APPENDIX L:
COMMENTS AND RESPONSES ON THE DRAFT EA

FRIENDS OF COBB MOUNTAIN

May 18, 2010

COMMENTS ON

CALPINE ENHANCED GEOTHERMAL SYSTEMS PROJECT, DRAFT EA, DOE\EA # 1733

In general terms, we find the EA to be well written with adequate coverage in all sections except one. This is the treatment of the matter of induced seismicity and its potential effects on the residential communities of Cobb and Anderson Springs, with regard both to the residents and their properties.

This particular project may be situated far enough away from these communities that seismic events caused by this project would be slight, but this cannot be guaranteed. Seismic events from M 2.0 upward are normally felt in both of these communities, no matter where they are centered in the Geysers field. One basic flaw in the analysis of induced seismicity in this document is that it is seemingly based solely on scientific data and theory -- scientifically based predictions in the abstract with little regard for the verbal testimony of residents as to their effects on them and their properties, as well as considerable objective data on the impacts of microseismicity.and associated ground motion. In the community of Anderson Springs there have been twenty cases of property damage acknowledged as having been caused by seismic events resulting from geothermal operations. The cumulative cost of repair for these damages has been $72,380, paid by a fund to which one industrial company contributes. With regard to the human annoyance factor, this has caused the community of Anderson Sprigs to file a Public Nuisance complaint, which is still to be settled, but can be solved only by mitigation of the quakes. The point is that seismic predictions in an EA or other environmental document based on scientific data alone are inadequate to the purpose of the document. The experiential factor is vital, and with the reasonable assumption that what has happened once without corrective action will happen again.

Data collected since the strong motion machines were installed at Anderson Springs and Cobb gives evidence that some quakes in the M 2.0-2.9 range -- the most characteristic range of felt quakes at The Geysers -- are capable of generating intensities of MM VI amd MM VII, which are in the destructive category. The attached pages of graphs and charts show the relation of seismic events in intensities VI and VII within the date range of 7/11/03 and 11/2/09. It should be noted that five MM VII events are recorded, one by an M 4.3 quake, two by M 3s (3.02 and 3.03) and two by an M 2.89 and an M 2.98. Among the MM VIs, seven were caused by M 2s, the lowest of which was caused by an M 2.63. The collection and publication of this data was done by Jeffrey D. Gospe, President of the Anderson Springs Alliance, and has been presented to and discussed at length by the Lake County Seismic Monitoring Advisory Committee (SMAC) appointed by the Lake County Board of Supervisors.

The residents neighboring The Geysers field are not opposed to geothermal energy development in itself, but it can only be acceptably developed with adequate mitigation of its environmental effects. We, Friends of Cobb Mountain and the Anderson Springs Community Alliance as organizations, and other members of these communities worked hard in the early days of geothermal development in the region for the control of noise, air pollution from hydrogen sulfide, and water pollution in streams and we ultimately won with the imposition of adequate measures of prevention and mitigation. Now we are faced with an increasingly unacceptable level of seismic activity, and it can only be supposed that this will be true in other localities of geothermal activity, and especially so with the introduction of EGS projects which are partially dependent on earthquakes as a tool. It is clear that this will be a limiting factor in the geothermal future, and it needs to be faced as a primary problem. Regrettably, the International Geothermal Protocol does not adequately face this issue, nor does the EA under present discussion. Earthquakes can simply not be brought to a level of public acceptability, as the Protocol suggests they may be. Much more attention must be given to the mitigation of induced seismicity.

No cut-off magnitude or intensity levels have been specified as safety and nuisance mitigations for this project. We recognize that the geographical location of the project seems sufficiently remote from residential communities that destructive and heavy nuisance impacts would not be expected, but we believe that it is not unreasonable to request that if a project-related seismic event of M 4.0 or greater occurs, or a Mercalli intensity VI (that is, 9.2%g to less than 18%g) is recorded at either the Cobb or Anderson Springs ground motion stations, a temporary shut-down be required pending study of the possible causes of the event, and that there be a complete shut-down of the project if higher Richter (above M 4.5) or Modified Mercalli readings of VII or higher (18%g+) occur.

