MM_Mod1_trans.out

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.0.0.8 - Last Revision Date: 07/27/2001
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*******************************************************************
UTEXAS4 S/N:00107  - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Wed Mar 12 17:17:35 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM
Utexas4\MM_Mod1_trans.dat

      SECTION M-M'
      MODEL 1
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

-----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
-----------------------------------------------------------
Description: Tofb-2 Obispo Formation

Point        X           Y

   1        0.00       139.00
   2       36.00       142.00

   3       69.00       146.00
   4       88.00       152.00
   5       95.00       153.00
   6      100.00       152.00
   7      114.00       146.00
   8      119.00       145.00
   9      124.00       147.00
  10      128.00       150.00
  11      137.00       174.00
  12      142.00       181.00
```

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Wed Mar 12 17:17:35 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod1_trans.dat

SECTION M-M': MODEL 1: With Transporter: Short Term Static Stability

TABLE NO. 41
****
* Critical Noncircular Shear Surface *
****

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****

X:	168.25	Y:	221.82
X:	168.93	Y:	221.50
X:	173.24	Y:	220.06
X:	190.14	Y:	216.12
X:	201.00	Y:	215.03
X:	231.00	Y:	216.04
X:	252.00	Y:	217.06
X:	275.00	Y:	219.10
X:	300.01	Y:	222.07
X:	320.20	Y:	225.21
X:	366.00	Y:	283.00

Minimum factor of safety: 2.35
Side force inclination: 13.61

Time required to find most critical surface: 18.0 seconds
Number of passes required to find most critical surface: 36
Total number of shear surfaces attempted: 756
Total number of shear surfaces for which the factor of safety was successfully calculated: 756

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	2.0000	4	2.000	2.5513	21	21
2	1.0000	10	1.000	2.4668	42	42
3	1.0000	3	1.000	2.4597	63	63
4	1.0000	4	1.000	2.4541	84	84
5	1.0000	4	1.000	2.4526	105	105
6	1.0000	4	1.000	2.4451	126	126
7	1.0000	3	1.000	2.4432	147	147
8	1.0000	3	1.000	2.4370	168	168
9	1.0000	2	1.000	2.4295	189	189
10	1.0000	1	1.000	2.4258	210	210
11	1.0000	1	1.000	2.4221	231	231
12	1.0000	1	1.000	2.4187	252	252
13	1.0000	2	1.000	2.4147	273	273
14	1.0000	1	1.000	2.4095	294	294
15	1.0000	1	1.000	2.4065	315	315
16	1.0000	2	1.000	2.4015	336	336

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Time and date of run: Wed Mar 12 17:17:35 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod1_trans.dat

SECTION M-M': MODEL 1: With Transporter: Seismic Coefficient = 0.33g

TABLE NO. 58

```
**************************************************************************
* Final Results for Stresses Along the Shear Surface                     *
* (Results are for the critical shear surface in the case of a search.) *
**************************************************************************
```

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 1.005   Side Force Inclination: 32.22

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	168.59	221.66	2365.8	2365.8	1491.9
2	168.97	221.49	1880.4	1880.4	1491.9
3	170.50	220.98	1975.1	1975.1	1491.9
4	172.62	220.27	2105.8	2105.8	1491.9
5	173.62	219.97	1825.0	1825.0	1491.9
6	176.64	219.27	2084.9	2084.9	1491.9
7	180.64	218.33	3961.2	3961.2	2983.8
8	182.50	217.90	4120.7	4120.7	2983.8
9	184.79	217.37	4282.2	4282.2	2983.8
10	188.35	216.54	4534.4	4534.4	2983.8
11	192.85	215.85	3961.0	3961.0	2983.8
12	198.29	215.30	4240.3	4240.3	2983.8
13	201.03	215.03	3627.1	3627.1	2983.8
14	202.03	215.06	2750.5	2750.5	1422.7
15	205.50	215.18	2953.6	2953.6	1527.7
16	210.50	215.35	3216.6	3216.6	1609.4
17	215.50	215.52	3475.8	3475.8	1684.6
18	221.00	215.70	3793.2	3793.2	1776.6
19	227.00	215.91	4168.6	4168.6	1885.5
20	230.50	216.02	4391.5	4391.5	1950.1
21	231.50	216.06	4381.1	4381.1	1960.7
22	234.50	216.21	4567.6	4567.6	2015.2
23	238.00	216.38	4762.7	4762.7	2072.3
24	241.25	216.54	4880.2	4880.2	2106.7
25	245.75	216.76	5043.0	5043.0	2154.3
26	248.50	216.89	5138.1	5138.1	2182.2
27	250.50	216.99	5209.3	5209.3	2203.0

MM_Mod1.dat

```
GRAphics output
HEAding follows -
      SECTION M-M'
      MODEL 1
      STATIC STABILITY AND YIELD ACCELERATION
      WITHOUT TRANSPORTER MASS

PROfile line data follow -
      1 1 Tofb-2 Obispo Formation
            0.0 139.0
            36.0 142.0
            69.0 146.0
            88.0 152.0
            95.0 153.0
            100.0 152.0
            114.0 146.0
            119.0 145.0
            124.0 147.0
            128.0 150.0
            137.0 174.0
            142.0 181.0
            201.0 215.0
            231.0 216.0
            252.0 217.0
            275.0 219.0
            300.0 222.0
            327.0 225.0
            352.0 228.0
            380.0 231.0
            410.0 235.0
            473.0 244.0

      2 2 Clay Bed
            201.0 215.0
            203.0 216.0
            231.0 217.0
            252.0 218.0
            275.0 220.0
            300.0 223.0
            327.0 226.0
            352.0 229.0
            380.0 232.0
            410.0 236.0
            473.0 245.0
            473.0 244.0

      3 1 Tofb-2 Obispo Formation
            203.0 216.0
            231.0 232.0
            263.0 233.0
            284.0 234.5
            306.0 237.0
            331.0 240.0
```

```
        359.0 244.0
        407.0 250.0

4 2 Clay Bed
        231.0 232.0
        232.0 232.5
        263.0 233.5
        284.0 235.0
        306.0 237.5
        331.0 240.5
        359.0 244.5
        407.0 250.5
        407.0 250.0

5 1 Tofb-2 Obispo Formation
        232.0 232.5
        248.0 239.0
        264.0 239.5
        289.0 241.5
        311.0 244.0
        335.0 247.0
        358.0 250.0
        405.0 256.0

6 2 Clay Bed
        248.0 239.0
        249.0 239.5
        264.0 240.0
        289.0 242.0
        311.0 244.5
        335.0 247.5
        358.0 250.5
        405.0 256.5
        405.0 256.0

7 1 Tofb-2 Obispo Formation
        249.0 239.5
        262.0 246.0
        284.0 262.0
        311.0 266.0
        341.0 270.0
        368.0 273.0
        410.0 279.0
        472.0 288.0

8 2 Clay Bed
        284.0 262.0
        285.5 263.0
        311.0 267.0
        341.0 271.0
        368.0 274.0
        410.0 280.0
        472.0 289.0
        472.0 288.0
```

9 1 Tofb-2 Obispo Formation

285.5 263.0
305.0 275.0
311.0 279.0
316.0 280.0
343.0 282.0
357.0 282.0
368.6 282.0
376.0 286.0
382.0 293.0
388.0 296.0
410.0 301.0
415.0 303.0
439.0 308.0
457.0 312.0
478.0 316.0
500.0 319.0
538.0 325.0
572.0 330.0
600.0 333.0

10 3 Qpf Pleistocene Colluvium

0.0 170.0
13.0 175.0
37.0 182.0
54.0 185.0
70.0 187.0
94.0 193.0
100.0 195.0
113.0 199.0
132.0 205.0
172.0 216.0
183.0 220.0
208.0 234.0
239.0 248.0
287.0 268.0
303.0 278.0
309.0 282.0
313.0 283.0
343.0 282.0

11 4 Qc Quaternary Colluvium

0.0 179.0
7.0 182.0
20.0 185.0
42.0 188.0
68.0 195.0
90.0 200.0
100.0 203.0
108.0 206.0
125.0 211.0
141.0 215.0
148.0 217.0
169.0 222.0

174.0 223.0

```
                182.0 228.0
                203.0 237.0
                218.0 243.0
                230.0 249.0
                237.0 253.0
                253.0 258.0
                273.0 266.0
                285.0 271.0
                298.0 279.0
                306.0 283.0
                312.0 285.5
                314.0 286.0
                317.0 285.0
                320.0 283.0
                323.0 286.0
                363.0 286.0
                366.0 283.0
                369.0 285.0
                377.0 290.0
                382.0 293.0


MATerial property data follow (for first stage) -
      1 Tofb-2 Obispo Formation
            140 = total unit weight
            Conventional shear strength
                  0.0 50.0
            No Pore Pressure
      2 clay Bed
            115 = total unit weight
            Nonlinear strength envelope
                  -100000.0 0.0
                  0.0 0.0
                  2793.7 1548.5
                  100000.0 27594.9

            No pore pressure
      3 Qpf Pleistocene colluvium
            115 = total unit weight
            Conventional shear strength
                  3000.0 0.0
            No pore pressure
      4 Qc Quaternary Colluvium
            115 = total unit weight
            Conventional shear strength
                  1500.0 0.0
            No pore pressure

SECond stage input activated
MATerial property data follow (for second stage) -
      1 Tofb-2 Obispo Formation
            140 = total unoit weight
            Conventional shear strength


                  0.0 50.0
            No pore pressure
```

```
        2 Clay Bed
              115 = total unit weight
              2-stage nonlinear strength envelope
                    -100000.0 0.0 0.0
                    0.0 0.0 0.0
                    2793.7 1548.5 1548.5
                    100000.0 27594.9 27594.9

              No pore pressure
        3 Qpf Pleistocene colluvium
              115 = total unit weight
              conventional shear strength
                    3000.0 0.0
              No pore pressure
        4 Qc Quaternary Colluvium
              115 = total unit weight
              Conventional shear strength
                    1500.0 0.0
              No pore pressure

HEAding follows -
SECTION M-M': MODEL 1: Without Transporter: Short Term Static Stability

ANAlysis/computation data follow -
        Noncircular Search
              148.0 217.0
              168.0 216.0
              172.0 216.0
              190.0 215.0
              201.0 215.0
              231.0 216.1
              252.0 217.1
              275.0 219.1
              300.0 222.1
              317.0 225.5
              366.0 283.0 fixed

              2.0 0.1
ITErations
        1000

COMpute
HEAding follows -

SECTION M-M': MODEL 1: Without Transporter: Seismic Coefficient = 0.35g

ANAlysis/computation data follow -
        Non-circular
              167.46 221.63
              169.06 220.84
              172.84 219.51
              190.08 215.75


              201.00 215.04
              231.00 216.00
              252.01 217.03
```

```
                275.01 219.04
                300.01 222.03
                317.43 224.88
                366.00 283.00

TWO stage computations
SEIsmic coefficient
0.35

COMpute
```

MM_Mod1.out

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.0.0.8 - Last Revision Date: 07/27/2001
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Name of input data file: I:\Project\6000s\6427.006\stability\MM
Utexas4\MM_Mod1.dat

      SECTION M-M'
      MODEL 1
      STATIC STABILITY AND YIELD ACCELERATION
      WITHOUT TRANSPORTER MASS

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

---------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
---------------------------------------------------------
Description: Tofb-2 Obispo Formation

Point        X          Y

   1        0.00      139.00
   2       36.00      142.00
   3       69.00      146.00
   4       88.00      152.00
   5       95.00      153.00
   6      100.00      152.00
   7      114.00      146.00
   8      119.00      145.00
   9      124.00      147.00
  10      128.00      150.00
  11      137.00      174.00
  12      142.00      181.00
  13      201.00      215.00
```

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
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Time and date of run: Wed Mar 12 18:04:50 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod1.dat

SECTION M-M': MODEL 1: Without Transporter: Short Term Static Stability

TABLE NO. 41
****
* Critical Noncircular Shear Surface *
****

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****

X:	167.46	Y:	221.63
X:	169.06	Y:	220.84
X:	172.84	Y:	219.51
X:	190.08	Y:	215.75
X:	201.00	Y:	215.04
X:	231.00	Y:	216.00
X:	252.01	Y:	217.03
X:	275.01	Y:	219.04
X:	300.01	Y:	222.03
X:	317.43	Y:	224.88
X:	366.00	Y:	283.00

Minimum factor of safety: 2.48
Side force inclination: 12.97

Time required to find most critical surface: 17.0 seconds
Number of passes required to find most critical surface: 33
Total number of shear surfaces attempted: 693
Total number of shear surfaces for which the factor of safety was successfully calculated: 692

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	2.0000	4	2.000	2.7419	21	20
2	1.0000	10	1.000	2.6032	42	41
3	1.0000	4	1.000	2.5932	63	62
4	1.0000	4	1.000	2.5915	84	83
5	1.0000	1	1.000	2.5854	105	104
6	1.0000	1	1.000	2.5814	126	125
7	1.0000	1	1.000	2.5768	147	146
8	1.0000	1	1.000	2.5720	168	167
9	1.0000	1	1.000	2.5673	189	188
10	1.0000	1	1.000	2.5630	210	209
11	1.0000	1	1.000	2.5588	231	230
12	1.0000	1	1.000	2.5550	252	251
13	1.0000	1	1.000	2.5517	273	272
14	1.0000	1	1.000	2.5492	294	293
15	1.0000	1	1.000	2.5451	315	314
16	1.0000	1	1.000	2.5407	336	335

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
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Time and date of run: Wed Mar 12 18:04:50 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod1.dat

SECTION M-M': MODEL 1: Without Transporter: Seismic Coefficient = 0.35g

TABLE NO. 58

```
***************************************************************************
* Final Results for Stresses Along the Shear Surface                      *
* (Results are for the critical shear surface in the case of a search.)   *
***************************************************************************
```

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 0.997   Side Force Inclination: 32.13

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	168.23	221.25	2520.7	2520.7	1504.9
2	169.03	220.85	2596.9	2596.9	1504.9
3	170.53	220.32	2121.5	2121.5	1504.9
4	172.42	219.66	2241.6	2241.6	1504.9
5	173.42	219.38	1839.5	1839.5	1504.9
6	176.17	218.78	2055.2	2055.2	1504.9
7	180.17	217.91	3881.4	3881.4	3009.8
8	182.50	217.40	4075.0	4075.0	3009.8
9	184.77	216.91	4227.6	4227.6	3009.8
10	188.31	216.14	4465.6	4465.6	3009.8
11	192.81	215.57	3770.7	3770.7	3009.8
12	198.27	215.22	4022.8	4022.8	3009.8
13	201.04	215.04	3616.3	3616.3	3009.8
14	202.04	215.07	2727.3	2727.3	1428.7
15	205.50	215.18	2928.9	2928.9	1534.3
16	210.50	215.34	3192.2	3192.2	1620.4
17	215.50	215.50	3449.7	3449.7	1696.4
18	221.00	215.68	3764.7	3764.7	1789.3
19	227.00	215.87	4137.4	4137.4	1899.3
20	230.50	215.98	4358.6	4358.6	1964.5
21	231.50	216.02	4337.7	4337.7	1974.6
22	234.50	216.17	4521.7	4521.7	2029.5
23	238.00	216.34	4714.2	4714.2	2086.9
24	241.25	216.50	4830.2	4830.2	2121.4
25	245.75	216.72	4990.7	4990.7	2169.3
26	248.50	216.86	5084.6	5084.6	2197.3
27	250.50	216.96	5154.8	5154.8	2218.2

MM_Mod2_trans.dat

```
GRAphics output
HEAding follows -
      SECTION M-M'
      MODEL 2
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

PROfile line data follow -
      1 1 Tofb-2 Obispo Formation
            0.0 139.0
            36.0 142.0
            69.0 146.0
            88.0 152.0
            95.0 153.0
            100.0 152.0
            114.0 146.0
            119.0 145.0
            124.0 147.0
            128.0 150.0
            137.0 174.0
            142.0 181.0
            201.0 215.0
            231.0 216.0
            252.0 217.0
            275.0 219.0
            300.0 222.0
            327.0 225.0
            352.0 228.0
            380.0 231.0
            410.0 235.0
            473.0 244.0


      2 2 Clay Bed
            201.0 215.0
            203.0 216.0
            231.0 217.0
            252.0 218.0
            275.0 220.0
            300.0 223.0
            327.0 226.0
            352.0 229.0
            380.0 232.0
            410.0 236.0
            473.0 245.0
            473.0 244.0

      3 1 Tofb-2 Obispo Formation
            203.0 216.0
            231.0 232.0
            263.0 233.0
            284.0 234.5
            306.0 237.0
```

```
        331.0 240.0
        359.0 244.0
        407.0 250.0

4 2 Clay Bed
        231.0 232.0
        232.0 232.5
        263.0 233.5
        284.0 235.0
        306.0 237.5
        331.0 240.5
        359.0 244.5
        407.0 250.5
        407.0 250.0

5 1 Tofb-2 Obispo Formation
        232.0 232.5
        248.0 239.0
        264.0 239.5
        289.0 241.5
        311.0 244.0
        335.0 247.0
        358.0 250.0
        405.0 256.0

6 2 Clay Bed
        248.0 239.0
        249.0 239.5
        264.0 240.0
        289.0 242.0
        311.0 244.5
        335.0 247.5
        358.0 250.5
        405.0 256.5
        405.0 256.0

7 1 Tofb-2 Obispo Formation
        249.0 239.5
        262.0 246.0
        284.0 262.0
        311.0 266.0
        341.0 270.0
        368.0 273.0
        410.0 279.0
        472.0 288.0

8 2 Clay Bed
        284.0 262.0
        285.5 263.0
        311.0 267.0
        341.0 271.0
        368.0 274.0
        410.0 280.0
        472.0 289.0
```

```
        472.0 288.0

9 1 Tofb-2 Obispo Formation
        285.5 263.0
        305.0 275.0
        311.0 279.0
        316.0 280.0
        343.0 282.0
        357.0 282.0
        368.6 282.0
        376.0 286.0
        382.0 293.0
        388.0 296.0
        410.0 301.0
        415.0 303.0
        439.0 308.0
        457.0 312.0
        478.0 316.0
        500.0 319.0
        538.0 325.0
        572.0 330.0
        600.0 333.0

10 3 Qpf Pleistocene Colluvium
        0.0 170.0
        13.0 175.0
        37.0 182.0
        54.0 185.0
        70.0 187.0
        94.0 193.0
        100.0 195.0
        113.0 199.0
        132.0 205.0
        172.0 216.0
        183.0 220.0
        208.0 234.0
        239.0 248.0
        287.0 268.0
        303.0 278.0
        309.0 282.0
        313.0 283.0
        343.0 282.0

11 4 Qc Quaternary Colluvium
        0.0 179.0
        7.0 182.0
        20.0 185.0
        42.0 188.0
        68.0 195.0
        90.0 200.0
        100.0 203.0
        108.0 206.0
        125.0 211.0
        141.0 215.0


        148.0 217.0
```

```
            169.0 222.0
            174.0 223.0
            182.0 228.0
            203.0 237.0
            218.0 243.0
            230.0 249.0
            237.0 253.0
            253.0 258.0
            273.0 266.0
            285.0 271.0
            298.0 279.0
            306.0 283.0
            312.0 285.5
            314.0 286.0
            317.0 285.0
            320.0 283.0
            323.0 286.0
            363.0 286.0
            366.0 283.0
            369.0 285.0
            377.0 290.0
            382.0 293.0

        12 5 Transporter Mass
            334.0 286.0
            334.0 298.0
            352.0 298.0
            352.0 286.0


MATerial property data follow (for first stage) -
        1 Tofb-2 Obispo Formation
            140 = total unit weight
            Conventional shear strength
                0.0 50.0
            No Pore Pressure
        2 Clay Bed
            115 = total unit weight
            Nonlinear strength envelope

                -100000.0 0.0
                0.0 0.0
                2793.7 1548.5
                100000.0 27594.9

            No pore pressure
        3 Qpf Pleistocene colluvium
            115 = total unit weight
            conventional shear strength
                3000.0 0.0
            No pore pressure
        4 Qc Quaternary Colluvium
            115 = total unit weight


            Conventional shear strength
                1500.0 0.0
```

```
            No pore pressure
        5 Transporter Mass
            150 = total unit weight
            Very strong

SECond stage input activated
MATerial property data follow (for second stage) -
        1 Tofb-2 Obispo Formation
            140 = total unoit weight
            Conventional shear strength
                0.0 50.0
            No pore pressure
        2 Clay Bed
            115 = total unit weight
            2-stage nonlinear strength envelope
                -100000.0 0.0 0.0
                0.0 0.0 0.0
                2793.7 1548.5 1548.5
                100000.0 27594.9 27594.9

            No pore pressure
        3 Qpf Pleistocene colluvium
            115 = total unit weight
            conventional shear strength
                3000.0 0.0
            No pore pressure
        4 Qc Quaternary Colluvium
            115 = total unit weight
            Conventional shear strength
                1500.0 0.0
            No pore pressure
        5 Transporter Mass
            150 = Total unit weight
            Very Strong

HEAding follows -
SECTION M-M': MODEL 2: With Transporter: Short Term Static Stability

ANAlysis/computation data follow -
        Noncircular Search
            148.0 217.0
            168.0 216.0
            172.0 216.0
            190.0 215.0
            201.0 215.0
            231.0 216.1
            252.0 217.1
            268.0 233.3
            284.0 234.6
            291.0 241.8
            305.0 243.6
            326.0 268.2


            341.0 270.1
            358.0 272.5
            366.0 283.0 fixed
```

```
            2.0 0.1
ITErations
      1000

COMpute
HEAding follows -
SECTION M-M': MODEL 2: With Transporter: Seismic Coefficient = 0.44g

ANAlysis/computation data follow -
      Non-circular
            152.50 218.07
            167.84 216.05
            172.11 216.32
            189.97 214.06
            201.02 215.05
            231.01 216.07
            251.52 217.97
            267.97 233.36
            283.80 234.95
            291.06 241.74
            304.89 243.77
            326.12 268.02
            341.01 270.07
            357.74 272.84
            366.00 283.00

TWO stage computations
SEIsmic coefficient
0.44

COMpute
```

MM_Mod2_trans.out

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.0.0.8 - Last Revision Date: 07/27/2001
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UTEXAS4 S/N:00107  - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Thu Mar 13 07:25:36 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM
Utexas4\MM_Mod2_trans.dat

      SECTION M-M'
      MODEL 2
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

---------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
---------------------------------------------------------
Description: Tofb-2 Obispo Formation

Point        X           Y

   1        0.00      139.00
   2       36.00      142.00

   3       69.00      146.00
   4       88.00      152.00
   5       95.00      153.00
   6      100.00      152.00
   7      114.00      146.00
   8      119.00      145.00
   9      124.00      147.00
  10      128.00      150.00
  11      137.00      174.00
```

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Thu Mar 13 07:25:36 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod2_trans.dat

SECTION M-M': MODEL 2: With Transporter: Short Term Static Stability

TABLE NO. 41
****
* Critical Noncircular Shear Surface *
****

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****

X:	152.50	Y:	218.07
X:	167.84	Y:	216.05
X:	172.11	Y:	216.32
X:	189.97	Y:	214.06
X:	201.02	Y:	215.05
X:	231.01	Y:	216.07
X:	251.52	Y:	217.97
X:	267.97	Y:	233.36
X:	283.80	Y:	234.95
X:	291.06	Y:	241.74
X:	304.89	Y:	243.77
X:	326.12	Y:	268.02
X:	341.01	Y:	270.07
X:	357.74	Y:	272.84
X:	366.00	Y:	283.00

Minimum factor of safety: 2.78
Side force inclination: 15.19

Time required to find most critical surface: 12.0 seconds
Number of passes required to find most critical surface: 19
Total number of shear surfaces attempted: 551
Total number of shear surfaces for which the factor of safety was successfully calculated: 546

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	2.0000	4	2.000	2.9517	29	26
2	1.0000	7	1.000	2.8786	58	53
3	1.0000	3	1.000	2.8786	87	82
4	0.5000	10	0.500	2.8564	116	111
5	0.5000	12	0.500	2.8435	145	140
6	0.5000	13	0.500	2.8381	174	169
7	0.5000	1	0.500	2.8377	203	198
8	0.5000	5	0.500	2.8252	232	227
9	0.5000	13	0.500	2.8186	261	256
10	0.5000	7	0.500	2.8186	290	285
11	0.2500	1	0.250	2.8115	319	314
12	0.2500	1	0.250	2.8115	348	343

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Thu Mar 13 07:25:36 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod2_trans.dat

SECTION M-M': MODEL 2: With Transporter: Seismic Coefficient = 0.44g

TABLE NO. 58
****
* Final Results for Stresses Along the Shear Surface *
* (Results are for the critical shear surface in the case of a search.) *
****

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 0.995 Side Force Inclination: 31.53

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	155.05	217.73	1308.7	1308.7	1507.8
2	160.17	217.06	1481.4	1481.4	1507.8
3	165.28	216.39	1654.1	1654.1	1507.8
4	168.42	216.09	1265.4	1265.4	1507.8
5	170.50	216.22	1290.2	1290.2	1507.8
6	172.06	216.32	1307.4	1307.4	1507.8
7	172.40	216.28	1791.8	1791.8	1507.8
8	173.34	216.16	3029.6	3029.6	3015.7
9	176.00	215.83	3186.0	3186.0	3015.7
10	180.00	215.32	3459.7	3459.7	3015.7
11	182.50	215.01	3621.8	3621.8	3015.7
12	186.49	214.50	3823.1	3823.1	3015.7
13	192.73	214.31	2953.1	2953.1	3015.7
14	198.24	214.80	3101.9	3101.9	3015.7
15	201.01	215.05	3176.6	3176.6	3015.7
16	201.06	215.05	3448.5	3448.5	3015.7
17	202.05	215.09	2582.2	2582.2	1432.8
18	205.50	215.20	2771.9	2771.9	1538.1
19	210.50	215.37	3018.8	3018.8	1623.6
20	215.50	215.54	3260.2	3260.2	1699.4
21	221.00	215.73	3555.8	3555.8	1792.1
22	227.00	215.93	3905.5	3905.5	1901.9
23	230.50	216.05	4113.1	4113.1	1967.0
24	231.01	216.07	4146.0	4146.0	1977.4
25	231.51	216.12	3903.2	3903.2	1955.0
26	234.50	216.39	4057.0	4057.0	2005.0
27	238.00	216.72	4216.8	4216.8	2056.9

MM_Mod2.dat

```
GRAphics output
HEAding follows -
      SECTION M-M'
      MODEL 2
      STATIC STABILITY AND YIELD ACCELERATION
      WITHOUT TRANSPORTER MASS

PROfile line data follow -
      1 1 Tofb-2 Obispo Formation
            0.0 139.0
            36.0 142.0
            69.0 146.0
            88.0 152.0
            95.0 153.0
            100.0 152.0
            114.0 146.0
            119.0 145.0
            124.0 147.0
            128.0 150.0
            137.0 174.0
            142.0 181.0
            201.0 215.0
            231.0 216.0
            252.0 217.0
            275.0 219.0
            300.0 222.0
            327.0 225.0
            352.0 228.0
            380.0 231.0
            410.0 235.0
            473.0 244.0

      2 2 Clay Bed
            201.0 215.0
            203.0 216.0
            231.0 217.0
            252.0 218.0
            275.0 220.0
            300.0 223.0
            327.0 226.0
            352.0 229.0
            380.0 232.0
            410.0 236.0
            473.0 245.0
            473.0 244.0

      3 1 Tofb-2 Obispo Formation
            203.0 216.0
            231.0 232.0
            263.0 233.0
            284.0 234.5
            306.0 237.0
            331.0 240.0
```

```
      359.0 244.0
      407.0 250.0

4 2 Clay Bed
      231.0 232.0
      232.0 232.5
      263.0 233.5
      284.0 235.0
      306.0 237.5
      331.0 240.5
      359.0 244.5
      407.0 250.5
      407.0 250.0

5 1 Tofb-2 Obispo Formation
      232.0 232.5
      248.0 239.0
      264.0 239.5
      289.0 241.5
      311.0 244.0
      335.0 247.0
      358.0 250.0
      405.0 256.0

6 2 Clay Bed
      248.0 239.0
      249.0 239.5
      264.0 240.0
      289.0 242.0
      311.0 244.5
      335.0 247.5
      358.0 250.5
      405.0 256.5
      405.0 256.0

7 1 Tofb-2 Obispo Formation
      249.0 239.5
      262.0 246.0
      284.0 262.0
      311.0 266.0
      341.0 270.0
      368.0 273.0
      410.0 279.0
      472.0 288.0

8 2 Clay Bed
      284.0 262.0
      285.5 263.0
      311.0 267.0
      341.0 271.0
      368.0 274.0
      410.0 280.0
      472.0 289.0
      472.0 288.0
```

```
9 1 Tofb-2 Obispo Formation
      285.5 263.0
      305.0 275.0
      311.0 279.0
      316.0 280.0
      343.0 282.0
      357.0 282.0
      368.6 282.0
      376.0 286.0
      382.0 293.0
      388.0 296.0
      410.0 301.0
      415.0 303.0
      439.0 308.0
      457.0 312.0
      478.0 316.0
      500.0 319.0
      538.0 325.0
      572.0 330.0
      600.0 333.0

10 3 Qpf Pleistocene Colluvium
      0.0 170.0
      13.0 175.0
      37.0 182.0
      54.0 185.0
      70.0 187.0
      94.0 193.0
      100.0 195.0
      113.0 199.0
      132.0 205.0
      172.0 216.0
      183.0 220.0
      208.0 234.0
      239.0 248.0
      287.0 268.0
      303.0 278.0
      309.0 282.0
      313.0 283.0
      343.0 282.0

11 4 Qc Quaternary Colluvium
      0.0 179.0
      7.0 182.0
      20.0 185.0
      42.0 188.0
      68.0 195.0
      90.0 200.0
      100.0 203.0
      108.0 206.0
      125.0 211.0
      141.0 215.0
      148.0 217.0
      169.0 222.0

      174.0 223.0
```

```
                182.0 228.0
                203.0 237.0
                218.0 243.0
                230.0 249.0
                237.0 253.0
                253.0 258.0
                273.0 266.0
                285.0 271.0
                298.0 279.0
                306.0 283.0
                312.0 285.5
                314.0 286.0
                317.0 285.0
                320.0 283.0
                323.0 286.0
                363.0 286.0
                366.0 283.0
                369.0 285.0
                377.0 290.0
                382.0 293.0


MATerial property data follow (for first stage) -
        1 Tofb-2 Obispo Formation
                140 = total unit weight
                Conventional shear strength
                        0.0 50.0
                No Pore Pressure
        2 Clay Bed
                115 = total unit weight
                Nonlinear strength envelope
                        -100000.0 0.0
                        0.0 0.0
                        2793.7 1548.5
                        100000.0 27594.9

                No pore pressure
        3 Qpf Pleistocene colluvium
                115 = total unit weight
                conventional shear strength
                        3000.0 0.0
                No pore pressure
        4 Qc Quaternary Colluvium
                115 = total unit weight
                Conventional shear strength
                        1500.0 0.0
                No pore pressure

SECond stage input activated
MATerial property data follow (for second stage) -
        1 Tofb-2 Obispo Formation
                140 = total unoit weight
                Conventional shear strength


                        0.0 50.0
                No pore pressure
```

```
        2 Clay Bed
              115 = total unit weight
              2-stage nonlinear strength envelope
                    -100000.0 0.0 0.0
                    0.0 0.0 0.0
                    2793.7 1548.5 1548.5
                    100000.0 27594.9 27594.9

              No pore pressure
        3 Qpf Pleistocene colluvium
              115 = total unit weight
              conventional shear strength
                    3000.0 0.0
              No pore pressure
        4 Qc Quaternary Colluvium
              115 = total unit weight
              Conventional shear strength
                    1500.0 0.0
              No pore pressure

HEAding follows -
SECTION M-M': MODEL 2: Without Transporter: Short Term Static Stability

ANAlysis/computation data follow -
        Noncircular Search
              148.0 217.0
              168.0 216.0
              172.0 216.0
              190.0 215.0
              201.0 215.0
              231.0 216.1
              252.0 217.1
              268.0 233.3
              284.0 234.6
              291.0 241.8
              305.0 243.6
              326.0 268.2
              341.0 270.1
              358.0 272.5
              366.0 283.0 fixed


              2.0 0.1
ITErations
        1000

COMpute
HEAding follows -
SECTION M-M': MODEL 2: Without Transporter: Seismic Coefficient = 0.45g

ANAlysis/computation data follow -
        Non-circular


              151.47 217.83
              167.85 215.93
              172.11 216.19
```

```
189.97 214.00
201.02 215.00
231.01 216.04
251.56 217.91
267.96 233.38
283.78 234.98
291.03 241.79
304.87 243.80
326.10 268.05
340.88 270.97
357.77 272.82
366.00 283.00

TWO stage computations
SEIsmic coefficient
0.45

COMpute
```

MM_Mod2.out

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.0.0.8 - Last Revision Date: 07/27/2001
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Name of input data file: I:\Project\6000s\6427.006\stability\MM
Utexas4\MM_Mod2.dat

      SECTION M-M'
      MODEL 2
      STATIC STABILITY AND YIELD ACCELERATION
      WITHOUT TRANSPORTER MASS

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

---------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
---------------------------------------------------------
Description: Tofb-2 Obispo Formation

Point         X            Y

   1        0.00       139.00
   2       36.00       142.00
   3       69.00       146.00
   4       88.00       152.00
   5       95.00       153.00
   6      100.00       152.00
   7      114.00       146.00
   8      119.00       145.00
   9      124.00       147.00
  10      128.00       150.00
  11      137.00       174.00
  12      142.00       181.00
  13      201.00       215.00
```

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Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod2.dat

SECTION M-M': MODEL 2: Without Transporter: Short Term Static Stability

TABLE NO. 41
****
* Critical Noncircular Shear Surface *
****

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****

X:	151.47	Y:	217.83
X:	167.85	Y:	215.93
X:	172.11	Y:	216.19
X:	189.97	Y:	214.00
X:	201.02	Y:	215.00
X:	231.01	Y:	216.04
X:	251.56	Y:	217.91
X:	267.96	Y:	233.38
X:	283.78	Y:	234.98
X:	291.03	Y:	241.79
X:	304.87	Y:	243.80
X:	326.10	Y:	268.05
X:	340.88	Y:	270.97
X:	357.77	Y:	272.82
X:	366.00	Y:	283.00

Minimum factor of safety: 2.79
Side force inclination: 15.17

Time required to find most critical surface: 11.0 seconds
Number of passes required to find most critical surface: 17
Total number of shear surfaces attempted: 493
Total number of shear surfaces for which the factor of safety was successfully calculated: 492

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	2.0000	4	2.000	2.9532	29	29
2	1.0000	7	1.000	2.8794	58	57
3	1.0000	4	1.000	2.8794	87	86
4	0.5000	13	0.500	2.8554	116	115
5	0.5000	2	0.500	2.8537	145	144
6	0.5000	6	0.500	2.8457	174	173
7	0.5000	14	0.500	2.8457	203	202
8	0.2500	13	0.250	2.8328	232	231
9	0.2500	1	0.250	2.8125	261	260
10	0.2500	1	0.250	2.8028	290	289
11	0.2500	1	0.250	2.8028	319	318
12	0.1250	4	0.125	2.7968	348	347

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
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Time and date of run: Thu Mar 13 07:59:05 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod2.dat

SECTION M-M': MODEL 2: Without Transporter: Seismic Coefficient = 0.45g

TABLE NO. 58
****
* Final Results for Stresses Along the Shear Surface *
* (Results are for the critical shear surface in the case of a search.) *
****

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 1.001   Side Force Inclination: 30.71

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	154.21	217.51	1229.7	1229.7	1498.0
2	159.67	216.88	1404.6	1404.6	1498.0
3	165.12	216.25	1579.4	1579.4	1498.0
4	168.43	215.97	1250.1	1250.1	1498.0
5	170.50	216.09	1275.3	1275.3	1498.0
6	172.06	216.19	1292.9	1292.9	1498.0
7	172.26	216.17	1746.9	1746.9	1498.0
8	173.21	216.06	2932.5	2932.5	2996.1
9	176.00	215.71	3091.6	3091.6	2996.1
10	180.00	215.22	3363.3	3363.3	2996.1
11	182.50	214.92	3524.3	3524.3	2996.1
12	186.49	214.43	3723.9	3723.9	2996.1
13	192.73	214.25	2898.7	2898.7	2996.1
14	198.24	214.75	3047.7	3047.7	2996.1
15	201.00	215.00	3920.0	3920.0	4665.6
16	201.01	215.00	3920.8	3920.8	4666.5
17	201.27	215.01	5045.0	5045.0	6004.5
18	202.26	215.04	2570.9	2570.9	1431.3
19	205.50	215.16	2748.7	2748.7	1530.3
20	210.50	215.33	2993.5	2993.5	1613.9
21	215.50	215.50	3233.5	3233.5	1689.1
22	221.00	215.69	3527.5	3527.5	1781.1
23	227.00	215.90	3875.3	3875.3	1889.9
24	230.50	216.02	4081.8	4081.8	1954.6
25	231.01	216.04	4114.6	4114.6	1964.8
26	231.51	216.09	3888.1	3888.1	1943.9
27	234.50	216.36	4042.3	4042.3	1993.7

MM_Mod1_trans_long.dat

```
GRAphics output
HEAding follows -
      SECTION M-M'
      MODEL 1
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

PROfile line data follow -
      1 1 Tofb-2 Obispo Formation
            0.0 139.0
            36.0 142.0
            69.0 146.0
            88.0 152.0
            95.0 153.0
            100.0 152.0
            114.0 146.0
            119.0 145.0
            124.0 147.0
            128.0 150.0
            137.0 174.0
            142.0 181.0
            201.0 215.0
            231.0 216.0
            252.0 217.0
            275.0 219.0
            300.0 222.0
            327.0 225.0
            352.0 228.0
            380.0 231.0
            410.0 235.0
            473.0 244.0


      2 2 Clay Bed
            201.0 215.0
            203.0 216.0
            231.0 217.0
            252.0 218.0
            275.0 220.0
            300.0 223.0
            327.0 226.0
            352.0 229.0
            380.0 232.0
            410.0 236.0
            473.0 245.0
            473.0 244.0

      3 1 Tofb-2 Obispo Formation
            203.0 216.0
            231.0 232.0
            263.0 233.0
            284.0 234.5
            306.0 237.0
```

```
        331.0 240.0
        359.0 244.0
        407.0 250.0

4 2 Clay Bed
        231.0 232.0
        232.0 232.5
        263.0 233.5
        284.0 235.0
        306.0 237.5
        331.0 240.5
        359.0 244.5
        407.0 250.5
        407.0 250.0

5 1 Tofb-2 Obispo Formation
        232.0 232.5
        248.0 239.0
        264.0 239.5
        289.0 241.5
        311.0 244.0
        335.0 247.0
        358.0 250.0
        405.0 256.0

6 2 Clay Bed
        248.0 239.0
        249.0 239.5
        264.0 240.0
        289.0 242.0
        311.0 244.5
        335.0 247.5
        358.0 250.5
        405.0 256.5
        405.0 256.0

7 1 Tofb-2 Obispo Formation
        249.0 239.5
        262.0 246.0
        284.0 262.0
        311.0 266.0
        341.0 270.0
        368.0 273.0
        410.0 279.0
        472.0 288.0

8 2 Clay Bed
        284.0 262.0
        285.5 263.0
        311.0 267.0
        341.0 271.0
        368.0 274.0
        410.0 280.0
        472.0 289.0
```

```
      472.0 288.0

9 1 Tofb-2 Obispo Formation
      285.5 263.0
      305.0 275.0
      311.0 279.0
      316.0 280.0
      343.0 282.0
      357.0 282.0
      368.6 282.0
      376.0 286.0
      382.0 293.0
      388.0 296.0
      410.0 301.0
      415.0 303.0
      439.0 308.0
      457.0 312.0
      478.0 316.0
      500.0 319.0
      538.0 325.0
      572.0 330.0
      600.0 333.0

10 3 Qpf Pleistocene Colluvium
      0.0 170.0
      13.0 175.0
      37.0 182.0
      54.0 185.0
      70.0 187.0
      94.0 193.0
      100.0 195.0
      113.0 199.0
      132.0 205.0
      172.0 216.0
      183.0 220.0
      208.0 234.0
      239.0 248.0
      287.0 268.0
      303.0 278.0
      309.0 282.0
      313.0 283.0
      343.0 282.0

11 4 Qc Quaternary Colluvium
      0.0 179.0
      7.0 182.0
      20.0 185.0
      42.0 188.0
      68.0 195.0
      90.0 200.0
      100.0 203.0
      108.0 206.0
      125.0 211.0
      141.0 215.0

      148.0 217.0
```

```
            169.0 222.0
            174.0 223.0
            182.0 228.0
            203.0 237.0
            218.0 243.0
            230.0 249.0
            237.0 253.0
            253.0 258.0
            273.0 266.0
            285.0 271.0
            298.0 279.0
            306.0 283.0
            312.0 285.5
            314.0 286.0
            317.0 285.0
            320.0 283.0
            323.0 286.0
            363.0 286.0
            366.0 283.0
            369.0 285.0
            377.0 290.0
            382.0 293.0

      12 5 Transporter Mass
            334.0 286.0
            334.0 298.0
            352.0 298.0
            352.0 286.0


MATerial property data follow
      1 Tofb-2 Obispo Formation
            140 = total unit weight
            Conventional shear strength
                  0.0 50.0
            No Pore Pressure
      2 Clay Bed
            115 = total unit weight
            Conventional shear strength
                  0.0 22.0
            No pore pressure
      3 Qpf Pleistocene colluvium
            115 = total unit weight
            Conventional shear strength
                  0.0 22.0
            No pore pressure
      4 Qc Quaternary Colluvium
            115 = total unit weight
            Conventional shear strength
                  0.0 22.0
            No pore pressure
      5 Transporter Mass
            150 = total unit weight


            Very strong
```

```
HEAding follows -
SECTION M-M': MODEL 1: With Transporter: Long Term Static Stability

ANAlysis/computation data follow -
      Noncircular Search
            148.0 217.0
            168.0 216.0
            172.0 216.0
            190.0 215.0
            201.0 215.0
            231.0 216.1
            252.0 217.1
            275.0 219.1
            300.0 222.1
            317.0 225.5
            366.0 283.0 fixed

            2.0 0.1
ITErations
      1000

COMpute
```

