Appendix N – Responses to DOE Comments on ISMP V3

On 22 April 2011, DOE provided comments to AltaRock on draft Version 3 of the ISMP, dated 4 April 2011. On 28 July 2001, in a teleconference attended by DOE, their Technical Monitoring Team, and AltaRock, we reviewed the comments and agreed on appropriate responses. Below, the transcribed comments from DOE are shown after bullet marks in blue, and responses and actions taken by AltaRock are shown after check marks in purple.

General

- This report is an excellent detailed document summarizing the work done and planned for the Newberry Volcano EGS Demonstration project located in Oregon. AltaRock should definitely be commended for their 'Public Outreach' efforts undertaken so far. In addition, their plans for microseismicity monitoring are rather impressive, including their well-thought out proposed mitigation plans.
- Based on the limited field data (e.g. geological setting, temperature gradient, etc…) available, this site has great potentials for an EGS development.
- The idea of opening an existing intersecting discontinuity in shear has the merit of not requiring the use of proppant, relying on the mismatch of both faces of the fracture to maintain permeability. However, this sought mechanism is based on some fundamental assumptions that could have been investigated and discussed in more details; i.e. what is the probability of inducing such hydroshear mechanism, and can it be optimized.

✓ This is discussed extensively in the Phase I Report in Section 7.2, Historic EGS Stimulations, and Section 7.8, EGS Reservoir Characterization.

Specific

- *Hydroshearing*
  - When pressuring a borehole, one either creates a new fracture (i.e. classical tensile hydraulic fracturing) or open a pre-existing fracture (i.e. in shear). The main difference between these two mechanisms resides in the fact that an existing fracture no longer has tensile strength. The tensile fracture will initiate and propagate against the minimum in-situ stress component. This 'internal battle' is, therefore, a function of the stress concentration prevailing at the wellbore wall (i.e. a function of the 3D orientation of the borehole in the in-situ stress regime); the relative orientation of the intersecting discontinuity; and, the tensile strength of the intact reservoir rock. AltaRock acknowledges that most of these parameters are unknown; hence, their estimation of opening a shear fracture at a given pressure of approximately 1,500 psi is questionable. This onset value of hydroshearing should be explained in more details as it implies a number of vague concepts.

    ✓ This is discussed extensively in the Phase I Report in Section 7.2, Historic EGS Stimulations, and Section 7.8, EGS Reservoir Characterization.
  - I would recommend that some discrete numerical models be run to investigate under which conditions shear and/or tensile features will be induced/propagated. Such models also allow the investigation of fluid viscosity and pumping rate which will both affect the ratio (shear fractures/tensile fractures).
  - Has AltaRock mentioned 'pre-conditioning' the wellbore prior to the main stimulation treatment in order to increase the likelihood of hydroshearing? (e.g. mud temperature, addition of reactive chemicals, etc…).
- *In-situ stress field*
  - Inferring the stress condition from existing faulting mechanism implies that the stress tensor has not rotated over geological times; a rather dangerous assumption, especially in a volcanic