Respectfully submitted,

Hamilton Hess, Chair
Friends of Cobb Mountain

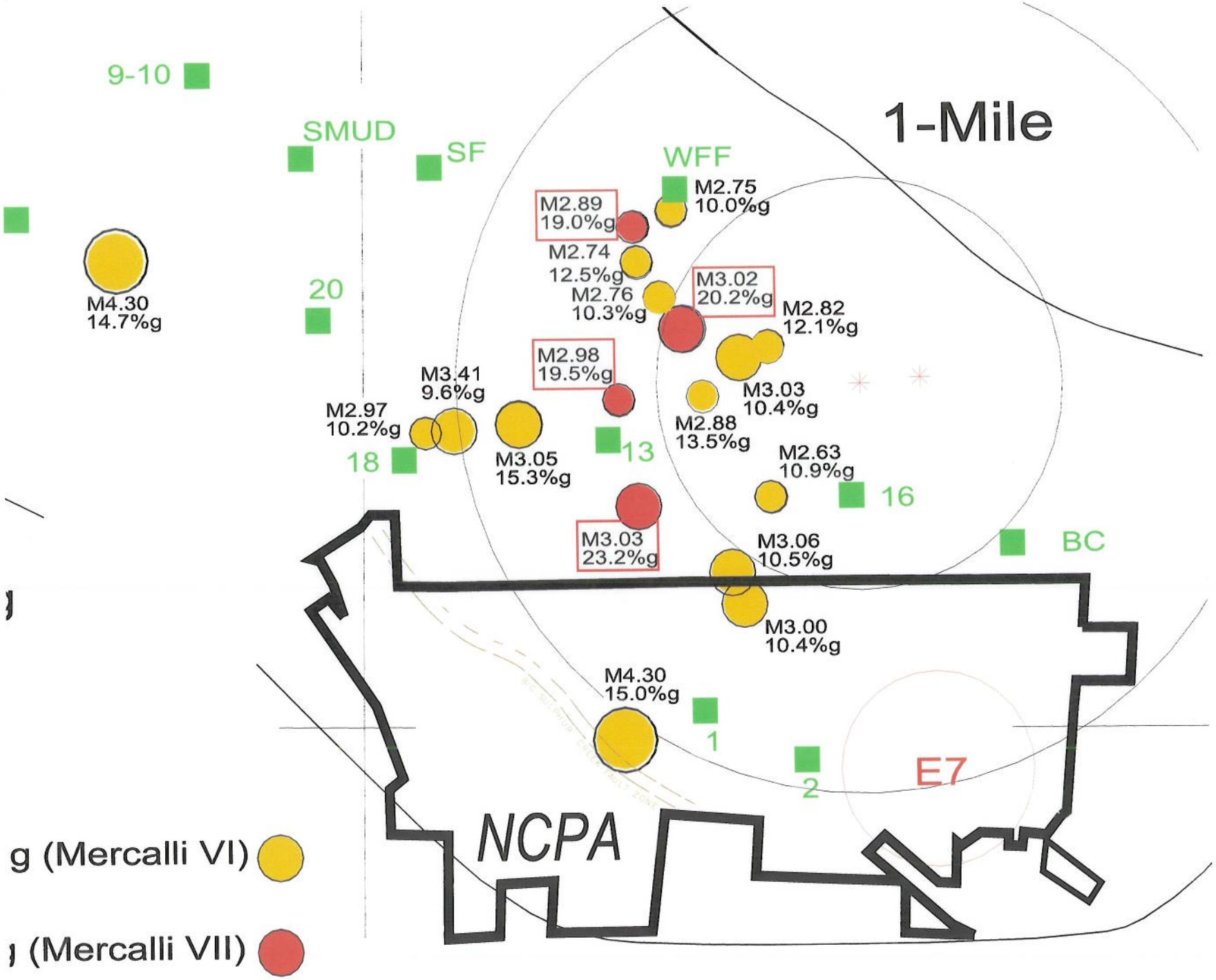
See acompanying charts and graphs.

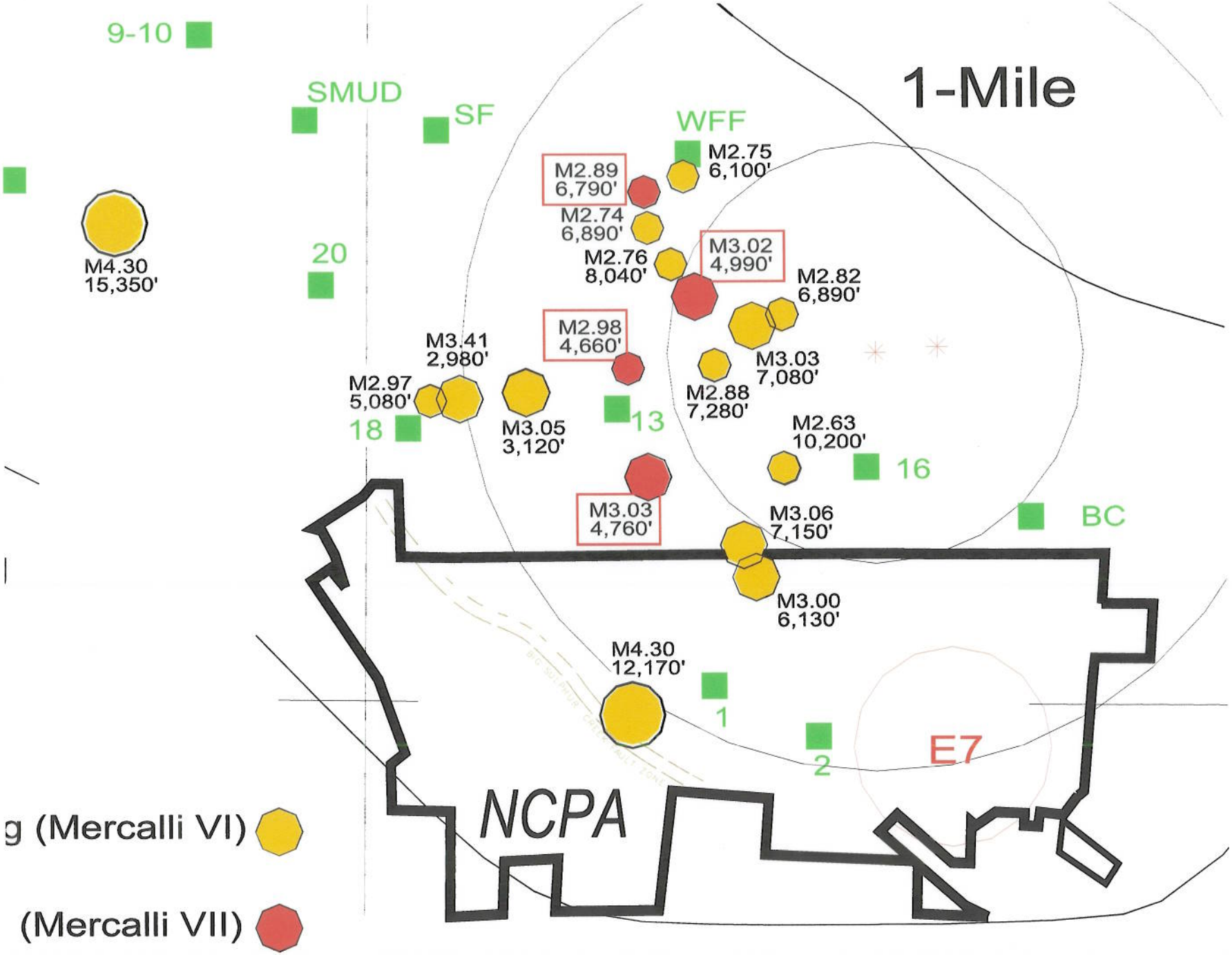
22 Geothermal Earthquakes YTD in 2009, Resulting in Modified Mercalli Intensities V or VI in Anderson Springs