MM_Mod1_trans_long.out

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.0.0.8 - Last Revision Date: 07/27/2001
(C) Copyright 1985-2000 S. G. Wright - All rights reserved
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* OR ADAPTABILITY OF THIS SOFTWARE.                             *
*****************************************************************

UTEXAS4 S/N:00107  - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Sat Mar 15 13:33:00 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM
Utexas4\MM_Mod1_trans_long.dat

      SECTION M-M'
      MODEL 1
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

---------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
---------------------------------------------------------
Description: Tofb-2 Obispo Formation

Point        X          Y

   1        0.00      139.00
   2       36.00      142.00
   3       69.00      146.00
   4       88.00      152.00
   5       95.00      153.00
   6      100.00      152.00
   7      114.00      146.00
   8      119.00      145.00
   9      124.00      147.00
  10      128.00      150.00
  11      137.00      174.00
  12      142.00      181.00
```

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Sat Mar 15 13:33:00 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod1_trans_long.dat

SECTION M-M': MODEL 1: With Transporter: Long Term Static Stability

TABLE NO. 41
****
* Critical Noncircular Shear Surface *
****

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****

X:	143.61	Y:	215.75
X:	167.65	Y:	212.96
X:	171.80	Y:	212.44
X:	190.05	Y:	212.57
X:	201.03	Y:	215.06
X:	231.00	Y:	216.05
X:	252.01	Y:	217.05
X:	275.00	Y:	219.06
X:	300.00	Y:	222.08
X:	317.42	Y:	224.89
X:	366.00	Y:	283.00

Minimum factor of safety: 2.02
Side force inclination: 17.54

Time required to find most critical surface: 6.0 seconds
Number of passes required to find most critical surface: 19
Total number of shear surfaces attempted: 399
Total number of shear surfaces for which the factor of safety was successfully calculated: 399

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	2.0000	1	2.000	2.2034	21	21
2	1.0000	10	1.000	2.0500	42	42
3	1.0000	2	1.000	2.0470	63	63
4	1.0000	3	1.000	2.0470	84	84
5	0.5000	8	0.500	2.0440	105	105
6	0.5000	2	0.500	2.0404	126	126
7	0.5000	10	0.500	2.0357	147	147
8	0.5000	2	0.500	2.0357	168	168
9	0.2500	8	0.250	2.0271	189	189
10	0.2500	2	0.250	2.0271	210	210
11	0.1250	1	0.125	2.0217	231	231
12	0.1250	2	0.125	2.0212	252	252
13	0.1250	1	0.125	2.0196	273	273
14	0.1250	1	0.125	2.0187	294	294
15	0.1250	1	0.125	2.0186	315	315

MM_Mod2_trans_long.dat

```
GRAphics output
HEAding follows -
      SECTION M-M'
      MODEL 2
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

PROfile line data follow -
      1 1 Tofb-2 Obispo Formation
            0.0 139.0
            36.0 142.0
            69.0 146.0
            88.0 152.0
            95.0 153.0
            100.0 152.0
            114.0 146.0
            119.0 145.0
            124.0 147.0
            128.0 150.0
            137.0 174.0
            142.0 181.0
            201.0 215.0
            231.0 216.0
            252.0 217.0
            275.0 219.0
            300.0 222.0
            327.0 225.0
            352.0 228.0
            380.0 231.0
            410.0 235.0
            473.0 244.0


      2 2 Clay Bed
            201.0 215.0
            203.0 216.0
            231.0 217.0
            252.0 218.0
            275.0 220.0
            300.0 223.0
            327.0 226.0
            352.0 229.0
            380.0 232.0
            410.0 236.0
            473.0 245.0
            473.0 244.0

      3 1 Tofb-2 Obispo Formation
            203.0 216.0
            231.0 232.0
            263.0 233.0
            284.0 234.5
            306.0 237.0
```

```
      331.0 240.0
      359.0 244.0
      407.0 250.0

4 2 Clay Bed
      231.0 232.0
      232.0 232.5
      263.0 233.5
      284.0 235.0
      306.0 237.5
      331.0 240.5
      359.0 244.5
      407.0 250.5
      407.0 250.0

5 1 Tofb-2 Obispo Formation
      232.0 232.5
      248.0 239.0
      264.0 239.5
      289.0 241.5
      311.0 244.0
      335.0 247.0
      358.0 250.0
      405.0 256.0

6 2 Clay Bed
      248.0 239.0
      249.0 239.5
      264.0 240.0
      289.0 242.0
      311.0 244.5
      335.0 247.5
      358.0 250.5
      405.0 256.5
      405.0 256.0

7 1 Tofb-2 Obispo Formation
      249.0 239.5
      262.0 246.0
      284.0 262.0
      311.0 266.0
      341.0 270.0
      368.0 273.0
      410.0 279.0
      472.0 288.0

8 2 Clay Bed
      284.0 262.0
      285.5 263.0
      311.0 267.0
      341.0 271.0
      368.0 274.0
      410.0 280.0
      472.0 289.0
```

```
    472.0 288.0

9 1 Tofb-2 Obispo Formation
    285.5 263.0
    305.0 275.0
    311.0 279.0
    316.0 280.0
    343.0 282.0
    357.0 282.0
    368.6 282.0
    376.0 286.0
    382.0 293.0
    388.0 296.0
    410.0 301.0
    415.0 303.0
    439.0 308.0
    457.0 312.0
    478.0 316.0
    500.0 319.0
    538.0 325.0
    572.0 330.0
    600.0 333.0

10 3 Qpf Pleistocene Colluvium
    0.0 170.0
    13.0 175.0
    37.0 182.0
    54.0 185.0
    70.0 187.0
    94.0 193.0
    100.0 195.0
    113.0 199.0
    132.0 205.0
    172.0 216.0
    183.0 220.0
    208.0 234.0
    239.0 248.0
    287.0 268.0
    303.0 278.0
    309.0 282.0
    313.0 283.0
    343.0 282.0

11 4 Qc Quaternary Colluvium
    0.0 179.0
    7.0 182.0
    20.0 185.0
    42.0 188.0
    68.0 195.0
    90.0 200.0
    100.0 203.0
    108.0 206.0
    125.0 211.0
    141.0 215.0

    148.0 217.0
```

```
        169.0 222.0
        174.0 223.0
        182.0 228.0
        203.0 237.0
        218.0 243.0
        230.0 249.0
        237.0 253.0
        253.0 258.0
        273.0 266.0
        285.0 271.0
        298.0 279.0
        306.0 283.0
        312.0 285.5
        314.0 286.0
        317.0 285.0
        320.0 283.0
        323.0 286.0
        363.0 286.0
        366.0 283.0
        369.0 285.0
        377.0 290.0
        382.0 293.0

    12 5 Transporter Mass
        334.0 286.0
        334.0 298.0
        352.0 298.0
        352.0 286.0


MATerial property data follow (for first stage) -
    1 Tofb-2 Obispo Formation
        140 = total unit weight
        Conventional shear strength
            0.0 50.0
        No Pore Pressure
    2 Clay Bed
        115 = total unit weight
        Conventional shear strength

            0.0 22.0
        No pore pressure
    3 Qpf Pleistocene colluvium
        115 = total unit weight
        Conventional shear strength
            0.0 22.0
        No pore pressure
    4 Qc Quaternary Colluvium
        115 = total unit weight
        Conventional shear strength
            0.0 22.0
        No pore pressure
    5 Transporter Mass


        150 = total unit weight
        Very strong
```

```
Heading follows -
SECTION M-M': MODEL 2: With Transporter: Long Term Static Stability

ANAlysis/computation data follow -
      Noncircular Search
            148.0 217.0
            168.0 216.0
            172.0 216.0
            190.0 215.0
            201.0 215.0
            231.0 216.1
            254.0 217.1
            268.0 233.3
            284.0 234.6
            291.0 241.8
            304.0 243.6
            326.0 268.2
            341.0 270.1
            354.0 272.5
            366.0 283.0 fixed

            2.0 0.1
ITErations
      1000

COMpute
```

MM_Mod2_trans_long.out

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.0.0.8 - Last Revision Date: 07/27/2001
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UTEXAS4 S/N:00107  - Version: 4.0.0.8 - Latest Revision: 07/27/2001
Licensed for use by: Larry Scheibel, Geomatrix Consultants
Time and date of run: Sat Mar 15 12:52:12 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM
Utexas4\MM_Mod2_trans_long.dat

      SECTION M-M'
      MODEL 2
      STATIC STABILITY AND YIELD ACCELERATION
      WITH TRANSPORTER MASS

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

-----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
-----------------------------------------------------------
Description: Tofb-2 Obispo Formation

Point          X           Y

   1         0.00      139.00
   2        36.00      142.00
   3        69.00      146.00
   4        88.00      152.00
   5        95.00      153.00
   6       100.00      152.00
   7       114.00      146.00
   8       119.00      145.00
   9       124.00      147.00
  10       128.00      150.00
  11       137.00      174.00
  12       142.00      181.00
  13       201.00      215.00
```

UTEXAS4 S/N:00107 - Version: 4.0.0.8 - Latest Revision: 07/27/2001
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Time and date of run: Sat Mar 15 12:52:12 2003
Name of input data file: I:\Project\6000s\6427.006\stability\MM Utexas4\MM_Mod2_trans_long.dat

SECTION M-M': MODEL 2: With Transporter: Long Term Static Stability

TABLE NO. 41
****
* Critical Noncircular Shear Surface *
****

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****

X:	143.73	Y:	215.78
X:	167.56	Y:	212.59
X:	171.68	Y:	212.08
X:	190.07	Y:	212.57
X:	201.05	Y:	215.02
X:	231.01	Y:	216.03
X:	253.41	Y:	218.06
X:	267.96	Y:	233.36
X:	283.80	Y:	234.94
X:	291.03	Y:	241.76
X:	303.96	Y:	243.66
X:	326.09	Y:	268.05
X:	341.01	Y:	270.06
X:	354.04	Y:	272.42
X:	366.00	Y:	283.00

Minimum factor of safety: 2.07
Side force inclination: 18.39

Time required to find most critical surface: 10.0 seconds
Number of passes required to find most critical surface: 17
Total number of shear surfaces attempted: 493
Total number of shear surfaces for which the factor of safety was successfully calculated: 493

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	2.0000	1	2.000	2.3132	29	29
2	1.0000	7	1.000	2.1770	58	58
3	1.0000	2	1.000	2.1770	87	87
4	0.5000	1	0.500	2.1694	116	116
5	0.5000	2	0.500	2.1632	145	145
6	0.5000	1	0.500	2.1498	174	174
7	0.5000	1	0.500	2.1381	203	203
8	0.5000	1	0.500	2.1105	232	232
9	0.5000	3	0.500	2.1105	261	261
10	0.2500	13	0.250	2.0943	290	290
11	0.2500	8	0.250	2.0828	319	319

ATTACHMENT B

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

PG&E

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

28 May 2002

Re: Transmittal of additional data for DCPP ISFSI Transport Route Analysis

DR. MAKDISI:

Please find attached soils data obtained from borings in the cutslope behind Units 1 and 2 at DCPP. These data are found in Appendic 2.5C of Volume III of the Units 1 and 2 Diablo Canyon Site Final Safety Analysis Report, as indicated in the footer for each data sheet.

Also attached are the rock shear wave velocity profiles obtained from borings in and around the powerblock, as developed for the LTSP and as presented in Chapter 5 of the LTSP Final Report. The tabulated range of velocities with depth is also attached, as found in the Response to NRC Staff Question 19 dated 2/3/89.

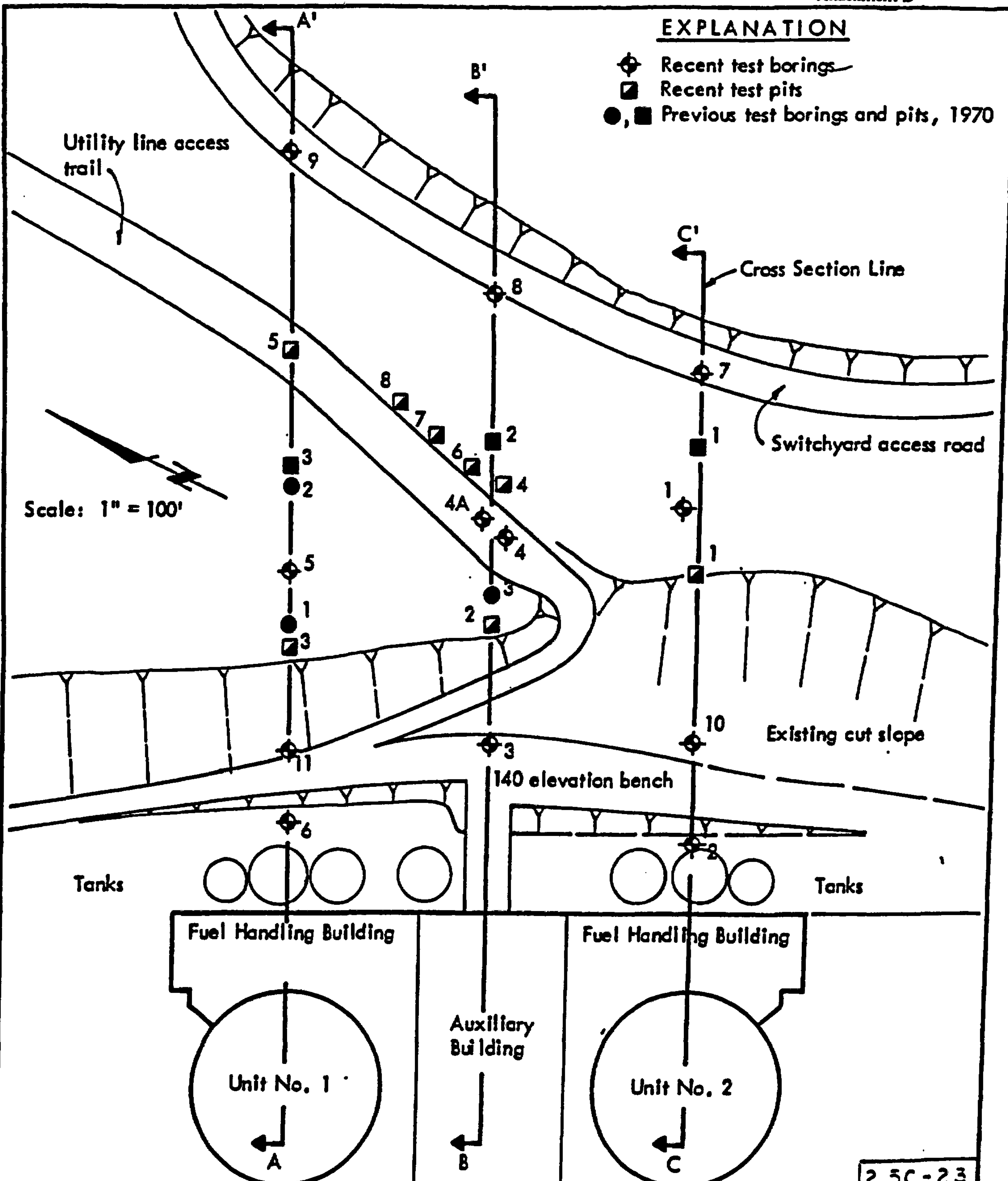
If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

Attachments

RF1

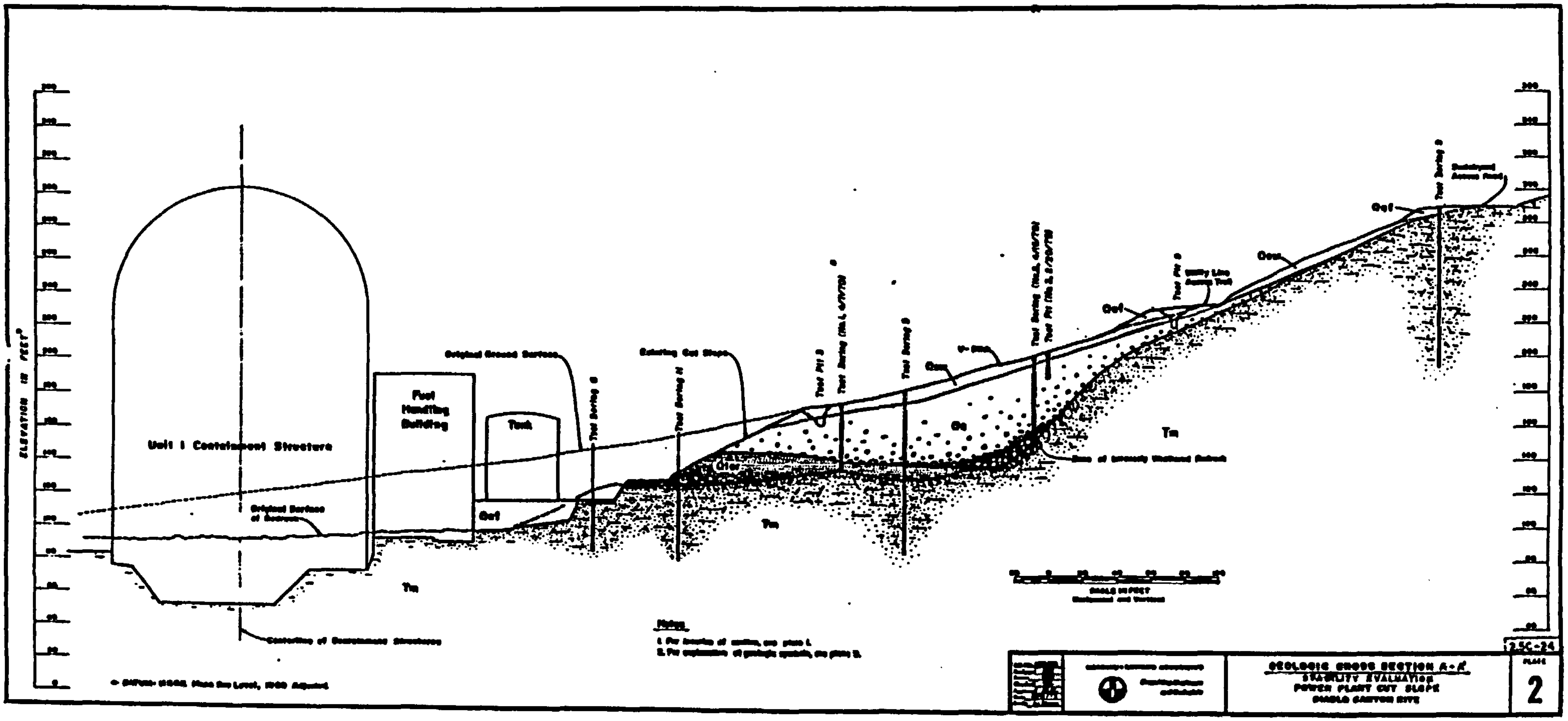


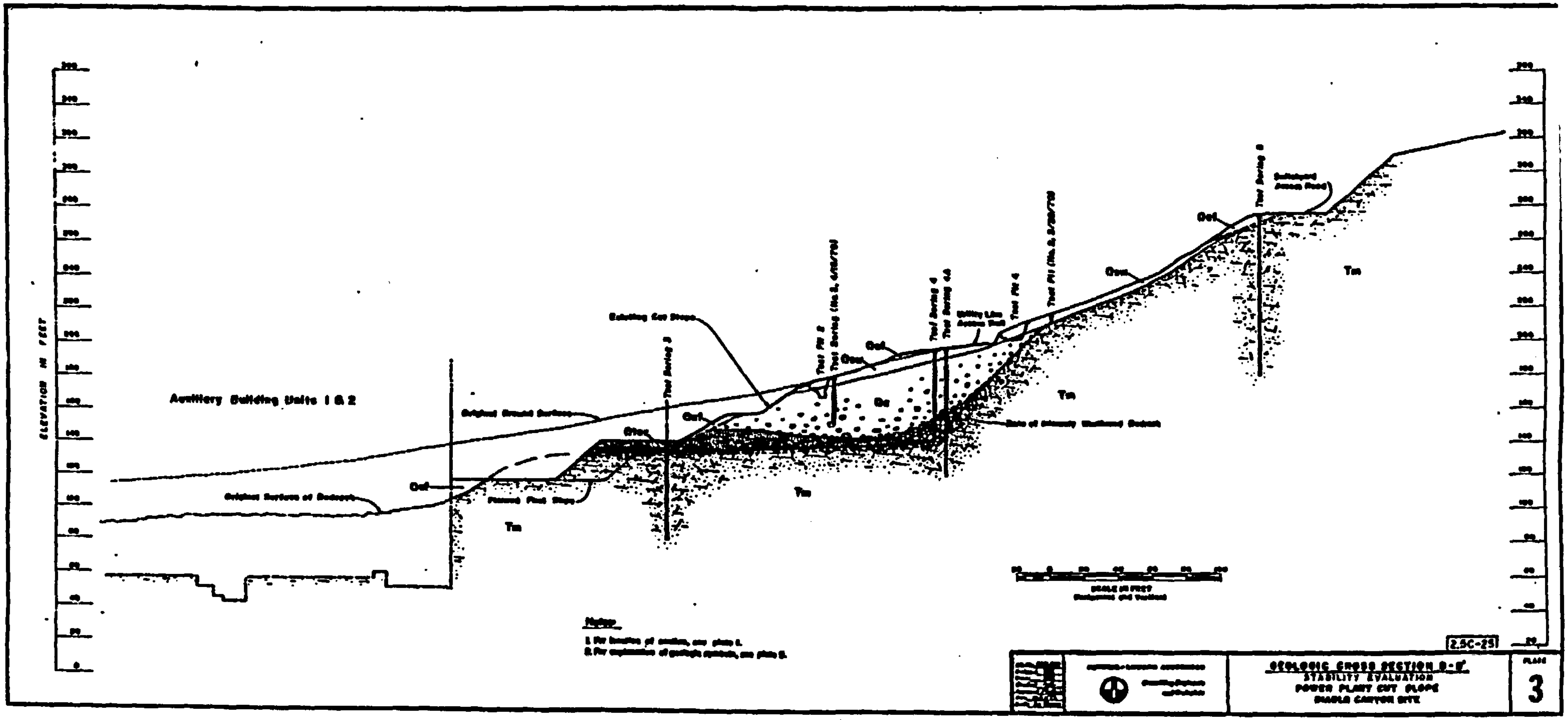
HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

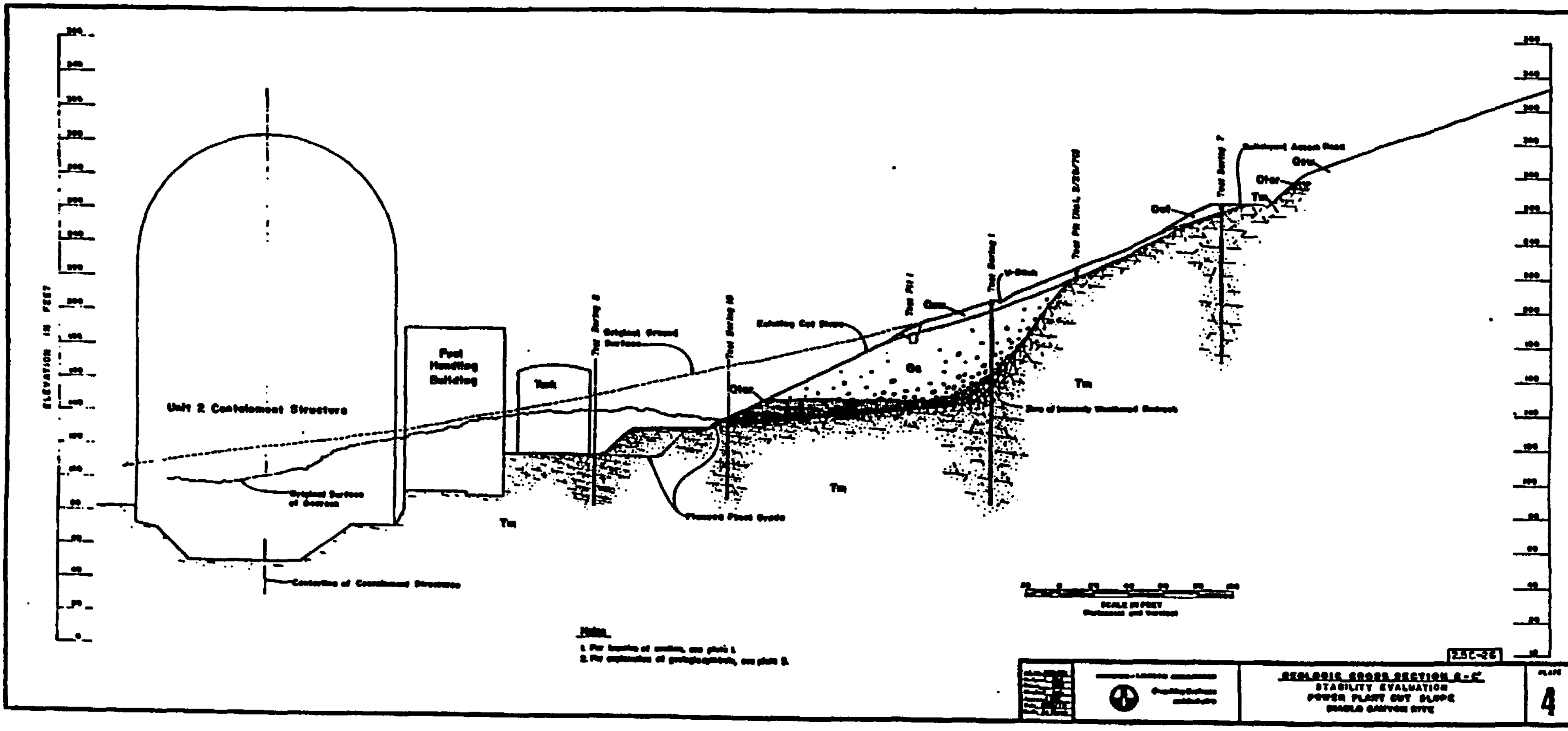
Job No. 569,021.04 Appr: [illegible] Date 12/12/73

LOCATION PLAN
Stability Evaluation
Power Plant Cut Slope
Diablo Canyon Site

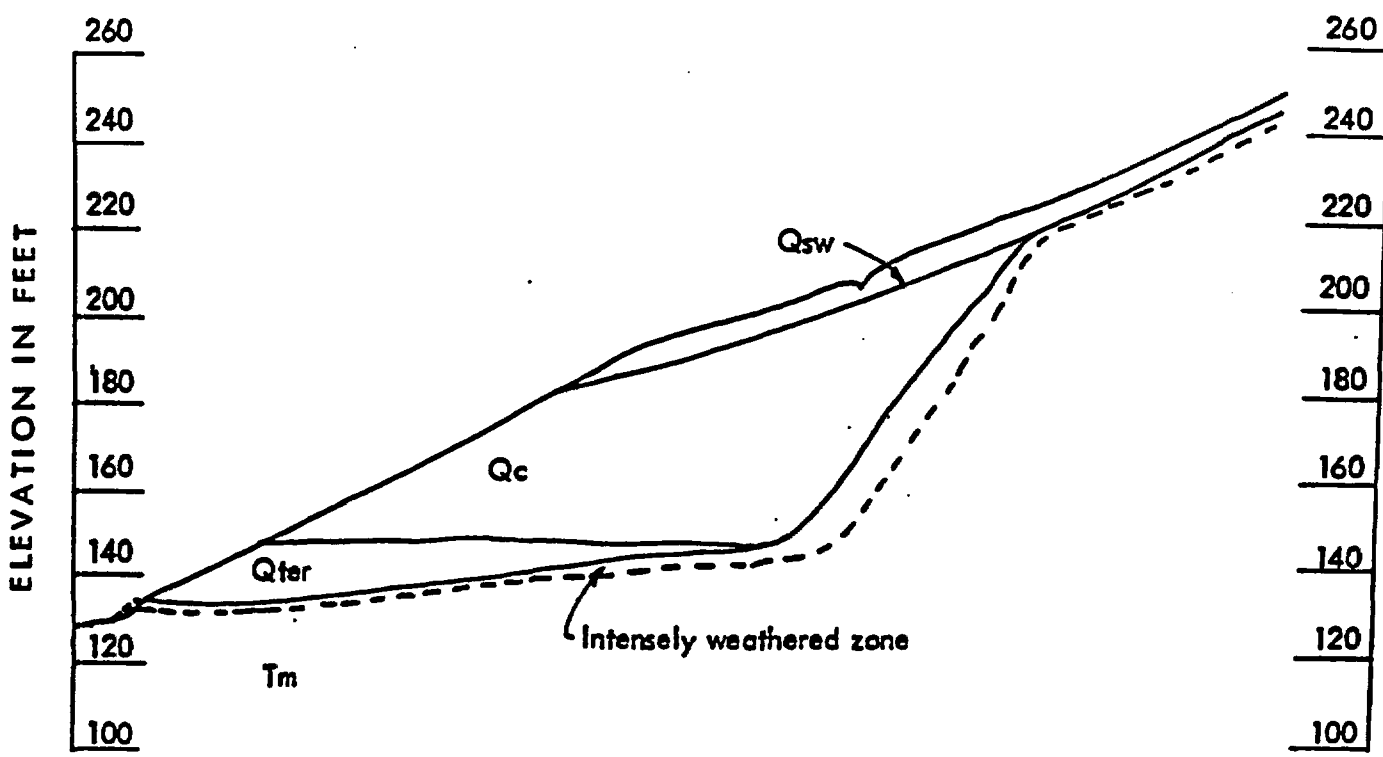
PLATE
1


Unit 1 Containment Structure
Fuel Handling Building
Tank
Tm
Qaf
Qcs
Qc
2.5C-24
GEOLOGIC CROSS SECTION A-A'
STABILITY EVALUATION
POWER PLANT CUT SLOPE
DIABLO CANYON SITE
2


Auxiliary Building Units 1 & 2
Tm
GEOLOGIC CROSS SECTION B-B'
STABILITY EVALUATION
POWER PLANT CUT SLOPE
DIABLO CANYON SITE
2.5C-25
3


ELEVATION IN FEET
Unit 2 Containment Structure
Fuel Handling Building
Tank
Tm
Qc
STABILITY EVALUATION
POWER PLANT CUT SLOPE
4

RF1



Geologic Unit	Description	Density In-Place (pcf)	Shear Strength Parameters
Qsw	Black Silty Clay (CH)	115	S = 1200 psf
Qc	Brown Sandy Clay (CH)	115	S = 2600 psf
Qter	Brown Silty Sand (SP-SM)	130	C = 0; Ø = 40°
Tm	Intensely Weathered Sandstone	115	S = 2900 psf
Tm	Bedrock (Sandstone)	140	C = 4000 psf; Ø = 35°

2.5C-29

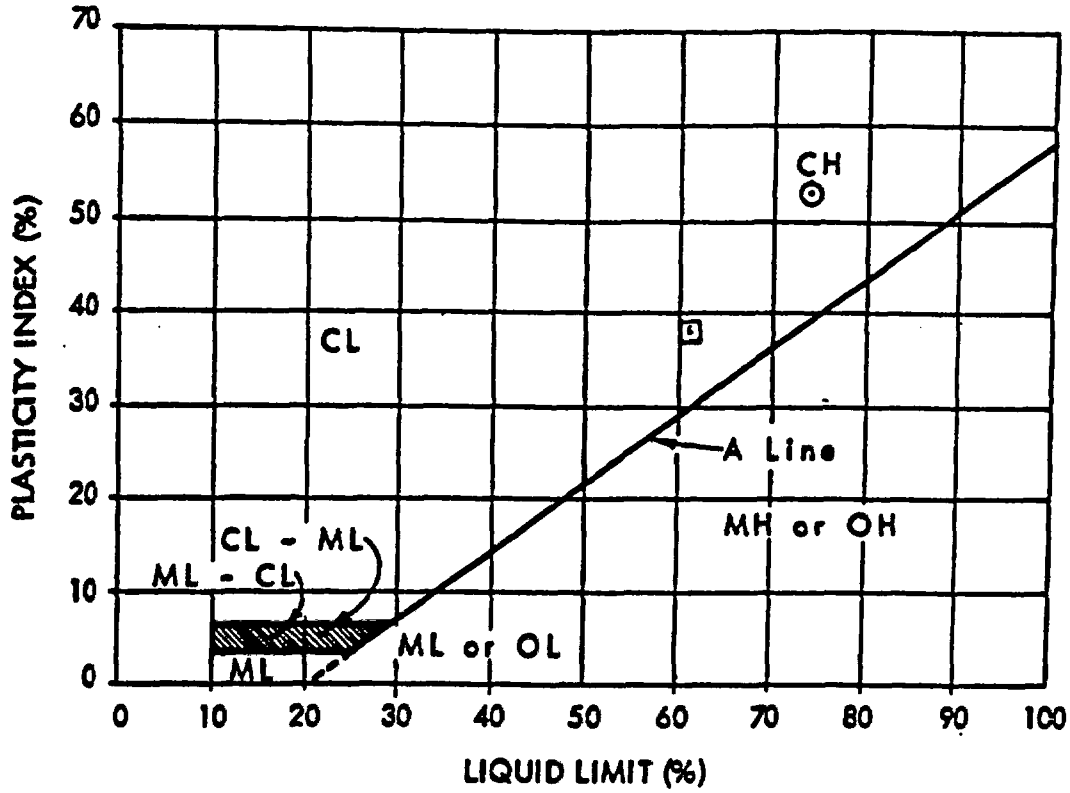
HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No. 569,021.04 Appr: [signature] Date 12/14/73

SOIL PARAMETERS
SECTION C-C'
Power Plant Cut Slope
Diablo Canyon Site

PLATE 7

RF 25



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
⊙	BLACK SILTY CLAY (CH) Boring 1 @ 4.2'	74	21	53	85
⊡	BLACK SILTY CLAY (CH) Boring 5 @ 2.5'	61	23	38	

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Job No. 569,021.04 Appr: JJS Date 12/10/73

PLASTICITY CHART
SURFACE SOIL (Qsw)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B1

RF1

BORING	DEPTH	TYPE OF TEST	CONFINING PRESSURE (psf)	MAXIMUM SHEAR STRESS (psf)
5	2.0	Consolidated-Undrained	860	3300
1	6.2	Unconsolidated-Undrained	1500	2860
TP4	3.5	Unconsolidated-Undrained	1500	1870
1	3.8	Unconsolidated-Undrained (Saturated)	800	1200

Note: Results are also shown on the Boring Logs (Appendix A)

25C-86

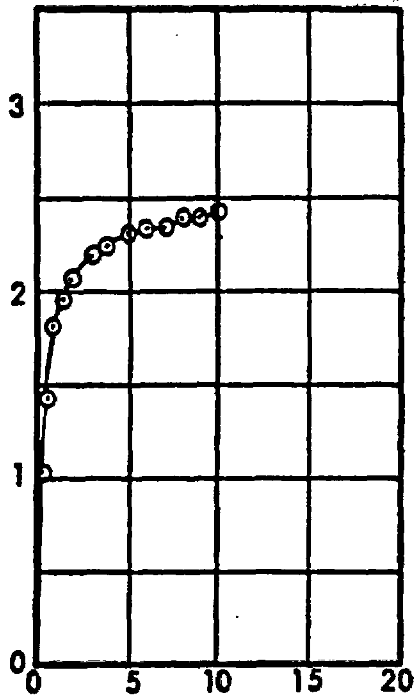
HARDING-LAWSON ASSOCIATES
Consulting Engineers and Geologists

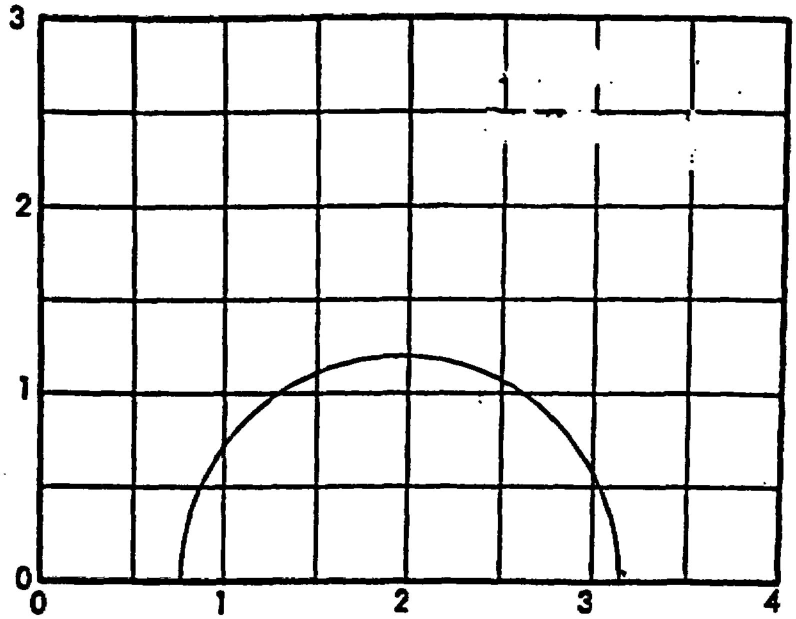
Job No. 569,021.04 Appr: JJS Date 12/11/73

TRIAXIAL SHEAR TEST RESULTS
SURFACE SOIL (Qsw)
Power Plant Cut Slope
Diablo Canyon Site

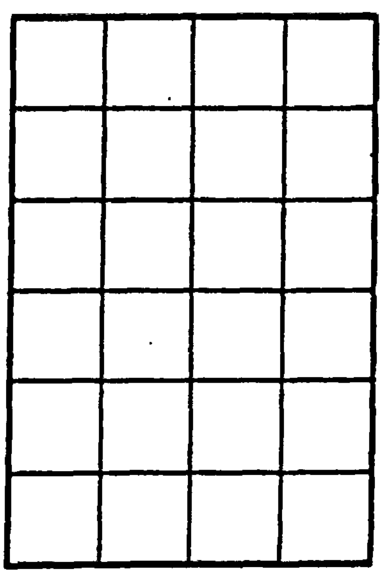
PLATE
B2

RF 31





Test Type: Unconsolidated-Undrained Controlled: Strain
Saturation Method: Backpressure G_s 2.70 (assumed)



	Test No.	A	B	C
Initial	Diameter (in.)	2.43		
	Height (in.)	5.30		
	Moisture Content	28.4 %	%	%
	Void Ratio	.824		
	Saturation	92 %	%	%
	Dry Density (pcf)	91		
Before Test	Moisture Content	33.1 %	%	%
	Void Ratio	.870		
	Saturation	100 %	%	%
	Pressure (psf)	800		
Final	Moisture Content	33.1 %	%	%
	Void Ratio	.870		
σ_1 Major Prin. Stress (psf)		3160		
σ_3 Minor Prin. Stress (psf)		800		
Time to Failure (min.)				