environment.
  - The observation of numerous break-outs however seems to indicate the existence of a large horizontal differential stress condition.
  - At present there are some discrepancies about the magnitude and orientation of the in-situ stress tensor; this constitutes one of the most important parameter in optimizing downhole treatments as well as the potential failure mechanisms
- *Reservoir depletion/production*
  - Based on assumptions made before, AltaRock predicts that the equipotentials will be aligned in the North/South direction (refer to Fig. 3.9). However, this also assumes that the induced fracture will be of the tensile-type; how about the orientation of the pre-existing shear?
  - ✓ While important to the outcome of the stimulation, an exhaustive discussion of hydroshearing and stress conditions at the project site were agreed to not be part of the ISMP. All of the above topics are discussed extensively in the Phase I Report, Sections 5 and 7.
- *Microseismicity*
  - In order to attempt prediction of microseismic activity, could we not just determine the accumulation of strain and relate strain relieve to microearthquake magnitude; which is something that can be computed by the discrete element method.
  - The report should state that the generation of small seismic signals is beneficial as it relieves energy; hence, our treatment should be designed to achieve this goal of spreading microseismicity over a large reservoir volume. Here again, fluid viscosity might play a significant role.
  - I have some serious reservations in proposing flow-back to decrease seismicity as it will also affect the closing of the fractures, especially in the neighborhood of the borehole where the stress concentrations are high; jeopardizing further production. Fracture flow capacity is proportional to the width cubed.
  - AltaRock must plan for the largest event and the rate and distribution of seismicity, both of which are unknown. I think they did as well as they could (Fugro report) in estimating the max events with several different models and approaches. Although the Fugro report is just an estimate, they also recognize that they will have to refine their estimates as the injection occurs, and have controls in place to stop any unwanted seismicity. The controls are all reasonable and are appropriate, and I do not think they could do much more with the knowledge and experience base that exists today. Also, the volumes they are proposing to inject are small compared to places like The Geysers, the historical seismicity is low in this area, and the mapped faults are away from their injection areas. These all point to a very low risk of any unwanted induced seismicity.
  - However, in cases such as Basel, Soultz, Cooper Basin (and to date Desert peak) the largest seismicity occurred after injection stopped. The largest event at Desert Peak occurred a month after wards (although it was only about 1.5). So the question could be, will their diverter technology or flow back measures be in time? Will AltaRock be able to stop the largest events? At this point the only option is to carefully watch the seismicity in the early stages (highlighting the importance of the most sensitive array as possible) and perform some control experiments on low levels of seismicity to see how long it takes to lower the seismicity. On the other hand if we accept that the largest event could only be a 3.5, who cares?
  - ✓ There is extensive discussion of these topics in the Fugro report (Appendix E), the URS report (Appendix F) and in the Phase I Report.
- *Engineering*
  - Per the phone call Will mentioned that there are cracks in the dam that need to be monitored, as well as rock slide potential on slopes, and potential cosmetic damage on structures - how will

this be monitored?

- ✓ The engineering reports on structures at the Newberry National Volcanic Monument document the current condition of the dam, the slopes susceptible to slides (Appendix I) and representative structures (Appendix H). Appendix I recommends appropriate signage and notification of visitors regarding rock falls and avalanche, and Appendix H recommends monitoring of the dam using 'tell-tales' to determine if existing cracks have been affected. The sundry notice submitted to the BLM for approval of Phase II stimulation activities will include details such as where signs will be placed, how the dam will be monitored, phone contacts for project information, and other mitigation actions detailed in this report.
- o Didn't find reference in plan to install tell-tales or crack monitors although both Simpson Gumpertz & Heger Inc. and Treadwell and Rollo recommend their use. It might be useful for AltaRock to inspect after every event above some threshold since this might protect them from frivolous claims. They also should install tell-tales.
- ✓ A specific plan to monitor the Paulina Lake dam will require input from a licensed civil engineer. As noted above, this will occur as a Phase II activity prior to stimulation.

Page Specific Comments

- Pg. 6 - The section numbers and titles listed in the right hand column don't match up with the revised document. Update as appropriate.
- ✓ Corrected in this ISMP.

- Pg. 8 - Should there be a peak ground acceleration trigger for the initial outlier alert? It would be useful to add a forward reference to Section 5.2, where the use of a diverter as a mitigation method is discussed at greater length. I have one concern regarding the use of a diverter as a mitigation tool. Suppose that an increase in microseismicity is observed, and a diverter is employed. If seismicity continues to increase, then won't the deployment of diverter make it very difficult to withdraw fluid from this zone until the diverter breaks down?
- ✓ No action was required for first part of comment, because it was agreed during the teleconference that a PGA trigger for outliers was already covered by the lower PGA at the nearest structures at the NVNM.
- ✓ There is an extensive discussion of the way diverters work in the Phase I Report. To clarify for this comment, the diverters are not impermeable; the diverter is a particulate, not a cement. Fluid will be able to flow back through the particle pack during a flow-back and, because the fluid will be hot, the diverter will degrade rapidly, allowing communication with the fracture.

- Pg. 8 - Diverter materials are an important component of the mitigation plan but information on their proven performance is lacking. This raises the question of how effective mitigation with diverter technology will be.
- ✓ The diverters have been tested twice and there is discussion of their efficacy in the Phase I Report. However, while the theoretical effectiveness to prevent a zone from being further stimulated when it is showing larger seismic events can be surmised, there can be no certainty that the diverters will work to mitigate seismicity of concern. This is an experimental stimulation and because there are so few people and structures near the stimulation target area the risk is very, very small that any harm would be caused if the diverters do not mitigate seismicity effectively. All of the other mitigation measures would go into effect if the diverters fail to reduce the amount of seismicity of concern as described in the ISMP.

