

AGENDA

SEISMIC MONITORING ADVISORY COMMITTEE

May 12, 2014

**Calpine Geothermal Visitors Center
15500 Central Park Road, Middletown**

- I. Introductions**
- II. Approval of SMAC report to the Board of Supervisors of November 18, 2013 meeting.**
- III. Anderson Springs Report, (Jeff Gospe) and Input**
- IV. Cobb Area Public Input**
- V. General Public Input**
- VI. Update of SE Geysers pipeline operations (Young)**
- VII. Summary of Seismic Data from USGS Network (Young)**
- VIII. Report by Calpine on Strong Motion Seismic Sensors (Hartline)**
- IX. Report by Calpine on Santa Rosa Pipeline Operations (Hartline)**
- X. Calpine EGS (Hartline)**
- XI. Report on LBNL Seismic Array (Majer) and Induced Seismicity Update**
- XII. Report by David Oppenheimer Seismic Data**
- XII. Report on Bottle Rock Power Co. Operations**
- XIV. Alta Rock EGS Project**
- XV. Coordination with Santa Rosa**
- XVI. Schedule Next Meeting for November 17, 2014**
- XVII. Adjournment**

**Seismic Monitoring Advisory Committee (SMAC)
Monday, November 18, 2013 @ 9:30 a.m.**

**Calpine Geothermal Visitors Center
15500 Central Park Road, Middletown, California**

REVISED MINUTES

Meeting called to order by Mark Dellinger. Minutes were recorded by tape recorder and transcribed to Draft Minutes. Dellinger moved to introductions.

Present: Mark Dellinger, Committee Chairman (Lake County Special Districts), David Oppenheimer (USGS via phone), Craig Hartline (Calpine), Bruce Carlsen (Calpine), Joe Austin (DOGGR), Ernie Majer (LBNL), Jeff Gospe (Anderson Springs), Meriel Medrano (Anderson Springs), Linda Diehl-Darms (Middletown), Bob Young (NCPA), Ed Voge (NCPA), Joe Iovanitti (Alta Rock), Joan Clay (Anderson Springs), Mike Sherman (City of Santa Rosa), Rick Coel (Lake County Community Development Department), Benjamin Minx (DOGGR), Tim Conant (Calpine), Will Evans Lake County Community Development Department), Jody Spooner (Calpine), Danielle Matthews Seperas (Calpine).

- I. Anderson Springs Report and Input: Jeff Gospe, Anderson Springs Community Alliance handed out his presentation that is now available at:
<http://www.geysers.com/smac.aspx>.

Mr. Gospe's presentation included discussion/review of four (4) slides. The first slide reflected all field wide events of magnitude 2.0 and larger for the period from January 2000 through November 17, 2013. Gospe stated that there was a huge increase in seismicity around year 2005 and that has "continued to decrease and really leveled off". He states that there is an average at about 315 annualized events for 2013 based upon the first 321 days. Slide two provides a look at magnitude 2.0 and larger events within three miles of Anderson Springs. Gospe commented that this slide shows a favorable trend, with a decrease to approximately half of the number of events experienced in 2006 and 2007. Gospe then presented a third slide showing that there have been an average of about twenty magnitude 3.0 and larger events since 2000, and the most recent years had events counts of 24(2010), 17(2011), 18(2012) and 19(2013 projected).

Gospe said that Anderson Springs is interested in hearing from Calpine and NCPA regarding the August 27 magnitude 3.76 seismic event. This event was felt by the Anderson Springs community and there are a number of claims. Gospe stated he was not in Anderson Springs the day of that event and called on

Meriel Medrano and Joan Clay to discuss the claims. Joan Clay responded that a meeting is set for Thursday, November 21 to review claims and that she does not have the details with her. Clay estimated that about \$6,500 in claims are related to that particular event. Clay further stated that Anderson Springs certainly appreciates both Calpine and Northern California Power Agency (NCPA) for the committee but that she thinks NCPA might be getting the business because they pay for damages and that this particular event is really on Calpine. Gospe commented that the event occurred about on the lease line; Bob Young followed up to say that he appreciated the comment but that their funds are only set up to pay damages and NCPA is not concerned. Meriel Medrano commented that generally, a majority of the damage claims have been from the Hot Springs Road area but for this event, claims are throughout the Anderson Springs community.

Gospe commented that the community was frustrated that Calpine's seismic hotline was down on August 27th. Due to a system-wide telephone outage at Calpine, the hotline went down as well. An alternate line was set up which is the back-up line now that the main line has now been restored.