Sample Source: Boring 1 at 3.8

Classification: Black Gravelly Silty Clay (CH)

Ø =
C =

2.5C-87

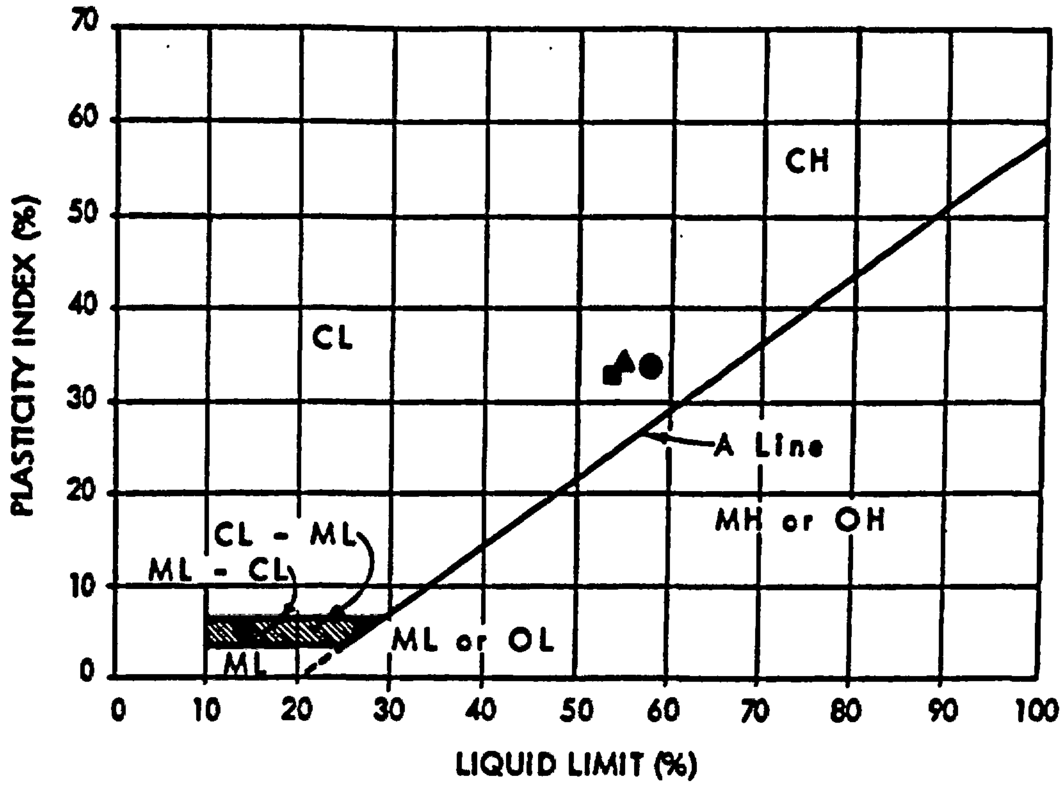
HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No. 569,021.04 Appr: JJS Date 12/12/73

TRIAXIAL COMPRESSION TEST REPORT
SURFACE SOIL (Qsw)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B3

RF 25



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
●	BROWN SANDY CLAY (CH) Boring 1 at 11.2'	58	24	34	71
▲	LIGHT BROWN GRAVELLY CLAY (CH) Boring 1 at 26.2'	55	21	34	36
■	LIGHT BROWN GRAVELLY CLAY (CH) Boring 1 at 31.2'	54	21	33	52

HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

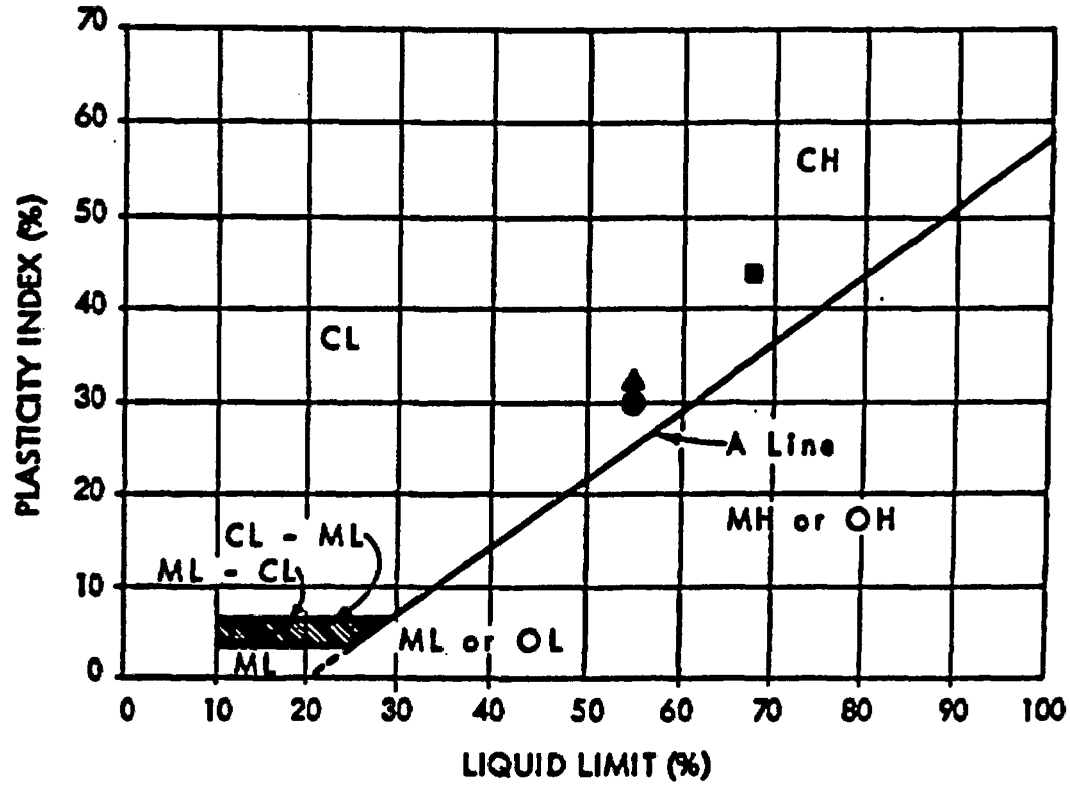
Job No. 569,021.04 Appr: JJS Date 12/12/73

PLASTICITY CHART
COLLUVIUM (Qc)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B4

2.5C-88

RF 25



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
▲	MOTTLED BROWN SANDY CLAY (CH) Boring 4 at 6.2'	55	23	32	
●	BROWN SANDY CLAY (CH) Boring 4A at 17'	55	25	30	
■	BROWN SILTY CLAY (CH) Boring 5 at 11.0'	68	24	44	

HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No. 569,021.04 Appr: JJS Date 12/12/73

PLASTICITY CHART
COLLUVIUM (Qc)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B5

RF1

UNCONSOLIDATED-UNDRAINED TESTS

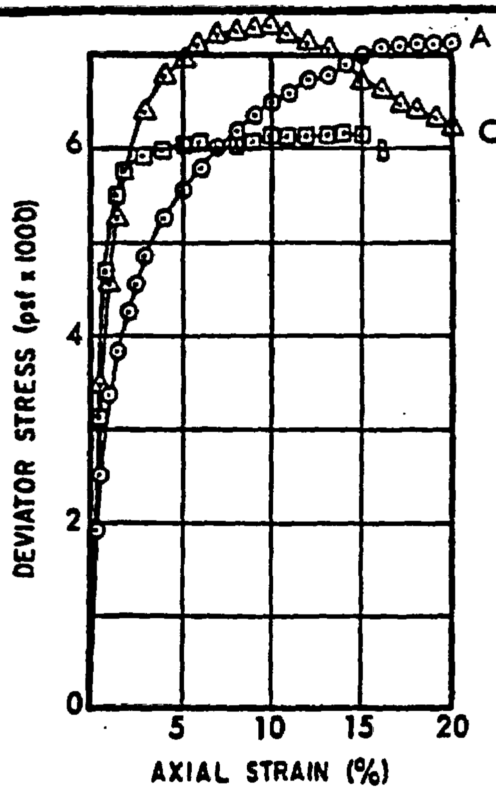
BORING	DEPTH	CONFINING PRESSURE (psf)	MAXIMUM SHEAR STRESS (psf)
Tests Performed for This Investigation			
1	15.2	1800	5050
1	25.2	2500	3470
5	11.0	1500	1990
TP3	4.5	2000	1440
1	10.8	860	3920
4	5.7	1500	3780
4A	17.0	2000	2850
TP2	6.0	1500	4340
TP3	7.0	1500	1820
Tests Performed for Previous Investigation (June 1970)			
TP2	2.0	2000	2190
TP2	3.5	1500	2290
2	5.0	1140	2900
2	10.0	1440	3300
2	15.0	2150	3830
2	20.0	2900	5040
2	25.0	3600	6150
2	30.0	4300	6700

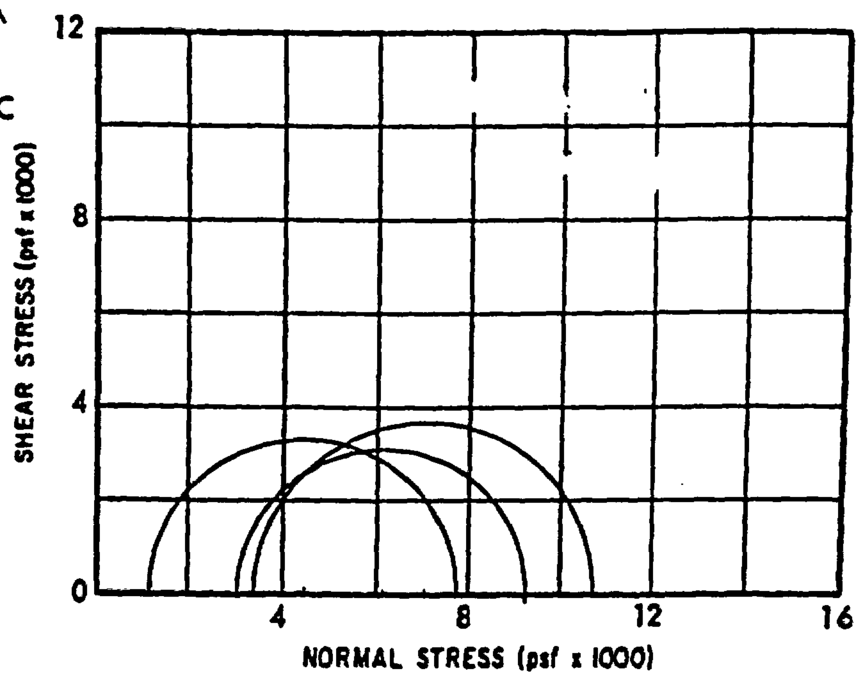
Note: Results are also shown on the Boring Logs (Appendix A)

2.5C-90

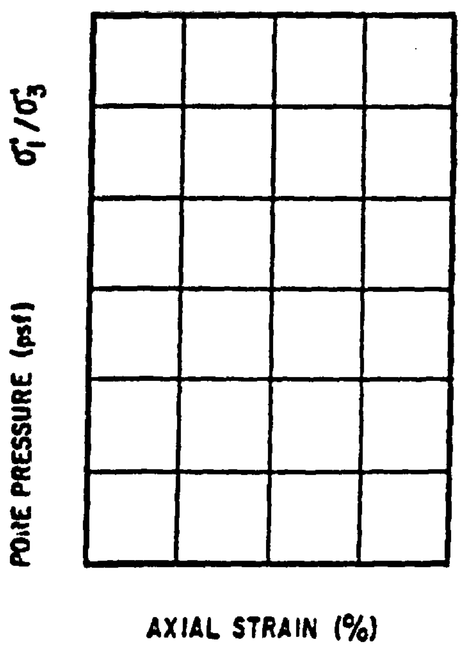
HARDING-LAWSON ASSOCIATES *Consulting Engineers and Geologists*	TRIAXIAL SHEAR TEST RESULTS COLLUVIUM (Qc) Power Plant Cut Slope Diablo Canyon Site	PLATE **B6**
Job No. 569,021.04 Appr: JFS Date 12/13/73		

RF 31





Test Type: Consolidated-Undrained Controlled: Strain
Saturation Method: Back Pressure G_s 2.80 Assumed



	Test No.	A	B	C
Initial	Diameter (in.)	2.43	2.87	2.43
	Height (in.)	5.85	6.50	5.80
	Moisture Content	25.7%	25.9%	32.4 %
	Void Ratio	.782	.849	.935
	Saturation	92 %	85 %	97 %
	Dry Density (pcf)	98	95	90
Before Test	Moisture Content	28.1%	28.9%	35.3 %
	Void Ratio	.776	.764	.879
	Saturation	100 %	100 %	100 %
	Pressure (psf)	1200	3000	3500
Final	Moisture Content	28.1%	28.9%	35.3 %
	Void Ratio	.776	.764	.879
σ_1	Major Prin. Stress (psf)	7690	9140	10810
σ_3	Minor Prin. Stress (psf)	1200	3000	3500
	Time to Failure (min.)			

Sample Source: Borings 4@10.7 5@29.0 4@30.7

Classification: Brown Sandy Clay (CH)

ø :
C :

2.5C-91

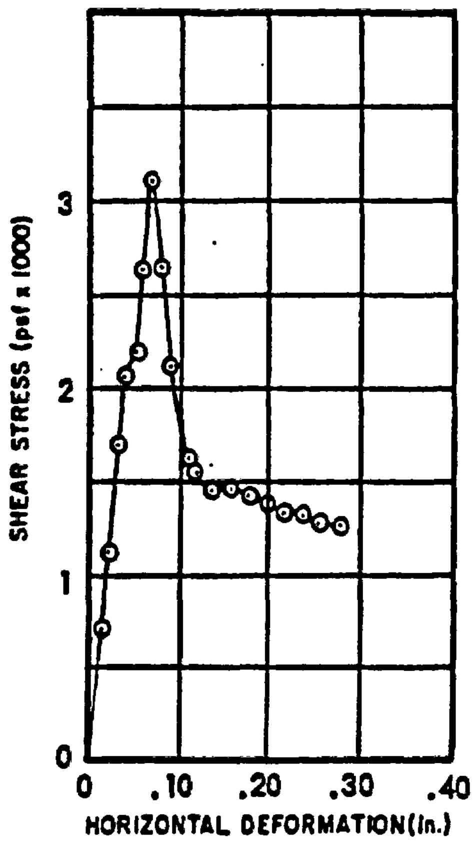
HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

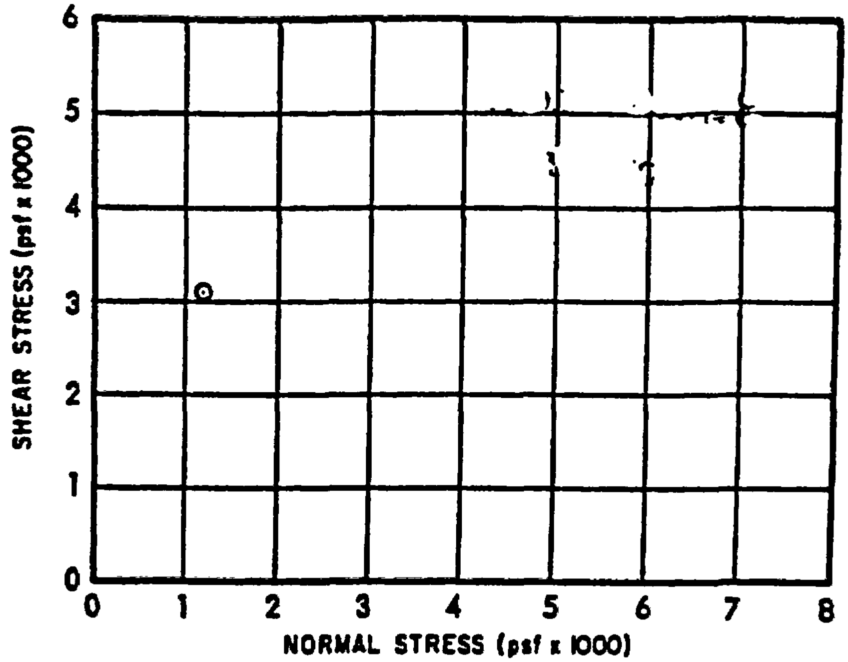
Job No. 569.021.04 Appr: [signature] Date 12/10/73

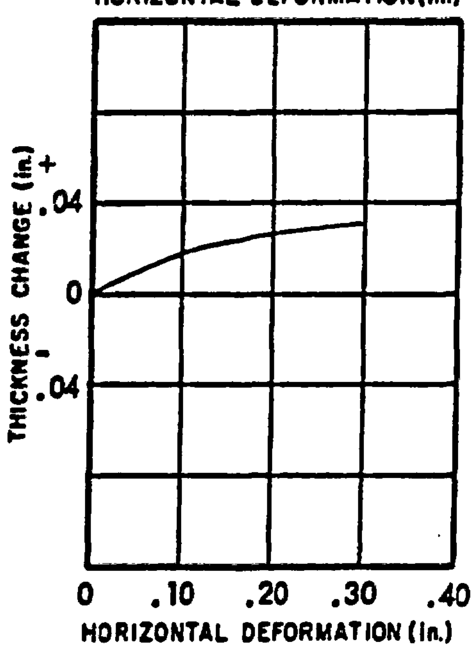
TRIAXIAL COMPRESSION TEST REPORT
COLLUVIUM (Qc)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B7

RF 32







Test Type: Consolidated Drained

Controlled Strain
G_s 2.70 (assumed)

	Test No.	A	B	C
Initial	Height (in.)	1.00		
	Moisture Content	23.2 %	%	%
	Void Ratio	.696		
	Saturation	90 %	%	%
	Dry Density (pcf)	99		
Before Test	Time for 50% Consolidation (min.)	---		
	Time for 95% Consolidation (min.)	---		
	Void Ratio after Consolidation	.672		
Final	Moisture Content	22.9 %	%	%
	Void Ratio	.670		
	Saturation	90 %	%	%
	Normal Stress (psf)	1200		
	Maximum Shear (psf)	3100		
	Time to Failure (min.)			

Sample Source Boring 1 at 10.0

Classification Brown Sandy Clay (CH)

Ø' =
C' =

2.5C-92

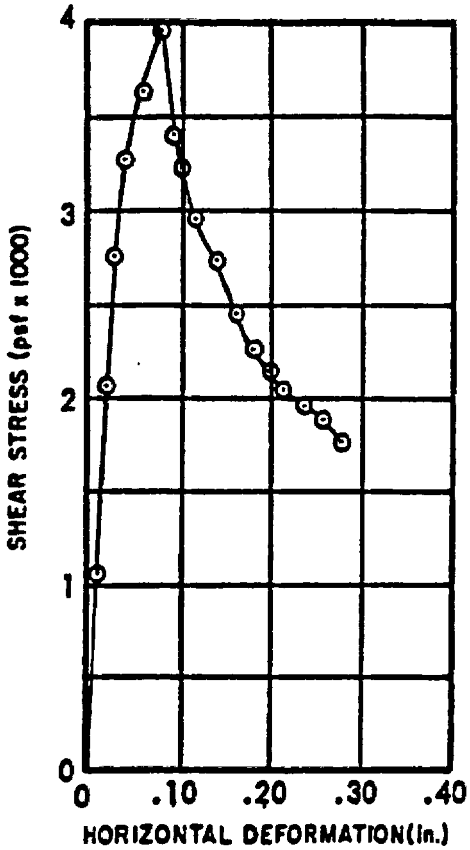
HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

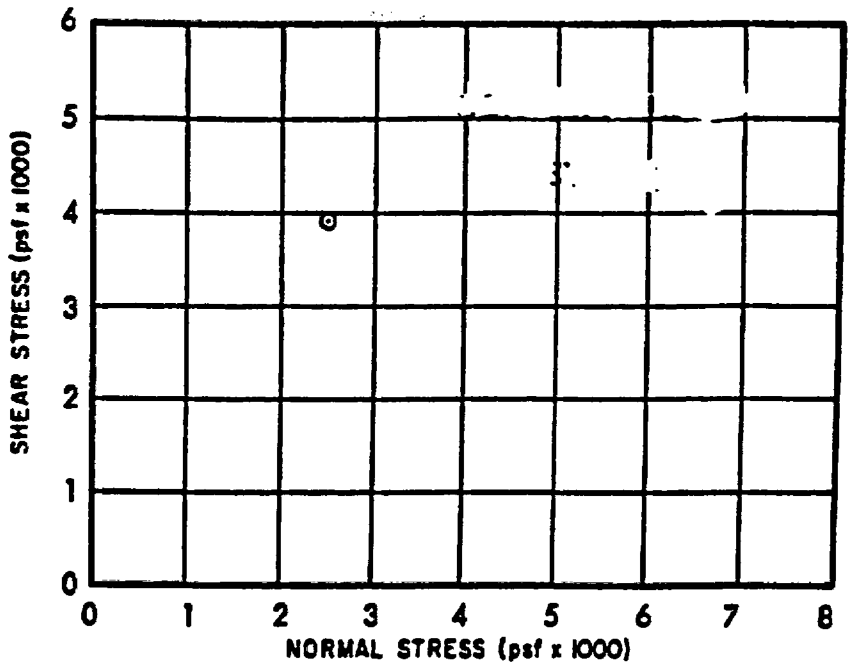
Job No. 569,021.04 Appr: JJS Date 12/14/73

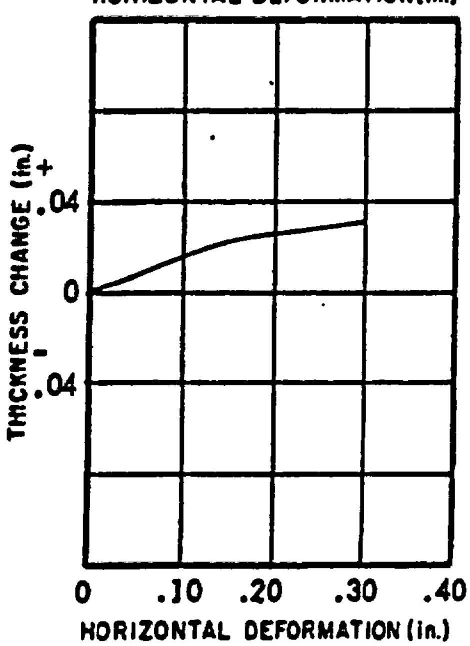
DIRECT SHEAR TEST REPORT
COLLUVIUM (Qc)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B8

RF 32







Test Type: Consolidated Drained

Controlled Strain

Gs 2.70 (assumed)

	Test No.	A	B	C
Initial	Height (in.)	1.00		
	Moisture Content	28.4 %	%	%
	Void Ratio	818		
	Saturation	94 %	%	%
	Dry Density (pcf)	93		
Before Test	Time for 50% Consolidation (min.)	---		
	Time for 95% Consolidation (min.)	---		
	Void Ratio after Consolidation	.768		
Final	Moisture Content	26.3 %	%	%
	Void Ratio	.823		
	Saturation	86 %	%	%
Normal Stress (psf)		2500		
Maximum Shear (psf)		3950		
Time to Failure (min.)				
Sample Source		Boring 4 at 23.2		
Classification		Brown Sandy Clay (CH)		

ø' =
C' =

2.5C-93

HARDING-LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No. 569,021.04 Appr: JJs Date 12/14/73

DIRECT SHEAR TEST REPORT
COLLUVIUM (Qc)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B9

2F1

SUMMARY OF RESULTS

UNCONSOLIDATED-UNDRAINED DYNAMIC TRIAXIAL TESTS

	CYCLIC SHEAR STRAIN (percent)	CYCLIC SHEAR STRESS (psf)
Sample 1		
	.015	124
	.060	280
	.160	260
Sample 2		
	.050	271
	.120	417
	.220	660
	.400	931

Note:

1. Confining Pressure = 3000 psf
2. Tests were strain controlled.
3. Cyclic shear stress tabulated is the average over 5 - 12 cycles at strain level indicated and is calculated as one-half the maximum cyclic deviator stress measured at each cycle.
4. Test procedures are described in the text of this Appendix.

2.5C-94

HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No. 569,021.04 Appr: JJS Date 12/13/73

DYNAMIC TRIAXIAL TESTS
COLLUVIUM (Qc)
Power Plant Cut Slope
Diablo Canyon Site

PLATE
B10

SASSI computer programs for three-dimensional analysis; (b) the development, implementation, and validation of analysis method and computer programs for soil/structure interaction analysis incorporating the spatial incoherence of seismic ground motions; and (c) the modification and validation of the soil/structure analysis method and computer program for analyzing the nonlinear dynamic response due to base-uplifting.

Characterization of Site Rock Properties

Recognizing the importance of fixing the site rock properties at the beginning of the Long Term Seismic Program, a priority task was performed to assemble and review all available site rock data and, based on this review, to assess the appropriate rock profile and properties for soil/structure interaction analysis. The rock data that have been assembled include two sets of data: one set consists of data contained in the source references of the Diablo Canyon Power Plant FSAR Section 2.5, which were obtained from the site investigations conducted from 1967 to 1973; the second set consists of data obtained from the additional site investigations conducted from 1977 to 1978. Both sets of data have been reviewed in detail.

The rock data available from the FSAR references consist of data obtained from both field geophysical surveys and laboratory tests of rock samples. These data were applicable mainly for rocks at shallow depths, that is, down to a depth of about 40 feet below the finished grade at El 85 feet. The rock data available from the 1977 to 1978 site investigations consist of data from borehole logging, field geophysical surveys, and laboratory tests of rock samples obtained from four deep boreholes drilled around the Plant to a depth of approximately 300 feet below grade.

Review of data from both sets indicated that the data from field-measured shear and compression wave velocities and rock densities are more mutually consistent and these data are considered to be more representative of the in situ properties of the rock mass below the plant foundation; the laboratory test values represent only very local rock conditions and the test results are marked with uncertainties resulting from the specimen saturation procedures used and the test equipment flexibilities. Thus, in deriving the low-strain rock property profiles for soil/structure interaction analysis purposes, emphasis was placed on field-measured data, especially the data taken from the depth below El 50 feet, because the foundations of the power block structures are located at elevations between 50 feet and 80 feet.

Based on the review of rock data assembled, representative profiles and the ranges of variation of rock shear wave velocity, Poisson's ratio, rock density, damping ratio at low-strain, and the strain-dependent variations of shear modulus and damping ratio, were derived. Figure 5-5 shows the mean shear wave velocity profile and the upper-bound and lower-bound of data developed from the assembled site rock data.

Because the rock shear wave velocity profiles developed from the assembled data showed relatively large scattering, a study was carried out to assess the sensitivity of soil/structure interaction response due to the variation of rock shear wave velocity profile. The sensitivity study was performed using a simplified soil/structure interaction model for the containment structure and the CLASSI computer program for soil/structure interaction analyses. The results of this sensitivity study indicated that, as the foundation rock shear wave velocity profile varies from the upper-bound to the mean and then to the lower-bound, the fundamental soil/structure interaction frequency for the coupled horizontal translation and rocking mode of the containment shell shifts from 4.6 hertz to 4.0 hertz, and then to 3.3 hertz. Despite the relatively large variation in the rock shear wave velocity profile, the frequency variation was found to be within approximately ±15 percent.

To provide an independent confirmation of the appropriateness of the rock property profiles developed for soil/structure interaction analysis, the fundamental soil/structure interaction frequency of the containment shell, which was sensitive to the variation of rock shear wave

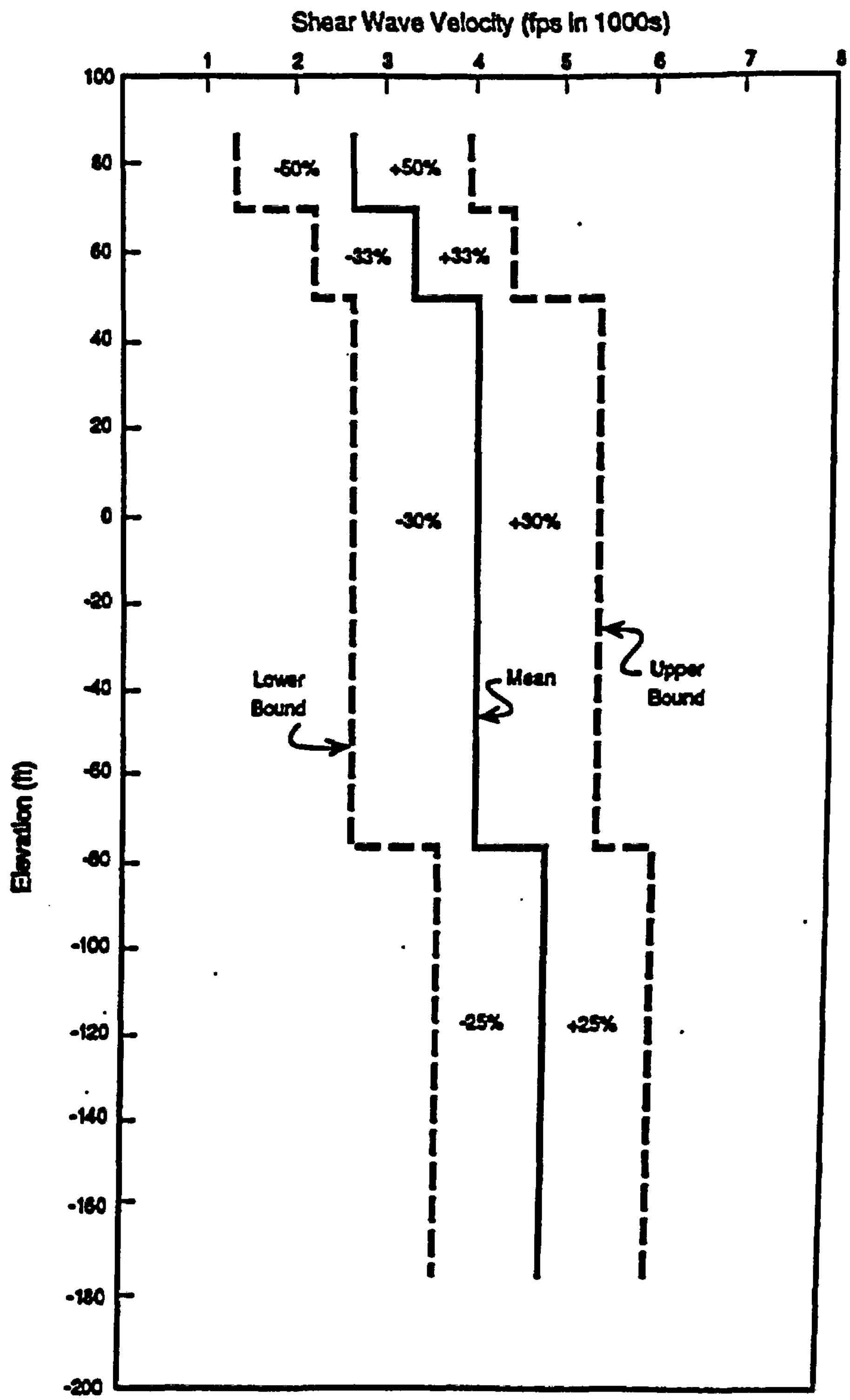


Figure 5-5

Site shear wave velocity profiles (based on 1978 downhole velocity measurements).

Table Q19-3

FOUNDATION ROCK PROPERTY PROFILES AND VARIATION BOUNDS FOR ROCK PROPERTY SENSITIVITY STUDY

Case	Rock Layer	Thickness (ft)	Shear Wave Velocity (ft/sec)	Mass Density (k-sec^2/ft)	Damping Ratio	Poisson's Ratio
	1	10	2600	0.00435	0.02	0.37
Mean	2	20	3300	0.00435	0.02	0.33
	3	125	4000	0.00444	0.02	0.33
	4	∞	4800	0.00463	0.02	0.30
Lower	1	10	1300	0.00435	0.02	0.37
	2	20	2200	0.00435	0.02	0.33
	3	125	2600	0.00444	0.02	0.33
Bound	4	∞	3600	0.00463	0.02	0.30
Upper	1	10	3900	0.00435	0.02	0.37
	2	20	4400	0.00435	0.02	0.33
	3	125	5400	0.00444	0.02	0.33
Bound	4	∞	6000	0.00463	0.02	0.30

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ATTACHMENT C

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 19, 2001

Re: Transmittal of additional inputs for DCPP ISFSI Transport Route Analysis

DR. MAKDISI:

As part of the scope of your analysis of the stability of the transport route for the DCPP ISFSI, you are assessing stability of the route at various sections using both unreduced ground motions previously transmitted to you (reference my October 31 2001 letter to you) and reduced ground motions based on incorporating results of a probabilistic seismic hazard analysis and the estimated exposure interval of the transporter on the route. A probabilistically reduced peak bedrock ground acceleration of 0.15g has been derived in calculation GEO.DCPP.01.02, and this value has been approved for further analyses. Accordingly, please scale the peak acceleration of the unreduced ground motions to this level for your transport route analyses.

In addition, you are assessing the stability of transport route road fill wedges at reduced ground motion levels and with the transporter load previously transmitted to you (reference my November 5 2001 letter to you). The exact subsurface configuration of any fill wedges along the access road is currently unknown, and is shown in only a general way on sections provided to you (reference my November 12 2001 letter to you) based on general descriptions provided in the road construction specification. However, given that the density of any compacted fill derived from the native material is likely to be at or above the density of underlying native material, fill strength is likely to be comparable to the native material, and the exact configuration of the fill is therefore not of consequence. Please proceed with near-surface stability analyses with this assumption.

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

ATTACHMENT D

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 5, 2001

Re: Forwarding of Cold Machine Shop Retaining Wall Calculation Inputs from Project Engineer

DR. MAKDISI:

Inputs to the calculation checking the stability of the DCPP Cold Machine Shop Retaining Wall under proposed ISFSI transporter loads have been provided to Geosciences from Richard Klimczak, Project Engineer for the ISFSI project. I am forwarding these inputs to you formally, as required by Geosciences Calculation Procedure GEO.001, rev. 4. Please incorporate these into your calculation in place of previous inputs provided to you informally, and complete the calculation as required by Geosciences Work Plan GEO 2001-03, rev. 1, Appendix H. A description of the inputs follows. A copy of the Work Plan is also enclosed for distribution to those on your staff who are responsible for performing the calculation. Please have them sign the Work Plan Attachment acknowledging their review and forward copies to me.

Letter to Robert White from Richard Klimczak, dated October 3, 2001. Subject: Transmittal of Information on the Transporter Movement Along the Transport Route.

The reference letter contains a copy of PG&E calculation 52.27.14.01, pages RLOC 02553 1215 through 1255 (42 pages). These calculation pages are enclosed in this forwarding letter. The reference letter also contains 11x17 copies of drawings 516992 and 516993. These drawings are also enclosed in this forwarding letter. The reference letter also lists applicable criteria for the transporter. These criteria have been superseded by the following letter, and should not be used in your calculation.

Letter to Robert White from Richard Klimczak, dated October 19, 2001. Subject: Transmittal of Information on the Transporter Movement Along the Transport Route.

This reference letter contains modified transporter criteria and should be used in place of those criteria in the 10/3/01 letter above.

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

Enclosures

Memorandum

Date: October 3, 2001 File #: 72.10.05

To: Robert White Phone: (415) 973-0544
PG&E Geosciences Dept

From: Richard L. Klimczak, Project Engineer

Subject: Diablo Canyon Units 1 and 2
Transmittal of Information on the Transporter Movement Along the Transport Route

PG&E Pacific Gas and Electric Company

Dear Rob,

This memorandum provides criteria for movement of the loaded Transporter from the Auxiliary/Fuel Handling Building (Power Plant) to the Cask Transfer Facility (CTF). Information provided herein is applicable to Calculations GEO.DCPP.01.02 and GE0.DCPP.01.27 and other evaluations of Transport Route stability.

Estimate of Total Yearly Travel Time of A Loaded Transporter Along the Transport Route: (Ref. Calculation GEO.DCPP.01.02)

Holtec Calculation HI-2002563, Rev. 3, Pg. K-2 shows 1.5 hours to travel between the Power Plant and the CTF. This calculation also conservatively assumes movement of 8 casks per year. Accordingly, we estimate 8 trips at 1.5 hours per trip for a total travel time of 12 hours along the transport route each year.

Transporter for HI-STORM 100 Transfer Cask: (Reference Calculation GEO.DCPP.01.27)

The following criteria applies to movement of the loaded Transporter from the Power Plant to the CTF and along the Transport Route:

1) Cask Transporter Weights:

Transporter weight	170,000 lbs.
Payload weight	275,000 lbs
Total weight:	445,000 lbs

2) Track Contact Surface Area:

Dimensions for each of two tracks	294 inches x 29.5 inches
Total effective contact area for two tracks	10,000 sq. inches
Estimated contact surface pressure	44.5 psi

3) Center to center spacing between tracks: 182 inches

The basis for this information is a 9/28/01 memorandum to the file, "Cask Transporter Track Contact Surface Area Estimate," prepared by Rich Hagler of the UFSP for static, level contact surface bearing pressures and the referenced HI-2002501, "Functional Specification for the Diablo Canyon Cask Transporter," Revision 4, July 30, 2001.

Evaluation of Stability of the Retaining Wall Located Adjacent to the Unit 2 Cold Machine Shop: (Reference Calculation GEO.DCPP.01.27)

The attached PG&E calculation and drawings apply to the evaluation of the retaining wall located adjacent to and to the east of the Unit 2 Cold Machine Shop

1) A copy of PG&E calculation 52.27.14.01, "Cold Machine Shop, Retaining Wall and Stairs," 42 pages, RLOC 02553 1215 thru 1255.

2) 11" x 17" copies of the following PG&E Drawings:

Drawing Number	Revision	Title
516992	8	Finish Grading Plan Cold Machine Shop
516993	3	Yard Facilities & Details Cold Machine Shop

This transmittal is per requirements of DCPP Procedure CF3.ID17.

If you have questions please contact me at (805) 595-6320 or A. Tafoya at (805) 595-6392.

Richard L. Klimczak
Project Engineer
Diablo Canyon Used Fuel Storage Project

Attachments: As listed

cc:	JStrickland	SLO B3	w/o	RKWhite 245 Market N4C, 418B w/o
	BHPatton	SLO BB	w/o	JISun 245 Market N4C, 422A w/o
	AFTafoya	SLO B10	w/o	JCYoung 245 Market N4C, 413C w/o
	CEHartz	SL0 B0	w/o	DCPP Chronological File
	RDHagler	SLO B13		DCPP RMS DCPP 119/1
	[redacted]	245 Market N4C, 422B	w/o	DCPP File No. 72.10.05

ATTACHMENT E

ANSI/ASCE 1-82
ANSI Approved
November 5, 1986

ASCE STANDARD

N-725 Guideline for Design and Analysis of Nuclear Safety Related Earth Structures

OCTOBER, 1988

AMERICAN SOCIETY OF CIVIL ENGINEERS

N-725 Guideline for Design and Analysis of Nuclear Safety Related Earth Structures

Approved April, 1982

Published by the
American Society of Civil Engineers
345 East 47th Street
New York, New York 10017-2398

Each section of this standard discusses site investigations to identify special considerations in performing such work. However, at the end of this Section 3.0 are identified reference materials on site investigations, including laboratory testing, that are generally applicable.

Geophysical exploration methods such as seismic refraction, reflection, and electrical resistivity should be used to locate ground water table, faulting, and determine depth to bedrock (if applicable). The subsurface exploration program should consist of borings, test pits, trenches or inspection shafts to reveal critical stratification, ground water table and obtain representative and undisturbed test samples.

Laboratory testing to determine soil parameters should include standard classification tests, strength tests on undisturbed samples and consolidation testing (if appropriate). In situ strength tests to determine strength parameters are also recommended. Static or dynamic Dutch cone penetration test (CPT) and standard penetration tests (SPT) should be considered to qualitatively evaluate in situ densities of cohesionless soils for correlation with static and dynamic parameters. A qualitative measure must employ a site determined correlation. The ground water table level shall be recorded in selected boreholes, with sufficient time allowed for stabilization of the water level. Any data relevant to the variability of the ground water table and the source of variation should be investigated.

Of particular importance are:

ANSI N 174 "Guidelines for Evaluating Site-Related Geotechnical Parameters for Nuclear Power Sites," Prepared by ANS Committee 2.11, ANSI, 1978

ASCE "Subsurface Investigation for Design and Construction of Foundations of Buildings" Manual No. 56, 1976

ASTM Book of Standards, Part 19, "Natural Building Stones; Soil and Rock; Peats, Mosses, and Humus"

ASTM "Special Procedures for Testing Soil and Rock for Engineering Purposes," STP 479

NRC Regulatory Guide 1.132 "Site Investigations for Foundations of Nuclear Power Plants," U.S. Nuclear Regulatory Commission Office of Standards, Sept. 1977

NRC Regulatory Guide 1.135 "Normal Water Level and Discharge at Nuclear Power Plants," U.S. Nuclear Regulatory Commission Office of Standards, Sept. 1977

ANSI N 45.2.20 "Supplementary Quality Assurance Requirements for Subsurface Investigations Prior to Construction Phase of Nuclear Power Plants," American National Standards Institute, 1979

ANSI N 45.2.5 "Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete, and Structural Steel, Soils and Foundations During the Construction Phase of Nuclear Power Plants QA-76-5" 1978

Code of Federal Regulations 10 CFR 100 Appendix A "Seismic and Geological Siting Criteria for Nuclear Power Plants," U.S. Atomic Energy Commission, November 1973.

4.0 Ultimate Heat Sink Earth Structure—Dams, Dikes, and Embankments

4.1 Scope

4.1.1 Purpose. The purpose of this section is to describe parameters and to present guidelines and criteria to be used in construction of ultimate heat sink structures, and to identify factors which should be considered throughout their conception, siting, design, and operation.