Average of 2.2 Events per Month for 1/1/2009 through 10/31/2009 with PGA >=3.90%g

#	Strong Ground Motion Event ID	Shaking Date	Shaking Time	EQ Time	EQ Date	EQ Magnitude	EQ Depth (km)	Lat	Lon	Leasehold	EQ Event ID	Hot Springs Road PGA (%g)	Recreation Center PGA (%g)	Rec Center PGA ÷ Hot Springs PGA
1	20090104_093358_ADSP-03433_EVT_DK1313	01/04/09	5:27:12 PM	5:27:10 PM	01/04/09	4.30	4.7	38.7823	-122.773	Calpine	51214595	14.7%	N/A	N/A
2	20090210_211726_ADSP-03433_EVT_DK1437	02/11/09	5:14:07 AM	5:14:06 AM	02/11/09	2.48	2.4	38.768	-122.716	Calpine	40231655	7.4%	N/A	N/A
3	20090221_040148_ADSP-03433_EVT_DK1483	02/21/09	11:58:44 AM	11:58:44 AM	02/21/09	2.44	2.1	38.7857	-122.726	Calpine	40232071	4.2%	N/A	N/A
4	20090307_081938_ADSP-03433_EVT_DK1541	03/07/09	4:17:10 PM	4:17:09 PM	03/07/09	2.51	1.7	38.7835	-122.741	Calpine	40232834	4.9%	N/A	N/A
5	20090331_102434_ADSP-03433_EVT_DK1623	03/31/09	5:21:55 PM	5:21:55 PM	03/31/09	2.89	2.8	38.771	-122.732	Calpine	40234090	5.0%	N/A	N/A
6	20090416_181616_ADSP-03433_EVT_DK1686	04/17/09	1:13:06 AM	1:13:05 AM	04/17/09	2.64	2.3	38.7785	-122.718	Calpine	51220026	8.2%	N/A	N/A
7	20090429_181356_ADSP-03433_EVT_DK1739	04/30/09	1:11:16 AM	1:11:15 AM	04/30/09	1.99	2.0	38.7738	-122.719	Calpine	51220735	4.2%	N/A	N/A
8	20090601_173538_ADSP-03433_EVT_DK1828	06/02/09	12:32:00 AM	12:32:00 AM	06/02/09	2.48	2.5	38.774	-122.713	Calpine	40237434	5.0%	N/A	N/A
9	20090630_104140_ADSP-03433_EVT_DK1936	06/30/09	5:27:29 PM	5:27:28 PM	06/30/09	3.84	4.1	38.8083	-122.79	Calpine	71241391	6.9%	N/A	N/A
10	20090701_054602_ADSP-03433_EVT_DK1940	07/01/09	12:42:55 PM	12:42:54 PM	07/01/09	2.98	3.9	38.8112	-122.795	Calpine	71241841	4.2%	N/A	N/A
11	20090716_023918_ADSP-03433_EVT_DK1987	07/16/09	9:35:50 AM	9:35:50 AM	07/16/09	2.76	2.5	38.7802	-122.723	Calpine	71249061	10.3%	N/A	N/A
12	20090826_063431_ADSP-03433_EW041	08/26/09	6:34:31 AM	6:34:31 AM	08/26/09	2.64	2.6	38.778	-122.71	Calpine	71271386	5.4%	4.8%	88%
13	20090826_122813_ADSP-03433_EW044	08/26/09	12:28:13 PM	12:28:12 PM	08/26/09	2.38	2.0	38.756	-122.715	NCPA	71271526	4.3%	2.9%	67%
14	20090826_140808_ADSP-03433_EW046	08/26/09	2:08:08 PM	2:08:08 PM	08/26/09	2.09	1.5	38.7592	-122.723	NCPA	71271576	4.5%	2.5%	56%
15	20090905_084841_ADSP-03433_EW076	09/05/09	8:48:41 AM	8:48:48 AM	09/05/09	2.82	2.1	38.7767	-122.713	Calpine	71271100	12.1%	N/A	N/A
16	20090913_223247_ADSP-03433_EW112	09/13/09	10:32:47 PM	10:32:47 PM	09/13/09	2.79	2.5	38.7785	-122.716	Calpine	71280676	6.0%	N/A	N/A
17	20090926_214530_ADSP-03433_EW142	09/26/09	9:45:30 PM	9:45:30 PM	09/26/09	1.96	2.1	38.7673	-122.711	Calpine	71286791	4.3%	2.7%	64%
18	20091007_200348_ADSP-03433_EW176	10/07/09	8:03:48 PM	8:03:46 PM	10/07/09	2.78	3.8	38.7928	-122.801	Calpine	71295951	4.9%	1.6%	32%
19	20091023_064623_ADSP-03433_EW218	10/23/09	6:46:23 AM	6:46:22 AM	10/23/09	3.05	4.0	38.7925	-122.755	Calpine	71298350	8.2%	4.1%	49%
20	20091031_065225_ADSP-03433_EW238	10/31/09	6:52:25 AM	6:52:24 AM	10/31/09	3.58	4.8	38.7945	-122.769	Calpine	71302365	7.2%	6.1%	85%
21	20091031_095206_ADSP-03433_EW240	10/31/09	9:52:06 AM	9:52:05 AM	10/31/09	2.74	2.4	38.7837	-122.724	Calpine	71302540	12.5%	5.6%	45%
22	20091031_122036_ADSP-03433_EW245	10/31/09	12:20:36 PM	12:20:36 PM	10/31/09	1.85	2.1	38.7838	-122.724	Calpine	71302640	4.6%	2.4%	51%
	Modified Mercalli Intensity VI Events in **RED** (i.e., PGA >9.2%g)				**Averages:**	**2.73**	**2.8**					**6.8%**	**3.6%**	**60%**
	All dates & times in Universal Mean Time				Minimums & Maximums:	1.85 to M4.3	5km to 4.8km					4.2%g to 14.7%g	1.6%g to 6.1%g	32% to 88%