- II. Cobb Area Public Input: None
- III. Posting SMAC Materials on Calpine's www.geysers.com Website
 - i. Calpine will take the lead in preparing SMAC meeting minutes from this point on to be posted on Calpine's website – www.geysers.com along with other SMAC meeting materials;
 - ii. Gospe inquired if the Board of Supervisors receives the meeting minutes. Mark Dellinger confirmed that the Board receives the full SMAC meeting package about a week before the upcoming SMAC meeting.
- IV. NCPA Report: Ed Voge, Reservoir Engineer was introduced and due to staffing changes with Murray Grande's retirement, Voge will be presenting for NCPA at SMAC meetings going forward. Voge's presentation was handed out and is now available at: <http://www.geysers.com/smac.aspx>.
 - i. Southeast Geysers and Pumping Operation – The first graph shown is the historical Southeast Geysers Effluent Pipeline (SEGEP) delivery to The Geysers. The pipeline has been in operation for a little over 16 years and during that entire time about 46.4 billion gallons of water to The Geysers at an

average rate of about 5,480 gallons per minute. Toward the end of the graph, it shows a rate of about 9 million gallons per day or 6,250 gallons per minute.

Voge presented a focused view on the last six months, the period of April 1st through September 30th of this year, where the rate received is at the full capacity of about 9 million gallons per day. There were two periods of extended shutdown or reduced flow. The first one occurred back in May, due to a pump failure at one of the pump stations and required repair that took about two weeks to get a replacement pump in place. The second extended period occurred in September when reduced flow was required due to maintenance on the Santa Rosa Geysers Recharge Project (SRGRP) pumping system. On average, SEGEP delivered about 8.38 million gallons per day during this six months period, or about 5,819 gallons per minute.

ii. Seismic Activity in the Last 6 Months: Voge reports that for the SE Geysers, seismic activity is down slightly. Fieldwide seismicity for the Geysers appears to be up slightly. There were 84 seismic events in the SE Geysers with a magnitude 1.5 or greater, and only two of those events were greater than 3.0. Steam projection, water injection, and seismic activity were all down slightly from the previous six month period (October 1st through March 31). For 2013, Voge estimated that there will be 180 seismic events of magnitude 1.5 and greater in the Southeast Geysers area and 1,283 events of magnitude 1.5 and greater throughout The Geysers.

V. Calpine Report: Craig Hartline, Senior Geophysicist handed out hard copies of his presentation. This presentation is now available at:
<http://www.geysers.com/smac.aspx>. Topic covered were:

- i. Seismic Monitoring Networks
Discussed the permanent seismic monitoring network(s) with real-time data processing:
 - Lawrence Berkeley National Laboratory network (31 stations)
 - US Geological Survey (5 contributing stations)
 - Strong Motion Instruments (3 stations)Also discussed two project-dedicated temporary seismic monitoring networks with remote data downloading:
 - Lawrence Berkeley National Laboratory 1 (5 stations)
 - Lawrence Berkeley National Laboratory 2 (9 stations; now removed)
- ii. Field-Wide Water Injection and Seismicity

Field-wide seismicity analysis for the interval of 01 April 2013 to 30 September 2013 was presented utilizing graphs, maps and 3D visualization, with comparisons to historical seismicity data and previous monitoring periods. Encouraging downward trends in the number of seismic events are seen particularly well for:

- Seismic events of magnitude 3.0 and greater
- Seismic events of magnitude 4.0 and greater

The challenge at present is to better understand the physical mechanisms responsible for these trends.

iii. Water Injection Modifications

Discussed Calpine's water injection goals for The Geysers:

Improve Injection Distribution

- Expansion to northwest and away from communities
- Additional injection wells
- Shallow low-rate injectors

Minimize Injection Rate Variations

- Individual wells and field-wide
- Emphasis on limited variation for wells nearest communities
- Lower injection rates per well being evaluated
- Effects of injection rate variability being evaluated far from communities
- Discussions with SRGRP source concerning more gradual transitions

Specific examples were provided in the slide presentation.

iv. Southeast Geysers Water Injection and Seismicity

Southeast Geysers seismicity analysis for the interval of 01 April 2013 to 30 September 2013 was presented utilizing graphs, maps and 3D visualization. This included 3D visualization of well-by-well injection volumes and the associated seismicity.

v. Strong Motion Sensor Stations and Data Analysis

No power or communication problems were noted for station ADSP or station COB for the period 01 April 2013 to 30 September 2013.