4.1.2 Use and Type of Structures. This section includes earth structures, which are a means of water conveyance, impoundment, diversion or control. These include but are not limited to the following:

(a) cooling water supply reservoirs
(b) essential cooling ponds
(c) essential heat sinks
(d) waste-water retention structures
(e) flood-protection dikes and levees

The maintenance of water retaining function is the prime consideration in the application of these structures.

4.2 Site Investigation. A general discussion of site investigation applicable to all earth structures is presented in Section 3.

4.2.1 Seismology and Geology. General seismic siting criteria are given in 10 CFR 100, Appendix A.[8]

Various other references provide useful information on the requirements, which must be satisfied by a thorough seismologic and geologic investigation.[9, 10]

4.2.2 Hydrology. Structures in combination with their appurtenant works (spillways, overflow sections, etc.) shall be designed to withstand historical and design basis floods as determined in accordance with ANSI N 170.[11]

4.2.3 Geotechnical. In the construction of earth structures, the structure cross section, materials of construction and their graduation, zoning and placement shall be consistent with site geology and foundation conditions. Investigations shall be undertaken and sufficient information obtained so that the engineer can design a structure which meets those requirements. References that discuss required geotechnical investigations in considerable detail should be consulted.[11, 12, 13, 14, 15, 16, 17]

4.3 Materials. The Geotechnical Engineer shall verify that materials used, and the specified manner in which they are used and placed, are compatible with the design. References that discuss selection of materials and appropriate cross sections and zoning include references 11 and 12 through 19.

Locally available materials may be used if they are appropriate. The embankment should be properly zoned to provide the following:

(a) an impervious zone
(b) transition zones between core and shells
(c) seepage control
(d) static and seismic stability
(e) wave protection.

Laboratory tests shall be conducted to evaluate required characteristics of various materials to be used in construction of embankments; these include classification tests and tests to evaluate gradation, compaction, strength and compression characteristics of the various types of materials.[12, 18, 20, 21, 24]

4.4 Design

4.4.1 Design Parameters.Parameters to be established for the design and safety evaluation of dams, dikes and baffles shall include the following:

(a) a geotechnical profile along the entire length of the structure foundation and across the structure foundation at ¼ the width in equal intervals, or more, in order to provide a basis for design
(b) soil properties sampled and tested under anticipated environmental and loading conditions including strength, compressibility, permeability and durability
(c) the potential for ground surface rupture or displacement due to geologic factors
(d) ground surface vertical and horizontal acceleration and damping coefficients for the SSE
(e) the design depth of water for the structure
(f) the height, length and period for the design wind = generated wave
(g) the characteristics of the maximum probable wave which could impinge upon the structures (i.e. average of highest one percent of all waves, H_1, or tsunami, or dam = break wave[11])
(h) properties and qualities of available cast shapes, rubble, stone, rock and filter materials used for construction of the structure
(i) cross sections showing structure geometry and composition of materials
(j) liquefaction potential of structure/soil foundations under (a) the SSE and (b) hydrodynamic changes in effective stress
(k) stability of the structure and its foundation under all design loading conditions (including hydrodynamic force systems associated with the SSE)

(l) ability of the structure to withstand continual hydrodynamic forces without relative movement of its internal components, which are sufficient to cause structural failure.

4.4.2 Operating Conditions. Operating conditions for impoundments will vary according to purpose, location (on-stream or off-stream) and other conditions unique to the plant being considered. These conditions may influence design of the structure as well as loading conditions, factors of safety-slope protection, materials of construction, zoning, seepage analyses, and other parameters. They may influence the design of ancillary facilities. The Geotechnical Engineer shall consider all normal operating conditions in design of the structure, as well as anticipated transients, abnormal and extreme environmental conditions, which are considered as design basis during the life of the structure (as defined by the Owner in the design specifications).

4.4.3 Static Loading Conditions. The following conditions shall be considered for dams and dikes:

(1) During construction
(2) End of construction
(3) Sudden drawdown from spillway crest to minimum pool evaluation: This may not be necessary if size of outlet or other passive means does not permit sudden drawdown. The relative permeability of the dam's upstream material and the potential rate of the maximum drawdown should be considered.
(4) Sudden drawdown from top of spillway gates to crest of spillway (if any), if such a condition could occur.
(5) Full reservoir or partial pool, downstream slope, steady seepage: The critical case should be determined through a parametric study of the factors influencing the selection of condition. Generally, the full reservoir case will govern unless it is an assured temporary condition. Steady seepage with a reservoir surcharge may fall into this category.
(6) Sudden drawdown on downstream slope: This case may occur where the downstream toe is subject to prolonged flooding and then rapid reduction of the toe water level. This case will not normally be critical where the downstream toe is relatively porous.

4.4.4 Static Stability and Performance

4.4.4.1 Dams and Dikes. Factors of safety for embankment stability studies should be based upon the ratio of available strength to applied stress or other load effects. The minimum factors of safety for the static loading conditions listed in Paragraph 4.4.3 shall be as follows:

Condition	Minimum Factor of Safety
1	1.1
2	1.3
3	1.0
4	1.2
5	1.5
6	1.2

In using these minimum recommended safety margins the Geotechnical Engineer should have a high degree of confidence in the reliability of the values used for the following parameters:

(a) type and gradation of material (identification)
(b) thoroughness and completeness of field exploration and laboratory testing (performance of materials)
(c) loading conditions
(d) degree of control and workmanship expected.

4.4.4.2 Baffles. For baffles (or dams which may be submerged), the fully submerged and drawdown conditions shall be considered. The effects of the failure of an earth structure upon the containing dike shall also be considered. Consideration shall be given to the flow of water through and over the earth structure. The minimum factor of safety of the baffle and its containing dike (or dam) shall be the same, or greater, as for the dike (or dam) itself.

4.4.5 Dynamic Loading Conditions. The effects of earthquake-induced forces, currents, floating debris, and wave action on behavior and peformance of safety class earth dams, dikes and baffles must be considered. The postulated failure conditions due to a dynamic load to be evaluated are as follows:

(1) Failure due to disruption of the structure by major differential fault movement in the dam foundation.
(2) Slope failure induced by SSE vibratory ground motions.
(3) Sliding of structures on weak foundation materials or materials whose strength may be reduced by liquefaction.
(4) Piping failure or seepage through cracks induced by ground motions.
(5) Overtopping of the structure due to seiches in the reservoir, slides or rock-falls into the reservoir or failure of the spillway or outlet works.

Other dynamic-induced forces to be considered in design are:

(a) transfer of momentum effects from moving currents at design maximum flood condition
(b) impact of any postulated floating missiles at design maximum flood condition
(c) design wave load effect (including the effect of wave frequency and momentum).

In general, failure mode (1) is precluded by siting restriction. While earth structures tend to be able to accommodate relatively large differential ground motion, at the present time there is no acceptable design procedure that would accommodate major differential fault movement in the reservoir embankment foundation. If the dam or dike is sited in a region (as defined by Federal Regulation) where such differential fault motion is credible, the dam or dike shall be assumed to fail.

4.4.6 Dynamic Stability and Performance. During an earthquake, large cyclic inertia forces are induced in an earth dam. These forces may be sufficiently large and may occur with sufficient cycles to produce excess pore water pressures or cause a reduction in shear strength of certain types of materials used in construction of an earth structure. Depending on the severity of the ground vibratory motions and the types of embankment materials, small to large permanent deformations of the embankment could occur during or after an earthquake. In loose saturated cohesionless soils complete loss of strength may occur, leading to failure of an earth structure. This same phenomena could also result from the effects of dynamic wave action, although the dynamic frequency characteristics of wave action make it a much less likely occurrence. Dams containing cohesive materials or well-compacted and graded materials generally suffered little or no damage as a result of strong ground shaking.[illegible] In assessing the safety of an earth dam during and after an earthquake (or other dynamic loading) the following factors should be considered:

(a) the magnitude and type of anticipated loading
(b) the degree of confidence in the method of analysis used in definition of material and design parameters.

The following minimum factor of safety is specified for the dynamic loading conditions listed in Section 4.4.5.

Condition	Minimum Factor of Safety
1	Precluded by siting criteria*
2	1.3
3	1.3
4	1.2
5	1.3

*Must evaluate based on the impact of a failure

4.5 Analytical Methods

4.5.1 Methods of Static Analysis. Various analytical methods for evaluating the static stability of an earth dam exist.[illegible] The state of the art of static analytical methods is probably substantially more advanced than other facets of dam design, and for a given set of input data, most of these acceptable techniques will give results consistent with each other.

The method utilized shall be compatible with the anticipated mode of failure, dam cross-section and soil test data. The complexity of the method selected should also be consistent with the size of the structure. Whichever method is used, the Geotechnical Engineer shall state the justification for the method used.

Analyses shall be performed for the various loading conditions given in Section 4.4.3. The critical failure surface shall be presented for each case together with its corresponding factor of safety. The analyses shall take into consideration such variables as material types used for each zone of the dam, dam geometry, variability of soil properties (including location of phreatic surface and variation of pore pressures within the embankment).

4.5.2 Methods of Dynamic Analysis. Various methods of analysis are available for evaluating the seismic stability of an earth dam.[27 through 34] These may be classified as follows:

(a) pseudo-static methods
(b) simplified procedures
(c) dynamic response analyses.

Conventional pseudo-static methods of analysis are acceptable if the seismic coefficient selected appropriately reflects the geologic and seismologic conditions of the site and if the materials are not subject to significant loss of strength under dynamic loads. Values of shear strength[illegible] used in this type of analysis should reflect any anticipated loss of strength due to the postulated design earthquake.

Although pseudo-static methods of analysis are simple to use, they do not provide information on the magnitude of permanent deformations, which would develop within the embankment as a result of an earthquake. Where this information is of importance, methods (b) and (c) should be used. In recent years several simplified procedures have been developed based on Newmark's original concept of cumulative deformation.[27, illegible] These simplified procedures may be used for earth dams constructed of materials that are not subject to significant loss of strength due to cyclic loading. (These include cohesive soils and well-compacted materials).

Dynamic response analyses using state-of-the-art methods shall be conducted for those dams located in highly seismic areas (or constructed of materials that could undergo significant loss of strength due to cyclic loading; i.e., hydraulic fill dams and tailing dams). Finite element techniques have been widely used for this purpose (although in recent years finite difference methods have also been developed.[30, illegible, 40] Appropriate dynamic material properties and ground motion parameters defined for the site shall be used in analyses. Considerable experience and engineering judgment are necessary in assessing the stability of an earth dam based on the results of a complex computer dynamic response analysis. In all cases, the results of such analyses shall be verified by general equilibrium checks.

5.0 Site Protection Earth Structures—Dams, Dikes, Breakwaters, Seawalls, Revetments

5.1 Scope

5.1.1 Purpose. The purpose of this Section is to describe criteria to be used as a guide in the design, evaluation and construction of those dams, dikes, breakwaters, seawalls and revetments classified as Seismic Category I. This standard is intended to identify factors to be considered in the construction of those structures and should in no way limit the investigation and analysis deemed necessary for determination of the suitability of such a structure and its site.

5.1.2 Use and Type of Structures. Dams, dikes, breakwaters, seawalls, and revetments are intended primarily to protect the nuclear plant site from hydraulic loads.

5.2 Site Investigations. A general discussion of site investigations can be found in Section 3.0. The investigation of sites for hydraulic protection earth structures shall be conducted in conformance with the following basic guidelines.

5.2.1 Waterfront Associated Parameters. These consist of natural shore and offshore zone characteristics, water motion characteristics, and shorefront behavior patterns. These shall be evaluated in conformance with Ref. 40. Investigation requirements shall be sufficient to clearly define the following basic waterfront associated parameters:

(a) coastal area and offshore profiles from the land bluff or escarpment for a sufficient distance offshore to define that depth of bed below stillwater level which can control the design wave form
(b) bathymetric and topographic contour maps of bed area sufficient to define the immediate influence of such features upon design of the structure
(c) natural protection features influencing water waves and flood
(d) exposure to storm attack
(e) characteristics of water waves, currents, surges and floods influencing the earth structure
(f) rate and composition of littoral transport and drift
(g) long-term stability of shoreline in terms of erosion or accretion rates.

Water and water level investigation requirements for design of the above structures shall include the following basic information:[m]

(a) stillwater or mean water level
(b) astronomical tide data
(c) seiche, wave setup and storm surge predictions
(d) design maximum flood elevation.

A determination of wind-generated water wave conditions as a basis for design shall include:[m]

(a) evaluation of all wave data applicable to the project site
(b) determination of the significant wave height and range of periods for the wave spectrum
(c) determination of the design depth of water at the structure
(d) determination of the design wave height, direction and condition (breaking, nonbreaking or broken) at structure site
(e) analysis of the frequency of occurrence of design conditions.

5.2.2 Geotechnical. Geotechnical parameters consisting of geologic, groundwater, foundation engineering and earthwork parameters shall be evaluated in conformance with Ref. 2.

Geotechnical investigation shall be sufficient to clearly define the following basic items:

(a) subsurface profiles along the length of the structure, and subsurface sections across the structure, prepared in a manner sufficient to define the spatial arrangement of soil and rock materials that could influence the structure design or safety
(b) detailed geologic and engineering descriptions of each material identified on the subsurface profiles and sections
(c) definition of physical properties, strength characteristics, and dynamic properties of the soil and rock materials defined on the subsurface profiles.

In establishing geotechnical site design parameters, if structures being considered are not at the nuclear plant site, then a literature review and search equivalent to that performed to develop nuclear plant site design parameters shall be undertaken to establish appropriate geologic, seismic, and natural phenomena.

Establishment of detailed geotechnical characteristics of subsurface materials shall include:

(a) surface geophysical surveys
(b) exploratory borings and excavations
(c) borehole geophysical surveys
(d) sampling of soil and rock materials
(e) the in-situ testing of soil and rock materials
(f) the laboratory testing of soil and rock materials.

Specific techniques and references applicable for each of the above outlined in reference (4) Special Procedures.

5.3 Materials. The investigation of soil, precast, armour, rock, rubble or stone for the construction of earth waterfront structures shall be sufficiently extensive to identify sources of adequate quality and volume for each of the required materials. Selection of a structure type and determination of the feasibility of the structures are dependent upon an adequate source and its associated quality. In general, Section 4.3 material selection requirements are equally applicable to site protection structures.

5.4 Design. Parameters to be established for the design and safety evaluation of dams, dikes, breakwaters, seawalls, revetments are generally the same as those given in Section 4.4.

5.4.1 Operating Conditions. Design conditions for site protection structures are generally those associated with extreme hydrological phenomena. However, normal operating conditions (which include erosion, weathering seepage or other normal operating phenomena that would affect performance of the protective structure) shall be considered in design.

5.4.2 Static Loading Conditions. The following conditions shall be considered for protective structures:

(1) During construction
(2) End of construction
(3) Design maximum flood evaluation as a hydrostatic load
(4) Load case where maximum design surcharge is present and water level is at its design minimum elevation.

5.4.3 Static Stability and Performance. Factors of safety for structural capacity should be based upon the ratio of available strength to applied stress or other load effects. The minimum factors safety for the static loading condition listed in Paragraph 5.4.2 shall be as follows:

Condition	Minimum Factor of Safety
1	1.1
2	1.3
3	1.2
4	1.5

In using these minimum recommended safety margins the Geotechnical Engineer should have a high degree of confidence in the reliability of values used for the following parameters:

(a) type and gradation of material
(b) thoroughness and completeness of field exploration and laboratory testing
(c) certainty of loading conditions
(d) degree of control and workmanship that can be assured.

5.4.4 Dynamic Loading Conditions. The dynamic force applicable to site protection structures are the same as those considered in Section 4.4.5.

5.5 Analytical Methods. The analytical methods applicable to ultimate heat sink structures are also applicable to site protection structures.

6.0 Site Contour Earth Structures—Retaining Walls, Natural Slopes, Cuts and Fills

6.1 Scope.

6.1.1 Purpose. The purpose of this Section is to describe criteria to be used as a guide in the design, evaluation and construction of those site contour control structures such as retaining walls, slopes, cuts and fills (classified as Seismic Category I). This standard is intended to identify factors to be considered in construction of those structures and should in no way limit the investigation and analysis deemed necessary for determination of the suitability of such a structure—or the effect such an earth structure would have on other nuclear plant structures.

6.1.2 Use and Type of Structure

6.1.2.1 Retaining Walls. A retaining wall is any permanent structural element built to support an earth bank that cannot support itself. It is used primarily to control site contours and may have specific application to construction of elevated or depressed roadways, erosion protection facilities, bridge abutments and retaining potentially unstable hillsides. Principal types of retaining walls considered in this standard include gravity walls, semigravity walls, cantilever walls, counterfort walls, buttressed walls, crib and bin walls, reinforced earth walls and anchored (or tie back) walls. The emphasis in this Section is on the design of earth structures used as retaining walls, and determination of loads on walls made of other materials.

6.1.2.2 Natural Slopes, Cuts and Fills. Natural slopes considered in this section are any landforms existing on, or adjacent to, the proposed site. A cut slope is any slope resulting from the excavation of in situ soils. Manmade fills are provided to maintain site grade. Slopes, cuts and fills covered by this specification are provided primarily to maintain site contours (and whose failure would adversely affect the function of any safety related nuclear plant structure).

6.2 Site Investigation. A general discussion of site investigation applicable to all earth structures is presented in Section 3.0.

6.2.1 Seismology and Geology. General seismic geology siting criteria are given in 10 CFR 100, Appendix A.[8] Various other references provide useful information on requirements that must be satisfied by a thorough seismologic and geologic investigation.[9, 10]

6.2.2 Hydrology. Earth structures used as retaining walls, slopes, cuts and fills are particularly sensitive to surface water erosion and groundwater level and movement. Such structures shall be designed to withstand historical and design basis flooding and precipitation in accordance with ANSI N 170.[11]

6.2.3 Geotechnical. In the construction of earth structures it is imperative that the structure cross-section, materials of construction and their gradation, zoning and placement be consistent with site geology and foundation conditions. Investigations shall be undertaken and sufficient information obtained so that the engineer can, with confidence, design a structure meeting those requirements. References discussing the required geotechnical investigations in considerable detail should be consulted.[21, 22, 23, 24, 25, 26, 27, 28]

Since natural slopes and cuts consider the use of in situ materials, available literature and information concerning the foundation geology of the soils (and of rocks on the site) shall be consulted. Past records of construction in the area and old well logs shall also be examined. Airphoto interpretation and site reconnaissance should be completed to reveal old slide scarps or other evidence of slope movements. Cross-sections and profiles of the slope should be made in sufficient quantity and detail to represent the slope and foundation conditions.

6.3 Materials. Section 4.3 material selection requirements are equally applicable to retaining walls, slopes and fills.

6.4 Design

6.4.1 Design Parameters. Parameters to be established for the design and safety evaluation of retaining walls, natural slopes, cuts and fills shall include the following:

(a) a geotechnical profile along the entire length and across the structure at intervals not to exceed 250 feet, which is adequate to serve as a basis for design
(b) the potential for ground surface rupture or displacement due to geological factors
(c) ground surface acceleration value for the SSE
(d) properties of available cast shapes, rubble, stone, rock, in situ and filter materials used for construction of the structure
(e) cross-sections showing structure geometry and composition of materials
(f) liquefaction potential of the earth structure and its foundation under (a) the SSE and (b) hydrodynamic changes in effective stress caused by the maximum design event
(g) stability of the structure and its foundation under hydrodynamic and surcharge force systems associated with maximum design event
(h) hydrological parameters shall be in accordance with ANSI N 170.[11]

6.4.2 Operating Conditions. Operating conditions for contour control structures will vary according to the purpose, location and other conditions unique to the plant being considered. These conditions may influence the design of ancillary facilities. The Geotechnical Engineer shall consider all normal operating conditions in design of the structure, as well as anticipated transients, abnormal and extreme environmental conditions considered as design basis during the life of the structure.

6.4.3 Static Loading Conditions. The following conditions shall be considered for contour control structures:

(1) During construction
(2) End of construction
(3) Maximum design surcharge to include any loading above grade by earth, material, structure, equipment and vehicles for design against sliding
(4) Load condition 3 coincident with most disadvantageous ground water design level
(5) Maximum design surcharge to include any loading above grade by earth, material, structure, equipment and vehicles for design against overturning
(6) Load condition 5 coincident with most disadvantageous ground water design level
(7) Design maximum flood and precipitation as a hydrostatic load.

6.4.4 Static Stability and Performance. Factors of safety for slope stability studies should be based upon the rate of available strength to applied stress or other load effects. The minimum factors of safety for the static load conditions listed in Section 6.4.3 shall be as follows:

Condition	Minimum Factor of Safety
1	1.3
2	2.0
3	1.5
4	1.3
5	2.0*
6	1.8
7	1.0

*For foundation failure by bearing in clay use a F.S. of 3.0. In using these minimum recommended safety margins the Geotechnical Engineer should have a high degree of confidence in the reliability of the values used for the following parameters:

(a) type and gradation of material
(b) thoroughness and completeness of field exploration and laboratory testing
(c) certainty of loading conditions
(d) degree of control and workmanship that can be assured.

6.4.5 Dynamic Loading Condition. The effects of earthquake-induced forces, dynamic surcharge loadings and the dynamic effects of the Design Maximum Flood and Precipitation[m] must be considered. The postulated loading conditions due to dynamic loads to be evaluated are as follows:

(1) Failure due to disruption of structure by major differential fault movement due to a SSE
(2) Slope failure induced by SSE vibratory ground motion
(3) Sliding of the earth structure on weak foundation materials or materials whose strength may be reduced by liquefaction
(4) Failure due to dynamic surcharge load effects if any
(4) Failure due to dynamic loads associated with the Maximum Design Flood or Precipitation.

6.4.6 Dynamic Stability and Performance. During an earthquake, or in response to other dynamic load phenomena, large cyclic forces may be induced in a slope or fill. These forces may be sufficiently large and may occur with a sufficient number of cycles to produce excess pore water pressures or reduction in shear strength of certain types of materials used in construction of an earth structure. Depending on the severity of the ground vibratory motions and the types of embankment materials, small to large permanent deformations of the embankment could occur during or after an earthquake. In loose saturated cohesionless soils complete loss of strength may occur, leading to failure of an earth structure. This same phenomena could also result from the effects of dynamic wave action although the dynamic frequency characteristics of wave action make it a much less likely occurrence. Structures containing cohesive materials or well-compacted and graded materials generally suffered little or no damage as a result of strong ground shaking.[m]

In assessing the safety of an earth structure during and after an earthquake—or other dynamic loading—the following factors should be considered:

ATTACHMENT F

Subject: Transporter Model Calculations | Project No. 6427.008D
By L.S. | Checked By C.J. Chang | Task No. GEO. DCPP.01.23
Date 2/29/03 | Date 3/4/03 | File No. Rev 3
Sheet 2 of 3

Information from PG&E letter dated October 3, 2001:

Total weight of transporter = 445,000 lb

Transporter is supported on two tracks -

Dimensions of each track = 294 in X 29.5 in (24.5 ft x 2.5 ft)

Total effective contact area for two tracks = 10,000 in^2 (69.4 ft^2)

Estimated contact surface pressure = 44.5 $\frac{lb}{in^2}$ (6,408 $\frac{lb}{ft^2}$)

Center to center spacing between tracks = 182 in (15.17 ft)

See Sheet 2 for layout of tracks -

Calculate total surface area of two tracks -

294 in x 29.5 in x 2 = 17,346 in^2 (120.5 ft^2)

However the effective contact area is only 10,000 in^2

Calculate the weight or mass on a 1-foot length of transporter for incorporation into the stability analyses.

To be conservative, assume that the full width of each track is effective and that the reduced effective contact area results in a reduction in length of each track but not width

Total force acting on a 1-foot segment of the transporter length

29.5 in X 12 in x 2 x 44.5 $\frac{lb}{in^2}$ = 31,506 lb/foot length

Calculate dimensions for weight (mass) model for transporter

Assume width = 17.625 ft or about 18'

Assume height = 12 ft (no information available on this)

Unit Weight = $\frac{31,506 \text{ lb}}{18 \text{ ft} \times 12 \text{ ft}}$ = 145.8 $\frac{lb}{ft^3}$ - say 150 $\frac{lb}{ft^3}$

GEOMATRIX CONSULTANTS

Subject Transporter Model Calculations

By L.S.

Date 2/29/03

Checked By

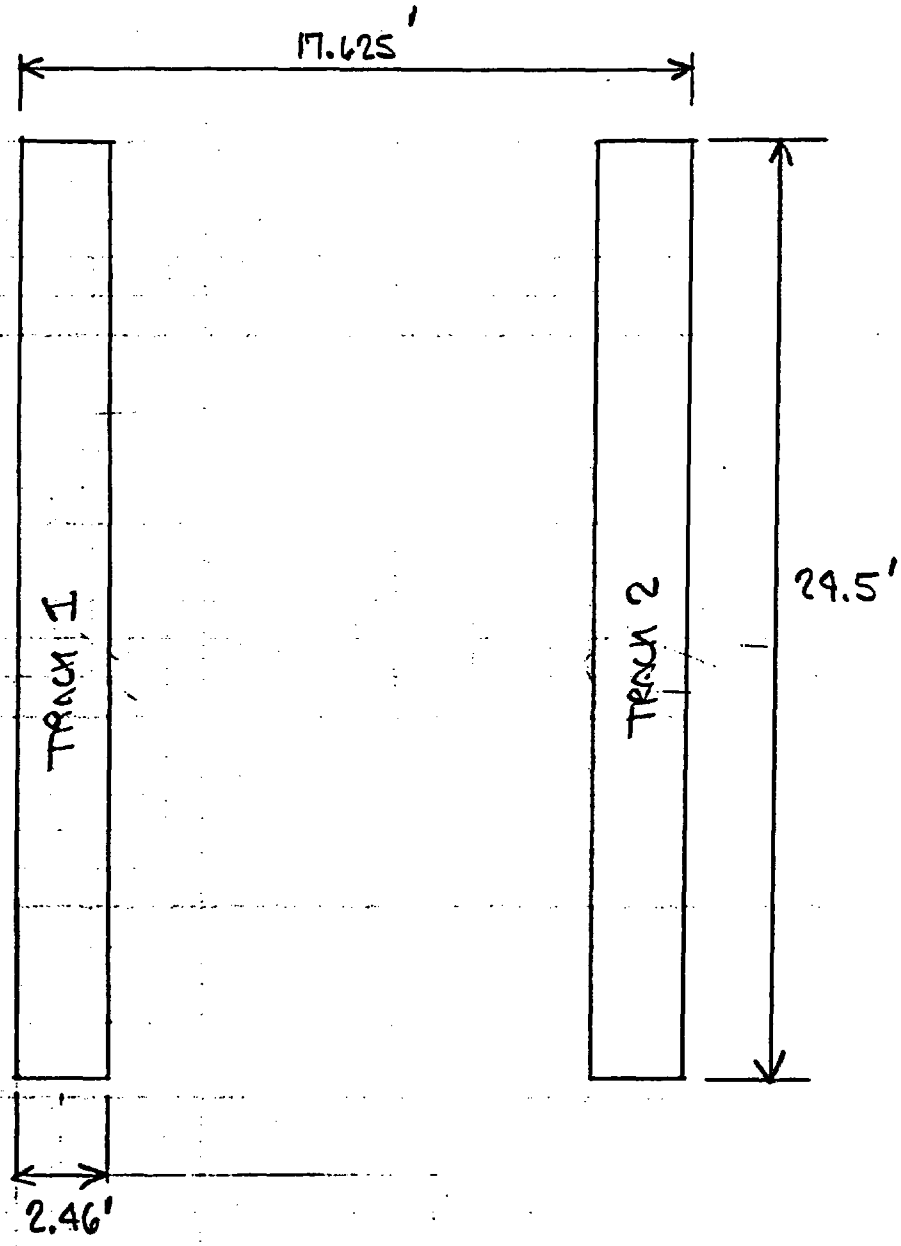
Date

Project No. 6427.00Bp

~~Task No.~~ GEO.DCPP.01.28

~~File No.~~ Rev. 3

Sheet 3 of 3



ATTACHMENT G

GEO.DCPP.01.26, Rev 3
Attachment G

Pacific Gas and Electric Company

Geosciences Department
245 Market Street, Room 422B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
Tel: (415) 973-2480
Fax (415) 973-5778

Dr. Faiz Makdisi
Geomatrix Consultants
2101 Webster Street
Oakland, CA 94612

March 17, 2003

RE: Transmittal of Cross Section M-M' and Rock Mass Models for Stability Analysis of Transport Route on Rock

Dear Faiz,

Transmitted herewith please find the cross section (Section M-M') and two rock mass models developed by William Lettis Associates (WLA) for slope stability analysis of the northern alignment of the transport route on rock. Electronic files for the Figures TR-1 thru TR4 (in pdf format) were forwarded to you on March 14 via the e-mail with the subject title of "FW: Transport Route Memo. Figs." The full documentation on the cross section development of modeling of the rock masses is attached to this transmittal.

Please use Cross section M-M' (Figure TR-2) to develop the analytical profile, and Model 1 (Figure TR-3) and Model 2 (TR-4) as potential sliding masses in your stability analysis.

If you have any questions, please feel free to call.

Joseph Sun

Attachment:
Memorandum from Jeffrey L. Bachhuber (William Lettis and Associates, Inc) to William Page (PG&E), PG&E Diablo Canyon ISFSI Response to NRC Review Request No. 5 – Transport Route Rock Slope Stability, Rock Mass Models, March 14, 2003.

Memorandum

Pacific Gas and Electric Company

Geosciences

245 Market Street, Room 410A
San Francisco, CA 94105

Mailing Address
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177

415.973.2792
Fax: 415.973.5778

Date: March 17, 2003

To: JOSEPH SUN
Geosciences Technical Coordinator for the DC ISFSI Project

From: WILLIAM D. PAGE
Senior Engineering Geologist, Geosciences Department

Subject: ITR of NRC Review Request No. 5 - Transport Route Rock Slope Stability, Rock Mass Models.

Dear Joseph:

As the Independent Technical Reviewer for NRC Request No. 5, I have completed my review of Mr. Jeffrey L. Bachhuber's Technical Memorandum dated March 14, 2003, titled:

> PG&E Diablo Canyon ISFSI Response to NRC Review Request No. 5 - Transport Route Rock Slope Stability, Rock Mass Models.

I find the approach to selecting and delineation of the potential rock mass models follows procedures established for the analysis of the ISFSI Site Area that are presented the SAR. The portrayal of the clay beds used in the models is conservative because any evidence of clay in the Boring HLA-9 is inferred to be a clay bed and not from other origins (i.e., analysis of clays in the borings for the ISFSI shows that many clay zones in the strata are filling joints or related to faults as shown in Data Report, Table B-4). The dip of the strata is accurately shown and the section is drawn generally down dip, along a steep portion of the slope. The depiction of potential rock mass models for stability analyses is logical and kinematically reasonable.

My technical and editorial review comments provided to Mr. Bachhuber in my emails of March 5, 2003 (addressing the February 28 draft of the technical memo) and March 14, 2003 (addressing the March 12 draft of the technical memo) have been satisfactorily addressed and there are no outstanding issues.

It is a pleasure to provide the project with this review. If you have questions, please do not hesitate to ask.

WILLIAM D. PAGE
223-36784

WLA

William Lettis & Associates, Inc.

1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
Voice: (925) 256-6070 FAX: (925) 256-6076

March 14, 2003

Dr. William D. Page
PG&E Geosciences Department
245 Market St., Room 421, N4C
San Francisco, CA 94177

RE: Technical Memorandum: Response to NRC Request No. 5 – Transport Route Rock Stability, Rock Mass Models

Dear Dr. Page:

Attached is a final version of the William Lettis & Associates, Inc. (WLA) technical memorandum "PG&E Diablo Canyon ISFSI Response to NRC Review Request No. 5 – Transport Route Rock Slope Stability, Rock Mass Models". This technical memorandum was performed under our CWA contract No. 1223-92, and was requested by PG&E to develop the technical basis and input geologic cross section and models for evaluating the stability of the portions of the ISFSI Transport Route underlain by bedrock. The attached version addresses all your comments sent to me on March 5 and March 14, 2003. A list of your comments, and my responses, is also attached to this letter.

Please call me at 925-256-6070 if you have any questions. Thank you very much,

Sincerely,

Jeffrey L. Bachhuber, C.E.G.
Principal Engineering Geologist

Attachment: Review Response List, Final Draft Technical Memorandum

WLA

RE: Response to W.D. Page comments on Draft Technical Memorandum: Response to NRC Request No. 6 – Transport Route Rock Stability, Rock Mass Models

By: Jeff L. Bachhuber March 14, 2003

The primary identified issues from your March 5 and 14, 2003 reviews of the memorandum, and my responses, are listed below.

1. "The map needs the strikes and dips used in the cross sections added to it so the reader can see them and not refer to the Site Geology map."

The strikes and dips used in cross section M-M' have been added to the final plan map Figure TR-1.

2. "The clay beds in boring 01-H need to be extended to follow the formula used for drawing clay beds (they are chopped off to the west)."

The cross section procedure actually stipulates that clay beds encountered in one boring, but not on an adjacent boring, be terminated in the cross section at a point mid-way between the two borings. Boring 01-B was projected a greater distance into the cross section, but the clay beds were still terminated at the mid-way point to adhere to the cross section criteria.

3. "The old preconstruction topography line on the section appears to be in error. I do not see how it can have been above the marine terrace. I sketched what I thought was reasonable on the Fax that I sent yesterday and discussed it with Charlie."

We replotted the original topography from the pre-construction Towill maps by registering cross section M-M' on the Towill map using the State of California northing and easting grid lines. The original ground topographic profile resulting from this process did not match the unmodified portions of the as-built cross section, and I adjusted the profile to achieve a visual best fit. The resulting profile has a somewhat lower elevation in the area of the Transport Route and Q_5 marine terrace, but still shows that significant excavation occurred in this area. Because the marine terrace exists at the margin of the excavation, it could have also been cut during the site grading. In fact, it appears that parts of the terrace have been nearly, or completely, removed by the past grading.

The modified pre-construction profile is shown on the attached final cross sections. The modified pre-construction profile does not impact the stability analyses of rock mass models because the analysis is based on the existing as-built profile that has not changed.

4. "explain why Section M-M' is not perpendicular to the slope".

This, and other editorial comments, were integrated into the final memorandum text.

TO: Dr. William D. Page – PG&E Geosciences

FROM: Jeffrey L. Bachhuber – William Lettis & Associates, Inc.

DATE: 14 March, 2003

RE: PG&E Diablo Canyon ISFSI Response to NRC Review Request No. 5 – Transport Route Rock Slope Stability, Rock Mass Models

1.0 Introduction

This memorandum presents the results from the William Lettis & Associates, Inc. (WLA) development of stability models for evaluation of the bedrock slope stability under the ISFSI Transport Route. This work was performed at the request of Pacific Gas & Electric Company (PG&E) under Contract Work Authorization No. 1223-92. Specific tasks included:

- Review of NRC request for information;
- Review of existing geologic cross sections and data in Calculation Package 0.21, Rev. 2, dated December 14, 2003;
- Selection and preparation of the analyses cross section M-M';
- Development of alternative slide mass models; and,
- Preparation of this memorandum.

Development of the slide mass models was performed by Mr. Jeff L. Bachhuber, C.E.G. Internal WLA review was performed by Dr. William R. Lettis, C.E.G., and Mr. Charles M. Brankman, R.G. Dr. William D. Page, C.E.G. of PG&E Geosciences Department provided Independent Technical Review (ITR).

2.0 NRC Request for Information

This memorandum presents the technical basis and input cross section for slope stability modeling in response to NRC Request No. 5 "provide an assessment of the long term stability of the subsurface materials under the transport route for sections of the transport route underlain by bedrock, considering the transporter loading superimposed on the long-term static loading."

3.0 Review of Existing Information

In preparation of the new cross section for stability analysis, existing data were reviewed from the ISFSI Safety Analyses Report, supporting documents, and WLA project file. Of particular relevance was existing cross section B-B''' included in GEO.DCPP.01.21, rev 2. Subsurface information shown on this cross section is based on geologic mapping and borings completed during the ISFSI studies, and previous studies by Harding-Lawson Associates (HLA) in 1973 and 1970 (Hagler, Richard D., February 26, 2003 Transmittal Letter for HLA borings). The locations of borings in the analyses section area are shown on Figure TR-1.

4.0 Selection of Cross Section Location

Several criteria were used to locate the analyses section M-M'(Figure TR-1). These criteria include:

- The cross section should cross the Transport Route where it is located on near-surface bedrock;
- The cross section should cross the hillslope where bedrock bedding dips downslope, permitting kinematically possible sliding along clay beds; and,
- The cross section should cross the steepest topography that meets the first two criteria.

5.0 Development of Cross Section M-M'

Analyses Cross Section M-M' (Figure TR-2) was developed according to the procedures described in GEO.DCPP.01.21, rev. 2. That portion of section M-M' downhill, and west of, the Transport Route aligns with the location of existing cross section B-B''' presented in GEO.DCPP.01.21, rev. 2. The topography for this part of M-M' was taken directly from section B-B'''. The geology along this part of the cross section was modified from section B-B''' to reflect more detailed analyses of available borings. Uphill of the Transport Route, the location of the eastern part of section M-M' deviates from section B-B''' by continuing straight uphill, rather than making a 90 degree northward bend. The topography and geology for the upper part of the section was derived from the Site Geologic Map, Figure 21-4 and section B-B''' in GEO.DCPP.01.21, rev. 2. Subsurface information was compiled from test pits and borings that are located within 100 feet of cross section M-M', and was projected at a right angle into the section line. The original boring logs from the investigation by HLA (1970, 1973) and from the ISFSI investigations (Data Report B, William Lettis & Associates, Inc., 2001) were reviewed, with particular attention to occurrences and characteristics of clay beds and seams, and subsurface bedding dip directions. In addition, the nearest bedding measurements from surface outcrops were also used to establish control for bedrock structure in the near surface. Clay beds were extended from the borings in accordance with the criteria presented in GEO.DCPP.01.21, rev. 2 and as was done for the cross sections through the slope above the ISFSI:

> Clay beds >1/4-inch thick – extended for 100 feet as a solid line and 100 feet as a dashed line from surface exposure, and to both sides of borings;
>
> Clay beds 1/8 - to 1/4-inch thick – extended for 50 feet as a solid line and 50 feet as a dashed line from surface exposures, and on both sides of borings; and,
>
> Clay beds <1/8 -inch thick – extended for 25 feet as a solid line and 25 feet as a dashed line from surface exposures, and on both sides of borings.

Clay beds are shown with shorter lateral continuity where they are known to be absent in adjoining boreholes. In these instances, the clay beds were extended to a point halfway between the two borings.

Two primary rock units are present on section M-M': dolomite (Tofb-1), and sandstone (Tofb-2) (Figure TR-2). The dolomite is present as a thin sequence in the upper part of the cross section. Most of the section, including the Transport Route is underlain by sandstone. Postulated slide mass models used for the stability analysis are located along clay beds entirely within the sandstone unit. Sandstone is exposed in the 15- to 20-foot high bedrock cutslope along the uphill margin of the Transport Route bench. Below the Transport Route, cross section M-M' extends across a small bedrock syncline, and the bedrock is covered by colluvium and Pleistocene fan deposits (Figure TR-2).

The location of the cross section is oriented in the downdip direction of bedding and inferred clay beds, and is skewed somewhat (about 10 to 20 degrees) from the topographic downslope direction. The downdip direction of bedding and clay beds is believed to provide the primary structural control for rock model sliding direction, and exerts a greater influence on the stability analyses than the skewing of the cross section location relative to the topographic downslope direction.

6.0 Rock Mass Sliding Models

6.1 Kinematic Stability Analysis

A suite of slide mass models were considered for stability analyses based on evaluation of kinematically-permissible failure modes and geologic conditions. Kinematic analyses methodology and results are discussed in Calculation Package GEO.DCPP.01.22, rev. 2. All rock mass slide models involve failure surfaces controlled by geologic structure (bedding) and inferred clay beds, and involve movement of a substantial amount of rock below the Transport Route bed. The northernmost part of the Transport Route that is founded on shallow bedrock crosses the axis of a bedrock syncline at about Station 46+10 (Figure TR-1). South of the syncline axis and on the south limb of the fold, bedrock dips into the hillside and large-scale rock sliding along bedding or clay beds is not kinematically feasible. No other persistent discontinuities were observed in the bedrock in this area that could serve as potential sliding planes. Therefore, large scale bedrock sliding south of Station 46+10 is unlikely, and was not considered for modeling.

North of Station 46+10 on the north limb of the syncline, bedding and potential clay beds dip downslope to the southwest to the direction to a point about midway between the Transport Route and power plant where the section crosses the syncline fold axis (Figure TR-2). The dip of the bedding and clay beds on the lower slope below the syncline axis is oblique into the slope, inhibiting bedding plane and clay bed sliding and constraining the daylighting locations of the slide mass models to the part of the slope east of the syncline axis. All proposed models therefore toe-out above the location of the syncline axis.