Courtesy of the Anderson Springs Community Alliance, November 9, 2009


1-Mile
9-10
SMUD
SF
WFF
20
18
13
16
BC
1
2
E7
NCPA
M4.30
14.7%g
M2.89
19.0%g
M2.75
10.0%g
M2.74
12.5%g
M2.76
10.3%g
M3.02
20.2%g
M2.82
12.1%g
M2.98
19.5%g
M3.41
9.6%g
M2.97
10.2%g
M3.05
15.3%g
M3.03
10.4%g
M2.88
13.5%g
M2.63
10.9%g
M3.03
23.2%g
M3.06
10.5%g
M3.00
10.4%g
M4.30
15.0%g
g (Mercalli VI)
(Mercalli VII)


1-Mile
9-10
SMUD
SF
WFF
20
18
13
16
BC
1
2
E7
NCPA
M4.30
15,350'
M2.89
6,790'
M2.75
6,100'
M2.74
6,890'
M2.76
8,040'
M3.02
4,990'
M2.82
6,890'
M2.98
4,660'
M3.41
2,980'
M2.97
5,080'
M3.05
3,120'
M3.03
7,080'
M2.88
7,280'
M2.63
10,200'
M3.03
4,760'
M3.06
7,150'
M3.00
6,130'
M4.30
12,170'
g (Mercalli VI)
(Mercalli VII)

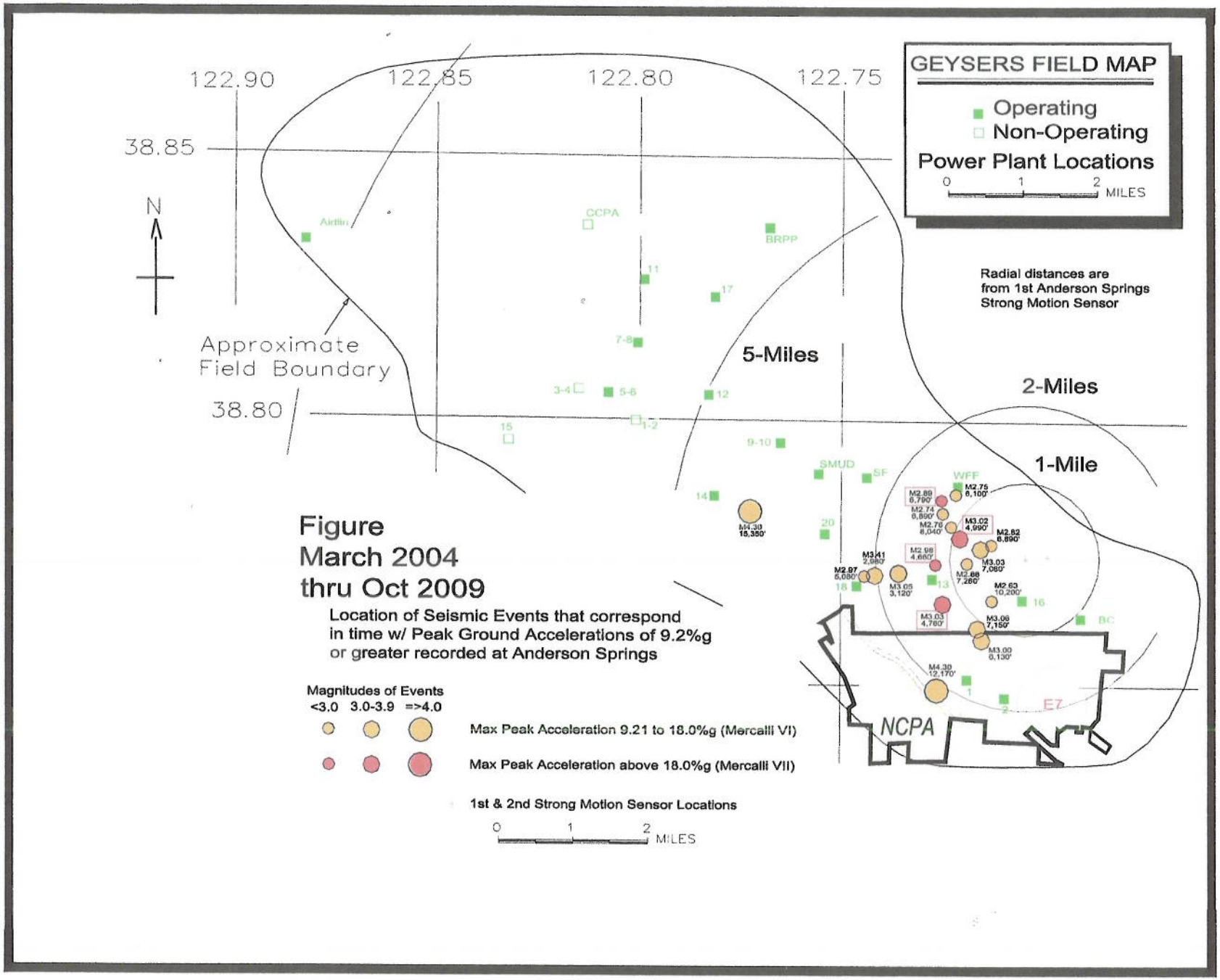


Figure
March 2004
thru Oct 2009

Location of Seismic Events that correspond in time w/ Peak Ground Accelerations of 9.2%g or greater recorded at Anderson Springs

