PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

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Calc Revision: 0
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Quality related: Y
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1. **CALCULATION TITLE:** Evaluation of Shear-Wave Velocity at the DCPP ISFSI

2. **SIGNATORIES:**

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3. RECORD OF REVISIONS:

Rev. No.	Reason for Revision	Revision Date
0	Initial Calc	04/27/10

4. PURPOSE:

The recent ground motion models used for the evaluation of the Shoreline fault (PGE, 2009) use the shear-wave velocity in the top 30 m as the site parameter. This parameter is called V_{S30}. In GEO.DCPP.09.01, the V_{S30} value for the powerblock was computed using a shear-wave profile measured at the powerblock location in 1978 (PG&E, 1988). The methods for measuring shear-wave velocity have improved significantly since 1978. New measurements of the shear-wave velocity profile were made at the DCPP ISFSI site as part of the ISFSI site characterization (PG&E, 2004). Because the ISFSI is located on the same geologic unit as the powerblock, the NRC staff requested that PG&E review the recent shear-wave velocity measurements that were at the DCPP ISFSI and compare them to the VS30 values used for the ground motion evaluations.

Per Notification 50086062, Task 22, the purpose of this calculation is to estimate the VS30 values from the ISFSI shear-wave profiles and determine if these values indicate that the VS30 value used for the Shoreline fault ground motion characterization (GEO.DCPP.09.01) is still applicable or if it needs to be updated.

5. ASSUMPTIONS:

No assumptions are made.

6. INPUTS:

6.1. Shear-Wave Velocity Profiles for the ISFSI

The shear-wave velocity profile for the ISFSI borings are shown in Figure 6-1 (PG&E, 2004, Figure 2.6-33)

6.2. VS30 for the Powerblock

The VS30 for the powerblock of 1212 m/s is given in GEO.DCPP.09.01 (PG&E, 2009)

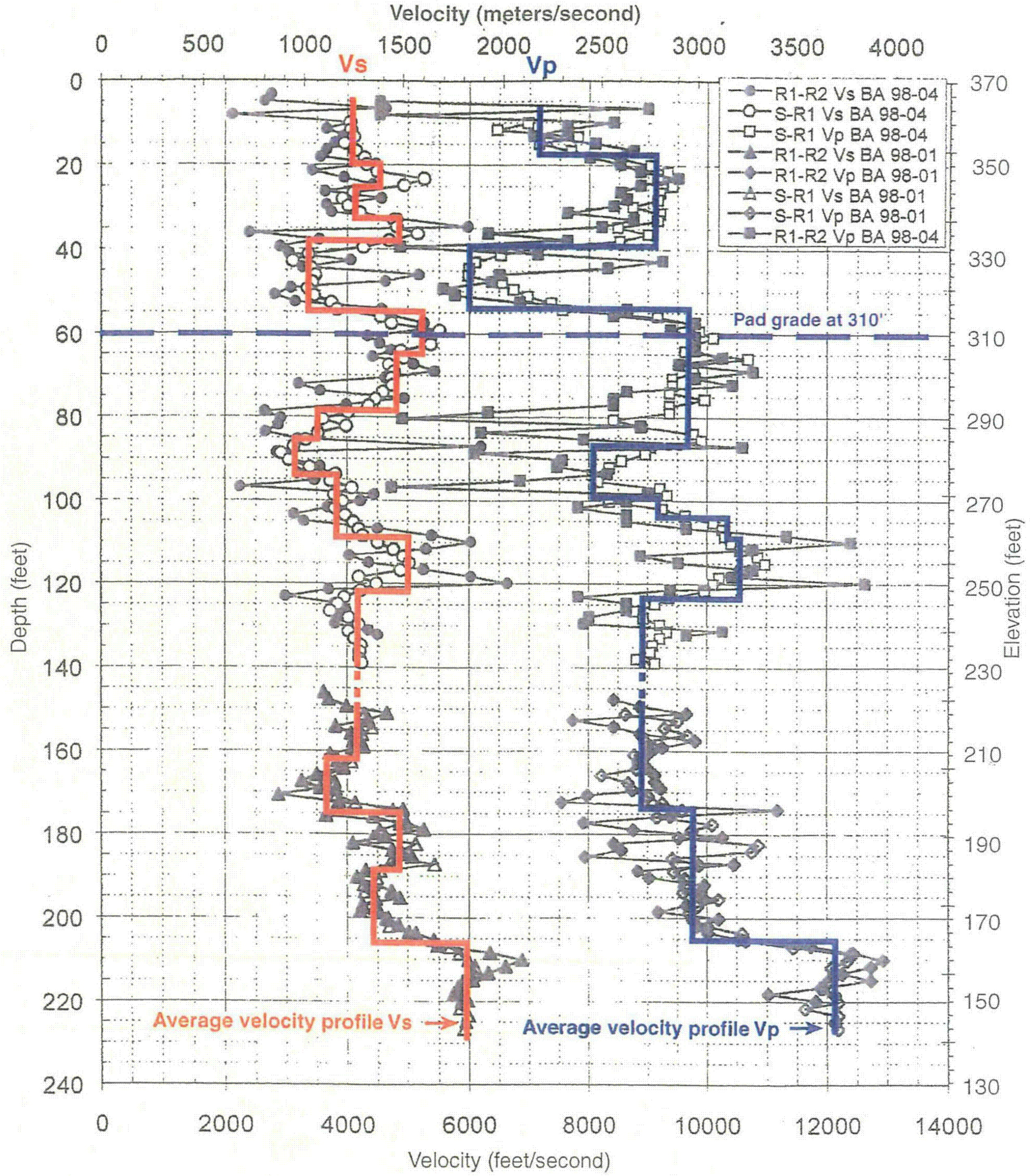
6.3. Original Elevation of the ground at powerblock