- Staged mitigation response of hold (2.0), reduce (2.7) and stop and flow (3.5) could be questioned on basis of later comment (page __) that 3.5 generates 32X energy than 2.5, which could be viewed as a very big step.

- ✓ While the step up from an M 2.7 event to an M 3.5 event is a large change in energy by comparison, these are very small seismic events, in an area with very low population, with a very low probability of anyone feeling them, or resulting in damage. This is especially true in this geologic setting with a zone of ash, tuff and cinder that is likely to attenuate seismic energy.

- Pg. 11 - 36,000 magnitude 2.0 worldwide events is a good way to calibrate how common there are.
- ✓ No action.

- Pg. 12 - To a layman, a 32X energy increase from 2.5 to 3.5 could be perceived to be a very big gap between slowing and stopping operations.
- ✓ While the step up from an M 2.7 event to an M 3.5 event is a large change in energy by comparison, these are very small seismic events, in an area with very low population, with a very low probability of anyone feeling them, or resulting in damage. This is especially true in this geologic setting with a zone of ash, tuff and cinder that is likely to attenuate seismic energy.
- Pg. 13-14 - It might make sense to add the MMI definition for a VIII event in Table 2.3, as this level is referenced in Table 2.4.
- ✓ Added in this ISMP. MMI VIII added to Tables 2-1 and 2-3.

- Pg. 15 - Which aspects/approaches of the new protocol are not followed in this ISMP?
- ✓ As explained later in this section, the only aspects of the new protocol not addressed in the ISMP are the long term effects. The reason for this is also addressed in the ISMP. The project is experimental and is only planned to last through the creation and testing of an EGS reservoir. If a power plant were found to be economic and the decision made to go forward with such a plan, then an EIS would be needed to address the construction and operation of the project. A new ISMP would then be developed and included as part of this EIS and the long term impact of any potential induced seismicity would be addressed in that ISMP.

- Pg. 16 - ARE acknowledges that this report addresses risk of the 21+77 day project, not "long term risk." How is this squared with the new mitigation standard? Suggests new standard could be applied to stop almost any project?
- ✓ As I understand it, the new protocol is a guideline, not a requirement. As such the implementation of the new protocol would be site specific. Since Newberry is an experimental project, it doesn't have any long term risk. If it moves beyond the experimental phase to an actual project, we would do an EIS for that project in which long term risk would be addressed.

- DOGAMI is the Oregon Department of Geology and Mineral Industries
- ✓ Corrected in this ISMP.

- Pg. 17 - 13th bullet - "Mineral Regulations" should be "Mineral Industries"
- ✓ Corrected in this ISMP.

- Pg. 19 - How frequent are rock falls along Road 500, and what are the interpreted causes of these events?
  - o Paragraph 1: AltaRock may want to add at the end of the new text that a web page will also be established to keep the public informed.
  - ✓ The following sentence was added, "The Demonstration web sites[12] will be updated to inform the public that the well stimulation has begun." In addition, specific website information and format will be addressed in the detailed operating plan to be submitted

with the sundry notice.

- o Sect 3.2.2: AltaRock may want to add that a web page will also be established to keep the public informed.
- ✓ Section 3.2.1 already describes the two project web sites that are currently active, in addition to response to previous comment above.

- Pg. 19-20 - There are three different sensitivity levels mentioned for the regional seismic network: 2.0, 2.5, and 3.0. I can see that this value might have changed in 2010 when two new stations were added, but this should still only result in two levels: one prior to 2010, and the other after the network was expanded.
- ✓ M > 3.0 was used in the statement, "historic record is probably only complete for events of $M_L \geq 3.0$." M < 2.0 was used in the statement "magnitudes too low to be detected by the regional network (M<2.0)." That is, the existing network is detecting some events in the M 2-3 range (in fact three events with $M_L \leq 2.2$ were detected), but the seismic record is incomplete in that range. Therefore, the use of sensitivity levels of 2.0 and 3.0 are retained. The one instance of M 2.5 was changed to M 2.0.

- Pg. 20 - I suggest qualifying the statement that "no earthquakes have been located within 10 km of well NWG55-29 or Newberry Volcano" by specifying a time and magnitude constraint (such "with a as ML >3.0 since 1980").
- ✓ Changed in this ISMP. "Located" changed to "recorded."