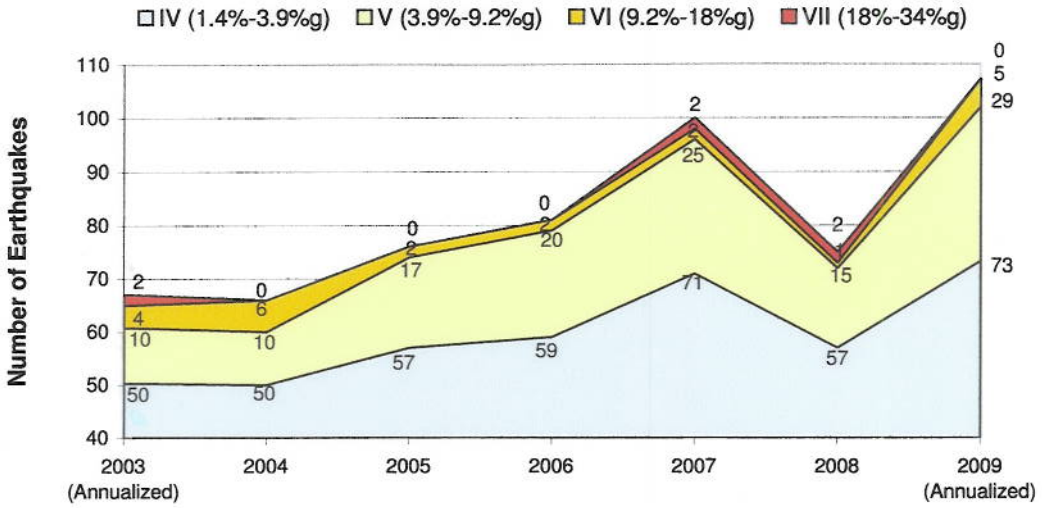
SUMMARY BY YEAR & MODIFIED MERCALLI INTENSITIES (%g Peak Ground Acceleration)

512 Earthquakes Generating Strong Peak Ground Accelerations (PGA ≥ 1.4%g or Modified Mercalli Intensities IV+)
Recorded in Anderson Springs over 76 Months (from July 11, 2003 through November 2, 2009)

	Modified Mercalli Intensity† (%g Peak Ground Acceleration)				
Year	IV (1.4%-3.9%g)	V (3.9%-9.2%g)	VI (9.2%-18%g)	VII (18%-34%g)	Grand Total
2003*	24	5	2	1	32
2003 (Annualized)	50	10	4	2	67
2004	50	10	6	0	66
2005	57	17	2	0	76
2006	59	20	2	0	81
2007	71	25	2	2	100
2008	57	15	1	2	75
2009 (Annualized)	73	29	5	0	107
2009*	56	22	4	0	82
Grand Total	**374**	**114**	**19**	**5**	**512**
	73%	22%	4%	1%	100%

* Actual data for partial years: 2003 based on 7/11/03 through 12/31/03; 2009 based on 1/1/09 through 7/19/09, and 8/16/09 through 11/2/09). For comparison purposes charts use annualized data for 2003 and 2009.

512 Earthquakes Generating Strong Peak Ground Accelerations
(PGA ≥ 1.4%g or Modified Mercalli Intensities IV+)



† **Definitions of Modified Mercalli Intensity Scale** (per USGS website)

IV = Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building.
V = Felt by nearly everyone; many awakened. Some dishes, windows broken. unstable objects overturned. Pendulum clocks may stop.
VI = Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII = Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

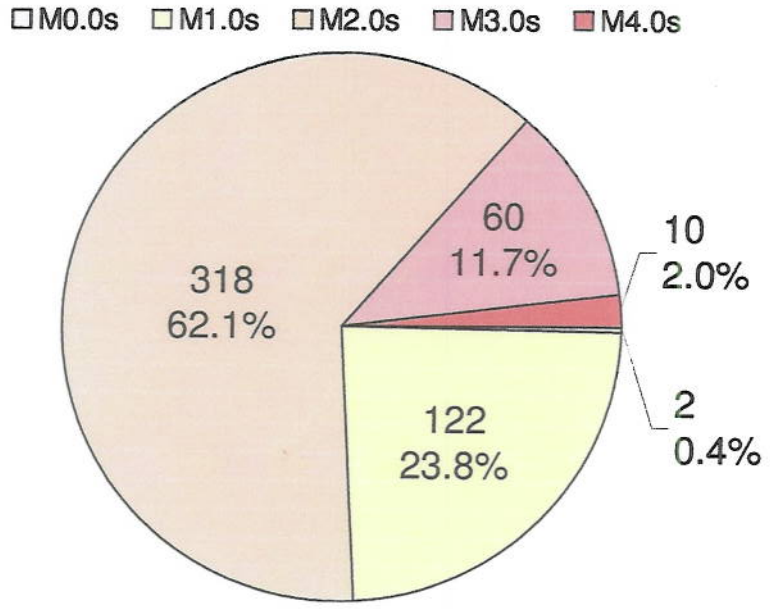
Courtesy of the Anderson Springs Community Alliance, November 9, 2009

SUMMARY BY YEAR & EARTHQUAKE MAGNITUDES

512 Earthquakes Generating Strong Peak Ground Accelerations (PGA ≥ 1.4%g or Modified Mercalli Intensities IV+)
Recorded in Anderson Springs over 76 Months (from July 11, 2003 through November 2, 2009)

YEAR	M0.0s	M1.0s	M2.0s	M3.0s	M4.0s	Grand Total
2003	1	9	17	4	1	32
Average PGA (%g)	3.5%	1.8%	3.5%	10.0%	7.4%	4.0%
Maximum PGA (%g)	3.5%	3.1%	9.3%	23.6%	7.4%	23.6%
2004	0	20	38	7	1	66
Average PGA (%g)	N/A	2.0%	3.3%	7.0%	15.0%	3.5%
Maximum PGA (%g)	N/A	5.3%	13.5%	15.3%	15.0%	15.3%
2005	0	14	52	9	1	76
Average PGA (%g)	N/A	2.1%	3.1%	3.9%	13.2%	3.2%
Maximum PGA (%g)	N/A	3.5%	8.4%	10.4%	13.2%	13.2%
2006	0	17	44	18	2	81
Average PGA (%g)	N/A	2.5%	3.0%	5.4%	5.5%	3.5%
Maximum PGA (%g)	N/A	6.1%	6.9%	13.6%	9.1%	13.6%
2007	0	26	65	7	2	100
Average PGA (%g)	N/A	1.9%	3.7%	6.8%	4.5%	3.5%
Maximum PGA (%g)	N/A	3.9%	19.5%	20.2%	5.6%	20.2%
2008	0	16	51	6	2	75
Average PGA (%g)	N/A	2.1%	3.7%	7.0%	5.7%	3.7%
Maximum PGA (%g)	N/A	3.8%	19.0%	23.2%	7.8%	23.2%
2009	1	20	51	9	1	82
Average PGA (%g)	2.0%	2.4%	3.7%	4.2%	14.7%	3.5%
Maximum PGA (%g)	2.0%	5.6%	12.5%	8.2%	14.7%	14.7%
GRAND TOTAL	**2**	**122**	**318**	**60**	**10**	**512**
% Total	**0.4%**	**23.8%**	**62.1%**	**11.7%**	**2.0%**	**100.0%**
Average PGA (%g)	2.7%	2.1%	3.4%	5.8%	8.2%	3.5%
Maximum PGA (%g)	3.5%	6.1%	19.5%	23.6%	15.0%	23.6%