The original elevation of the ground in the powerblock area ranges from 85 ft to 200 ft (PG&E, 1988, Figure 5-3)

6.4. Elevation of the powerblock foundation

The elevation of the powerblock foundation is 52.6 ft (PG&E, 1988, Figure 5-3)

Borings 98BA-1 and 98BA-4

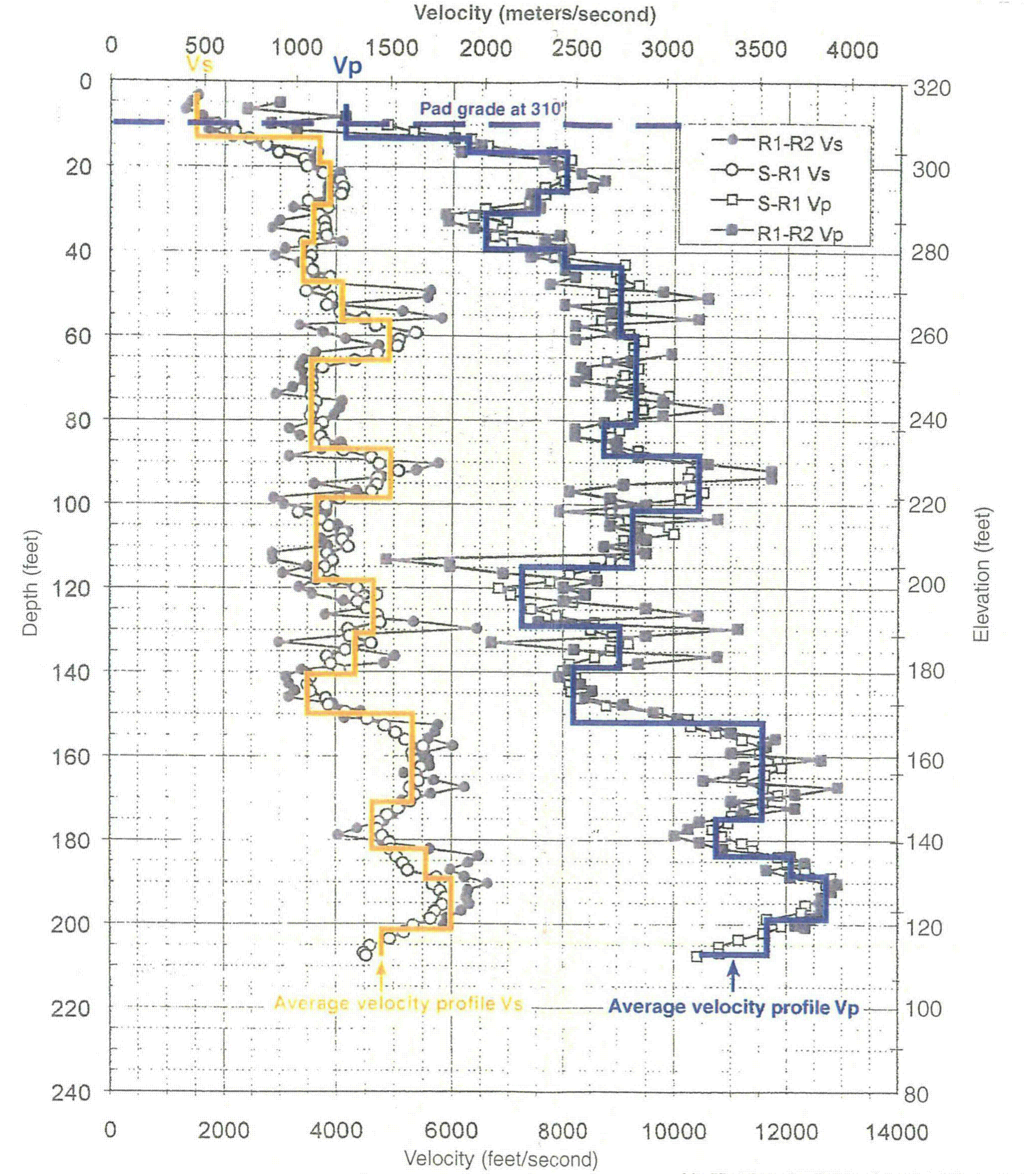


Note: Average velocity profiles interpreted from data

R1 - R2 = Receiver-to-receiver velocity (3.3-foot spacing)
S-R1 = Source-to-receiver velocity (10.3-foot spacing)

Figure 6-1. Velocity profile from ISFSI borings.

Boring 98BA-3



Modified from GEOVision (1998), in William Lettis & Assoc. Inc., 2001, DCPP ISFSI Data Report C.

SAFETY ANALYSIS REPORT
DIABLO CANYON ISFSI
FIGURE 2.6-33 ISFSI SITE SUSPENSION LOGS AND INTERPRETED AVERAGE SEISMIC VELOCITIES

7. METHOD AND EQUATION SUMMARY:

7.1 METHODOLOGY:

The VS30 is traditionally based on the shear-wave velocity profile in the top 30 m. For the application of the powerblock, we need to use the shear-wave velocity in the 30 m below the foundation. Therefore, the VS30 from the ISFSI is computed from the embedment depth of the powerblock to a depth of 30 below the embedment depth.

7.2 EQUATIONS:

7.2.1. VS30

The VS30 is defined by equations 1 and 2 in Boore (2004):

$$\overline{Vs}(30) = 30 / tt(30) \qquad (7\text{-}1)$$

Where tt is the travel time over 30 m and is given by

$$tt(30) = \int_0^{30} \frac{dz}{Vs(z)} \qquad (7\text{-}2)$$

7.2.2. Conversion of feet to meters

$$1ft = 12in \frac{2.54cm}{in} \frac{m}{100cm} = 0.305m \qquad (7\text{-}3)$$

This is a well known relation.