- Table 3-1 - The table mentions web sites but it would be helpful if the text discussed their use.
- ✓ Text added on page 19, see above

- Pg. 21 - what did the mag 5.4 look like with stations inside of the study area compared to stations outside of the study area? They hypothesize that the shaking in the study area will be less than outside due to the surface conditions, usually on poorly consolidated material it is more (i.e building on land fill experience more damage than bedrock)
- ✓ On the teleconference, it was explained that the primary reason for showing this event was to confirm that the network was working, and it was agreed that differences in instrumentation and installation would make comparison to a permanent PNSN station inconclusive.

- Pg. 22 - "to assure that any seismicity approaching NNVM will be rapidly detected" is misleading, because it implies events moving progressively further from the project. Yet elsewhere in the report it is acknowledged that "outliers" can occur without progressive warning.
- ✓ Changed to "to provide accurate locations for seismic events nearest the NNVM."

- Paragraph immediately after Fig 3-1 states that 6-10 borehole and 4-7 surface seismometers will be installed.
- ✓ No action required.

- Pg. 23, last paragraph - Assuming only 10 stations are in place the 90% threshold allows only one to be down at any given time. If seventeen are in place again only one down at any given time.
- ✓ The 90% functional stations is a requirement set by Jay Nathwani (DOE). In order to meet this requirement, there will be spare parts and a technician on site at all times to deal with any problems that occur.

- How do the location errors vary as the size of the event? What size of an event does the 400 m

horizontal value correspond to? What are the vertical siting errors?

- ✓ The 400 m error was modeled by Foulger Consulting based on uncertainty of the velocity model and arrival times picks. Event size was not directly modeled – that would require advance knowledge of an attenuation and velocity model. In the real world, location errors will decrease for larger events and with time as the velocity model is improved and the relocation routines improved.

- Pg. 24 - The 1 and 3 km circles don't appear to be centered around the microseismic ellipse. The well is deviated, but wouldn't it make sense to have these circles centered around where the seismicity is expected to occur?
- ✓ The figure is corrected in this ISMP to show the stimulation zone centered around the middle of the open-hole section of NWG 55-29.

- What is the confidence level of the stress model? I.e., what is the risk that stress field is not as expected and the stimulation zone radiates toward NNVM?
- ✓ The stress field determination is extensively discussed in the ISMP and Phase I Report. Even if the stress field is not oriented as expected and the fractures extend in a different direction, there is a buffer zone large enough around the expected stimulation area, and the NVNM is far enough away, that mitigation triggers and actions remain effective . Text added to caption, "Even if the EGS reservoir grows in an unexpected direction (not north-south), the map shows sufficient room for an EGS reservoir of any orientation around NWG 55-29."

- Pg. 26 - I would recommend that on auto locate the threshold should be lowered to at least 5 on P-wave and 2 on S-wave, At Desert peak we had it on 2. This may give them better control on b-values on the lower end events, thus estimate total fracturing.
- ✓ Changed in this ISMP.

- Using the three methods described in this section, how well could they be used to estimate seismic events that occurred at Basel and Soultz? The seismogenic index method of Shapiro for these areas is briefly discussed in Section 3.8, but it doesn't seem that this analysis was extended to the use of the other methods. The Shapiro method relies on the injected fluid volume. What about effects associated with: a) the injection pressure used, and b) thermal effects from injecting cold fluid into hot rock? High injection pressures may be quite significant, especially in the case where the stimulation process could change from hydroshear to hydrofrack.
- ✓ Pressure at the wellhead is a result of frictional pressure drop in the wellbore, which is function of the velocity squared, pressure drop through the well bore wall and the near-well bore area (skin), and the pressure drop away from the wellbore, which is exponential. The pressure at the wellhead may need to be higher than the threshold required for shear failure in the wellbore at stimulation depth, at the front of the extending fractures, in order to cause shear failure. As a result, fracture "jacking" may occur near the well bore. It is hoped that enough thermal stress and earlier shear movement will allow these near wellbore fractures to stay open and permeable. Regardless, it is widely understood that large faults are required to create large seismic events. Based on our review of area geology and well drilling results, no significant faults have been identified. If high pressures are needed to extend the fractures 500 m from the well bore, and the extending fractures intersect an unknown fault, the pressure at the point where that fault is intersected will be substantially lower than the pressure near the well bore. If larger events do occur out away from the well bore, diverter can be applied and hydroshearing can be moved away from the zone that is allowing larger slip.

- Pg. 27 - “M>3.0 is less than 1% over 50 day period.” How does this square with the new mitigation standard for “long term risk?”
- ✓ As discussed above, applicability of this ISMP is limited to field activities that will occur in as part of this Demonstration, culminating in the long term circulation test that will occur at the end of Phase II. It is our understanding that the new mitigation standards should not apply significantly beyond anticipated activities.