Distribution of Earthquakes by Magnitude



Courtesy of the Anderson Springs Community Alliance, November 9, 2009

Response to Friends of Cobb Mountain Comments on the Calpine EGS EA

2 June 2010

The thoughtful and well written comments from the Hamilton Hess and the Friends of Cobb Mountain are appreciated. The following are responses to the technical comments contained in the 18 May 2010 letter.

1. *This particular project may be situated far enough away from these communities that seismic events caused by this project would be slight, but this cannot be guaranteed. Seismic events from M 2.0 upward are normally felt in both of these communities, no matter where they are centered in The Geysers field.*

   It is true that there are no "guarantees" involved in earthquake prediction; for this reason, scientists prefer to state observations in either relative or quantitative probabilistic terms.

   Figure 1 shows the number of felt earthquakes based on the calls to the Calpine "hotline" telephone versus distance from the event to the Calpine strong motion instrument ADSP. Not all hotline calls from Anderson Springs are included but only those within 0.5 km of the ADSP strong motion instrument, which encompasses a large portion of the community. During the time period from January 1, 2004 to August 31, 2009, there were 2,020 earthquakes of **M** 2.0 and greater, of which 120 were reported as having been felt in Anderson Springs (or 6% of the total earthquakes over M 2.0). Of the 120 earthquakes reported as "felt" during this timeframe, the vast majority occurred within 10 km of the community.

2. *One basic flaw in the analysis of induced seismicity in this document is that it is seemingly based solely on scientific data and theory – scientifically based predictions in the abstract with little regard for the verbal testimony of residents as to their effects on them and their properties, as well as considerable objective data on the impacts of microseismicity and associated ground motion.*

   Analyses based on communications from the community (including telephone calls to the Calpine hotline) have been performed to better understand the impacts of induced earthquakes at The Geysers (e.g., Figure 1). Thus "verbal testimony of the residents" both from the hotline and through community discussions are being considered in mitigation measures.

3. *Data collected since the strong motion machines were installed at Anderson Springs and Cobb gives evidence that some quakes in the M 2.0-2.9 range – the most characteristic range of felt quakes at The Geysers – are capable of generating intensities of MM VI and MM VII, which are in the destructive category.*

   As stated on page 5-1 in the induced seismicity report included as Appendix I to the EA, correlations between any single ground motion parameter and intensity are highly uncertain. The correlations between peak horizontal ground acceleration and perceived shaking, as provided on page 5-1 (Wald *et al.*, 1999), is very approximate for The Geysers since it was developed based upon eight larger California earthquakes of **M** ≥ 5.8 (Wald *et al.*, 1999) that

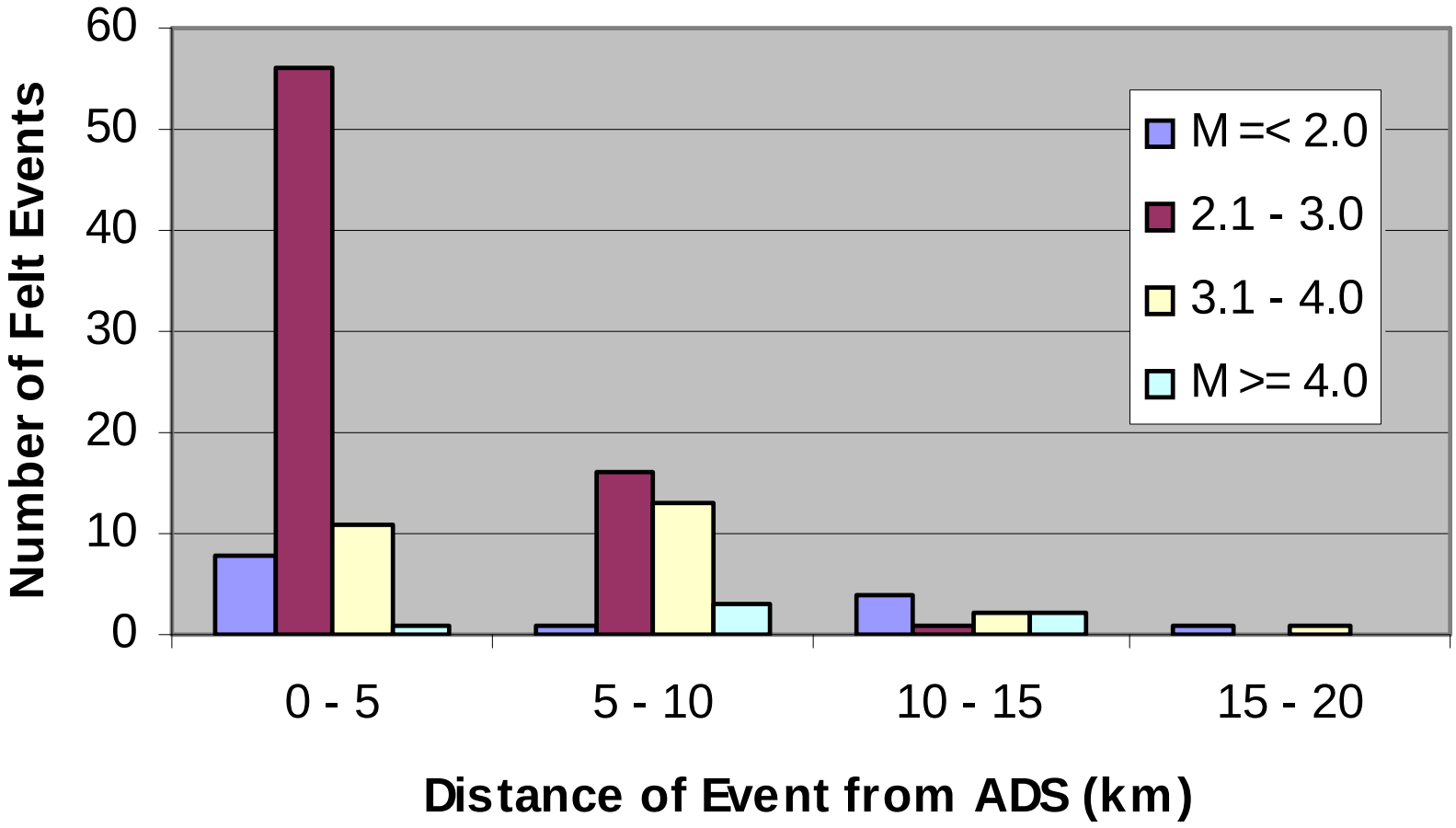
were tectonic events, which occur much deeper and have much longer durations than the shallow small magnitude Geysers earthquakes.

