AGENDA

SEISMIC MONITORING ADVISORY COMMITTEE

November 14, 2016 @ 9:30 a.m.
Calpine Geothermal Visitors Center
15500 Central Park Road, Middletown

Call In: 1-888-449-6492; Participant Passcode: 226083

I. Introductions

II. Approval of SMAC report to the Board of Supervisors of May 9, 2016 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 (Voge, Drake)

VII. Summary of Seismic Data from USGS Network (Voge, Drake)

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 Lind Gee Seismic Data

XIII. Report on Bottle Rock Power Co. Operations

XIV. Coordination with Santa Rosa

XV. Member Recommendations

XVI. Schedule Next Meeting for Monday, May 8, 2017

XVII. Adjournment

SEISMIC MONITORING ADVISORY COMMITTEE (SMAC)

Monday, May 9, 2016, 9:30 a.m.
Calpine Geothermal Visitors Center
15500 Central Park Road
Middletown, California

FINAL MINUTES

Meeting called to order by Jan Coppinger, Committee Chair (Lake County Special Districts) at 9:46 a.m. Minutes were recorded by tape recorder and transcribed to Draft Minutes. Coppinger initiated introductions.

Present: Jan Coppinger, Committee Chair (Lake County Special Districts), Craig Hartline (Calpine), Jody Spooner (Calpine), Margaret Lewis (Calpine), Cheryl Engels (Anderson Springs), Ed Voge (NCPA), Les Drake (NCPA), Bruce Carlsen (Calpine), Joan Clay (Anderson Springs), Joe Austin (DOGGR), Jeff Gospe (Anderson Springs), Ernie Majer (LBNL), Bob Young (NCPA), Danielle Matthews Seperas (Calpine) via conference call.

I. November 16, 2015 Meeting Minutes for Approval: Jan Coppinger

Jan Coppinger presented the Draft Minutes for approval and they were approved by consensus.

Note: The minutes will not be in order of the agenda.

II. Northern California Power Agency (NCPA) Report: Lester Drake

Drake's presentation covered the operations in the South East Geysers pipeline for the period of October 1, 2015 through March 31, 2016. The presentation covered two main areas: 1) Pipeline Operations; 2) Observed Seismicity.

i. Pipeline Operations:
   a. The Southeast Geysers Effluent Pipeline (SEGEP) has been in operation for over 18 years and has delivered almost 51 billion gallons of water at an average rate of 5,232 gpm to The Geysers steam fields for injection.
   b. During the more recent 6 month period from October 1, 2015 – March 31, 2016, the SEGEP Pipeline has been in operation 99+% of the time. Pipeline delivery rates have averaged 6.1 million gallons per day (MGD) or 4,236 gpm.

ii. Observed Seismicity / South East Geysers
   a. The USGS recorded a total of 79 seismic events of magnitude 1.5 and greater within the SE Geysers area from October 1, 2015 through March 31, 2016. During this period, there were no seismic events in the area equal to or greater than magnitude 3.0. The largest recorded magnitude during this period was 2.95. This event occurred January 18, 2016. Regarding seismic activity between magnitude 1.5 and 3.0, the Southeast Geysers averaged 13.2 events per month which is slightly up from 10.7 per month for October 1, 2015 – March 31, 2016.
   b. Steam production for the SE Geysers was 16.86 billion pounds for the past six months with is slightly down from the previous six month period where 17.95 billion pounds was produced.

iii. Seismic Activity in the Geysers Known Geothermal Resource Area
   a. There have been 500 events of magnitude of 1.5 and greater recorded by USGS for the past 6 months.
   b. There were 4 earthquake events of magnitude 3.0 and greater. The largest event was 3.73 occurring March 19, 2016. The event was located in the Northeast Geysers 5.9 miles from the Anderson Springs instrument.

c. 1072 seismic events greater than magnitude 1.5 are projected for 2016. This is an increase from 758 events recorded in 2015.

III. Calpine Corporation: Craig Hartline

i. Current Status of Seismic Monitoring Networks
   a. LBNL Seismic Monitoring Network – Seismic data recorded into the 36 individual Lawrence Berkeley Seismic Monitoring stations is sent by radio telemetry to: 1) The North Geysers Radio Repeater (28 stations); 2) The Socrates Container (8 stations). Several SE Geysers seismic monitoring stations damaged by Valley Fire were repaired by LBNL specialists.
   b. USGS/Northern California Seismic Network – Two USGS monitoring stations were destroyed by the Valley Fire and quickly repaired.
   c. Strong Motion Stations – Discussions with Dr. Ernie Majer (LBNL) and Dr. Lind Gee (USGS) to develop short-term and long-term plans for the strong motion stations in the communities of Cobb and Anderson Springs including detailed assessment of the existing strong motion equipment; design of a "next generation" strong motion system; equipment and power/communication options. A detailed, on site assessment was conducted by Jim Cullen in which the extracted electronic components from each sensor for detailed analysis were read by USGS. Specifications and costs were presented by Hartline regarding equipment and relocations of stations.

ii. Seismicity Hotline
   a. Due to the very special circumstances resulting from the Valley Fire, there have been no calls to the Calpine Seismic Hotline since September 2015, and none during the most recent reporting period.

iii. Water Injection Volumes and induced Seismicity Hypocenters
   a. Hartline presented a time-synchronized animation slide regarding water injection volumes and induced seismicity (from statistical to physical analysis).