7. SOFTWARE:

No specialized software was used. All calculations were made by hand using an Excel spreadsheet.

8. BODY OF CALCULATION:

8.1 Digitization of the velocity profiles

The velocity profiles for the ISFSI, shown in Figures 6-1 and 6-1, were digitized. The digitized values are listed in Table 8.1 for borings 98BA-1 and 98BA-4. Table 8-2 shows the digitized values for boring 98BA-3.

Table 8-1. Digitized shear-wave velocity profile for ISFSI borings 98BA-1 and 98BA-4.

Top (m)	Bottom (m)	VS (m/s)
0.0	5.3	1242
5.3	7.2	1381
7.2	9.3	1251
9.3	10.9	1474
10.9	16.1	1019
16.1	19.3	1592
19.3	23.3	1465
23.3	25.5	1069
25.5	28.3	947
28.3	32.7	1166
32.7	36.8	1524
36.8	49.1	1272

Table 8-2. Digitized shear-wave velocity profile for ISFSI boring 98BA-3.

Top (m)	Bottom (m)	VS (m/s)
0.0	3.9	464
3.9	5.8	1130
5.8	8.8	1179
8.8	11.6	1090
11.6	14.3	1042
14.3	17.2	1251
17.2	20.0	1502
20.0	26.4	1090
26.4	30.0	1514
30.0	35.9	1110
35.9	39.7	1421
39.7	42.6	1328

At the powerblock, the original surface elevation was between 85 ft and 200 ft (input 6-3). The foundation elevation is 52.6 ft (input 6-4). The lower range of the original elevation of 85 ft is selected as a minimum elevation. The difference between these two elevations gives the embedment depth.

Embedment depth = 85 ft - 52.6 ft = 32.4 ft

The depth in ft is converted to depth in m using equation 7-3.

Embedment depth = 32.4ft * 0.305 m/ft = 9.88 m

This embedment depth is rounded to 10 m.

Tables 8-3 and 8-4 shown the VS profiles at the ISFSI from 10 m depth to 40 m depth.