6.2 Model Basal Slide Planes

Basal failure planes for each slide mass model are located along clay beds or clay zones that are interpreted to exist from evaluation of exploratory borings. Although no clay beds were observed in outcrop above or below the Transport Route, they are assumed to occur within the slope as interpreted from the borings. The controlling clay beds for the analysis were interpreted from boring HLA-9 (Figures TR-1; TR-2), and consist of five clay zones documented in the original boring log (Attachment A). These potential clay beds are summarized in Table 1. The clay zones were not described on the boring log as clay beds by the HLA geologist, and no geometric information is included on the log to verify that these zones are actual clay beds rather than "clay-filled" rock fractures. Hence, all the clay zones are conservatively interpreted to be laterally extensive clay beds, and were modeled as potential slide planes for the slide mass models. The clay zones encountered in HLA-9 were not encountered in the closest up-dip borings, 01-B and 01-H, and are terminated between the borings in section M-M'.

TABLE 1. Interpreted Clay Beds and Properties from Boring HLA-9

Depth (ft.)	Description	Interpreted Thickness for Model (inches)
22.1	"1/4" clay seam"	> 1/4
28.0	"clay cuttings"	1/8 to 1/4
44.5	"clay clumps"	1/8 to 1/4
51.0	"into clay, smooth drilling"	1/8 to 1/4
65.5	"1/2" clay filled fracture"	> 1/4 (1/2)

The apparent dip of the inferred clay beds in cross section M-M' are based on the nearest bedding measurements, in surface exposures and bedding and clay bed orientations from the nearest ISFSI borings that had downhole structural measurements. The apparent dip of the bedding is well constrained by multiple measurements in the upper portion of section M-M' that traverses the ISFSI site, and in the power block area. However, between the Transport Route and the power block, the bedrock is covered by colluvium and Pleistocene fan deposits, and the HLA borings in this area did not include downhole structural measurements. The axis of the small syncline below the Transport Route is projected from the nearest bedding measurements. The apparent dip of bedding and inferred clay beds was uniformly flattened between the projected syncline axis and nearest uphill outcrop bedding measurement (Figure TR-2).

6.3 Upslope Margin of Slide Models

The upslope, headscarp margins of the rock mass margins were constrained by the following considerations:

6.3.1 The upslope termination of the clay beds constrains the uphill location of the slide mass models and location of tension cracks;

terrace shoreline angle and contact between Tofb-1 and Tofb-2, and is placed at the base of the cutslope along Reservoir Road, as described above.

8.0 Conclusion

The alternative slide mass models, shown on Figures TR-3 and TR-4 capture the potential range of possible rock mass movements based on geologic and topographic conditions. These models are considered reasonable and are recommended for stability analyses of the Transport Route bedrock stability conditions.

9.0 References

Hagler, R.D., February 26, 2003, DCPP Boring Logs: Transmittal Letter for 1973 Harding-Lawson Associates boring logs.

William Lettis & Associates, Inc., 2001, Diablo Canyon ISFSI Data Report B, Rev. 1, Borings in ISFSI Site Area.

Hanson, K.L., Lettis, W.R., Wesling, J.R., Kelson, K.I., and Mezger, L., 1992, Quaternary marine terraces, south-central coastal California: implications for crustal deformation and coastal evolution: in, Quaternary coasts of the United States: marine and lacustrine system: SEPM Special Publication No. 48, p. 323-332.

Geosciences Calculation packages

GEO.DCPP.01.21, rev. 2, Dec. 14, 2001 Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site.

GEO.DCPP.01.22, rev. 2, June 14, 2002, Kinematic Stability Analysis for Cutslopes at DCPP ISFSI Site.

6.3.2 Constraint on the uphill location of potential slide blocks is provided by the approximately 430,000 years old Q_5 marine terrace shoreline angle (Hanson and others, 1992) that is mapped approximately 120 feet uphill from the intersection of the Transport Route and Section M-M' (Figures TR-1, TR-2). This marine terrace shoreline angle is at an elevation of about 290 feet, and trends northwest along topographic contour approximately normal to the analysis section. The shoreline angle does not appear to be displaced or disrupted by past bedrock movements, providing geologic evidence that rock mass movements have not extended upslope of this horizon for at least 430,000 years;

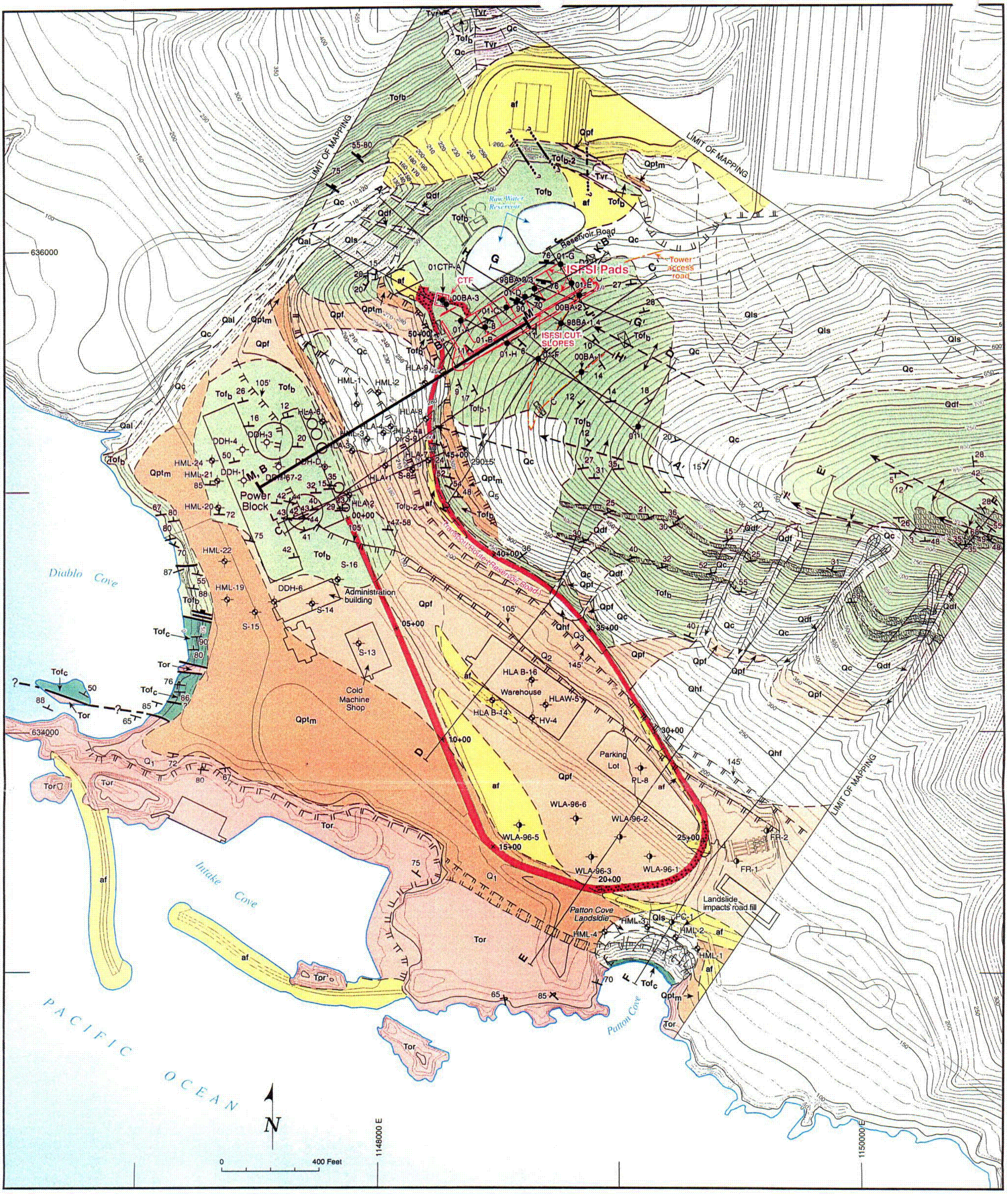
6.3.3 The contact between dolomite (Tofb-1) and sandstone (Tofb-2) occurs uphill from the Transport Route, at about the location of the Q_5 terrace shoreline angle (Figures TR-1, TR-2). This contact does not show evidence of past displacements, and no translated blocks of Tofb-1 dolomite were found in the existing roadcut or described in the borings below the road. This provides further constraint on the uphill margin of sliding block models, which should therefore daylight below the geologic contact;

6.3.4 Analysis of preconstruction air photos and detailed mapping of bedrock at the ISFSI site (Calculation Package GEO.DCPP.01.21, Rev. 2) above the Transport Route show no evidence of ancient rock slides in the bedrock above the route; and,

6.3.5 The Transport Route locally is on a bedrock cut bench with a 15- to 20-foot high rock cutslope along the uphill margin of the route. The cutslope exposes stable bedrock that has performed well since construction of the road bench. The changes in slope geometry from construction of the road bench are favorable for stability and reduce the driving forces on the slope below the road. The inboard edge of the road bench is an area of minimal cover over the clay beds, and also is a geometric corner that is a loci for stress concentration. Therefore this point forms a logical daylighting point for the headscarp tension crack in the rock models.

7.0 Rock Slide Block Models

Figures TR-3 and TR-4 show the slide mass models that were selected for stability analyses. These two models capture the reasonable range in size and uphill-downhill geometry for possible mobilized rock masses that are feasible based on interpretation of the geology and inspection of the kinematics for potential slope instability. Both models have basal sliding surfaces on clay beds that were interpreted from boring HLA-9, and are inferred to have a gentle downslope dip of between about 2 and 8 degrees (Figures TR-1; TR-2). These inferred clay beds would daylight at the surface under thick overburden Pleistocene fan and Quaternary colluvial deposits on the slope below the road. The uphill margins of the slide block models would break up through jointed rock in a stair-stepping manner between clay beds, either at termination points along the beds, or after traveling a distance of about 25 feet along the inferred clay bed. Evaluation of clay bed continuity, waviness, and rock mass jointing spacing suggest that the 25-foot length is a reasonable assumption for the continuous length of failure planes along the thinner clay beds. The extent of the failure planes along the clay beds was also constrained by the location of the slide block headwall/tension crack, which is constrained to occur below the Q_5



Explanation

Quaternary

- af — Artificial fill (engineered)
- Qal, Qdf, Qc, Qls, Qhf — Quaternary deposits - alluvium, debris flow, colluvium, landslide, Holocene colluvial fan
  NOTE: Only surficial deposits greater than about 5 feet thick shown
- Qpf — Pleistocene colluvial fan
- Qptm — Pleistocene marine terrace deposit (inferred)

Tertiary

- Tvr — Volcanic rock (middle Miocene), diabase intrusive sills and dikes

Obispo Formation (lower and middle Miocene)

- Tofb (Prominent outcrops) — Member Tof, Unit b - dolomite, dolomitic siltstone, dolomitic sandstone, and sandstone, medium to thick bedded.
- Tofc — Member Tof, Unit c - shale, claystone and siltstone, thin to medium bedding, extensively sheared.
- Tor — Member Tor - volcanic rock, zeolitized and silicified tuff

Geologic contact, solid line where well-defined, dashed where approximate, queried where uncertain.

Fault, dashed where approximate, queried where uncertain

Landslides, arrows indicate direction of movement, hachures define headscarp region

Qdf — Debris flow path

Axis of syncline, larger arrow shows plunge, dashed where approximate

Axis of anticline, larger arrow shows plunge, dashed where approximate

Axis of monocline, larger arrow shows plunge, dashed where approximate

290' Q2 — Buried shoreline, angle of marine terrace wave cut platform; number and elevation indicated

Footprint of 500-kV tower

85 — Strike and dip of fault

10 — Strike and dip of bedding

85 — Overturned bedding

Horizontal bedding

Boring from 1967 power block study

1977 boring DDH-D at power block

Boring from previous HLA and HML studies

Boring for ISFSI investigations, WLA 1998 to 2001

Boring for ISFSI siting investigations, WLA 1996 to 1998

Transport route; stippled where transport route will be underlain by new engineered fill

M M' — Geologic cross section

NOTE: The base topography for this map is a compilation of four different topographic maps: (1) the 1:2,400-scale Towill Corporation map based on 1966 aerial photography; (2) the 1986, 1:2,400-scale PG&E Plot Plan map; (3) 1970s era, 1:240-scale PG&E topographic/civil maps ("20-scale civil drawings"); and (4) the 2000-2001, 1:600 scale ISFSI Site map. These maps were merged and edited to eliminate map border conflicts and registered to the California State Coordinate System. Some of the maps listed above were received from PG&E Geoscience Department under letter of transmittal dated October 26, 2001 (PG&E Geosciences, 2001b).

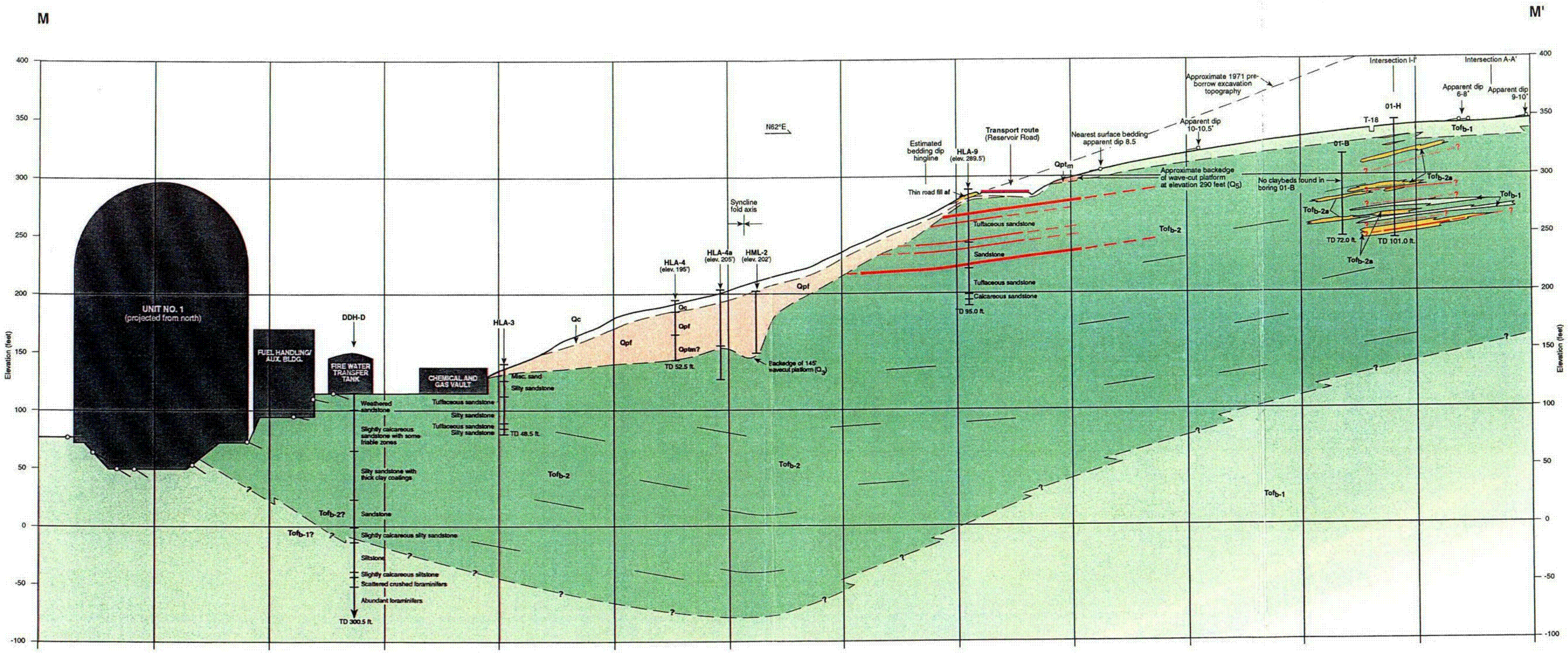
Page 12 of 5?
GEO.DCPP.01.28, Rev. 3
Attachment G

C-01

DIABLO CANYON ISFSI

FIGURE TR-1
GEOLOGIC MAP OF THE ISFSI STUDY AREA AND TRANSPORT ROUTE VICINITY

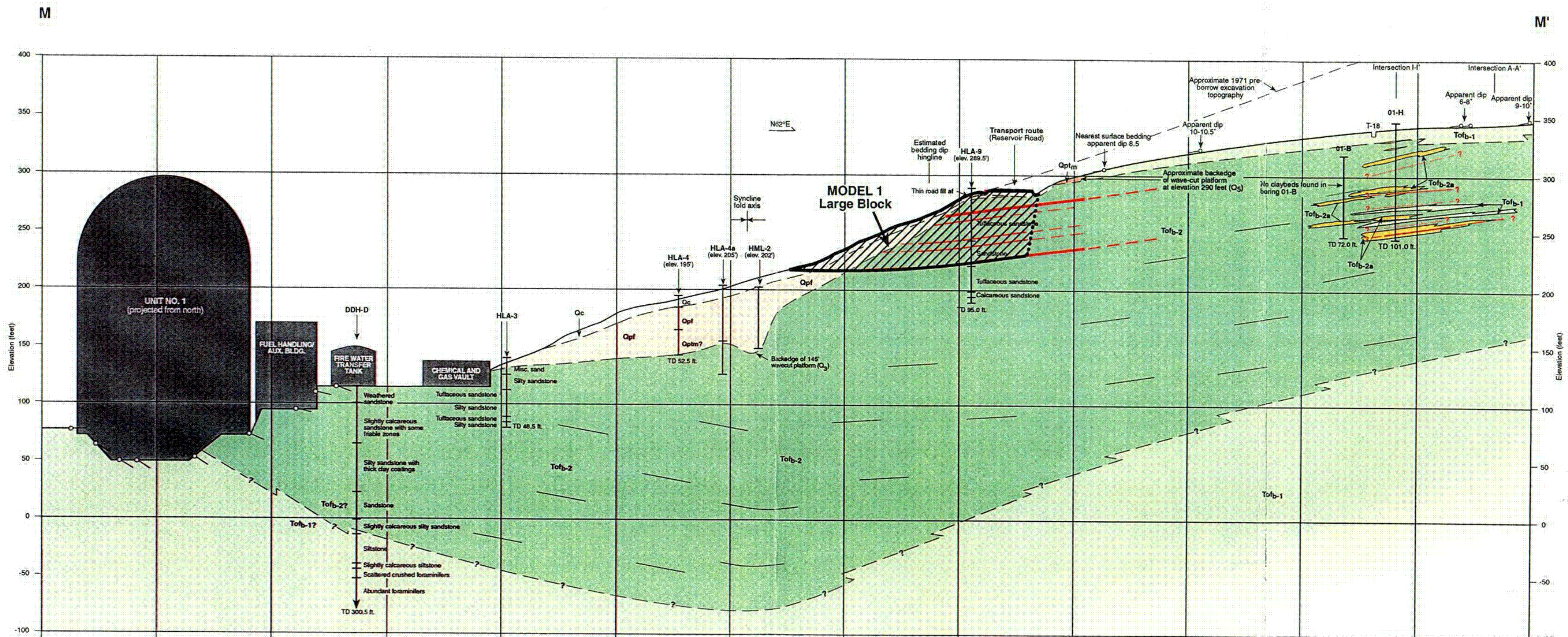
NRCReq.5TransRteRockStabMemo — February 28, 2003



Note: Geologic section modified from Section B-B' presented in Figure 21-3 of GEO.DCPP.01.21 Rev. 2, December, 2001.

DIABLO CANYON ISFSI

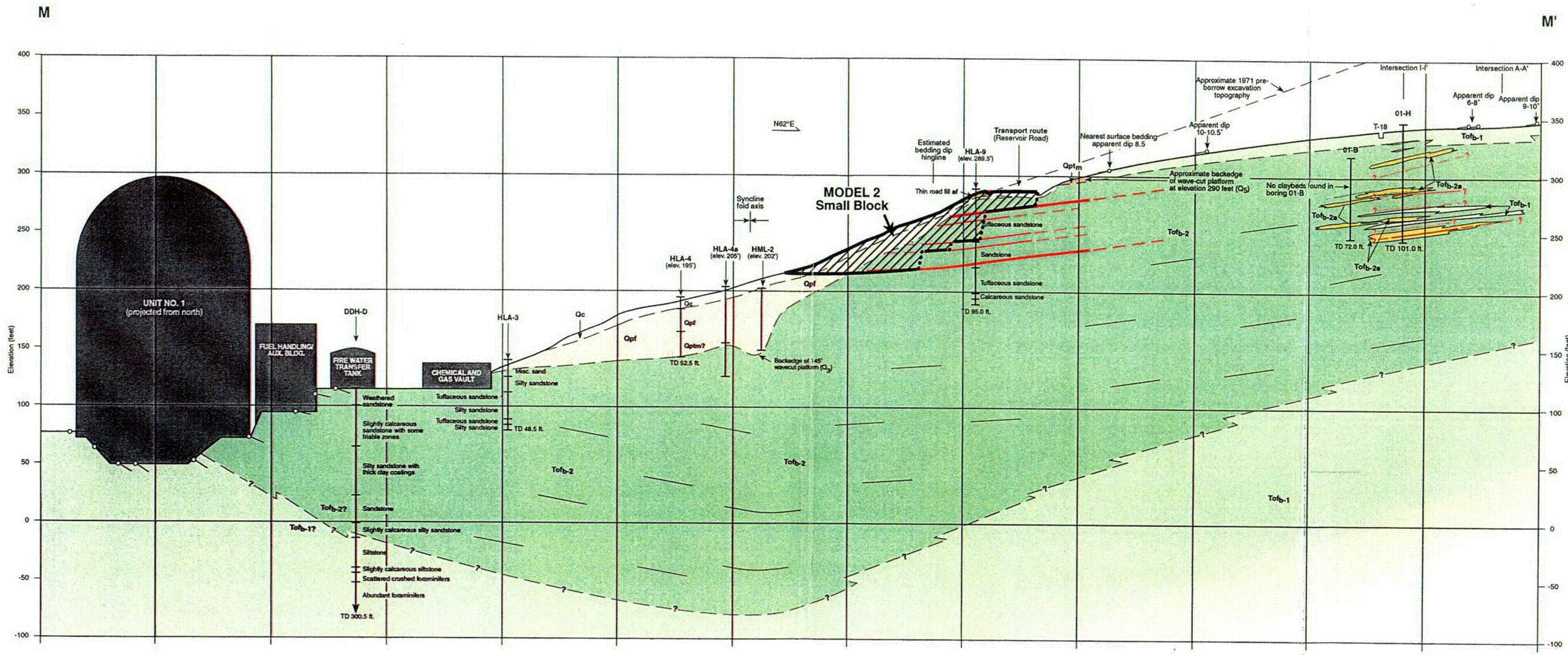
FIGURE TR-2
CROSS SECTION M-M'



Note: Geologic section modified from Section B-B' presented in Figure 21-3 of GEO.DCPP.01.21 Rev. 2, December, 2001.

DIABLO CANYON ISFSI

FIGURE TR-3
CROSS SECTION M-M', MODEL 1



Note: Geologic section modified from Section B-B' presented in Figure 21-3 of GEO.DCPP.01.21 Rev. 2, December, 2001.

DIABLO CANYON ISFSI

FIGURE TR-4
CROSS SECTION M-M', MODEL 2

ATTACHMENT A – Boring Logs Used for Section M-M'

ATTACHMENT A – Boring Logs Used for Section M-M'

FIELD LOG OF BORING (CONTINUED)

SHEET 2 OF 6

PROJECT: DIABLO CANYON | NO: 569.02.04 | BORING NO 9

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND	D RATE				DEPTH	GRAPHIC LOG	
	9.23	5.0		M						11		SANDY CLAY IN CUTTINGS 11 TO 11½
10.27	10.31	9.0	260	M						2		
	10.36	3.0		"						3		NX CORE RUN 13' TO 14½ (BLOCKED)
10.41	10.46	5.0	60/80	F		.5	3	4	M	4		18" RECOVERED, 100% RECOVERY w/ thin, discontinuous fractures, MnO₂ coated
14½	10.52	6.0	80	"						5		ROCK DRILLING AT 14½'
11.09	11.11	2.0	200	M						6		ROUGH DRILLING, SANDY CLAY CUTTINGS
	11.13	2.0	"	"						7		DRILLING SMOOTHER, BUT WITH SANDY CLAY CUTTINGS
	11.14	1.0	"	"						8		
	11.15	1.0	"	"						9		
	11.17	2.0	"	"						20		
	11.20	3.0	"	"						1		NX CORE RUN 21' TO 26' - 56" RECOVERY
11.29	11.33	4.0	80	F		.2	3	3	M	2		CLAY SEAM AT 22.1' CALCITE FILLED FRACTURE AT 22.4' FAINT BEDDING AT 15-20° DIP
	11.37	4.0	"	"		1	3	3	M	3		
	11.43	6.0	60	"		.2	2	½	D	4		BROWN SANDSTONE, HIGHLY TUFFACEOUS, MEDIUM GRAINED
	11.46	3.0	"	"		1	2	½	D	5		
	11.50	4.0	"	"		.5	2	½	D	6		
12.0½	12.05	3.0	140	M						7		ROCK DRILLING AT 26'
	12.11	2.0	"	"						8		CLAY CUTTINGS AT 28'
	12.13	2.0	160							9		
	12.1?	1.0	"							30		

FPB

HARDING, MILLER, LAWSON & ASSOCIATES

2.5C-176

FIELD LOG OF BORING (CONTINUED)

SHEET 3 OF 6

PROJECT: DIABLO CANYON 569.021.04 | NO | BORING NO 9

DEPTH	TYPE	BLOWS	DRIVEN	REC'D	COND	D RATE				DEPTH	GRAPHIC LOG	
	12:15	1.0	100	M						31		
	12:16	1.0	"	"								WASH CIRCULATION GOOD
12:23	12:25	2.0	20	"						2		
	12:26	1.0	"	"						3		
	12:28	2.0	"	"						4		
	12:30	2.0	200	"						5		
										6		NO CLAY CUTTINGS AT 36'
	12:33	3.0	"	"						7		
	12:36	3.0	"	"						8		
	12:38	2.0	"	"						9		
	12:40	2.0	"	"						40		
	12:44	9.0	"	"								NX CORE RUN 41' TO 45' (BLOCKED)
12:57	1:04	6.0	80	F		.5	3	4	M	1		4.3' RECOVERED, 90% RECOVERY
												THIN SANDSTONE SLIGHTLY TUFFACEOUS
	1:08	4.0	"	"		.4	3	3	M	2		FINE GRAINED THIC BEDDED
										3		THIN IRREGULAR FRACTURES, CALCITE &
	1:12	4.0	"	"		.3	3	3	M			RANGE COATED, PITTED WITH CALCITE
												CRYSTAL COATINGS.
	1:18	6.0	"	"		<.1	2	2	D	4		CLAY CLUMPS IN BOTTOM END AT 44.5'
												DEEPLY WEATH'D TO CLAY 44.5 TO 45'
1:58	2:00	2.0	240	M						5		ROCK DRILLING AT 45', NO CLAY IN
												CUTTINGS,
	2:02	2.0								6		
	2:03	1.0								7		
	2:05	2.0								8		
	2:08	3.0								9		
										50		

PPB HARDING, MILLER, LAWSON & ASSOCIATES

2.5C-177

HLA-9/4

FIELD LOG OF BORING (CONTINUED)

SHEET 4 OF 6

PROJECT: DIABLO CANYON 569.021.04 | NO | BORING NO 9

DEPTH	TYPE	BLOWS	DRIVEN	REC'D	COND	D RATE				DEPTH	GRAPHIC LOG	
	2:10	2.0	240	M						51		
	2:11	1.0	"	"								INTO CLAY, DRILLING SMOOTH AT 51'
										2		PENETRATION FAST
	2:12	1.0	"	"						3		
	NO TIME		"	"						4		
2:19	2:21	2.0	"	"						5		ROUGH DRILLING AT 55' NO
												CLAY CUTTINGS
	2:23	2.0	280	"						6		
	2:26	3.0	280	"						7		
	2:28	2.0	300	"						8		
	2:30	2.0	260	"						9		
			220	"						60		
NO										1		TIMES NOT NOTED FROM BOARD
TIMES												BEFORE ERASING
										2		
										3		
												NX CORE RUN 64' TO 69'
										4		WASH CIRCULATION & DRILLING INTERUPTED AT 65'
7:35	NO		80	F		.2	3	3	M			DUE TO WATER SHORTAGE - SEE REPORT
	TIMES	"	"	M:	>!	3	3 4	M L		5		4.1' RECOVERED, 82% RECOVERY
										6		½" CLAY FILLED FRACTURE AT 65'
[illegible]	7:44	"	80	F	"	;'	3	4	L			COLOUR CHANGE IN ROCK AT 65.4',
										7		TAN TO GREY & LESS FRACTURED
												66' GRAY SANDSTONE, HIGHLY TUFFACEOUS.
8:05	8:14	6.0	80	F	"	;'	3	4	L	8		MED. GRAINED, MASSIVE THK BEDDED
												1/8" SILT FRACTURE FILLING AT 65' ≈ 10° DIP
	8:21	7.0	80	F	":	):	3	4	L			
										9		WASH HOSE BURST AT END OF RUN &
1:55	1:58	3.0	220	M						70		BEARING IN SWIVEL ON CORE BARREL BROKEN
												HOSE REPAIRED. ROCK DRILLING AT 69'

PPB HARDING, MILLER, LAWSON & ASSOCIATES

2.5C-178

FIELD LOG OF BORING (CONTINUED) SHEET 5 OF 6

PROJECT: DIABLO CANYON 589.021.04 | NO | BORING NO. 9

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND	D RATE			
	1:59	1.0	220	M					
	2:02	3.0	•	•					
	2:08	6.0	•	-					
	2:11	3.0	•	-					
	2:16	5.0	•	-					
	2:18	2.0	•	-					
	2:20	2.0	-	-					
	2:23	3.0	-	-					
	2:25	2.0	•	-					
	2:28	3.0	•	•					
	2:31	3.0	.	-					
	2:34	3.0	EC	•					
	2:39	5.0	•	•					
	2:42	4.0	-	•					
	2:47	4.0	-	-					
	2:51	4.0	-	•					
	2:54	3.0	-	-					
	2:56	2.0	-	•					
	2:57	3.0	•	•					
	3:02	3.0	•	•					
327						.3	3	3	M

DEPTH: 71', 2, 3, 4, 5, 6, 7, 8, 9, 80, 1, 2, 3, 4, 5, 6, 7, 8, 9, 90

BEN CALCAREOUS SANDSTONE [illegible]

[illegible] SWIVEL REPLACED

NX CORE RUN 90' TO 95'

LS' RECOVERED, 75% RECOVERY

PPB

HARDING, MILLER, LAWSON & ASSOCIATES

2.5C-179

HLA-9/6

FIELD LOG OF BORING (CONTINUED) SHEET 6 OF 6

PROJECT: DIABLO CANYON 589.021.04 | NO | BORING NO 9

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND	D RATE			
	3:2[illegible]	6.0	25	F		.2	3	4	M
	3:26	5.0	46	•		.2	3	4	M
	3:29	3.0	20	•		.8	?	3	M/D
	3:41	5.0	•	•		.2	3	3	M/D
	3:47	3.0	•	•					

DEPTH: 91, 2, 3, 4, 5, 6, 7, 8, 9, 100, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0

CALCITE FILLED [illegible] FRACTURE

BEN SANDSTONE, HIGHLY TUFFACEOUS, MASSIVE, THICK BEDDED, MED GRAINED WITH OCC RECRYSTALLIZED FOSSIL FRAGMENTS AT 92'

(LOST 2.1' OF CORE WHEN BARREL REMOVED.)

LOOSING WASH BUT CIRCULATION MAINTAINED. WASH HOSE BURST AT END OF RUN – STOP DRILLING AT 95'

Reviewed by S.R. Conway, E.G. 916

PPB

HARDING, MILLER, LAWSON & ASSOCIATES

2.5C-180

LOG of ROCK BORING 01-B

Edited for ISFSI SAR

Project	Job Number	Boring Location	Total Depth
DCPP-ISFSI	1223-A-1	NW Corner of ISFSI Pad	72.0

Type & Diameter of Boring	Elevation and Datum	Ground Water Depth	Depth to Bedrock
HQ core - Triple barrel core barrel	318.9	not recorded	4.4'

Drilling Contractor and Rig	Length of Core Barrel and Bit	No. of Core Boxes	Date Started
Cascade - CME 95 - Kirk & Julio	8'7"	4	4/21/01

Casing Size and Depth	Borehole Inclination	Logged By	Date Completed
8" Hollow Stem Auger - to 4.0'	90	JGH	4/21/01

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
0–4						Slough?			Set Auger/Casing to 4.0' depth. Cored sandstone	Gray coarse sand-silt w/ clay and bioturbation surface coating	Driller reported 1' of sluff in auger before starting.
3–4	2:23								Sluff		1.4' of Run 1 - Sluff
4–7	5:12, 3:26, 2:26	1	3.5/4.0	88	1.3/4.0, 32%	SW		R1/R3	SANDSTONE - Dolomitic greywacke, 7.5YR 6/, Medium-grained, well-sorted sand, well oxidized. Moderately hard. Subrounded grains.	(To c-2); -Jo, 0°, St, Sl, op; -Jo, 65°, Wa, Sl, Sl op; Jo, 0°, Wa, Sl, op; -Jo, 90°, Wa, Sl, Op, clayey infill < 1/16" thick; Jo, 0°, St, Sl, op	7:23 AM; @170 PSI; 100% Circ.
7–12	4:20, 7:55, 4:03, 2:50	2	5.0/5.0	100	2.3/5.0, 46%	SW		R1/R2	Same as above; alternating medium grained and medium to coarse-grained layers w/ gradational texture changes	-Jo, 80°, Wa, VR, op; -Jo, 40°, Wa, Sl, Op; -Jo, 25°, Wa, Sl, op; -Jo, 0°, Wa, Sl, Ti; -Jo, 0°, Wa, Sl, op; -Jo, 90°, Wa, Sl, op; -Fe, 0°, Pl, Sl, Ti; -Jo, 0°, Wa, Sl, op; -Jo, 60°, Wa, Sl, op	@11' - 90% Circ. @170 PSI
12–15	3:05, 4:26, 3:20	3	5.0/5.0	100	2.4/5.0, 48%		F3		Same as above; gray lamination 10° dip	-Jo, 30°, 85°, Sl, Wa, op; -Jo, 90°, Pl, Sl, op; -Jo, 60-90°, Wa, Sl, Ti, healed; -Jo, 0°, Pl, Sl, op; -Jo, 0°, Pl, Sl, Ti	8:16; @9'; 70% circ 110 psi; @12.5' - 50% Circ.

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fo-Fault, Fo-Foliation, Jo-Joint, Mb-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type of infilling, slickensides, etc.

Checked JLB

ROCK BORING LOG

Project	Job Number	Date	Boring No
DCPP ISFSI	12230-1	4/21/01	01-B

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Strength	Lithologic Description	Description of Discontinuities	Remarks
15–17 (8:35)	3:43, 3:37	3	5/5	100	2.4/5, 48%	SW	R2	(Top ...)	-Jo, 0-20°, Wa, Sl, He, OX Jo, 0°, Pl, Sl, Ti, OX Jo, 0°, Wa, Sl, Op Jo, 0°, Pl, Sl, Op, OX Jo, 60°, Pl, Sl, Op, OX Jo, 0°, Pl, Sl, Op, OX	
17–22 (8:40)	7:13, 5:03, 5:28, 4:57	4	4.9/5.0	98	2.45/5.0, 49%	SW; SW; SW	R2; D; R2	Same as above Possible Bedding 19.5 - gradational wavy contact, lighter colored bed more resistant. 19.9 - flat lying, wavy contact SANDSTONE, Dolomitic greywacke, 10YR 7/6, medium-grained, well-sorted, well oxidized sand, massive w/ few dolomite filled micro fractures.	MR -Jo, 90°, Wa, Sl, Op, Ox & MnO Jo, 0°, Wa, Sl, Op, MnO -Me?, 0°, Pl, Sl, Op Polished surface ... 4/21/01 -Jo, 0-90°, Wa, Sl, Op, OX -Jo, 0°, Pl, Sl, Ti, MnO -Be, 0°, Wa, Sm, Ti Be, 0°, Wa, Sm, Ti Jo, 0°, Wa, Sl, Op, OX Jo, 0°, Wa, Sl, Op, &OX -Jo, 90°, Wa, Sl, Op, OX -Jo, 0°, Wa, Sl, Op, OX -Jo, 20°, Pl, Sl, Op, OX Jo, 0-20°, Pl, Sl, Op+Fi-CaCO3 -Jo, 0°, Wa, Sl, Op - vug	@17.5': Spindel Packing Burst. Drillers ... fittings. - No Down Time - @20': 50% Circ 150 PSI
22–27 (9:15)	?, 5:42, 3:57, 4:53, 5:20 (CB2)	5	5.0/5.0	100	3.2/5.0, 64%	SW	R2	Same as above Some thin calcite/dolomite veins and small (1/8"±) angular weathered shale/claystone clasts (weathered to clay) JLB 4/21/01	-Jo, 0°, St, VR, Op, OX & MnO -Jo, 30°, Wa, Sl, Ti, OX -Jo, 10-60°, Wa, Sl, Ti, OX -Jo, 30°, Pl, Sl, Ti, OX -Jo, 0°, St, Sl, Op, OX -Jo, 10°, Wa, Sl, Op, OX -Jo, ~90°, Wa, Sl, Op -Jo, 20°, Wa-St, Sl, Op -Me, 0°, Pl, Sl, Ti -Jo, 20°, Wa, Sl, Ti	@ @25.5': 50% Circ @95 PSI
27–30 (10:55)	2:48, 3:07, 3:03, 2:50	6	5.0/5.0	100	2.0/5.0, 40%	SW	R2	Same as above Small vugs	-Jo, 60-90°, Wa, VR, Op -Me, 0°, Pl, Sl, Ti -Jo, 90°, Wa, Sl, Op -Jo, 20°, Pl, Sl, Op -Jo, 0°, Wa, Sl, Op - vug Jo, 70°, Wa, Sl, Op	@29': 40% Circ @90 PSI @29.5': Driller reports softer drilling.

Correlative w/ Top of ... in ...

Top ...

(D) all

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fo-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

checked JLB 4/21/01

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI/CTF	12230-1	4/21/01	01-B

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
30–32	4:45, 3:57, 3:57	6	5/5	100	2/5, 40%	SW		R2	Medium grained dolomitic SANDSTONE, well-(graywacke) mod. sorted, well cemented; disseminated weathered shale-claystone angular clasts (4% ±), oxidized streaks, joints, laminations	-Jo, ~0°, Pl, Sl, Op; -Jo, 90°, Wa, Sl, Op, Ox; 3-Jo, 0°, Pl, Sl, Op; -Jo, 60°, Wa, Sl, Op; -Me, 0°, Pl, Sl, Mud	@32' - 30% circ @95 PSI
32–37	3:18, 3:57, 5:34, 5:10, 4:33	7	5.0/5.0	100	3.4/5.0, 68%	SW		R2	Same as above (TOFb-2, TOFb-2a)	-Jo, 75°, Pl, Sl, He, Ox; -Jo, 20°, Pl, Sl, He, Ox; -Jo, 0°, Pl, Sl, Op-Ox; 3-Jo, 0°, Wa, Sl, Op; -Jo, 80°, Pl, Sl, He, Ox; 3-Jo, 45°, Pl, Sl, Op, Ox; -Jo, 45°, Pl, Sl, He, Ox; -Jo, 90°, Pl, Sl, He, Ox; -Jo, 90°, St, Sl, Op, Ox; } Crushed zone	
37–42	6:00, 5:56, 3:29, 5:35, 3:53	8	5.0/5.0	100	2.0/5.0, 40%	SW / SW / SW		R2 / R1 / R2	same as above; Gradational Contact; SANDSTONE - greywacke 7.5YR ¾, Coarse-grained, Poorly Sorted, w/small gravel (Slate + Qtz), Massive, slightly hard, Slightly oxidized, mod. well cemented; Gradational Contact; SANDSTONE, Dolomitic, greywacke, 7.5YR ⅘, Medium-grained, well-sorted, well-oxidized sand. Massive. Moderately hard.	-Jo, 60°, Pl, Sl, Op; -Jo, ~90°, Wa, Sl, Ti; -Jo, 70°, Wa, Sl, Op, Ox; -Jo, 0°, St, Sl, Op, Ox; } Jo, ~0°, Wa, Sl, Ti, Ox; -Jo, 70°, Pl-Wa, Sl, Ti; -Jo, ~0°, Wa, Sl, Ti; -Jo, 30°, Wa, Sl, Sl Op; -Jo-Fa, ~60°, Wa, Sl, Fi ~ Clay + rock frags 1.5 cm thick; Me, ~0°, Wa, Sl, Op; -Crushed zone; -Jo, ~90°, Wa-St, Sl, Op, Ox; Jo, 40°, Pl, Sl, Sl Op, Fi ~1/16" Clay, Slicks; -Jo ~40°, Wa, Sl, Ox	@38' 20-30% circ @~100 PSI; JGH 5/4/01 @12:40 - refusal
42–45	3:22, ~3:53	9	5.0/5.0	100	1.7/5, 34%	SW		R2	grades into fine grained Sandstone, Massive, 10YR 7/3 very pale brown	St, 30°, Wa, Ti; Jo, 30°, Pl, Cl, Op, trace clay; Jo, 40°, Pl, Sl, Op, Ox, Fi; Jo 30° Pl, Sl, Op, Ox; JGH 5/4/01 (Slickensides on Jo surface) Polished, 20°, Wa, Sl, Op; Jo, Pl, Sm, Op, trace clay; Jo, 0°, Sm, Op, trace clay; Jo, 0°, Sl, Op, Ox, trace clay; Jo, Wa, Sl, He, Ti; Jo, 0°, Pl, Ti; Jo Pl-St, Sl, Op, Ox; Broken, 30°, 40°, Wa, Sl, Op	@42' 40% circ @100 PSI; @43.2' Lost all H2O 0% circ; @45.8' Lost all circ. again 0%

Left margin: 11:17 / 11:27 (at 32); 11:45 / 12:10 (at 37); 2:44 / 12:52 (at 42); Tofb-2 (30–37); Friable zone JGH 5/4/01 (38–40); Tofb-2 (42–45)

Right margin: Correlation of Tofb-2 sandstone JGH 5/4/01; JGH — @2:50 ROKE (?) ; (D) all water

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

Checked JLB 5/4/01

@45' - Lost 4 tubs of H2O. 0% Circ.

