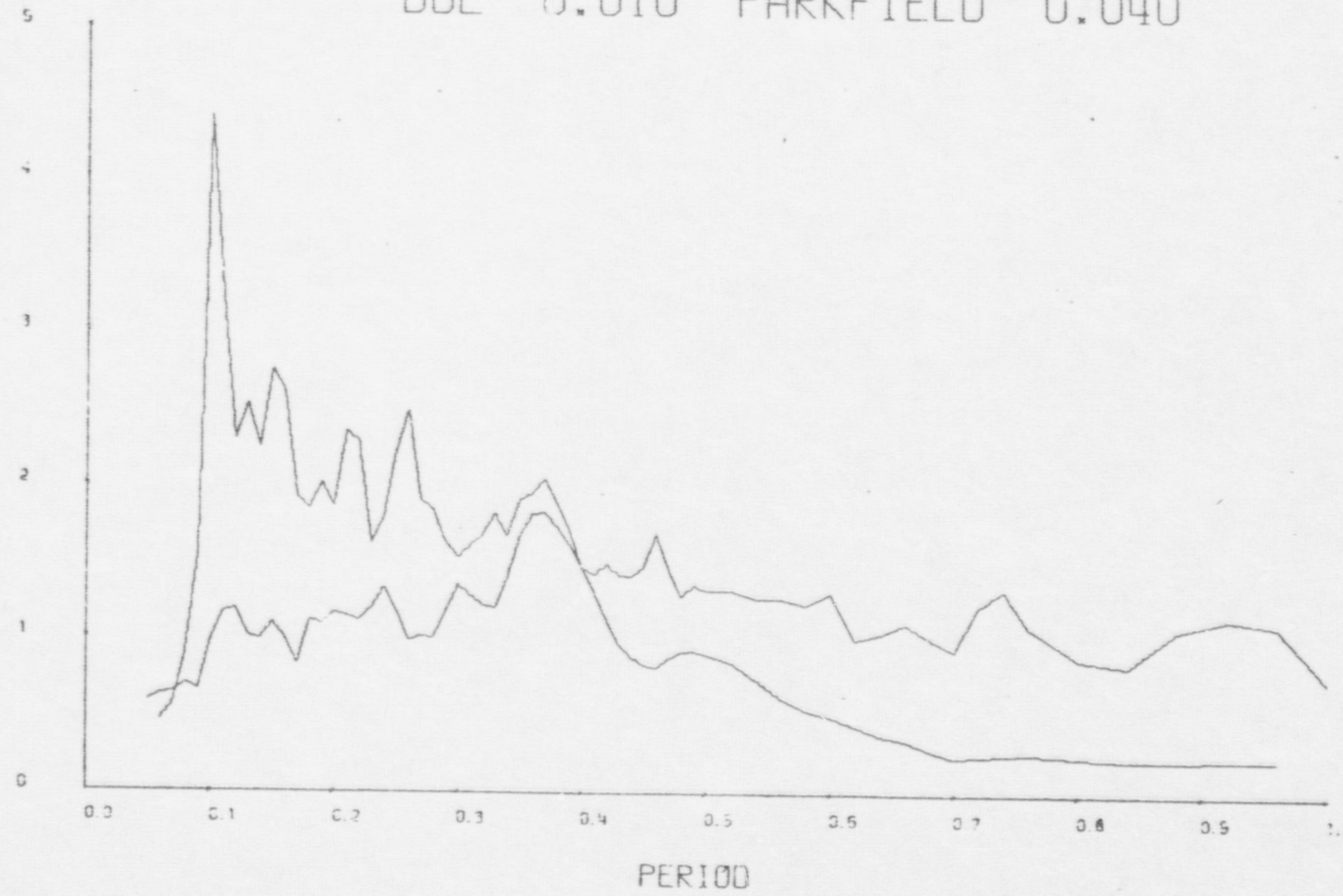


FIGURE 11

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URS
A URS Systems Affiliate

April 12, 1973

Mr. Frank Brady
Pacific Gas & Electric Company
77 Beale Street
San Francisco, California 94105

SUBJECT: Diablo Canyon Nuclear Power Plant Unit No. 1
Tanks on Compacted Engineered Fill

Dear Mr. Brady:

The purpose of this letter is to summarize data transmitted previously to PG&E regarding the seismic design criteria for the subject tanks at Diablo Canyon Unit No. 1.

The circular tank, 40 foot in diameter and 40 feet high, is founded on approximately 25 feet of compacted sandy clay fill. The fill had an average wet density of 120 pcf (ρ_1) and an assumed shear velocity of 900 fps (γs_1). The base of this fill surface slopes at an average angle to the horizontal of 20° and is underlain by the typical sandstone foundation rock present at Diablo Canyon. The sandstone has a wet density of 140 pcf (ρ_2) and a shear wave velocity of 2,000 fps (γs_2) as determined by our field investigations and summarized in JABE-PGE-DC-2R.

The dynamic amplification factor (DAF) was then calculated using the equation:

$$DAF = \left(\frac{\rho_2 \ \gamma s_2}{\rho_1 \ \gamma s_1}\right)^{1/2}$$

We determined that the representative DAF at the site will average 1.5 under the tank. Because of the sloping rock-soil interface beneath the tank, the resonant period of the compacted soil layer will fall between 0 and 1.0 seconds which we understand is below that of the tank. Therefore, soil resonance will not affect the response of the tank, and response spectra pertinent to the fill surface for the design of the tank can be obtained by multiplying the sandstone rock spectra by the factor 1.5.

Very truly yours,

URS/JOHN A. BLUME & ASSOCIATES, ENGINEERS

Fred R. Conwell

Fred R. Conwell
Chief Engineering Geologist

FRC/cj

UNITED STATES OF AM ICA
NUCLEAR REGULATORY COMMISSION

In the Matter of PACIFIC GAS AND ELECTRIC COMPANY Units 1 and 2 Diablo Canyon Site	)	Docket Nos. 50-275-OL 50-323-OL

CERTIFICATE OF SERVICE

The foregoing document(s) of Pacific Gas and Electric Company has (have) been served today on the following by deposit in the United States mail, properly stamped and addressed:

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Dated: July 18, 1975