The VS30 is computed using equations 7-1 and 7-2. Combining these two equations and converting the integral to discrete layers leads to:

$$V_{S30} = \frac{30m}{\sum_{i=1}^{N_{30}} \frac{H_i}{V_{Si}}} \qquad (8\text{-}1)$$

Where H is the thickness of the layer. For borings 98BA-1&4, the values of H_i and $\frac{H_i}{V_{Si}}$ are listed in Table 8-3. The summation of the travel times is listed in the bottom of the table. Using the values from Table 8-3 and eq. 8.1, the V_{S30} is given by

$$V_{S30} = \frac{30m}{0.02443\,\text{sec}} = 1228 m/s$$

For boring 98BA-3, the values of H_i and $\frac{H_i}{V_{Si}}$ are listed in Table 8-4. The summation of the travel times is listed in the bottom of the table. Using the values from Table 8-4 and eq. 8.1, the V_{S30} is given by

$$V_{S30} = \frac{30m}{0.02470\,\text{sec}} = 1215 m/s$$

Table 8-3. VS profile for ISFSI boring 98-1 & 98-4 from a depth of 10 to 40 m.

Top (m)	Bottom (m)	H (m)	VS (m/s)	Travel Time (sec)
10.0	10.9	0.9	1474	0.00060
10.9	16.1	5.3	1019	0.00513
16.1	19.3	3.2	1592	0.00199
19.3	23.3	4.0	1465	0.00276
23.3	25.5	2.2	1069	0.00204
25.5	28.3	2.8	947	0.00295
28.3	32.7	4.4	1166	0.00373
32.7	36.8	4.1	1524	0.00273
36.8	40.0	3.2	1272	0.00250
			Sum:	0.02443

Table 8-4. VS profile for ISFSI boring 98-3 from a depth of 10 to 40 m.

Top (m)	Bottom (m)	H (m)	VS (m/s)	Travel Time (sec)
10.0	11.6	1.6	1090	0.00149
11.6	14.3	2.7	1042	0.00259
14.3	17.2	2.9	1251	0.00229
17.2	20.0	2.8	1502	0.00187
20.0	26.4	6.4	1090	0.00585
26.4	30.0	3.6	1514	0.00239
30.0	35.9	5.9	1110	0.00535
35.9	39.7	3.8	1421	0.00266
39.7	40.0	0.3	1328	0.00021
			Sum:	0.02470

9. RESULTS AND CONCLUSIONS

RESULTS

The computed VS30 values from the ISFSI site are compared to the VS30 value for the powerblock in Table 9-1. The VS30 values from the ISFSI are within 2% of the V_{S30} values previously estimated for the powerblock.

Table 9-1. Computed V_{S30} values (for 10 m embedment) for the powerblock and the ISFSI borehole sites.

	V_{S30} (m/s) for 10 m Embedment (applicable to the powerblock)
Powerblock	1212
ISFSI 98BA-1&4	1228
ISFSI 98BA-3	1215

CONCLUSIONS

Previous studies have shown that there is significant variability of VS30 for sites within a given geologic unit. The coefficient of variation for Tertiary rock geologic units (e.g. Tss) is about 40% (Chiou et al. 2008,. Table 2). The range of the VS30 values for the ISFSI sites and the powerblock shown in Table 9-1 are well within this 40% range.

We conclude that the VS30 values measured from the ISFSI boreholes using modern methods are consistent with the VS30 values from the earlier surveys at the powerblock. The V_{S30} of 1210 m/s used in the Shoreline Fault ground motion calculations (GEO.DCPP.09.01) is an appropriate value for characterizing the VS30 at the powerblock.

10. LIMITATIONS

The digitization of the ISFSI profiles has a limited accuracy of a few percent. This limits the accuracy of the computed VS30 values to a few percent.

11. IMPACT EVALUATION

This calculation shows that the previously used V_{S30} values for the powerblock are still valid. Therefore, there is no impact of the results of this calculation.

12. REFERENCES

Boore, D. M (2004). Estimating Vs(30) (or NEHRP Site Classes) from Shallow Velocity Models (Depths < 30 m, Bulletin of the Seismological Society of America, Apr 2004; 94: 591 - 597.

Chiou, B., R. Darragh, N. Gregor, and W. Silva (2008). NGA project strong motion data base, Earthquake Spectra, 24:23-44.

PG&E (2009). Comparison of the response spectra for the Shoreline and Hosgri faults with the ISFSI Long Period (ILP) Response Spectrum", Geosciences Calculations GEO.DCPP.09.01.

PG&E (2004).Diablo Canyon ISFSI Safety Analysis Report. Nuclear Regulatory Commission Docket No. 72-26

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