As stated on page 5-2 of the induced seismicity report included as Appendix I to the EA, the highest peak horizontal ground acceleration recorded to date on the Calpine strong motion instrument is 0.21 g at a distance of 2.0 km from ADSP. No damage was reported in that event according to the hotline calls and so no intensities in the "destructive" range have been observed to date.

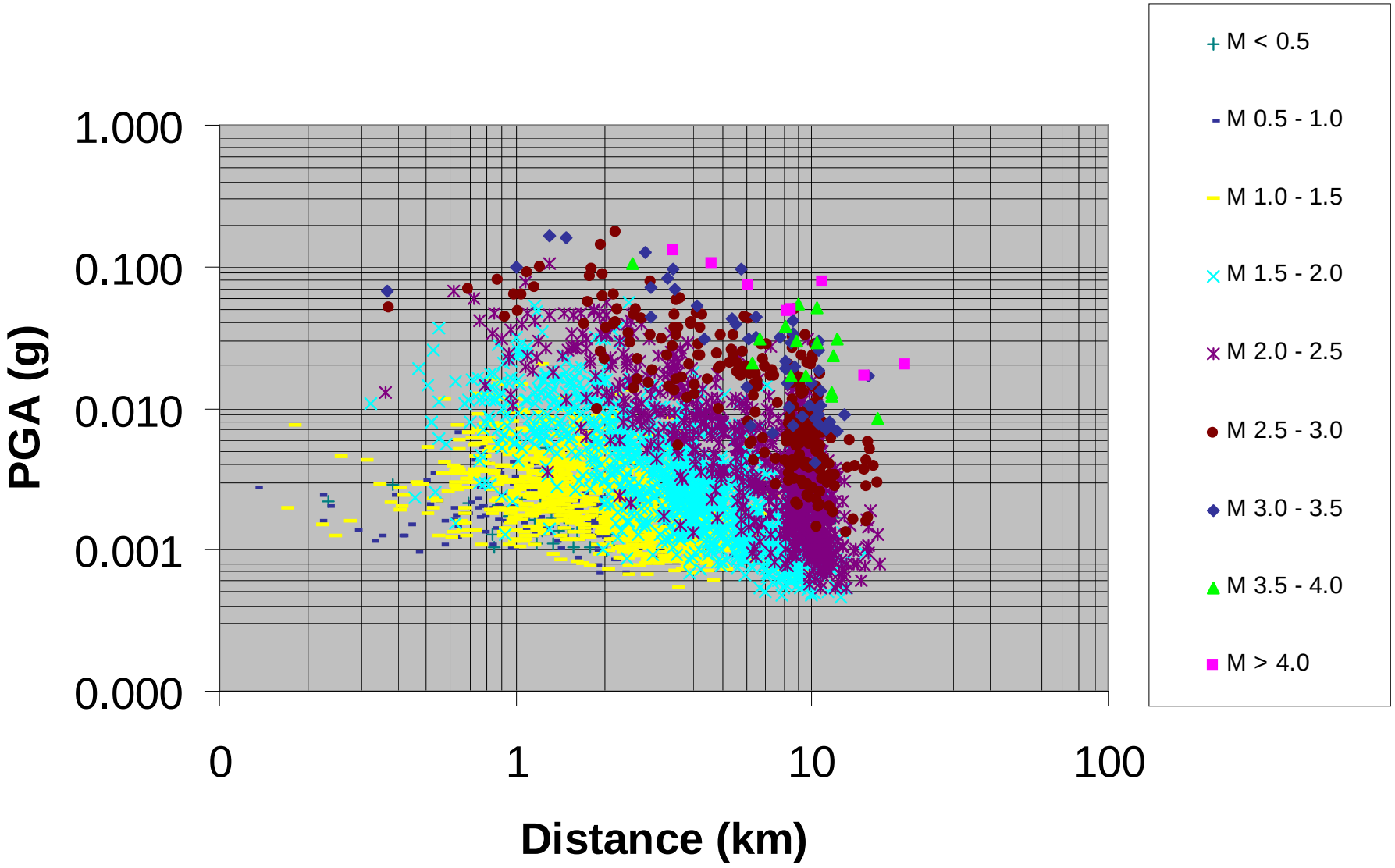
4. *No cut-off magnitude or intensity levels have been specified as safety and nuisance mitigations for this project. We recognize that the geographical location of the project seems sufficiently remote from residential communities that destructive and heavy nuisance impacts would not be expected, but we believe that it is not unreasonable to request that if a project-related seismic event of M 4.0 or greater occurs, or a Mercalli intensity VI (that is, 9.2% g to less than 18% g) is recorded at either the Cobb or Anderson Springs ground motion stations, a temporary shutdown be required pending study of the possible causes of the event, and that there be complete shutdown of the project if higher Richter (above M 4.5) or Modified Mercalli readings of higher (18% g+) occur.*