iv. Field-Wide Seismicity Analysis
   a. October 1, 2015 to March 31, 2016 - ≥2.0-140; ≥2.5-38; ≥3.0-4; ≥3.5-1.

v. Yearly Field-wide Water Injection and Seismicity. Hartline stated the yearly numbers are lower. Some events weren't captured due to the destruction of monitors from the Valley Fire.
   a. Water injection vs. Magnitude 1.5 showing a slight increase at 791 events from 736.
   b. Magnitude 2.0 and greater are showing an increase of 209 events from 193 events during the past reporting period.
   c. Magnitude 2.5 and greater showed 63 events a decrease from 65 events.
   d. Magnitude 3.0 and greater are 7 events, the same as last year's events of 7.

vi. Monthly Field-wide Water Injection and Seismicity – Hartline explained the events of ≥4.0 have decreased to about one event per year from January 1, 2000.

vii. Seismicity and Faults / Fracture Zones – Calpine 3D visualization and 3D structural model building – Seismic event magnitude is dependent on fault area, average lip and rock rigidity. A 3D structural model is currently under development for The Geysers geothermal field. This structural model (including pre-existing fault zones and fractures) is already assisting to understanding induced seismicity at The Geysers. Hartline shared with the group several examples of seismicity near injection sites.

viii. Additional Seismic Monitoring and Research
   a. Three Dimensional Structural Model Building, Induced Seismicity Analysis, Drilling Analysis and Reservoir Management at The Geysers Geothermal Field, Northern California. This paper was presented at the Geothermal Resource Council Annual Meeting September 20-23, 2015, in Reno Nevada, as well as at the 41st Workshop on Geothermal Reservoir Engineering at Stanford University February 22-24, 2016.
   b. Department of Energy, National Energy Technology Laboratory, Funding Opportunity Announcement DE-FOA-00001445. Development of Technologies for Sensing, Analyzing, and Utilizing Novel Subsurface Signals in Support of the Subsurface Technology and Engineering (SubTER) Crosscut Initiative.

IV. **<u>Lawrence Berkeley National Laboratories Report</u>: Ernie Majer**

i. Operational Update
   a. Current array are all operational after the fire: 34 permanent 3-c stations; 5 temp stations around EGS well (Prati 32/31).
   b. SE part of array augmented with former 500 foot deep Alta Rock boreholes. All five are now instrumented.
   c. LBNS is working with Calpine and the USGS on strong motion data collection.
   d. Web site access: www.LBL.gov . Operational on June 1, 2016, and will include all data from 2002 to present time.
   e. Adding 5 US Geothermal stations on the west edge of the production zone (Plant 15).

ii. Initiative Update
   a. Two new initiatives in DOE that will have induced seismicity as one of the main focus areas:
      - FORGE (Frontier Observatory for Research in Geothermal Energy) 10 year effort. Dedicated field site for understanding EGS; LBNL and USGS involved in two potential sites (Fallon, NV and Coso, CA).
      - SubTER (Grand challenges in subsurface engineering). Proposal by Array Information Technology (with Calpine, USGS, LBNL) to DOE for application of Fiber Optic sensors to measure deformation with MEQ and strain at The Geysers (Submitted on May 5, 2016).

iii. A Bit of Science
   a. Napa – Mag 6.0 Effect.
      - There have been observations of large distant events triggering smaller events (not just at The Geysers).
      - The Japan Mag 9 did not trigger any events at The Geysers (even when the energy went by).
      - Investigation was done if the Napa vent did “trigger” local events. There were typical aftershock sequences at The Geysers.

iv. Funding Update
   a. DOE extended the Lake County Project to 12/31/16.
   b. DOE did not extend the data archival effort.
   c. We have requested FY17 funding to continue data collection after the Lake County project funds are used up (early 2017).

V. **Anderson Springs Report:** Mr. Jeff Gospe stated he will be stepping down from his position as Anderson Springs representative though may occasionally attend meetings in the future. Gospe discussed building concerns and seismicity mitigation. Gospe also discussed the EIR mandates and the lack of representation from Cobb and Middletown, questioning the process of filling those representatives.
Note: Further discussion stated the Lake County Board of Supervisor shall appoint the public environmental members and affirm the agency members’ nominations, and suggested a recommendation for the Board of Supervisors. There was mention that, though seismicity was important, the focus now is on rebuilding due to the Valley Fire. This item of recommendations will be brought up at the next meeting and these recommendations will be taken to the LC Board of Supervisors. Documentation will be looked at regarding what is required for member replacements and terms, and emailed to members.

VI. **Cobb Area Public Report**: No comments from Cobb Area.

VII. **General Public Input:** No comments from the general public.

IX. **Report on Bottle Rock Power Company:** No update

X. **Report on Coordination with Santa Rosa:** No Update

Note: Earlier discussions included the announcements of Hamilton Hess, Jeff Gospe, and Mark Dellinger retiring from the Seismic Monitoring Advisory Committee.

A mention that the Calpine Cartwright Geothermal Visitor Center is not manned on Monday so if you arrive early, please wait and the doors will open by 9:30.

Next meeting: The next SMAC meeting will be ***November 14, 2016*** at the Calpine Geothermal Visitors Center. Meeting was adjourned by Chair Coppinger at 11:37 a.m.

Meeting Agenda and Full Presentations are available online at:
http://www.geysers.com/smac.aspx