Provided an analysis of Peak Ground Acceleration for the following:

- Anderson Springs (ADSP) 01 January 2004 to 30 September 2013
- Anderson Springs (ADSP) 01 April 2013 to 30 September 2013

For this period:

- Modified Mercalli Intensity VII: one event trigger
- Modified Mercalli Intensity V: six event triggers

- Cobb (COB) 01 January 2004 to 30 September 2013
 - Cobb (COB) 01 April 2013 to 30 September 2013
- For this period:
Modified Mercalli Intensity V: two event triggers

- vi. Strong Motion Triggers By Modified Mercalli Intensity (MMI) and Year
Strong motion triggers were analyzed since the 2003 installation of station ADSP and station COB. Graphs were provided of:
- ADSP triggered strong motion events per year (MMI I-VII)
2010 peak, significant downward trend
 - COB triggered strong motion events per year (MMI I-VII)
2009 peak, slight downward trend
 - ADSP triggered strong motion events per year (MMI IV-VII)
2007 peak, significant downward trend
 - COB triggered strong motion events per year (MMI IV-VII)
2010/2012 peaks
- vii. Historical Seismic Energy Release Analysis
Seismic energy release was analyzed utilizing the relationship:
 $\text{Log}_{10}(\text{Energy}) = 11.8 + 1.5 * \text{Magnitude}$
The primary goal of this ongoing program is to better understand the relationship between water injection and seismic energy release (and not just the number of seismic events) field-wide and within in subareas of the field defined as 0.02 degrees of latitude by 0.02 degrees of longitude. The field-wide peak in seismic energy release was 2006. Most subareas reflect that 2006 peak, and show a recent downward trend in energy release. Of particular interest for future investigation are subareas in proximity to the communities that have experienced no decline in energy release or a rise in seismic energy release. Injection wells within those subareas, along with the local geology, are being more carefully evaluated.
- viii. Northwest Geysers Enhanced Geothermal System (EGS) Demonstration Community Update: This research collaboration between the U.S. Department of Energy and Calpine Corporation involved the Prati State 31 and Prati 32 well, which were recompleted as a production-injection well pair in September, 2011. An Enhanced Geothermal System has been created in deep hot dry rock.

Follow up comment: Dr. Oppenheimer commented that Calpine's analysis is what has been missing from this conversation. He said that this is the direction that we should be heading – the analysis takes a good, hard look at the data to try and figure how we can manage the development in a more intelligent fashion.

VI. LBNL Report – Update on Protocol for Induced Seismicity Associated with EGS:

- i. Seismic Network – LBNL has their stations at The Geysers augmented by the USGS seismic monitoring network. Winterization stage is underway to make sure all the batteries are charged up for the winter and everything is in good working order. Work is also underway to convert some older Unocal stations to borehole.
- ii. Protocol for Induced Seismicity associated with Enhanced Geothermal Systems – following guidelines within the National Research Council's publication entitled "Induced Seismicity Potential in Energy Technologies" (2013), the Bureau of Land Management (BLM) is planning to move toward adoption of more consistent best practices in their regulatory process for all geothermal. The government shutdown has delayed that conversation.

However, recent media attention concerning hydraulic fracturing (or "fracking") along with scientific publications by Bill Ellsworth and Emily Bronsky, indicate that geothermal is getting some of the "overlap". There are many questions to be answered, and input from geothermal industry in this discussion is required. Geysers operators Calpine and NCPA have participated in the development of the National Research Council's publication, including their seven step adaptive approach. These steps are generally aligned with Calpine's program to monitor seismicity, understand the underlying mechanisms, and work towards potential mitigation measures. LBNL does not feel that a one-page instruction sheet requested by regulators is a realistic option. BLM has a deadline of 2015 to put these regulations in place throughout the country and they are moving towards the adoption of an adaptive approach. Ernie Majer feels that this is the right direction. In other words, learn as you go – and avoid putting regulations in place that don't take the local community issues and the local geology into account. Majer states that this will evolve over the next few years as a better understanding of the physical mechanisms related to induced seismicity is developed. He believes the focus is the oil industry but waste water injection in EGS is also a national issue.

VII. USGS Report: - David Oppenheimer

- i. Program to upgrade the seismic data recording technology and instruments (including a move away from dial-up modems. Individual USGS sites may have to be updated. Calpine is working with Verizon regarding a new cellular tower in the vicinity of The Geysers..

VIII. Bottle Rock Power: None

IX. Coordination with Santa Rosa: None

X. Next Meeting:

- i. Next meeting is scheduled for May 12, 2014 at 9:30 a.m. at the Calpine Geothermal Visitor Center, 15500 Central Park Road, Middletown, California.