   Figures 2 and 3 show the PGA values recorded at ADSP and COB, respectively, from March 2003 through August 2008. Figure 2 shows that at distances beyond 10 km, only the larger events (**M** ≥ 3.5) record PGA values above 0.01 g (1% g) and no event had a PGA exceeding 0.10 g (10% g). Note that ADSP may have unusual site effects at the instrument site compared to the rest of the community, i.e., the ground motions are biased high. Anderson Springs is located about 14 km from the Prati State 31 and 32 wells. Figure 3 shows that no events have recorded a PGA higher than 0.03 g (3% g) at a distance greater than 8 km. Cobb is situated at about 10 km from the Prati State 31 and 32 wells. Although it is extremely difficult to estimate, it is not expected that earthquakes much larger than **M** 3 will result from the EGS operations at Prati State 31 and 32 due to the low pumping rates and thus it is unlikely that a PGA, such as 0.18 g, will be observed in Cobb.

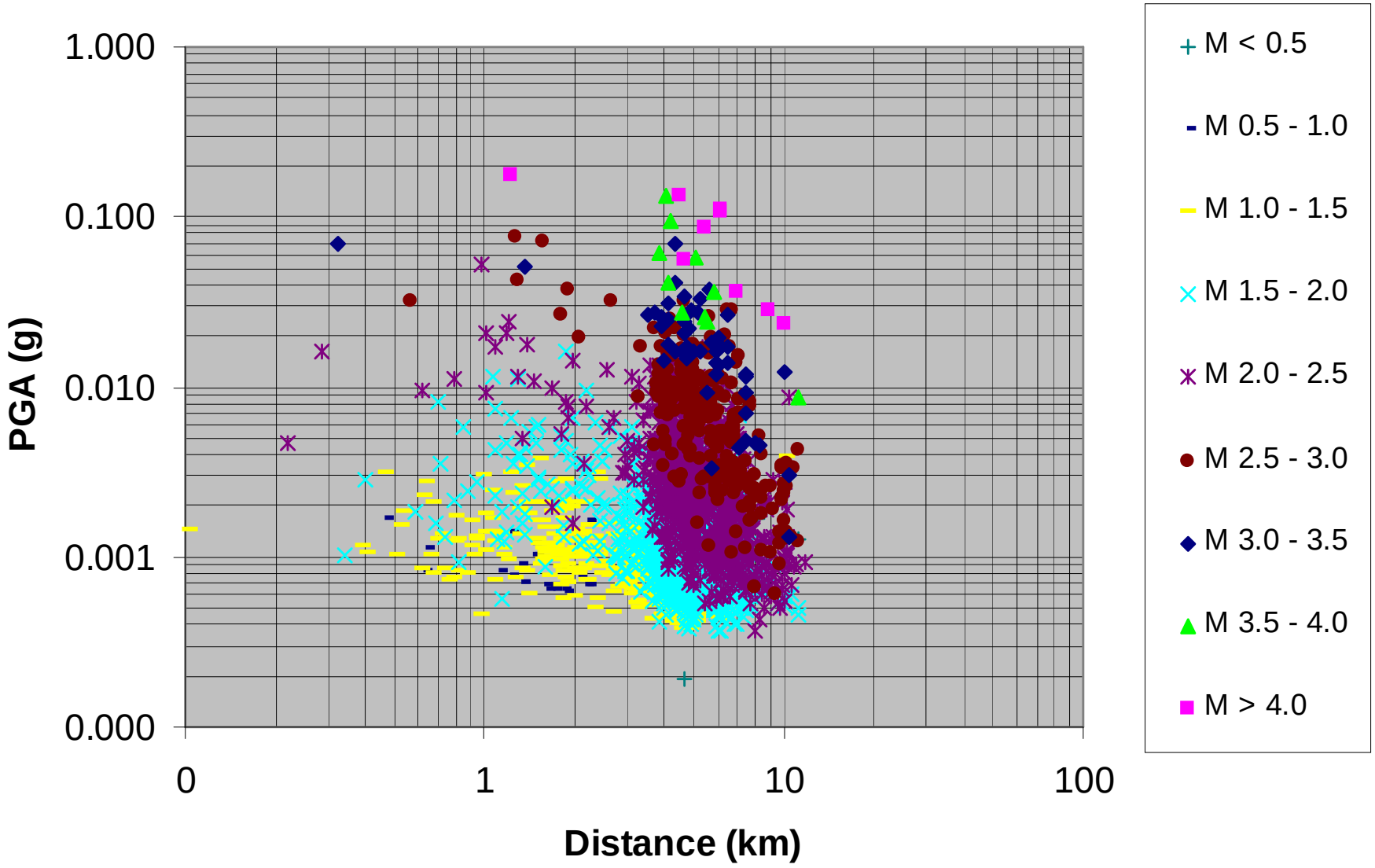
   It is understood that there has been a general desire to put numerical limits on induced seismicity in terms of ground motions, magnitude (M) or Modified Mercalli intensity (MMI), however, the damage potential of The Geysers earthquake ground motions, if an earthquake occurs, is not well understood and so defining an absolute limit is difficult. As previously stated, no events have recorded a PGA higher than 0.03 g (3% g) at a distance greater than 8 km and no event at distances greater than 10 km had a PGA exceeding 0.10g (10% g). A comprehensive evaluation of the potential for induced seismicity is presented in the induced seismicity report included as Appendix I to the EA.



URS	Project No. 26817267 Calpine	Number of Felt Events Within 500m of ADSP per Magnitude and Distance 1 Jan 2004 - 31 Aug 2009	Figure 1



URS	Project No. 26817267 Calpine	ADSP PGA Versus Hypocentral Distance 3/25/2003 - 8/31/2008	Figure 2



URS	Project No. 26817267 Calpine	COB PGA Versus Hypocentral Distance 3/25/2003 - 8/31/2008	Figure 3