ROCK BORING LOG

Project	Job Number	Date	Boring No
DCPP ISFSI/CTF	1223a-1	4/21/01	01-B

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Strength	Lithologic Description	Description of Discontinuities	Remarks
45–47	2:59, 4:48	9	5/5	100%	1.7/5 34%	SW	R2	fine grained sandstone (TofC...). @46-46.9 interbed of med. grained SS, grades back into fine grained sandstone, massive. @46.8 clay seam	J0, 70°, Wa, Sl, Op, MnO & ox; J0, 70°, Pl, Sl, Op; J0, 60°, Pl, Sm, Op, Fi, clay, ox; J0, 60°, Pl-St, Sm, Op ... clay 35-40°	@45.5 - gained back ~20% circ.
47–52	5:26, 6:23, 3:25, ?, 3:22	10	5.0/5.0	100%	1.4/5 28%	SW	R2, R1 @48.7 slightly softer, R2	fine grained sandstone massive, hard, 10YR 8/2 very pale brown	J0, 80°, Wa, Sl, Op, MnO & ox; J0, 0°, Pl, Sm, Op; J0, Wa, Sl, Op; J0, 70°, Pl, Sl, Op, ox; J0, 70°, Pl, Sm, Op; J0, 80°, Wa, Ro, MnO, ox, Op, trace clay; J0, 40°, Pl, Sl, Ti; J0, 50°, Pl, Sm, Op, ox, trace clay; J0, vert, Wa, Ro, Ti; J0, Wa, 80°, Sl; J0, 45°, Pl, Sl, Op, ox; J0, 70°, Pl, Sl, Op, ox; Broken Rock; J0, 35°, Pl, Sm, Op, ox; J0, Wa, 80°, Ro, Op, MnO & ox; J0, 60°, Pl, Sl, Op, MnO & ox	@49' still no circ. ~15 gal circ @ 100 psi + 2,000 R PM
52–57	2:58, 5:29, 6:53, 3:35, 5:49	11	4.7/5.0	94	3.1/5.0 62%	SW / MW / SW	R2 / R1-R0 / R2	Gradual contact into pale brown coarse grained sandstone. @54.6 dark gray sandstone, med., altered, friable, softer than above; gley 1 7/10Y-6/10Y light greenish gray - greenish gray. @55.6 back to pale brown med.-coarse grained sandstone, sharp contact, massive, 10YR 7/3-7/4 very pale brown, hard	Broken; J0, 80°, Wa, Sl, clay coating <1/16"; Fa; J0, 80°, Pl, Ro, Ti, Fi, 1-2mm clay, stiff, well polished, slicks; J0, 30°, Pl, Ro, Ti; gradational, irregular banded contact; J0, 60°, Pl, Sm, Op, Fi, 1mm clay; J0, 70°, Pl, Sm, Op, Fi, 1mm clay, w/ slicks; Be(?), banded, 12-18° dip?; J0, 85°, Pl, Sm, Op, ox; J0, 20°, Wa, Ro, Ti; J0, 70°, Wa, Ro, Ti, Fi, 1/32" clay, polished w/ slicks	@55.0' - 20-30% circ. Color change reported by Driller to gray. @56.0' Driller reported color change back to orange.
57–60	5:27, 11:12, 2:47	12	4.7/5	94	2.4/5 48%	SW	R2	Clear contact into very fine grained dolomitic sandstone to fine grained sandy dolomite, massive, hard, dolomite/calcite veins	healed microfractures; J0, 70°, Wa, Sl, Op, MnO & ox; J0, 75°, Pl, Sl, Op, ox; J0, 0°, Pl, Sl, Op; J0, 0°, Pl, Ro, Ti; J0, 60°, Wa, Sl, Op; J0, 0°, Pl, Sl, Op; J0, 0°, Pl, Sm, Op; J0, 60°, Wa, Sl, Op, MnO & ox; J0, 60°, Pl, Sm, Op; J0, 60°, Pl-Wa, Sl, Op	loss of circulation all water from hole gone between 58 & 59'

Margin notes: 1:35, 1:52 (at 47); TofC (at 50); 2:14, 2:24 (at 52); 2:44 (at 57); "D" (at 59–60)

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

Checked JLB 4/26/01

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI/CTF	1223a-1	4/21/01	01-B

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description
60	2:15					SW		R2	very fine to fine grained dolomitic sandstone 10YR 8/2 very pale brown (Tofb-2)
61	4:28	12	4.7/5.0	94	2.4/5 48%				
62	1:27 (@ 62.4)							R3	J.H. 5/4/01
63	1:52	13	4.8/5.0	96	2.8/5.0 56%	SW		R2	Same as above
64	2:37								
65	2:08								
66	1:38								
67	3:01								Same as above
68–70	4:47	14	5.0/5.0	100	2.4/5.0 48%	SW		R2	
70	2:08								
71	2:12								@70.8 Same rock as above but grey color gley 1 7/10y light greenish grey
72									B.O.H. 72'
73									
74									
75									

Description of Discontinuities

- J0, 0°, Pl, Sl, op
- J0, 0°, Pl, Sl, op
- healed micro fracture
- J0, 0°, Pl, Sl, op
- mechanical break
- Broken
- Mc(0°?) Pl, Sl, op
- J0, 30°, Pl, Sl, op, ox
- Mc(30°?) 0°, Pl, Sl, op
- Mc(30°?) Wa, Sl, op
- J0, 0°, Wa, Sl, op
- Mc(30°?) Wa, Sl, op, 0°
- Mc(30°?) 0°, Wa, Sl, op
- Mc(30°?) 0°, Wa, Sl, op
- J0, 30°, Wa, Sl, op, mno [illegible] ox
- Mc(30°?) Wa, Sl, op
- Mc(30°?) 0°, Wa, Sl, op
- J0, 30°, Wa, Sl, op
- Mc(30°?) Wa, Sl, op
- Mc(30°?) 0°, Sl, op
- J0, 0°, Wa, [illegible]
- J0, 30°, Pl, [illegible]
- Mc(30°?) 0°, Pl, Sm, op
- Mc(30°?) 0°, Sm, Sl, op
- J0, 30°, Wa, Sl, op
- Mc(30°?) 0°, Wa, Sl, op
- Mc, shear break
- Broken
- Mc — J0, 80°, Pl, Sl, op,
- Mc
- Mc
- J0, 80–90°, Wa, He, ti; Ri, ox sand
- J0, 60°, Pl, He, ti
- Mc
- Mc — J0, 70°, Wa, Sl, op, ox
- Mc
- Mc — J0, 60°, Pl, Sl, op, mno & ox
- Mc
- J0, 70–90°, Wa, Sl, op, mno & ox
- Mc
- Mc
- Mc
- Mc
- Mc
- Mc
- Mc
- Mc
- Mc
- Mc
- J0, 20°, Wa, Sl, op
- Mc
- Mc
- Mc

Remarks

@61' lost all circulation 0.0% circulation

most Mc (30°) discontinuities in run 13 are probably Mc. driller reports chattering. Driller not using mud. this might be the reason for the Mc. breaks

5:45 PM

∅ return on circulation water

6:00 PM

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Mc-Mechanical break, Sh-Shear, and Ve-Vein. Joint description: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

Friable zone [illegible] by [illegible] [illegible]
[illegible] [illegible] on [illegible] [illegible]
Edited for ISFSI [illegible] [illegible] 5/28/01

LOG of ROCK BORING 01-H

Project	Job Number	Boring Location	Total Depth
DCPP ISFSI	12234-1	DCPP ISFSI	101'

Type & Diameter of Boring	Elevation and Datum	Ground Water Depth	Depth to Bedrock
HQ double barrel core barrel	346.6' (JLB 5/31/01) ~~346~~ (Sea Level)	NA *	0

Drilling Contractor and Rig	Length of Core Barrel and Bit	No. of Core Boxes	Date Started
All Terrain Drilling; Failing 1500 Rig [illegible]	5' 61	7	04/18/01

Casing Size and Depth	Borehole Inclination	Logged By	Date Completed
Auger to 4'; set casing to 6"	90°	KDW + JGH	04/19/01

*Not determined, water and mud injected during drilling

WLA

Depth (feet)	Log / Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
0–3.5									Auger to 3.5'		
3.5–8	12:24, 12:00, 12:06, 12:13, 12:24	1	4.5/4.5	100	2.9/4.5 64%	SW; MW; SW	Mo; Cl; Mo	R1-R2; R1; R1-R2	SANDSTONE, dolomitic (slight fizz of powder), f-grained, hard, well cemented, lithic fragments, Fe+Mn stain 10YR 6/6 (brownish yellow) (Tofb-1). Jo, He, 30°. Jo, Vert, Wa, Ti, Sl, Mn stain. Jo, hor, Wa, Ti, Sl, no stain. More pervasive Mn stain betw. 6 and 6.4'. Jo, He, 20°, zone of alt. around it. Altered zone - gray coloring	Jo, 20°, Pl, Ti, Sl, Fe+Mn stain. Jo, subhor., Wa, Sl, Ti, no stain (several). Jo, 50°, Wa, Sl, Ti, no stain. Jo, 30°, Wa, Sl, Ti, no stain. Jo, 40°, Wa, Sl, Ti, no stain. Jo, 55°, Wa, Sl, Ti, Mn stain, clay films JGH 5/14/01. Jo, 30°, Wa, Sl, Ti, Mn stain. Jo, 30°, Wa, Sl, Ti, Mn stain (minor). Jo, He, 30°, alteration to gray along it (a zone). Jo, 40° to 40° (sic) Wa, Sl, Ti, no stains, but bounds altered zone. Jo, 60°, Wa, Sl, Ti, Fe+Mn stains, He	Began coring @ 12:45pm. downfeed 180psi. @~5' taking H_2O ~50% return. dwnfd 150psi ~70% return. dwnfd 170psi (A)
8–13	12:32, 12:48, 12:50, 13:00	2	5/5	100	3.4/5 68%	SW-MW; MW	Mo	R1-R2; R1	Same as above. Alteration bands @ 9.2 + 20. Jo, ~30°, Wa, Sl, Op, clay films JGH. Calcite veins, vert., betw. 10.4 and 11'. (Tofb-2, Tofb-2a). Jo, 30°, Ti, Sl, Wa no stain	Jo, 30°, Wa, Ro, Ti, no staining, some altered. 3 Jo, 20° to hor., Wa, Sl, Ti no stain. Jo, 20°, Wa, Rl, Ti, Mn stain. Jo, 50°, Wa, Sl, Ti, no stain, breaking zone. Jo, 35°, Wa, Sl, Ti no stain. Jo, 30°, Wa, Sl, Ti, no stain, v. fresh. Jo, 30°, Wa, Sl, Ti, Mn+Fe staining. Jo, 25°, Wa, Sl, Ti, Mn+Fe staining. Jo, He, 30°. Jo, 30°, Wa, Sl, Ti, no stain. ~Jo, 90°, Wa, Sl, Op, clay (Imm) JGH 5/14/01. Jo, 75°, Wa, Ti, Ro, Fe+Mn stain, zone. Jo, He, 70°, Fe stain	120psi. 110psi 60% return (B). 120psi 60% return. Tofb-1 / Tofb-2. @ 12' 120psi 50% return. @ 13' 120psi 60% return (C)
13–15	13:00, 13:55, 14:00	3	3/3	100	1.3/3 43%	MW	Mo	R1	SANDSTONE, v. sl dolomitic, becoming coarser 2.5Y 6-5 4/6 (olive yellow to light olive yellow), less well cemented than above	Jo, 50°, Wa, Sl, Ti, no stain, both fresh. Jo, He? 30° to 30° (sic) fresh, Wa, Ti, Sl, no stain. Jo, 30°, Wa, Sl, Ti no stain, fresh. Jo, 30°, Wa, Sl, Ti no stain, fresh	job H' 100psi / No Return @~1min. @~10min ~10% return. @ 14' 110 psi / 10% return. 150psi

Left margin annotations: Alt. Zone (~7.5'); Tofb-1; Alteration band (~9.2'); Friable (weak) zone 2.0 JGH 5/14/01; Tofb-2 (~12'); Tofb (~14')

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Mo-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough). Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI	R23a-1	4/18/01	01-H

Pad Grade = 310'
> 50' below grade

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
15–16		3	3/3	100	1.3/3 43%	MW	MO	R1	SANDSTONE, v. Sl dolomitic lithic frags (Tofo-2, to Tofo-2a) Jo, hor, Wa, Sl, Ti, no stain; E stain on SANDSTONE	Jo, 80°, Wa, Ti, R1, no stain; Jo, 80°, Wa, Ti, R1, no stain; Jo, 40°, Wa, Ti, Sl-Ro, no stain; Jo, 30°, Wa, Ti, Sl, E stain; missing section	120 psi 50% return
16–21	35:20 … 9:12 (0, 1:10, 8:50, 3:30, 10:29)	4	4.7/5	94	4.6/5 92%	SW; HW; SW	Mo; W	R2; R1; R2	As above, med grained (contrasted rock/grains) lithic frags. (few to many); weathered zone @ 16.3-16.7; color contact @ 17.2' ~35° 2.5Y 6/4 (light yellowish brown) over 5Y 6/1 (olive gray); color contact (gray over brown) 60° @ 18.0'; @ 19.6 Mn? stains ~50° and Alteration; not planar "wispy" & irregular; total missing section this run = 0.4'. Arbitrarily divided between top + bottom of run	Jo, 60°, Wa, Sl, no stain; Jo, hor, Wa, Sl, no stain; Mc, hor.; Mc, hor; No apparent Jo or Mc; Jo, ?, 60°	120 psi 50% return; 150psi; 120psi
21–26	0, 3:45, 25:2?, 3:43, 6:30	5	5/5	100	4.0/5 80%	SW; HW; SW	Mo	R2; R0; R2	SANDSTONE, dolomitic, Same grainsize as above well cemented; 10YR 5/6 (yellowish brown); @ 23.7 to 24.0' altered, weak SANDSTONE, friable, highly sheared; 10YR 6/6 (brownish yellow)	Jo, Subhor, Wa, Sl, Ti, Mn + Fe Staining; Jo, 60°, Wa, Sl, Ti, Mn + Fe Staining @ bottom of small rubble zone; Mc - hammer blow; Jo, 80°, Wa, Ti, Sl, no stain, friable edges; Jo, 60°, Wa, Ti, Sl, Fe stain; Jo, varied, arcuate along length of core, Wa, Ti, Sl, Mn + Fe Stained; Jo, subhor, Wa, Ti, Sl, no Stain 23.7 to 24.0 contains many blocks w/ no stain on their surfaces; Jo, subhor, Wa, Sl, Ti, Fe + Mn staining; Jo, 70°, Wa, Sl, Ti, Fe + Mn stain; Mc - from hammer blow	@22' 180psi 50% return; @23' 190psi 50% return; @ 36:00 hit soft zone 150 psi; Ran out of H_2O @ 41 min; Resumed 5 min later, 190psi; 190psi 30% return
26–30	0, 8:53, 15:00, 37:00, 36:00	6	4.9/5	98	4.85/5 97%	SW	Wi	R2; R1	SANDSTONE, hard, well cemented, med grained 10YR 6/6 (brownish yellow) color Δ to 5Y 4/1 (dark gray) @ 26.4 to 26.8'; color Δ @ 27.6 to 28.0 back to brownish yellow; color Δ @ 29.1-29.3 to gray; @ 29.6' texture change to friable SANDSTONE	Mc - hammer blow; Jo, 60°, Wa, Sl, Ti, Fe + Mn stain; Jo, hor., Wa, Sl, Ti, no stain - fresh; Jo, hor (bedding?) Wa, Sl, Ti, no stain is the contact to more friable SANDSTONE	150psi; 190% psi 30% return; 190% psi; 200psi

Margin notes: missing section; weathered zone; color contacts; Tofo-2a; Mn stains; friable (minor) zone 2a slides; altered zone; Tofo-2a; Tofo-2 - color change; friable zone slides. C; D

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Mc-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

01-H/3

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI	1223a-1	04/19/01	01-H

WLA

Column headings: Depth (feet) | Log | Drill Rate (min/ft) | Run No. | Recovery/Cut | % Recovery | RQD | Weathering | Fracture Spacing | Strength | Lithologic Description | Discontinuities | Description of Discontinuities | Remarks

Left margin: Friable zone (310 Shales) Tofb-2a; color contact; Tofb-2; weak fracture zones; thin staining; calcite vein

Depth	Drill Rate / Time	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
30–31		6	4.9/5	96	4.85/5 (97%)	SW	Wi	R3	fresh SANDSTONE, med-grain 5Y 4/1 (dark gray)	No Jo, etc ↓	
31–32	4:58; 1:25	↓ CB 3				MW		R1	Same as above. between 31.9' and 31.3 texture gradually changes to SANDSTONE, well cemented & hard, fine-med. grained	He, all hor. + rounded	200 psi
32–33	17:45					SW			@ 32.15 color change from gray to 10YR 5/4 (yellowish brown)	Jo, 10°, Wa, TT, Sl, Fe + Mn stained	200 psi
33–34	24:00	7	4.7/5	94	1.9/5 (38%)		Mo	R2	Jo, vert., Wa, Sl, Ti, Fe + Mn stained	Jo, sub-hor., Wa, Sl, Ti, no stain (3); Jo, Wa, TT, Sl, no staining - broken on one side of vert. fract but He on other side	190 psi 20% return
34–35									total 0.3' missing section arbitrarily split 2" @ Top 1" @ Bottom	Jo, 60°, Wa, Sl, Ti, Mn + Fe staining; Jo, 30°, Wa, Sl, TT, little Mn staining; Jo, 30°, Wa, Sl, Ti; little Mn, much Fe staining	200 psi
35–36	37:25; 44:31									Jo, subhor, Wa, Sl, Ti, Fe + little Mn staining; Jo, sub vert., He, calcite-lined	ended 4 the day; Began @ 7:00am
36–37								R2	As above. Jo, Wa, Sl, Ti, Mn stain, vert.	Jo, 80°, Wa, Sl, Ti, no stain; Jo, 50°, Wa, Sl, TT, little Mn stain	200 psi 10% return
37–38	14:00					SW	Mo			Jo, 35°, Wa, Sl, Ti, Mn + Fe stain; Jo (many) subhor. to 70°, Wa, Sl, Ti, Fe staining; Jo, 50°, Wa, Sl, Ti, little Mn + Fe stain	210 psi ?10% return
38–39	21:40	8	5/5	100	4.0/5 (80%)					Jo, He, vert. to 80°	150 psi 10% return
39–40	22:35							R1-	@ 39.35' two very thin clay layers between fracture blocks; Jo, He, 30°	Jo, 40°, Wa, Sl, Ti; Fe + Mn stain; Jo, 10°, Wa, Sl, Ti; no staining, appears to be along a clay layer; Jo, 40°, Wa, Sl, TT, no stain, clay layer, fractured zone ≈0.05' thick	170 psi; ss2 shales coating; 0% return
40–41	29:20					SW	Mo	R2	Jo ≈2, subhor., bounding crushed, weak, powdery zone (little to no clay) ≈0.01 to 0.5' thick Wa, Sl, Ti, no staining	Jo/be, 15, Pl, thin clay; Jo, 20°, Pl, Sm to Sl, no slickensides, Ti, Fe + Mn stain; clay lining; Jo, 10°, Pl to Wa, Sl, Ti, Fe + Mn stain	@ 7:38am ran out of H2O in water truck; @ 7:45 we have H2O again
41–42	43:10								dolomitic SANDSTONE as above, w/ increasing CaCO3 in system @ 41.2' ... Jo, He, 30°	Jo, 30°, Wa, Sl, Ti, Fe + Mn staining; Jo, hor. to 30°, Sl, Ti, Wa, Fe staining, ... @ base; Jo, He, 60°	170 psi; @ 40': 150 psi; 150 psi ~15% return
42–43	16:35; 21:25	9	5.1/5	102	4.5/5 (90%)	SW	Mo	R2+	Jo, 30°, Wa, Sl, TT, Fe + Mn stain	Jo, He zone with Mn along surfaces doesn't dry out fast; Jo, 60° to vert., Wa, Sl, Ti, Mn stain; Jo, 35°, Wa, Sl, Ti, Mn + Fe stain; Jo, 20°, Wa, Sl, Ti, Fe + Mn stain	@ 42' 200 psi; @ 43' 220 psi 10-20% return over 2' (varies)
43–44	29:35								Sandstone has been weathered out next to calcite vein @ 43.6; Jo, He, Mn stain; Jo, 15°, Wa, Sl, Ti, Fe stain	Jo, 30°, He with calcite vein infrequently & 03 3?; zone Jo, He, Mn staining, dry out slowly; Jo, 80°, Wa, Sl, TT, Mn + Fe stain	@ 44' 160 psi
44–45	50:20								vugs @ 43.6' where rock weathered out & @ 44.7' & along fractures	Jo, 40°, Wa, Sl, Ti, Mn + Fe stain; Jo, 80°, Wa, Sl, TT, Mn stain	@ 45' 160 psi

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Mc-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI	1223a-1	04/19/01	01-H

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
45–46	9:26	9	5.0/5	100	90% 4.6/5	SW	Mo	R2+	dolomitic SANDSTONE, very hard, well cemented, increase in carbonate with depth 2.5Y 5-6/4 (light yellowish to light olive brown)	Jo, 80°, Sl, We, Ti, Mn Stain; Jo, subhor., Sl, We, Ti, Fe stain (×3); Jo, 30°, Sl, Wi, Ti, Fe + Mn stain; Jo, vert, We, Sl, Ti, Fe stained	10% Return
46–51	1:40	CB4 / 10	5.0/5	100	3.8/5 76%	SW	Mo	R2	Same as above; @ 46.3' vugs (dissolution); zone of gray alteration Zn.; @ 50.5' clay "clast" – ¾" long + ¼" high, long axis = hor. Bedding parallel?	Jo, hor., We, Sl, Ti, Fe stain; Jo, He, 30°] both with calcite; Jo, He, 10°] veins; Jo, 40°, We, Sl, Ti, no stain, fresh; Jo, subvert, He but partially re-opened; calcite veining; Jo, 70°, We, Sl, Ti, minor Fe + Mn; Jo, 40°, We, Sl, Ti, Fe + Mn stain; Jo, He, 40°, alt. to gray along it; Jo, He, 70° " " " (zone); Jo, 30°, We, Sl, Ti, Fe + minor Mn stain; Jo, He, vert to 70°, alt. along it, beginning to re-break; Jo, 80° + 30°, We, Sl, Ti, Mn + Fe stain	150 psi; @49' 160 psi; @50' 160 psi; @51' 160 psi, 30% return
51–56	21:20	11	5/5	100	4.1/5 82%	SW	Mo	R2	Same as above 10YR 6/6 (yellow); Crushed zone 51.8' 4/19/01; @ 54.3' to 55' very gradually becomes less hard / more weathered with depth; @ 53.6' Mn stain – dendrol, Jo, He, vert; 54.3 to 55.5'. 2.5Y 6/2 (gray). Color transition zone; ← gradational; below 55.5' 5Y 3/1 (dark mineral color – other minerals = white), more friable	Mc – hammer blow; Jo, 80°, We, Ti, Sl, Mn stain; Jo, He + rebreaking in places We, Sl, Ti, vert + very irregular Mn staining; Jo, subhor., He, " "; Jo, He, 30°; Jo, subhor to 40°, top of fragmented zone; Jo, 80°, top Jo bounding fragmented zone, We, Sl, Fi to Op, calcite vein along bottom; Jo, 30°, We, Sl, Ti, Mn stain; Jo, 10°, We, Sl, Ti, no stain; Jo, 35°, We, Sl, Ti, no stain (only gray); Jo, subhor., We, Sl, Ti, no stain	180 psi; 50% Return; 210 psi; 200 psi; 200 psi ~10% return
56–60	45:00	12	5/5	100	4.1/5 82%	SW-MW / SW	Mo	R1	gradational; Same as above, becoming more friable with depth; gradational @ 57.8' color change from gray to 10YR 5/6 (yellowish brown); [KOW 5/30/01] ~0.01'; @ 59.9' clay layer; Jo, He, 70°; @ 57.9' transition to more friable SANDSTONE	Jo, 10°, We, Sl, Ti, no stain; Jo, 30°, We, Sl, Ti, Mn + Fe staining; Jo, 10°, We, Sl, Ti, Mn + Fe staining; Jo, 10°, We, Sl, Ti, Mn + Fe stain; Jo, He, 10° + vert.; Jo (zone of fracturing) 10°, We, Sl, Ti, no stain (both surfaces)	@56' ~70% Return; @57' 160 psi; @58' 160 psi 50% Return; @59' 200 psi; @60' 220 psi 50% return

Left margin notes: clay → (at ~50.5'); Color transition zone → (at ~54.5'); Friable Zone; Color Change (at ~58'); Tmo-?

Right margin: C (at ~51'), D (at ~57')

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fo-Fault, Fo-Foliation, Jo-Joint, Mc-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or We-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI	12234-1	04/19/01	01-H

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
60–61		12	5/5	100	9.1/5		Mo	R1	10YR 4-6/3 (yellowish brown) friable SANDSTONE, med. grained, mod. weathered; 0.05-0.3' Gray zone 5Y 3/1; below 60.8' 10YR 4-5/3	Jo, subhor., Wa, Sl, Ti, no stain; Jo, subhor., not parallel to color change, Wa, Sl, Ti, no stain	220 psi
61–66		13	5/5	100	4.8/5 (96%)	SW	Mo / Wi	R2	SANDSTONE, well cemented, medium-grained, 10YR 5/4 (yellowish brown); @ 2.7 to 3' ~0.02" clasts orange clay	Jo, 45°, Wa, Sl, Ti, minor Mn stain; Jo, subhor., Wa, Sl, Ti, Fe stain; Jo, subhor., Wa, Sl, Ti, no stain; Jo, He, 80°; Jo, 30°, Wa, Sl, Ti, minor Fe stain; Jo, 80°, Wa, Sl, Ti, Mn & Fe stain; Jo, hor.–40°, Wa, Sl, Ti, no stain, fresh; Jo, 80°, Wa, Sl, Ti, Mn stain	50–70% Return (varies); 200 psi; 220 psi; 220 psi; 220 psi
66–71		14	5/5	100	4/5 (80%)	SW	Mo / Wi	R2	Same as above [KDW 5/30/01]; @ 67.2' clay layer 0.01' thick orange clay; @ 67.4' 30° dip sand & bed of clay, 30° dip, 0.01' [KDW 5/30/01]	Jo, 80°, Wa, Sl, Ti, Mn stain (X2); Jo, 50°, Wa, Sl, Ti, Fe stain; Jo, subhor., Wa, Sl, Ti, no stain; Jo, 70°, Wa, Sl, Ti, Fe stain; Jo, hor., Wa, Sl, Ti, no stain; Jo, subhor., Wa, Sl, Ti, no stain; Jo, ~10, Wa, Sl, Op, clay film or discontinuous streaks, see sketch; Jo, 50°, Wa, Sl, Ti, Fe stain, minor Mn; Jo, 60°, Wa, Sl, Ti, no stain; Jo, hor., Wa, Sl, Ti, little Fe stain	50% Return; 220 psi; 240 psi; 220 psi; 220 psi
71–75	No Data	15	5/5	100	3.45/5 (69%)	SW	Mo	R2	Same as above [KDW 5/30/01]; @ 72.8' clay layer 0.01' thick JB 6/6/01; crushed zone JLB 5/4/01; Jo, He, Mn stained 10°	Jo, He, 30°; Jo, 30°, Wa, Sl, Ti, Fe stain; Jo, subhor., Wa, Sl, Ti, no stain; Jo, 70°, Wa, Sl, Ti, Fe stain; Jo, He, 80°; Jo, He, 80°; Jo, ~30, Wa, Sl, Fi, brown clay; Jo, He, 40° JLH 5/4/01; Jo, 60°, Wa, Sl, Ti, Fe stain; Jo, 65°, Wa, Sl, Fe stain, Ti; Jo, 10°, Wa, Sl, Ti, Fe & Mn stained	50% +/-; 200 psi; 220 psi; 240 psi; 220 psi

Margin notes: Tofb-1 color change; Tofb-1 friable; Tofb-2; C; D

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint description: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

01-H/6

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI	12234-1	04/19/01	01-H

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
75–76 (Tofb-2)	21:30	15	5/5	100	69%; 3.45/5	SW	Mo	R2	SANDSTONE, well cemented 10YR 5/4 med.-coarse grained, massive, moderately hard	Jo, 0°, Wa, Sl, Ti, Fe (minor) staining; Jo, 30°, Wa, Sl, Ti, fresh, no stain	220 psi; C
76									Well-oxidized sand grains	Jo, 90°, Wa, Sl, Op, Slox; Jo, 0°, Wa-St, Sl, Op	Tofb-2 / Tofb-1
76–78 (Tofb-1)	4:45; 16:40	16 (↓ 36)	5/5	100	3.2/5; 64%	SW		R1-R2	Run 16 - Same as above	Jo, 60°, Pl, Sl, Ti; Jo, 0°, Wa, Sl, Ti; Jo, 0°, Wa-St, Sl, Ti	200 psi; @ 5:50 we lost circulation in Tofb-1; @ 16:40 circl. back to 10-20%; B
78										Jo, ~60°, Wa, Sl, Ti	Tofb-1 / Tofb-2
78–81 (Tofb-2)	13:55; 18:45								@ 79.3-79.6 Zone of friable rock. Well oxidized with clay lined fracture dip ~60°, clay 21-5mm thick	Jo, ~60°, Pl, Sl, Ti; Jo, ~60°, Wa, Sl, Fi, w/ clay; Jo, 60°, Pl, Sl, Fi, ~1cm clay; Jo, ~60°, Wa, Sl, Fi, mixed clay S.S. frags.; Jo, 0°, Pl, Sl, Ti	220 psi; 220 psi; C
81	20:40				SW			R1-R2	Same as above		
81–82 (Tofsb-2a friable zone)	8:12				SW			R1-	SANDSTONE, altered, organic rich, Medium grained, well sorted, massive	Jo, 10°, Wa, Sl, Ti, no stain; Jo, 10°, Wa, Sl, Ti, no stain	
82–86	13:20; 13:52; 6:18; 11:50	17	4.8/5.0	96	3.2/5.0; 64%	SW	Mo	R1-	SANDSTONE, dolomitic graywacke, med. grained, well sorted, well oxidized sand massive; JCH 5/4/01 Jo, irr., Wa, Sl, Ti, Fe Stain; Jo, irr., Wa, Sl, Ti, E Stained	Jo, 0, Wa, Sl, Fi - clay seam 0.05' thick JCH; Jo, irr., Wa, Sl, Ti, no stain; Jo, 65°, Wa, Sl, Ti, Fe stain fractured zone, minor Fe + Mn; Jo, 60°, Wa, Sl, Ti, Fe stain; Jo, 30°, Wa, Sl, Ti, Fe stain; Jo, 20°, Wa, Sl, Ti, E stain; Jo, 30°, Wa, Sl, Ti, E stain; Jo, 60°, Wa, Sl, Ti, no staining	200 psi 0-10% Return 5/4/01; @ 11 min Tofb-2 lost circ. @ 83 200 psi; Tofb-1; @ 84' gained back 50% of circ. Running at 220 psi; B
86–89	5:17; 5:32; 8:32	18	2.9/5	58	2.9/5; 58%	SW	Mo	R1	Same as above; @ 88.3' alt. zone / color change, weak SANDSTONE to gray (as above) to 88.6' Return as above	Jo, 50°, Wa, Sl, Ti, E, minor Mn; Mc; No other Jo; Mc	Tofb-1 / Tofb-2; C
89	↓ CB 7				SW	Mo		R1	As above to 89.2'		
89–90	3:30	19	2/2	100	0.5/2; 25%	HW	Cl	R1-R0	Then softer + more fractured; Crushed	4 surfaces Mn stained, various orientations, Small pieces; Jo, 30°, Wa, Sl, Ti, E + Mn stains	@ 90' - 220 psi

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Mc-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
DCPP ISFSI	12230-1	04/19/01	01-H

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
90	14:20	19	2/2	100	0.5/2 25%	HW	Cl	R1-R0	SANDSTONE, weathered, friable in blocks, med to coarse-grained (Tofb-2, Tofb-2a)	Js, 80°, Wa, Sl, Ti, no stain; Js, 70°, Wa, Sl, Ti, no stain; Js, various, Wa, Sl, Ti no stain	
91	14:30								Run 20 - lost 0.5' core - arbitrary 0.25' on each end; SANDSTONE, not very weathered, hard, m-grained, Fe stained	highly fract'd zone, various orient. little to no Fe stain	@91' - 80 PSI
92								R1	Fe stain ← various fract'd zones orientations	Js, 20°, Wa, Sl, Ti, little Fe stain	@93' - 150 PSI
93	14:47	20	4.5/5	90	1.1/5 22%	SW	Cl		Js, various, Wa, Sl, Ti, Fe stain	Js, 30°, Wa, Sl, Ti, little Fe stain; Js, 30°, Wa, Sl, Ti, little Fe stain; Js, 60°, Wa, Sl, Ti, little Fe stain; Js, 40°, Wa, Sl, Ti, no stain; Js, 40°, Wa, Sl, Ti, Fe stain (little)	@94' - 220 PSI
94	15:19								@93.5' color Δ to dark gray 5Y4/2; @94.5' layer of dark gray clay ~0.02' wide	Js, 30°, Wa, Sl, Ti, no stain; Js, 10°, He; Js, He, 50°	@95' 250psi
95	15:25 No DATA						Mo	R1		Js, He, 60°	
96									← 0.25' missing; Gray SANDSTONE, as above to 96.25'; @96.25' yellow brown SANDSTONE, hard, med grained, altered moderately	Js, 40°, Sl, Wa, Ti, clay filling, slickensides, Fe stains; Js, Wa, @80°, Sl, Wa, Ti, no stains; highly fractured zone, all orientations, little Fe & Mn staining	
97	17:0?									Js, 80°, Wa, Sl, Ti, Fe staining	@97' 250psi
98	14:45		5/5	100	0.4/5 8%	SW-MW	Cl	R1-	highly → fractured	Js, 80°, Wa, Sl, Ti, Fe staining; Js, 80°, Wa, Sl, Ti, Fe staining	250psi; 250psi
99	15:38								@99.85' silty soft zone above gray SANDSTONE	Js, 80°, Wa, Sl, Ti; Js, 10°, Wa, Sl, Ti, no stain	250psi
100	15:55								@99.9' color change back to dark gray	Js, 40°, Sl, Wa, Ti, no stain; Js, 10° to 20°, Wa, Ti, Sl no stain; Js, 30°, Wa, Ti, Sl, no stain	250psi
101	16:00										End of Boring TD 101' 5:20pm 04/19/01
102											
3											
4											
5											

Left margin annotations: Friable (weathered) zone 90-98 ft (Tofb-2a); Color Δ, clay; Tofb-2 (98-101). Right margin: C, D, C, D.

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

RF13

LOG OF BORING 3

Equipment: 5" Rotary Wash
Elevation: 140.7 Date: 10/15/73

Shear Strength (lbs/sq ft): 5000 4000 3000 2000 1000 0 | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Qff

Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Shear Strength
8.6	101	~2	
15.5	94	~6	
7.6	112	~21	Tc 11,770; UU2500

Tofb

BROWN SANDY CLAY (CL)
stiff, dry, with occasional rock debris (Fill)

BROWN SAND (SP)
dense, dry, medium-grained, with occasional small gravel
moist @ 2.5'

BROWN GRAVELLY SAND (SW)
dense, moist, slightly cemented with silt, medium to coarse-grained with fine to coarse well-rounded gravel

TAN TUFFACEOUS SANDSTONE
medium-grained, thick-bedded, moderately fractured, moderately hard, moderately strong, moderately weathered, with abundant small calcite inclusions

TAN SILTY SANDSTONE
fine-grained, massive, very thick-bedded, closely to moderately fractured, moderately hard, weak to strong, moderately to little weathered, with occasional thin clay fracture fillings
deeply weathered tuffaceous siltstone @ 21.0' to 21.8' and 24.0' to 25.5', low hardness, friable

BROWN SILTY SANDSTONE
fine-grained, slightly tuffaceous, massive to blocky, thick-bedded, closely to occasionally fractured, moderately hard to hard, moderately strong, moderately weathered, with occasional deeply weathered tuffaceous siltstone

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

(Continuation of Log)

LIGHT BROWN TUFFACEOUS SANDSTONE - medium-grained, moderately fractured, moderately hard, moderately strong, moderately weathered

GRAY-BROWN SILTY SANDSTONE
fine-grained, blocky, thick-bedded, occasionally fractured, moderately hard, moderately strong, little weathered, well consolidated

LIGHT BROWN TUFFACEOUS SANDSTONE - medium-grained, closely to moderately fractured, moderately hard, moderately strong, little weathered

2.5C-58

HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

LOG OF BORING 3
Stability Evaluation
Power Plant Cut Slope

PLATE
A 5

RF13

LOG OF BORING 4

Equipment 5" Rotary Wash
Elevation 195.0 Date 10/26/73

Shear Strength (lbs/sq ft): 5000 4000 3000 2000 1000 0 | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Shear Strength	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Description
			0	BROWN GRAVELLY SANDY CLAY (CL) medium stiff, moist (Fill)
				BLACK TO DARK BROWN SANDY CLAY (CH) - medium stiff, moist, with occasional rock fragments
UU1500 Atterberg Limits Test	24.0	91	5	MOTTLED LIGHT TO DARK BROWN SANDY CLAY (CH) - stiff, moist, with abundant sub-angular rock fragments; occasional caliche veins & inclusions from 5.0' to 9.0'
CU1200	25.7	98	10	becoming very stiff @ 10'; occasional caliche veins & inclusions from 5.0' to 9.0'
			15	sandstone boulder from 15' to 16'
			20	slight increase in silt content
			25	
CU3500	32.4	90	30	
			35	BROWN CLAYEY GRAVEL (GC) very dense, moist, with abundant boulders of silty sandstone, tuffaceous sandstone
			40	

QC; Qpf [illegible]; Qpf; Qpf [illegible] -or- Qtm

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

(Continuation of Log)

Depth (ft): 40, 45, 50, 55, 60, 65, 70, 75, 80

Qpf [illegible] -or- Qtm

HARDING-LAWSON ASSOCIATES
Consulting Engineers and Geologists
[illegible] Date 12/10/73

LOG OF BORING 4
Stability Evaluation
Power Plant Cut Slope

2.5C-59

PLATE A 6

GEO.DOPP.01.LO, FN 5
Attachment G

Page 34 of 37

RF13

LOG OF BORING 4A

Equipment 5" Rotary Wash
Elevation 197.5 Date 11/2/73

Shear Strength (lbs/sq ft): 5000 4000 3000 2000 1000 0 | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

0 – MOTTLED BROWN GRAVELLY SANDY CLAY (CL) - medium stiff, moist (Fill)

BLACK SANDY CLAY (CH) medium stiff, moist

5 –

Qc

BROWN SANDY CLAY (CH) stiff, moist, with occasional rock fragments

10 – Qc -or- Qff Folg...

with abundant rock fragments below 13'

15 –

UU2000 — 27.4 — 96
Atterberg Limits Test

20 –

Qff

25 –

30 –

35 –

40 –

(Continuation of Log)

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

40 – Qff

45 – BROWN CLAYEY GRAVEL (GC) very dense, moist, with sandstone boulders

Qff ...

LIGHT BROWN TUFFACEOUS SANDSTONE - fine to medium-grained, moderately hard, moderately strong, moderately weathered

50 –

55 –

Tofb

60 –

65 –

70 – deeply weathered with occasional sandy clay from 70' to 72'

TAN TO GRAY TUFFACEOUS SANDSTONE - fine-grained, massive, thick-bedded, moderately to occasionally fractured, moderately hard, moderately strong, little weathered, well consolidated

75 –

80 –

2.5C-60

HARDING - LAWSON ASSOCIATES
Consulting Engineers and Geologists

... 549,021.04 ... Date 12/11/73

LOG OF BORING 4A
Stability Evaluation
Power Plant Cut Slope

PLATE
A 7

RF

LOG OF BORING 9

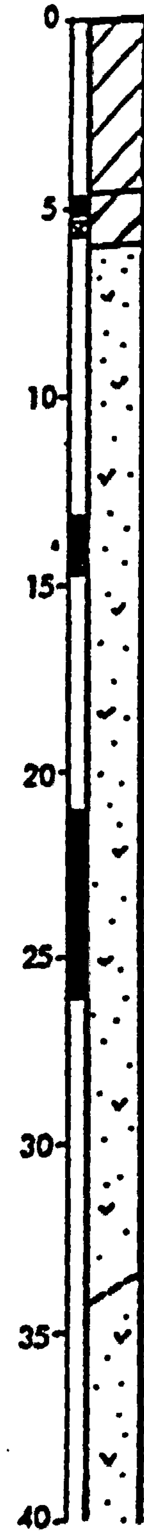
Equipment 5" Rotary Wash
Elevation 288.5 Date 11/5/73

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Unconfined Compression Test
Compressive Stress = 2590 psi

Paleosol ?

Tofb



BROWN GRAVELLY CLAY (CL)
stiff, moist (Fill)

DARK GREEN-BROWN SANDY CLAY (CH) – very stiff, moist

TAN TUFFACEOUS SANDSTONE
massive, thick-bedded, closely fractured, low hardness, weak, deeply weathered

becoming moderately hard, moderately strong, moderately weathered, with occasional sandy clay fracture fillings @ 10'

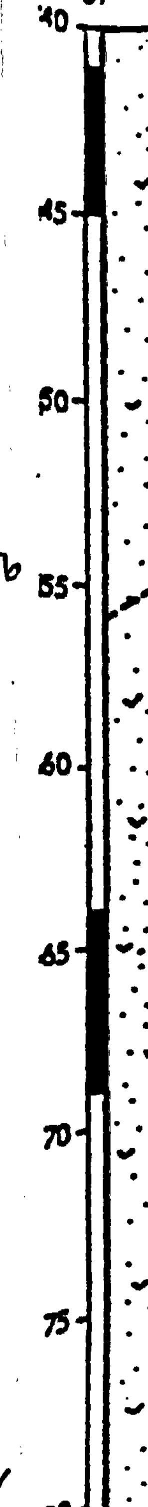
medium grained, closely to moderately fractured, moderately hard, weak, moderately weathered

change to low hardness, friable to weak, deeply weathered @ 23'

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

(Continuation of Log)

Tofb



TAN SANDSTONE
slightly tuffaceous, fine-grained, thick-bedded, closely fractured, moderately hard, weak to moderately strong, moderately weathered

intensely fractured, deeply weathered, with clay fracture fillings from 44.5' to 45'

sandy clay fracture fillings from 51' to 55'

BROWN TO GRAY TUFFACEOUS SANDSTONE – medium-grained, massive, thick-bedded, occasionally fractured, moderately hard, moderately strong, little weathered, moderately consolidated, with thin irregular fracture fillings of silt

(Continued on Plate A-16)

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Consulting Engineers and Geologists

569.021.04 Appr. TTC Date 12/11/73

LOG OF BORING 9
Stability Evaluation
Power Plant Cut Slope

PLATE
A15

RF11

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

LOG OF BORING 9 (cont.)

Equipment
Elevation Date

Depth: 80, 85, 90, 95, 100

T of 6

BROWN CALCAREOUS SANDSTONE
fine-grained, closely fractured, moderately hard, weak, moderately weathered

BROWN TUFFACEOUS SANDSTONE
medium-grained, massive, thick-bedded, closely fractured, moderately hard, weak to moderately strong, moderately weathered

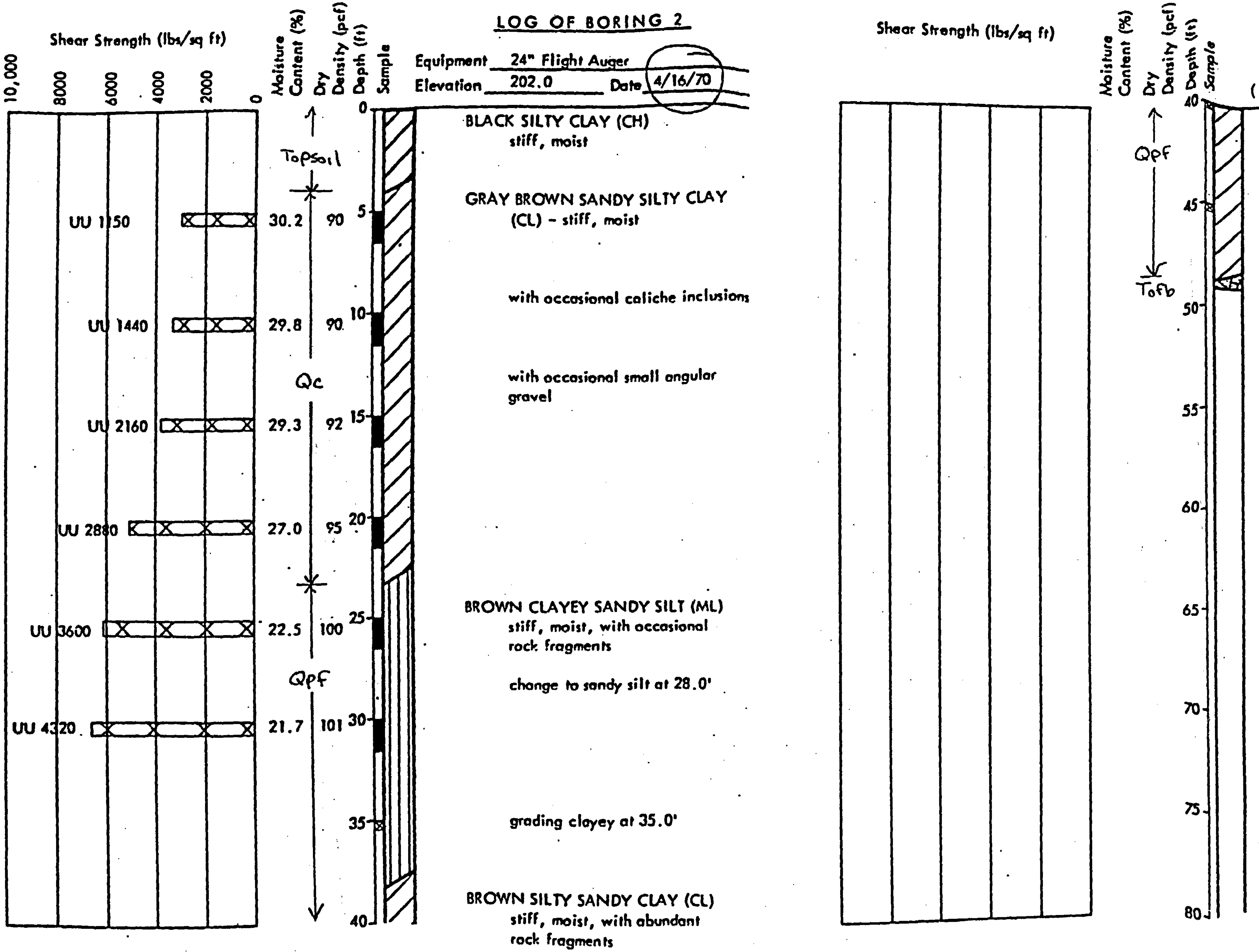
2.5C-69

HARDING-LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No 569,021.04 Appr: ___ Date 12/13/73

LOG OF BORING 9
Stability Evaluation
Power Plant Cut Slope
Diablo Canyon Site

PLATE
A16



FSAR UPDATE

UNITS 1 AND 2
DIABLO CANYON SITE

FIGURE 2.5-24
POWER PLANT SLOPE
LOG OF BORING 2

ATTACHMENT

7-1

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number: 30
Calc Revision: 3
Calc Date: 3/17/2003
Quality Related:
ITR Verification Method: A

1.0 CALCULATION TITLE:

DETERMINATION OF POTENTIAL EARTHQUAKE-INDUCED DISPLACEMENTS OF POTENTIAL SLIDING MASSES ALONG DCPP ISFSI TRANSPORT ROUTE (NEWMARK ANALYSIS)

2.0 SIGNITURES

PREPARED BY [signature] DATE 03/21/03
ZHILIANG WANG — Printed Name
Geomatrix — Organization

VERIFIED BY: [signature] DATE 3/21/03
Faiz I. Makdisi — Printed Name
Geomatrix — Organization

APPROVED BY: [signature] DATE 3/21/03
Lloyd S. Cluff — Printed Name
Geomatrix — Organization

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. EG567
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Exp. 9/30/03

3.0 RECORD OF REVISIONS

Rev. No.	Reason for Revision	Revision Date
0	Initial Issue	11/21/01
1	Revised to address comments from 6/4/2002 NQS Assessment Report 01339023. Removed superseded figures from attachments. Added new attachments (e.g. list and excerpts of input and output files). Numerous editorial changes.	06/25/02
2	Rev No. on this sheet for 6/25/02 corrected to 1. Page 8 of calculation revised to show correction to CD label name. Page 39 of calculation revised to show what is listed on CD.	12/20/02
3	1. Added analyses for a new section M-M' along north end of transport route. 2. Re-calculated deformations for all sections using seismic coefficient time histories computed in GEO.DCPP.01.29, revision 3. 3. Attachments 1 through 7 are copied from GEO.DCPP.01.30, revision 1, no unchanged were made. 4. Added new Attachment 8 which includes excerpts of files used for the deformation calculations for sections L-L', M-M' and E-E' based on seismic coefficient time histories developed in GEO.DCPP.01.29, revision 3.	03/17/03

4.0 PURPOSE

The purpose of this calculation package is to estimate earthquake-induced permanent displacements of potential sliding masses along DCPP ISFSI transport route using Newmark-type analyses.

The calculations reported in this package were performed in accordance with the requirements of Geomatrix Consultants, Inc. Work Plan, Revision 2 (dated December 8, 2000), entitled "Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site" for sections L-L', E-E' and D-D' along the transporter route as identified in calculation package GEO.DCPP.01.21. In response to PG&E AR A0574914, analysis for a fourth section (Section M-M') representing the northern end of the transporter route was made.

Also in response to PG&E AR A0574914, seismic displacements of all potential slide masses on sections L-L', M-M', E-E', and D-D' were re-calculated using the seismic coefficients computed based on summation of boundary forces as documented in GEO.,DCPP.01.29 Rev. 3, and the yield accelerations that incorporates the effects of inertial load from the transporter as documented in GEO.DCPP.01.28 rev. 3.

5.0 ASSUMPTIONS

The order of magnitude of seismic displacement of potential slide masses along the transport route during the design ground motions can be reasonably represented by the displacements computed for the four cross sections presented in this calculation package.

6.0 INPUTS

1. Five sets of rock motions originating on the Hosgri fault: Transmittal from PG&E Geosciences dated September 28, 2001 (Attachment 1 as confirmed in Attachment 7).

2 Plan and three cross-sections along the transport route (Sections D-D′, E-E′, and L-L′) from calculation package GEO.DCPP.01.21.
3. Plan and cross sections M-M' along north end of transport route from calculation package GEO.DCPP.01.21, and GEO.DCPP.01.28, revision 3.
4. Azimuths of three cross-sections along transport route (Attachment 3, as confirmed in Attachment 2).
5. Orientation (azimuth) of the strike of the Hosgri fault: Transmittal from William Lettis & Associates dated August 23, 2001 (Attachment 4).
6. Direction of positive fault parallel component on Hosgri fault: Transmittal from PG&E Geosciences dated October 18, 2001 (Attachment 5 as confirmed in Attachment 6).
7. Yield accelerations that incorporate the inertial force from the transporter and locations for potential sliding masses from calculation package GEO.DCPP.01.28, revision 3.
8. Seismic coefficient time histories computed using the boundary forces acting on the potential slide masses from calculation package GEO.DCPP.01.29, revision 3.

7.0 METHOD AND EQUATION SUMMARY

Development of Rotated Motions along Sections L-L′ and E-E′

Geosciences department of PG&E developed five sets of earthquake rock motions (sets 1, 2a, 3, 5, and 6 as listed in Table 1) for the ISFSI site (see Attachment 1, as confirmed in Attachment 7) to be used as input to the analyses. These motions are estimated to originate on the Hosgri fault about 4.5 km west of the plant site. Both fault normal and fault parallel components were determined for each of the five sets of motions. The fault parallel component incorporated the fling effect and its positive direction was specified in the southeasterly fault direction (see Attachment 5, as confirmed in Attachment 6). The fault normal component has a direction normal to the fault, and its polarity can be either positive or negative depending on the assumed location of the initiation of the rupture. Based on Attachments 2 and 4, the direction of movement along cross section L-L′ (which as shown in Figure 1 has an azimuth of 67 degrees) is 91 degrees (counter-clock wise) from the direction of the strike of the Hosgri fault. The fault normal component can be at $\pm$ 90 degrees from fault parallel direction, that is 91+90 = 181 (or 91-90 = 1) degrees from the direction of section L-L′. From these relations, the ground motion component along section L-L′ can be determined from the specified components along the fault normal and fault parallel directions. Section M-M' is about 100 degrees (counter-clock wise) from the direction of the strike of the Hosgri fault. Section E-E' has an azimuth of 35 degrees as shown in Figure 1, and thus is 123 degrees (counter clock wise) from the direction of the positive fault parallel component of the Hosgri fault. The computed motions along the directions of sections L-L′ and E-E′ will be referred to as the rotated components.

The rotated component along each of the specified section is the sum of the projections of the fault normal and fault parallel components along the direction of the section. The formulation is as follows:

$$Rot^{+} = F_P \cos(\Phi) + F_N \sin(\Phi)$$

and

$$Rot^{-} = F_P \cos(\Phi) - F_N \sin(\Phi)$$

in which the F_P and F_N are fault parallel and fault normal components of the acceleration time-histories, Rot^{+} is the component along the section (for a positive fault normal component) and Rot^{-} is the component along the section (for a negative fault normal component). Φ is the angle between up-slope direction of the section analyzed and the fault parallel direction (southeast). The five sets of earthquake motions on the Hosgri fault, are now rotated to earthquake motions along the up-slope direction of cross sections L-L′ and E-E′. For a given angle between the analyzed section and the fault direction, there are 10 rotated earthquake motions, because for each set the positive and negative directions of the fault normal component are considered separately.

Procedures for Permanent Displacement Calculation

The procedure used to estimate permanent displacements is based on the concept of yield acceleration proposed by Newmark (1965) and modified by Makdisi and Seed (1978). It involves the following steps:

1. A yield acceleration, k_y, at which a potential sliding surface would develop a factor of safety of unity, is estimated using limit equilibrium, pseudo-static slope stability methods. The yield acceleration depends on the slope geometry, the ground water conditions, the undrained shear strength of the slope material, and the location of the potential sliding surface. The analyses are presented in calculation package GEO.DCPP.01.28, revision 3.

2. The seismic coefficient time history (and the maximum seismic coefficient, k_{max}) induced within a potential sliding mass is estimated using two-dimensional dynamic finite element methods. The seismic coefficient is the ratio of the force induced by an earthquake in a sliding block to the total mass of that block. These analyses are presented in calculation package GEO.DCPP.01.29, revision 3.
3. For a specified potential sliding mass, the seismic coefficient time history for that mass is compared with the yield acceleration k_y. When the seismic coefficient exceeds the yield acceleration, down-slope movement will occur along the direction of the assumed failure plane. The movement will decelerate and will stop after the level of the induced acceleration drops below the yield acceleration, and the relative velocity of the sliding mass drops to zero. The accumulated down-slope permanent displacement is calculated by double-integrating the increments of the seismic coefficient time history that exceed the yield acceleration. The program DEFORMP (see software section below) was used to compute the permanent displacements. The results of these computations are presented below.

8.0 SOFTWARE

The program DEFORMP was verified in GEO.DCPP.01.35 and used in this package for the displacement computation. A list of the DEFORMP input and output files included in the enclosed compact disc is attached (Attachment 8). Key excerpts of files are also attached.

9.0 BODY OF CALCULATION

The earthquake-induced deformation was initially estimated (in an approximate manner) using a Newmark type (Newmark, 1965) analysis for a sliding block on a rigid plane. A representative yield acceleration of 0.5g (based on estimates from calculation package GEO.DCPP.01.28 for sections E-E', L-L' and D-D') and a yield acceleration of about 0.3g for section M-M' from the same calculation package, were used to estimate the deformation potential for the various rock input motions. The displacement was computed for the negative direction (representing down-slope movement) only. The down-slope permanent displacement of the sliding mass was integrated by using the input rock motions in the positive direction (representing up-slope direction) only. These preliminary displacement estimates formed the basis for selecting the ground motion time histories that provided the largest displacement potential, for subsequent use as input to the dynamic response analyses.

Table 1 shows the calculated down-slope permanent displacements (for the five sets of rotated rock motions) using the program DEFORMP, following the Newmark rigid block approach described above. The input and output files using program DEFORMP are included in the enclosed compact disc. The results indicate that, on average, ground motion sets 1, 5, and 6, provided the largest displacements (0.24 feet to 0.51 feet) for yield acceleration of 0.5g. Set 1 motion produced 0.30 feet of displacement at section E-E′, however sets 5 and 6 motions when combined with the negative fault normal component, produced comparable displacements at section E-E'. Section M-M' (which has a yield acceleration close to 0.32 g) has similar orientation to section L-L', and thus ground motions rotated to L-L' direction were used to evaluate which sets of ground motions would generate the largest displacement potential for Section M-M'. The results shown in the last column of Table 1 suggest that ground motion sets 5 and 6 would have the highest displacements potentials for Section M-M'. On the above basis, ground motion sets 5 and 6 were selected to be used for the seismic response calculation documented in GEO.DCPP.01.29.

Both motions are rotated relative to the orientations of sections L-L′ M-M', and E-E′ using the fault parallel and the negative fault normal components.

TABLE 1.
DOWN SLOPE DISPLACEMENT CALCULATED BASED ON ROTATED INPUT MOTIONS ALONG SECTIONS L-L′ AND E-E′ (DISPLACEMENT UNIT: FEET, YIELD ACCELERATION: 0.5g)

Set No.	Earthquake	Polarity of FN	ky=0.50g		ky=0.32 g
			$E\text{-}E_{123}$	$L\text{-}L_{91}$	$L\text{-}L_{91}$
Set 1	Lucerne	FN-	0.05	0.11	1.06
		FN+	0.30	0.16	0.57
Set 2a	Yarimca	FN-	0.10	0.23	0.91
		FN+	0.08	0.03	0.28
Set 3	LGPC	FN-	0.09	0.09	0.60
		FN+	0.08	0.06	0.66
Set 5	El Centro	FN-	0.24	0.18	1.58

		FN+	0.13	0.15	1.11
Set 6	Saratoga	FN-	0.51	0.38	1.51
		FN+	0.07	0.05	0.28

10.0 RESULTS AND CONCLUSIONS

Earthquake-induced Displacements at full ground motions

The results of stability analyses were reported in calculation package GEO.DCPP.01.28, revision 3. In this revision, the inertial force of the transporter was considered in the stability analyses of the transporter route, represented by cross sections of L-L'. M-M' E-E' and D-D', to obtain the revised factors of safety and corresponding yield accelerations. Using the yield accelerations for potential sliding masses having the lowest factor of safety obtained for sections L-L′, M-M', D-D' and E-E′ in calculation package GEO.DCPP.01.28, revision 3, the potential for permanent displacements was evaluated using the concept of yield acceleration and procedure described above.

The potential sliding masses, defined by selected elements in the finite element meshe of the two dimensional dynamic response models, are shown in Figures 2 through 4 for sections L-L', M-M' and E-E' respectively.. In this calculation package, the above calculation was performed in QUAD4MU using its built-in to compute the seismic coefficient time histories by summing the forces acting on the element boundaries separating the slide masses from the underlying stable mass. The computed seismic coefficient time histories for the potential sliding masses are presented in Figures 5, 6 and 7 for sections L-L′, M-M' and E-E′, respectively. The computed peak seismic coefficient, k_{max}, for the potential sliding masses at sections L-L′, M-M' and E-E′ are listed in Table 2.

The seismic coefficient time histories shown in Figures 5, 6 and 7 were then double integrated for the portions above the corresponding yield acceleration, using the program DEFORMP, to obtain earthquake-induced displacements. Note that the positive direction (shown in Figure 1) of the rock motions is consistent with the coordinate system selected for the dynamic analysis, i.e. the horizontal coordinate increases in the up-slope direction. As mentioned before, the integration was made for the ground motion amplitudes exceeding the yield acceleration in the positive direction only, and the resulting displacement in the down-slope direction was computed for each potential sliding mass.

The relationships between calculated displacement and yield acceleration, k_y, for each of the three potential sliding masses considered, are presented on Figures 8, 9 and 10 for sections L-L′, M-M' and E-E′, respectively. The relationships between calculated displacement and yield acceleration ratio, k_y/k_{max}, for the potential sliding masses considered, are presented on Figures 11, 12 and 13 for sections L-L′, M-M' and E-E′, respectively.

The yield accelerations estimated for potential sliding masses at sections L-L', M-M', E-E', and D-D' are also presented in Table 2. These results that incorporate the effect of the inertial force from the transporter were from calculation package GEO.DCPP.01.28, revision 3. For the yield acceleration values listed in Table 2, the earthquake-induced down-slope displacements for the potential sliding masses at sections L-L', M-M' and E-E' were estimated from Figures 11, 12 and 13, and are summarized in the same table. For the potential sliding mass at section D-D', the seismic coefficient time history for a potential sliding mass at section E-E' was used to calculate earthquake-induced deformation (i.e. Figure 10). The orientations of section E-E' and D-D' are very similar, but section E-E' has a thicker colluvium deposit than that at section D-D', so the seismic amplification effects at section E-E' would be greater than those at section D-D'. Therefore it is conservative to use the response from section E-E' for estimating the displacement at section D-D'.

In Section M-M', model 1 yields the larger seismic induced displacements as shown in Table 2 and thus model 1 will be used to represent the displacement potential for the northern section of the transport route on rock. Computed permanent displacements using set 5 motion as input, range from about 1.4 feet, for the potential sliding mass at section M-M′ to about 0.2 feet for the potential sliding mass at section D-D'. Computed displacements using ground motion set 6 as input, range from 1.5 feet for the sliding mass at section M-M'′, to about 0.3 foot for the potential sliding mass at section E-E′. In both cases, displacement computed at section M-M' are slightly higher than those computed at sections L-L', E-E' and D-D'.

Earthquake-induced displacements at reduced ground motion levels

Peak accelerations computed along the slope surface at sections L-L′ and E-E′, using reduced input bedrock motions (scaled to 0.15g), were reported in calculation package GEO.DCPP.01.29. The computed peak accelerations in the vicinity of the potential sliding masses at the two sections analyzed were of the order of 0.3g. The estimated peaks (k_{max}) of seismic coefficient time histories within the specified potential sliding masses are expected to be less than 0.3g. The computed yield accelerations shown in Table 2 for the corresponding sliding masses are of the order of 0.5 g. Therefore, because the earthquake-induced peak accelerations are less than the yield acceleration, the potential for downslope displacements are expected to be negligible.

TABLE 2
COMPUTED DOWN-SLOPE DISPLACEMENTS
USING SET 5 AND SET 6 INPUT MOTIONS

Sliding Mass Location	Input Motion	Factor of Safety	Yield Acceleration, K_y, (g)	Peak Seismic Coefficient, k_{max}, (g)	Down-slope Displacement, feet
L-L′	Set 5	2.02	0.48	1.01	0.8
M-M' Model 1	Set 5	2.35	0.33	0.93	1.4
M-M' Model 2	Set 5	2.78	0.44	0.95	0.5
E-E′	Set 5	3.36	0.50	0.94	0.6
D-D′	Set 5	2.21	0.63	0.94	0.2
L-L′	Set 6	2.02	0.48	0.88	0.5
M-M'	Set 6	2.35	0.33	0.88	1.5
M-M' Model 2	Set 6	2.78	0.44	0.90	0.8
E-E′	Set 6	3.36	0.50	0.81	0.3
D-D'	Set 6	2.21	0.63	0.81	0.1

11.0 LIMITATIONS

The displacements computed in this calculation package are a reasonable representation of the expected range of seismic induced displacements during the design ground shaking, considering that the four cross sections analyzed represent the likely variation of ground conditions along the transport route.

12.0 IMPACT EVALUATION

The results are only applicable to the transporter route.

13.0 REFERENCES

1. Geomatrix Consultants, Inc. Work Plan, Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site, Revision 2, dated December 8, 2000.
2. Geosciences Calculation Package GEO.DCPP.01.28, Revision 2, Stability and yield acceleration analysis of potential sliding masses along DCPP ISFSI transport route.
3. Geosciences Calculation Package GEO.DCPP.01.29, Revision 2, Determination of seismic coefficient time histories for potential sliding masses on DCPP ISFSI transport route.
4. Geosciences Calculation Package GEO.DCPP.01.35, Revision 2, Verification of computer code – DEFORMP.
5. Makdisi, F.I., and Seed, H.B., 1978, Simplified procedure for estimating dam and embankment earthquake-induced deformations: Journal of the Geotechnical Engineering Division, American Society of Civil Engineers, v. 104, no. GT7, July, pp. 849-867.
6. Newmark, N.M., 1965, Effects of earthquakes on dams and embankments: Geotechnique, v. 15, no. 2, p. 139-160.

14.0 ATTACHMENTS

1. 09/28/2001, PG&E Geosciences, Robert K. White, Re: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses.
2. 6/7/02, PG&E Geosciences, Robert K. White, Re: Determination of azimuths for cross-sections D-D', E-E′, and L-L′ for DCPP ISFSI transport route stability analyses
3. 11/9/01, William Lettis & Associates, Inc., Jeff Bachhuber, Re: Azimuths for Analytical Cross-sections – ISFSI, e-mail transmittal to F. Makdisi.

4. 08/23/2001, William Lettis & Associates, Inc., Jeff Bachhuber, Re: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project.
5. 10/18/2001, PG&E Geosciences, Joseph Sun, Re: Positive direction of the fault parallel component time history on the Hosgri fault.
6. 10/25/2001, PG&E Geosciences, Robert White, Re: Input parameters for calculations.
7. 10/31/2001, PG&E Geosciences, Robert White, Re: Confirmation of preliminary inputs to calculations for DCPPISFSI site
8 List and key excerpts of input and output files.

Compact Disc (CD), labeled, GEO.DCPP.01.30, rev. 3", Dated 3/21/03, with input and output files for computed earthquake-induced displacements of potential sliding masses.

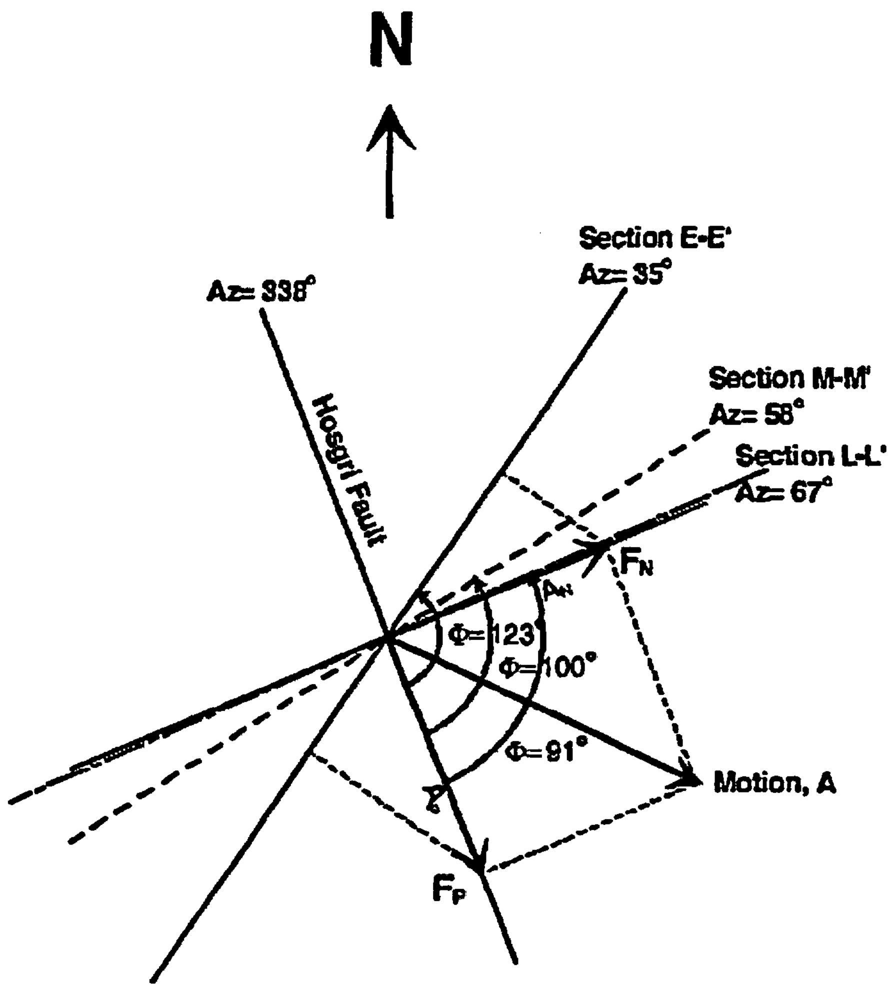


Figure 1. Orientations of Section E-E', Section L-L', Section M-M' and Hosgri Fault

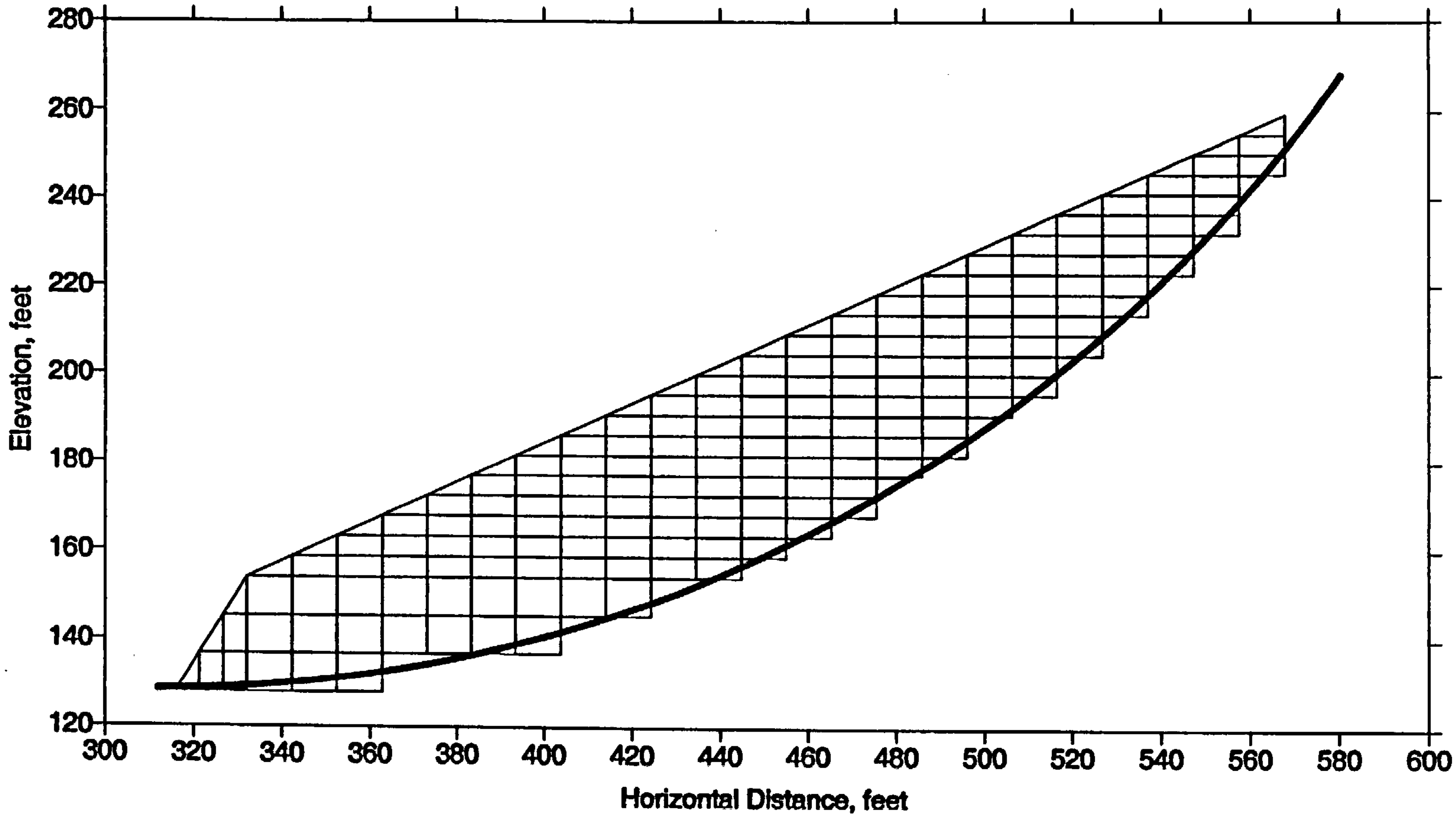


Figure 2. Potential Sliding Mass to Compute Seismic Coefficient Time Histories for Cross Section L-L'.

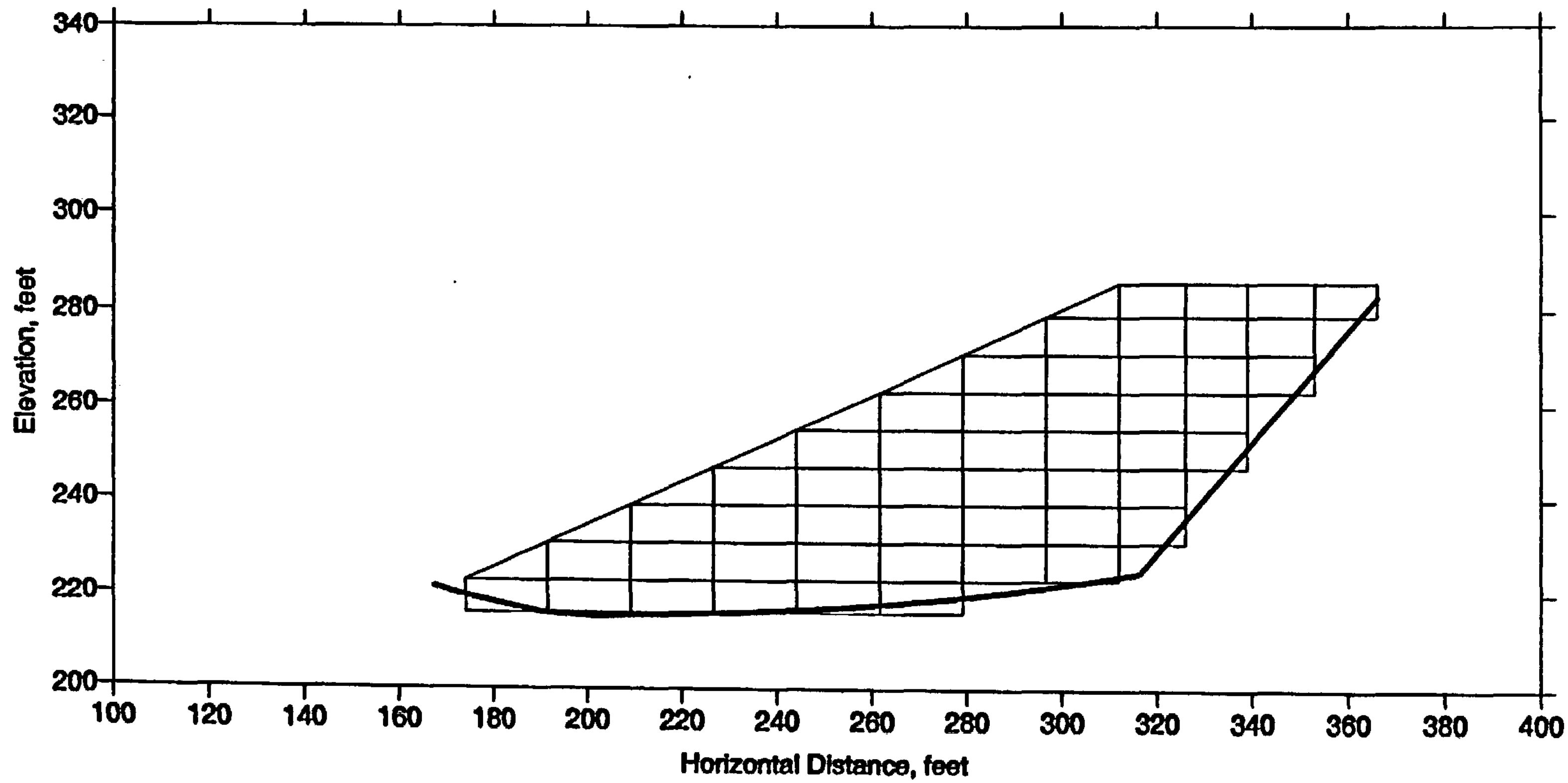


Figure 3. Potential Sliding Mass to Compute Seismic Coefficient Time Histories for Cross Section M-M'.

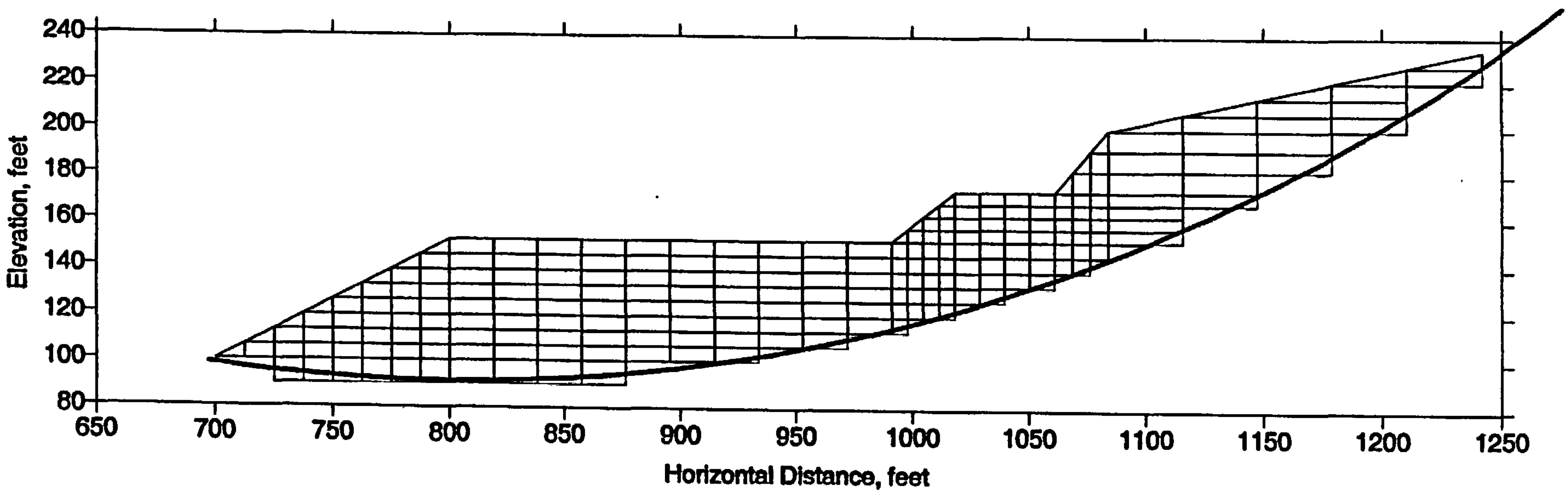


Figure 4. Potential Sliding Mass to Compute Seismic Coefficient Time Histories for Cross Section E-E'.

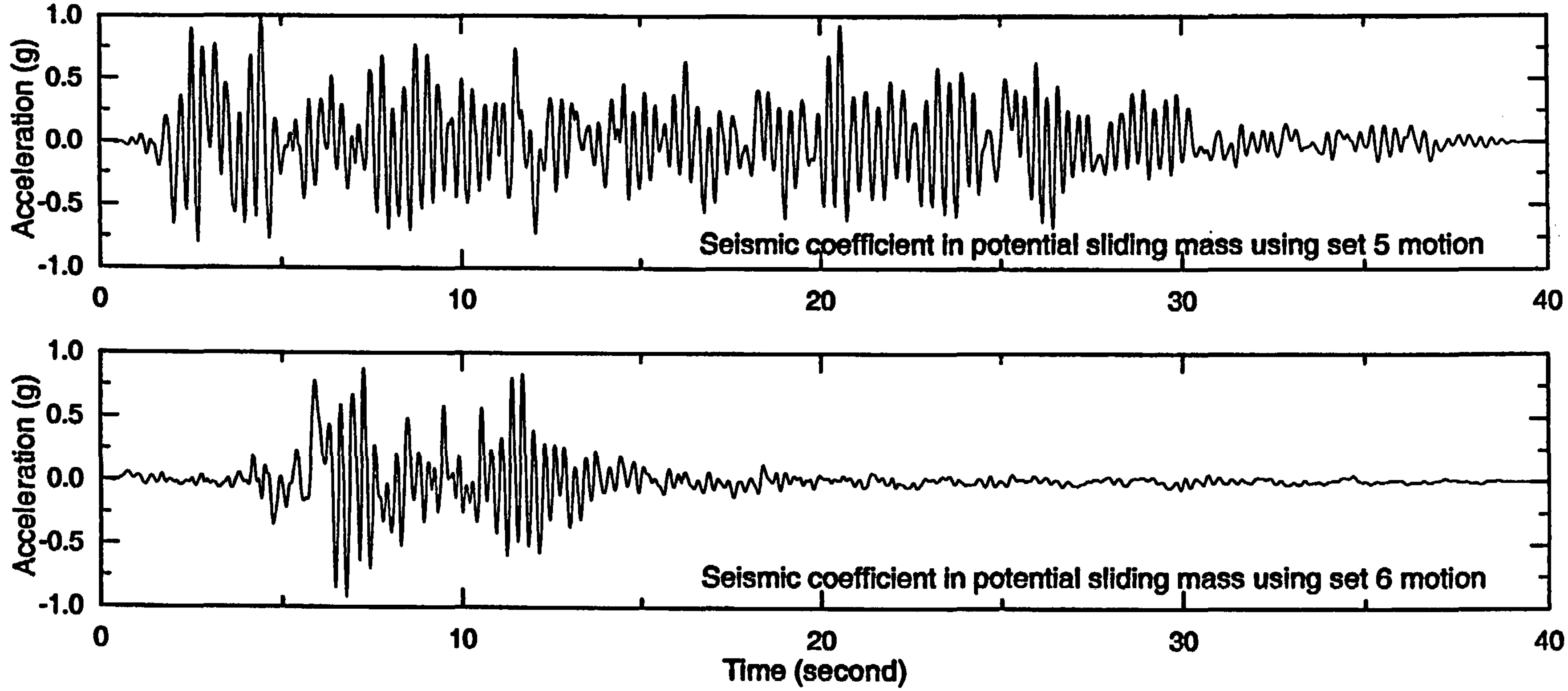


Figure 5. Seismic coefficient time histories of potential sliding masses at section L-L'.

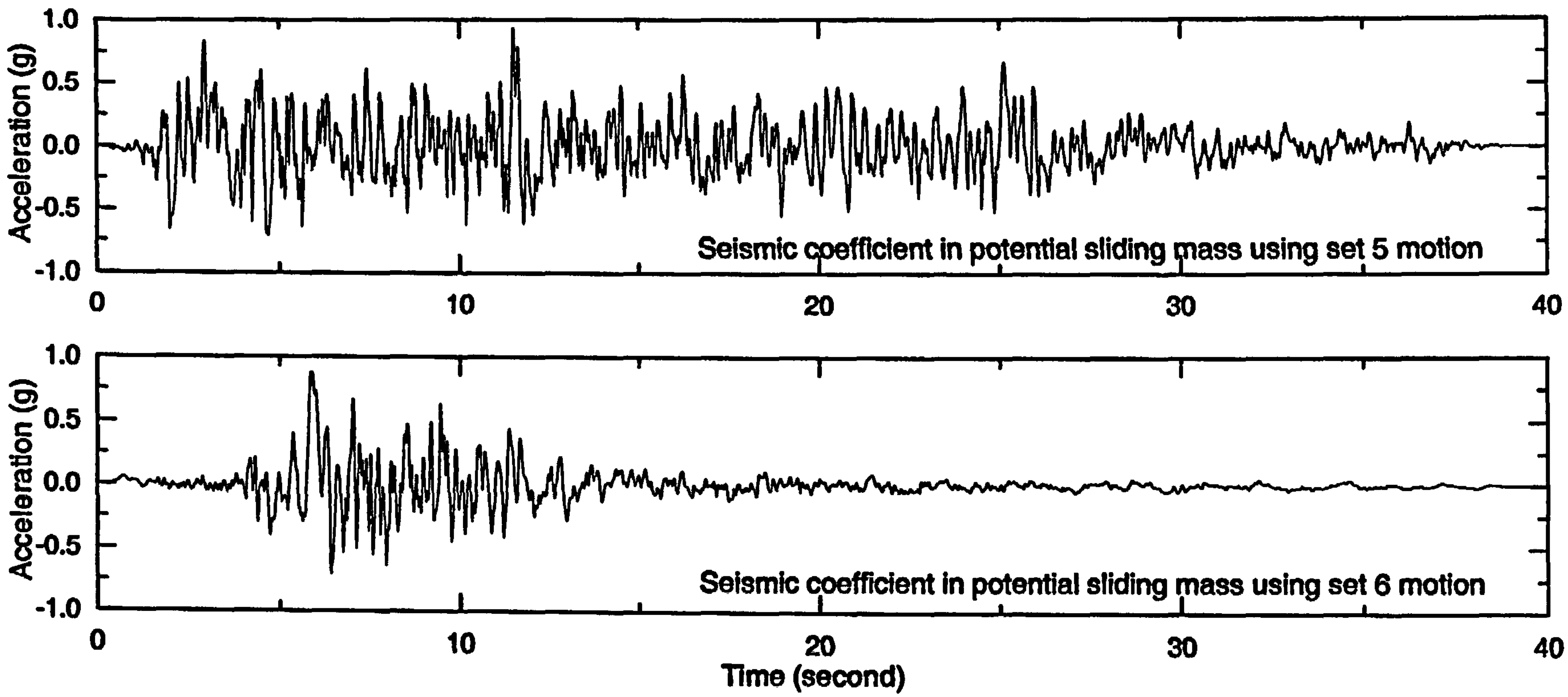


Figure 6. Seismic coefficient time histories of potential sliding masses at section M-M'.

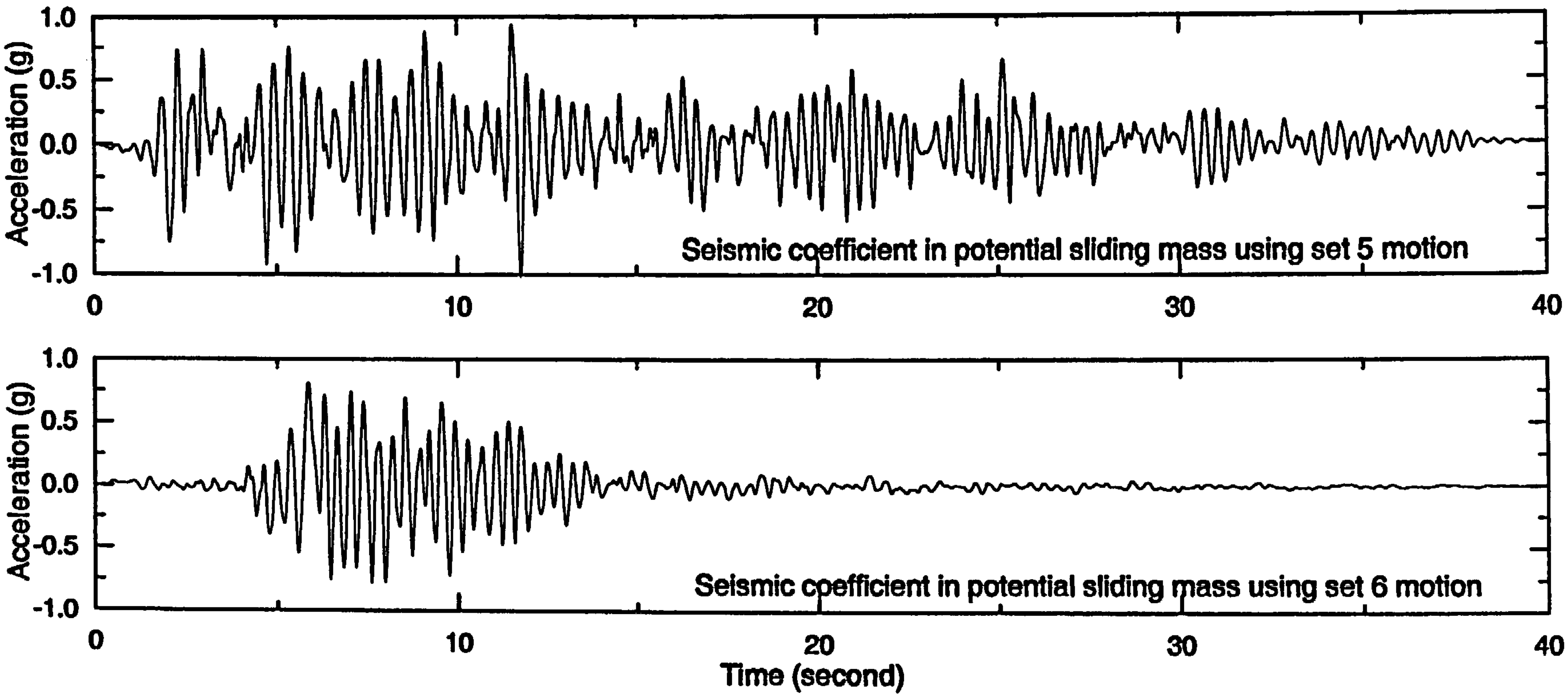


Figure 7. Seismic coefficient time histories of potential sliding masses at section E-E'.

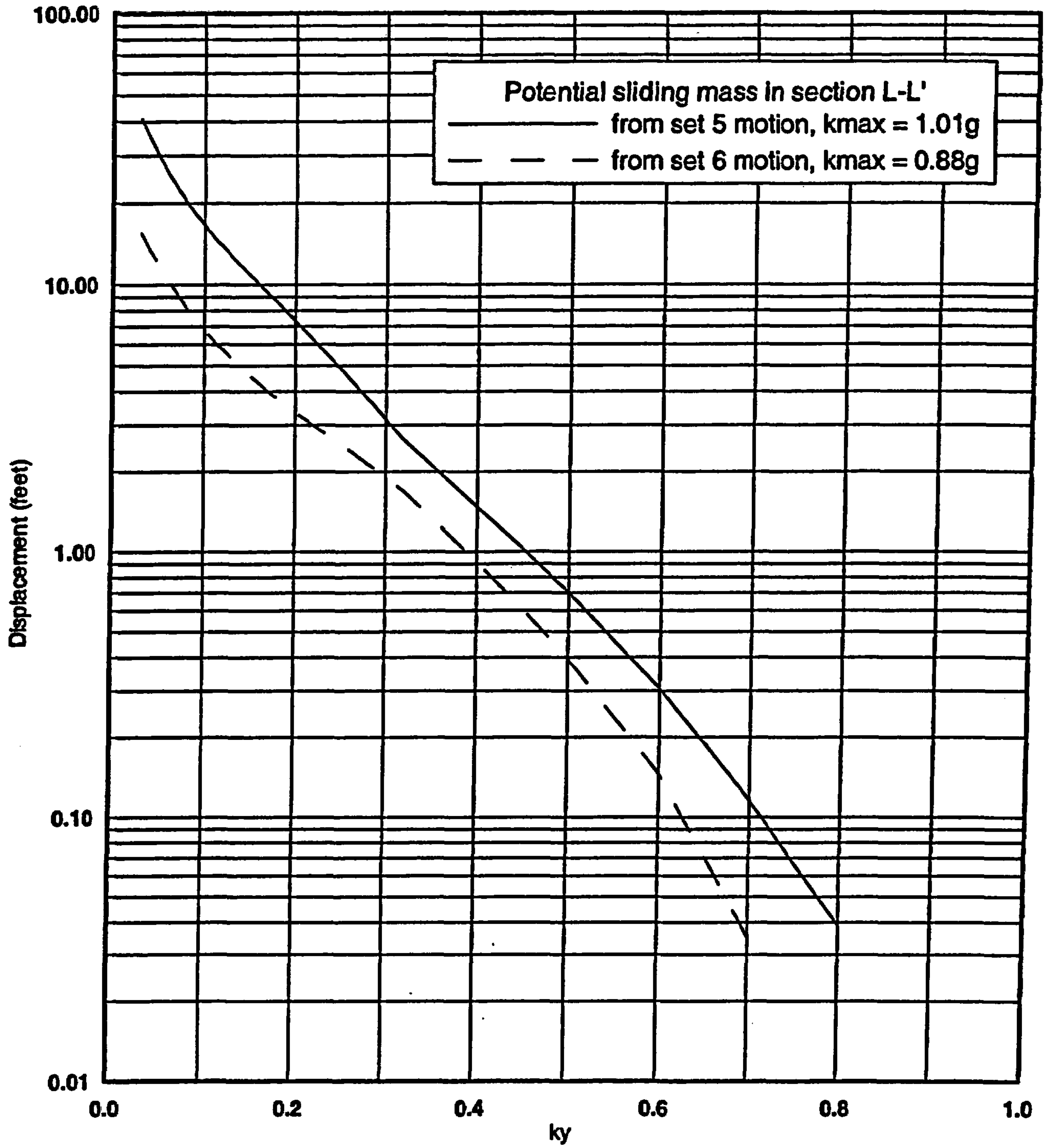


Figure 8. Permanent displacement versus yield acceleration from seismic coefficient time histories, section L-L'.

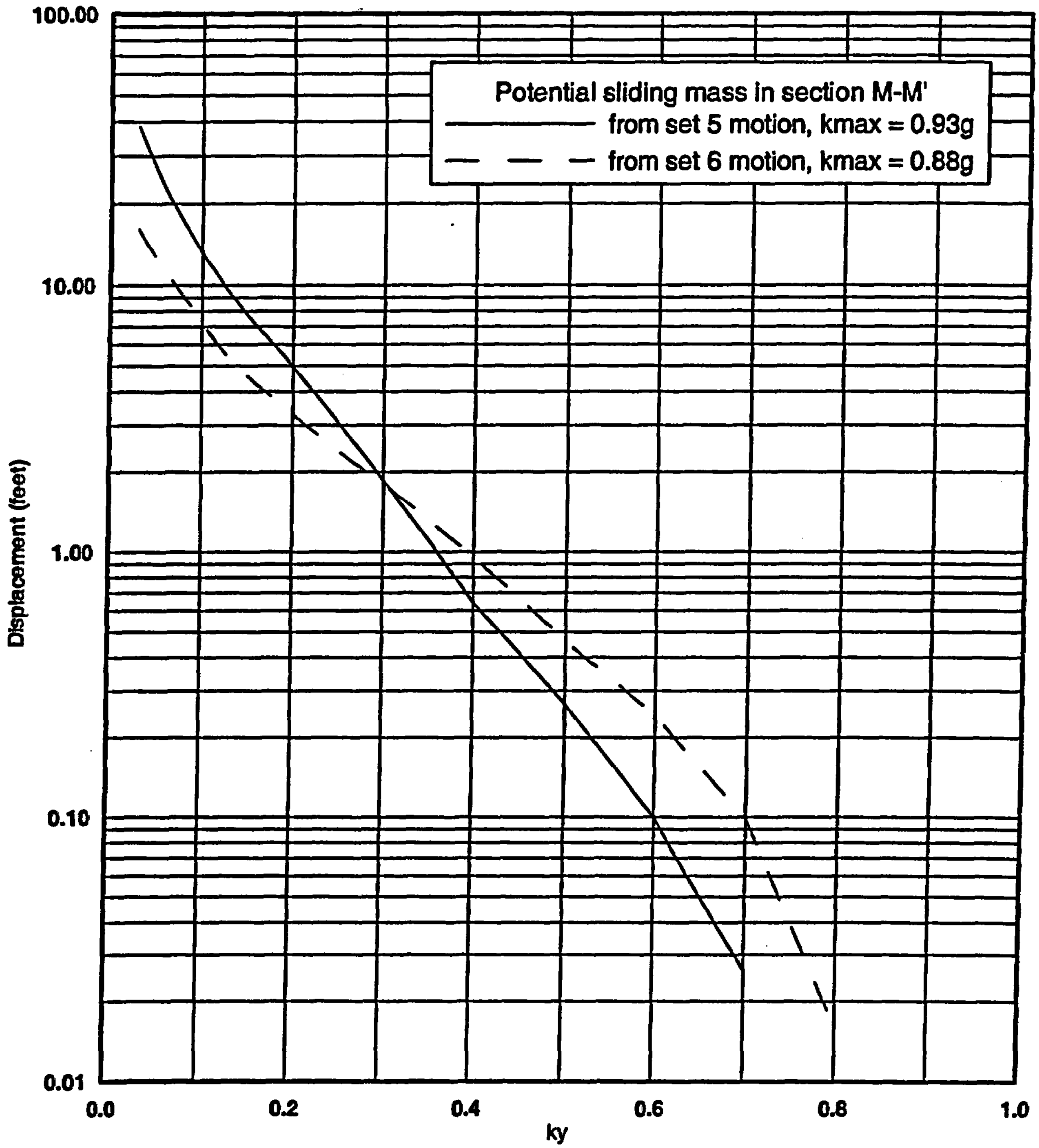


Figure 9. Permanent displacement versus yield acceleration from seismic coefficient time histories, section M-M'.

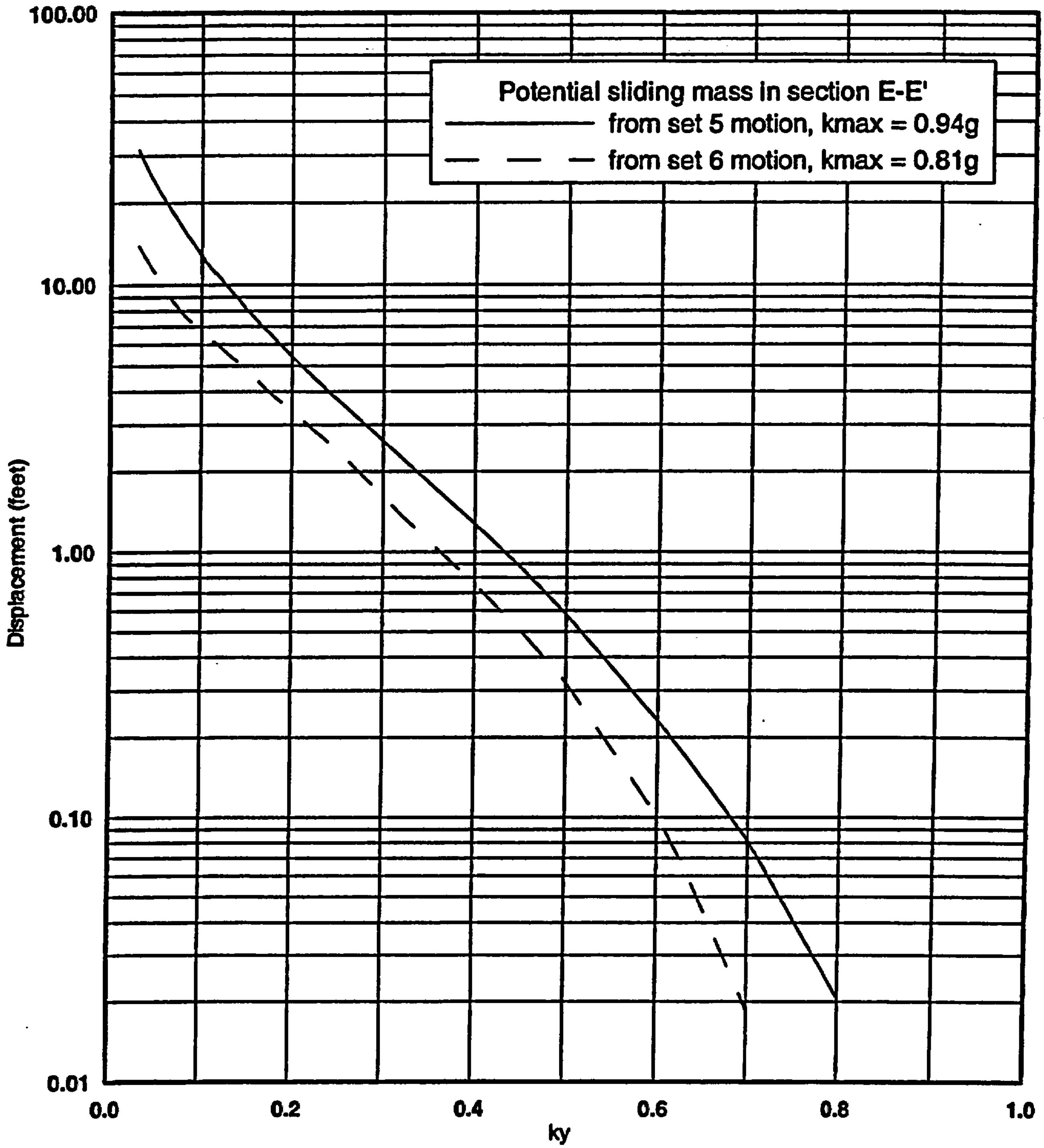


Figure 10. Permanent displacement versus yield acceleration from seismic coefficient time histories, section E-E'.

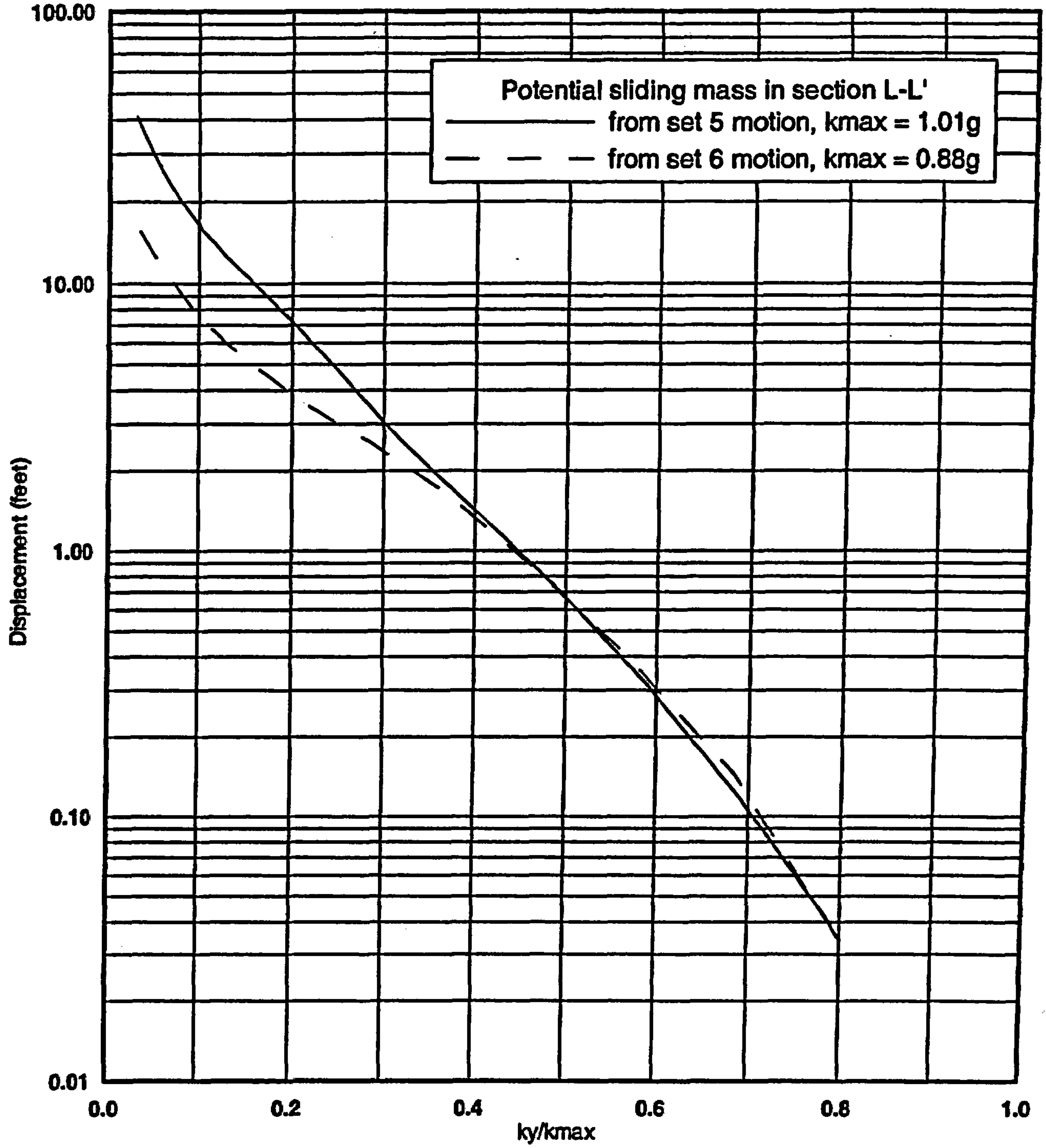


Figure 11. Permanent displacement versus yield acceleration ratio from seismic coefficient time histories, section L-L'.

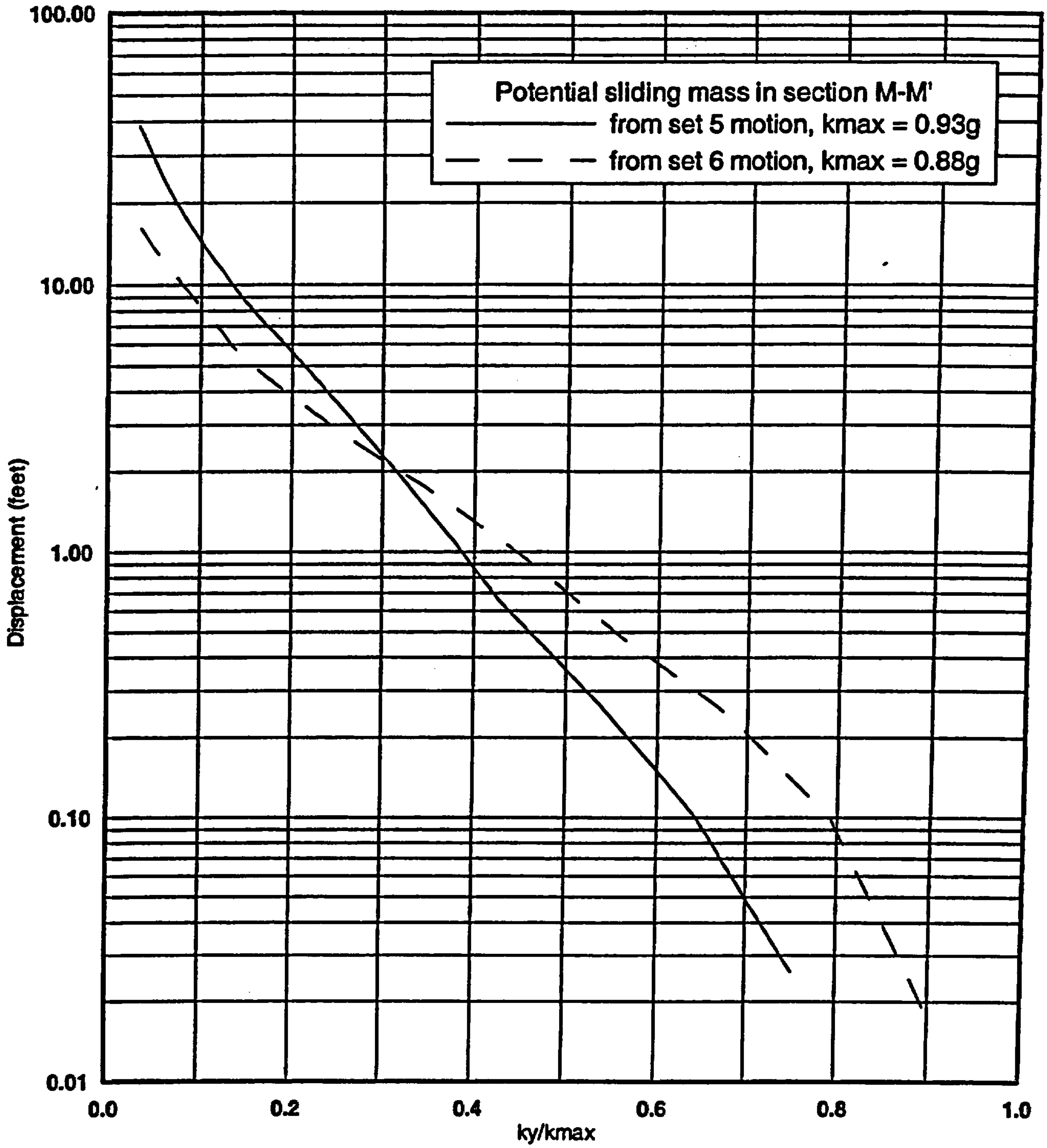


Figure 12. Permanent displacement versus yield acceleration from seismic coefficient time histories, section M-M'.

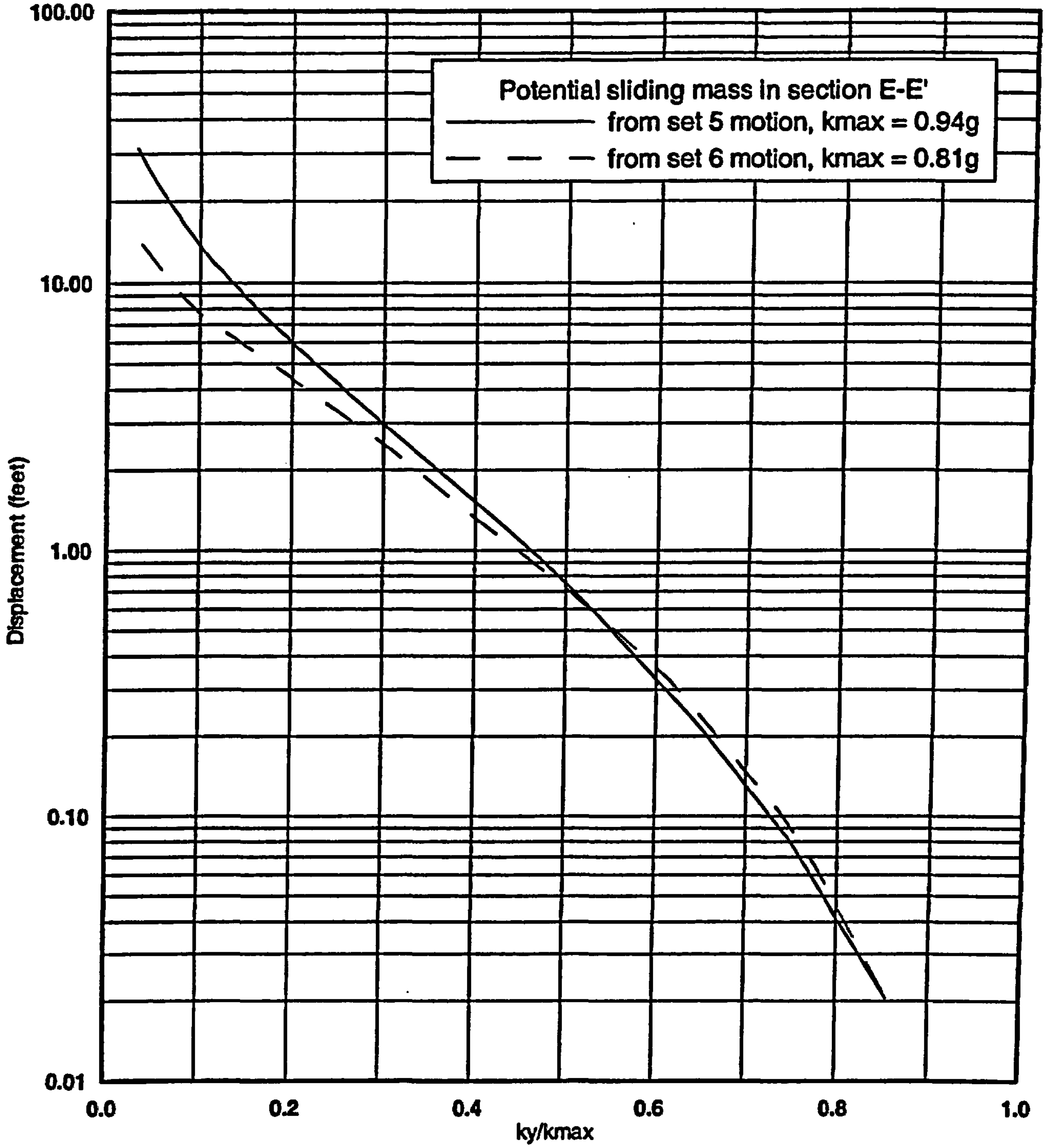


Figure 13. Permanent displacement versus yield acceleration ratio from seismic coefficient time histories, section E-E'.

ATTACHMENT 1

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

Dr. Faiz Makdisi
Geomatrix Consultants
2101 Webster Street
Oakland, CA 94612

September 28, 2001

Re: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses

DR. MAKDISI:

This is to confirm transmittal of inputs related to slope stability analyses you are scheduled to perform for the Diablo Canyon Power Plant (DCPP) Independent Spent Fuel Storage Installation (ISFSI) under the Geomatrix Work Plan entitled "Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for the Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site."

Inputs transmitted include:

Drawing entitled "Figure 21-19, Cross Section I-I'," dated 9/27/01, labeled "Draft," and transmitted to you via overnight mail under cover letter from Jeff Bachhuber of WLA and dated 9/27/01.

Time histories in Excel file entitled "time_histories_3comp_rev1.xls," dated 8/17/2001, file size 3,624 KB, which I transmitted to you via email on 8/17/2001.

Please confirm receipt of these items and forward confirmation to me in writing.

Please note that both these inputs are preliminary until the calculations they are part of have been fully approved. At that time, I will inform you in writing of their status. These confirmation and transmittal letters are the vehicles for referencing input sources in your calculations.

Although the Work Plan does not so state, as you are aware all calculations are required to be performed as per Geosciences Calculation Procedure GEO.001, entitled "Development and Independent Verification of Calculations for Nuclear Facilities," revision 3. All of your staff assigned to this project have been previously trained under this procedure.

I am also attaching a copy of the Work Plan. Please make additional copies for members of your staff assigned to this project, review the Work Plan with them, and have them sign Attachment 1. Please then make copies of the signed attachment and forward to me.

If you have any questions, feel free to call.

Thanks.

Rob White

ROBERT K. WHITE

Attachment

cc: Chris Hartz

ATTACHMENT 2

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

7 June 2002

Re: Determination of azimuths for Cross Sections D-D', E-E', and L-L' for DCPP ISFSI Transport Route Stability Analyses

DR. MAKDISI:

For your use in DCPP ISFSI transport route stability analyses, we have determined the azimuth of each section from Figure 21-3 of Geosciences Calculation GEO.DCPP.01.21, rev. 2, as follows:

Section D-D': 38 degrees
Section E-E': 35 degrees
Section L-L': 67 degrees

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

ATTACHMENT 3

Faiz Makdisi

From: Jeff Bachhuber [bachhuber@lettis.com]
Sent: Friday, November 09, 2001 9:42 AM
To: Page, William
Cc: FMakdisi@geomatrix.com
Subject: AZIMUTHS FOR ANALYTICAL CROSS SECTIONS - ISFSI

Nov. 9, 2001

Bill:

Per your request, we have calculated azimuths for cross sections used for stability analyses for the DCPP ISFSI project. The azimuths were determined using a protractor and the WLA (2001) Geologic Map of the ISFSI Site and Transport Route Vicnity (Figure 21-3 from Calculation Package 21). The following azimuths were determined:

Section D-D': above transport route - 029°
below transport route - 038°
average total section above and below transport route - 032°

Section E-E': below elevation 600' - 035°
above elevation 600' - 019°

Section I-I': 300°

Section L-L': 067°

Please call me if you have any questions regarding these azimuths, or require additional information.

WILLIAM LETTIS & ASSOCIATES, INC.

Jeff Bachhuber
Jeff Bachhuber
William Lettis & Associates, Inc.
1777 Botelho Dr., STE 262
Walnut Creek, CA 94596
bachhuber@lettis.com
(925) 256-6070 TEL
(925) 256-6076 FAX

ATTACHMENT 4

WLA

William Lettis & Associates, Inc.

1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
Voice: (925) 256-6070 FAX: (925) 256-6076

MEMORANDUM

GEO.DCPP.01. 30

REVISION 1

TO: Dr. Faiz Makdisi - Geomatrix Consultants, Inc.
FROM: Jeff L. Bachhuber - William Lettis & Associates, Inc.
DATE: August 23, 2001

RE: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project

FAIZ:

This memorandum provides a revised strike azimuth of 338° for the Hosgri fault for evaluation of ground motion directional components for slope stability analyses at the PG&E DCPP ISFSI site. The revised azimuth presented in this memorandum supercedes the previous estimated azimuths (328° to 335°) presented in our memorandum dated August 8, 2001, and is based on a re-evaluation of fault maps in the PG&E LTSP (1988), and ISFSI project Calculation Package GEO.01.21.

The revised estimated average strike for the Hosgri fault nearest the ISFSI site (between Morro Bay and San Luis Bay) is 338°. Figure 21-23 of Calculation Package GEO.01.21, which previously showed an azimuth of 340° for the Hosgri fault, will be revised to correspond to this re-interpreted average strike. Discrete faults and local reaches of the fault zone exhibit variations in strike azimuth between about 328° and 338°, but the average overall strike of 338° is believed to be the best approximation for the ground motion modeling.

Please call me if you have any questions or require further input for this issue.

Jeff Bachhuber

Cc: Rob White/Bill Page - PG&E Geosciences

ATTACHMENT 5

Pacific Gas & Electric Company
Geosciences Department

P.O. Box 770000, Mail Code N4C
San Francisco, CA 94177
Fax: (415) 973-5778

TELEFAX COVER SHEET

Date: Oct 18 '01

Number of pages including cover sheet: 3

To: Faiz Makdisi
Company: Geomatrix

Phone: (510) 663-4100
Fax: (510) 663-4141
cc:

From: Joseph Sun
Company: PG&E

Phone: (415) 973-2460
Fax: (415) 973-5778

REMARKS: ☐ Per request ☐ For review ☐ Reply ASAP ☐ Please comment

Faiz,

The fault parallel with fling ground motions positive is to the south east. We will follow up with a formal transmittal of the calc package to you

Joseph

c:\data\forms\fax cover.doc

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.14
Revision 1
Date October 15, 2001
Calc Pages: 26
Verification Method: A
Verification Pages: 17 & 8 Attachments

TITLE: Development of time histories with Fling

PREPARED BY: [illegible signature] DATE October 15, 2001

Norman Abrahamson — Printed Name
Geosciences — Organization

VERIFIED BY: [illegible signature] DATE October 15, 2001

Joseph Sun — Printed Name
Geosciences — Organization

APPROVED BY: [illegible signature] DATE 10/15/01

Lloyd Cluff — Printed Name
Geosciences — Organization

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. 1725
STATE OF CALI...

Expires: 12/31/02

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. EG567
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Expires: 12/31/02

6. BODY OF CALCULATIONS

Step 1: S-wave arrival times
The approximate arrival times of the S-waves is estimated by visual inspection of the velocity time histories (Figures 1, 2, 3, 4, and 5). The selected arrival times are listed in Table 6-1.

Table 6- 1. Time of Fling

Set	Reference Time History	Approximate Arrival time of S-waves	Arrival Time of fling (t_1) (sec)	Polarity*
1	Lucerne	8.0	7.1	-1
2a	Yarimca	9.0	8.5	-1
3	LGPC	4.0	3.4	-1
5	El Centro (1940)	1.5	0.0	1
6	Saratoga	4.5	3.7	-1

* The polarity is applied to the fault parallel time history from calculations GEO.DCPP.01.13 (rev 1) to cause constructive interference between the S-wave and the fling (eq. 5-2).

A fling arrival time is selected by visual inspection of the interference of the velocity of the transient motion and the fling (Figures 1, 2, 3, 4, and 5). The selected fling arrival time are listed in Table 6-1.

Since DCPP is on the east side of the Hosgri fault and the fault has right-lateral slip, the permanent tectonic deformation at the site will be to the southeast. In the time histories the fling has a positive polarity. Since the tectonic deformation will be to the southeast, the positive direction of the fault parallel time history is defined to the southeast.

Step 2: Fling Time History
Using the values of A, ω, and T_{fling} given in input 4-1, and the values of t_1 given in Table 6-1, the fling time history is determined using eq. (5-1). The computed fling time histories for the 5 sets are shown in Figures 1, 2, 3, 4, and 5.