- Pg. 28 - “More of a nuisance than a hazard to the vast majority of local residents” could be interpreted to imply that it could be more of a hazard than a nuisance to a small minority.
- ✓ It is a logical fallacy to assume that because a statement is true the opposite of that statement is also true. However, one of the reasons that Newberry is such a good place to do an EGS experimental project is that this is an area with very, very few people and no permanent residents within close proximity of the stimulation area. As a result there is a very, very low probability that anyone will feel any induced seismicity from the project. Nonetheless, our public outreach program attempts to clarify just such issues to nearby stakeholders.

- Bedrock competence discussion (Newberry vs. Geysers) is good but rather brief.
- ✓ The geologic setting and implications of the geology to seismic hazards are explained in detail in both the URS and Fugro reports as well as in the Phase I Report.

- If the peak ground acceleration is highest at the well site (based on the shake map), then wouldn't it make more sense to deploy a SMS at the well pad? This could be done in addition to the unit at Paulina Lake (where the amount of ground motion is important to monitor to determine the risk to structures within the Monument).
- ✓ The SMS is placed at Paulina Lake because this is where the nearest structures are located. The SMS is best positioned where ground motion will be felt by people and structures, rather than as a tool to merely measure the degree of ground shaking. Thus, it would be inappropriate at the well site.

- I suggest changing the duration of geothermal production at The Geysers from "> 30 years" to > 50 years" Couldn't the seismic velocity model determined from the USGS shots be used to support this statement? If so, then put in concrete references that compare and contrast the seismic velocities and attenuation that have been determined at Newberry and The Geysers.
- ✓ Corrected in this ISMP.

- Pg. 29 - I don't see any of the caldera ring fractures on Fig. 3.3. However, these are mentioned as Quaternary faults identified by the USGS in the text on p. 33. Is there a reason why they aren't depicted in the figure?
- ✓ Figure 3.3 has been changed to note that only the Class A faults are shown. Ring fractures do not extend to depth so they are not considered Class A faults.

- Pg. 30 - Is “light damage” defined anywhere? I didn’t see it.
- ✓ Changed in this ISMP: reference to MMI VI made.

- Pg. 31 - Change "winters days" to "winter days"
- ✓ Corrected in this ISMP.

- Pg. 32 - How fast could mitigation measures be taken, and how long would it take for them to

have an effect? There is some discussion of this in Section 5.3 (so perhaps put in a forward reference to this section here). The key concern is that the early, lower level trigger events, will provide enough warning so that the appropriate action is taken and that larger scale events will not occur.

✓ Changed in this ISMP to reference Section 5.3 in earlier discussion.

- Pg. 34 - discrepancy between simple north-south interpreted stress field and the juxtaposition of three structural styles could raise questions about confidence level of stress model and risk of propagation in other directions than N-S.

✓ The stress model is discussed extensively in Section 5 of the Phase I Report. Also, the following sentence was added to the ISMP, "Even if the EGS reservoir grows in an unexpected direction (not north-south), there is no additional risk to the project, as there is sufficient room for an EGS reservoir of any orientation around NWG 55-29 (shown below in Figure 3-9)."

- there are two references that are listed as "error, reference not found"

✓ Changed in this ISMP.

- "minimum principle stress" should be "minimum principal stress"

✓ Changed in this ISMP.

- Pg. 36 - Isn't the actual rock strength needed as an input for AltaStim? Given that no minifrac was conducted on the well to determine when hydrofracking would occur, how will this value be constrained? There is a short discussion of this in Section 4.1, so a forward reference to this section might be appropriate.

✓ Yes, geomechanical testing and a strength model are discussed in Sections 3 and 5. The step-rate testing described in Section 4.2 will help determine the hydroshearing pressure. The following sentence was added, "Further constraints on AltaStim inputs are discussed below in Sections 4.1 and 4.2."

- Pg. 41 - "Largest events occur on the fringes, even outside of the main cloud of events." This whole issue of "outliers" raises questions about the assurances elsewhere in the report of small stimulation size.

✓ Based on past EGS experience, outliers cannot be ruled out, that is why we have planned for the possibility of the occurrence of outliers. An exception report will document any seismic event further than 1000 m from the well bore (section 5.2). Mitigation actions, postponement of planned flow increases and use of diverter, will be taken for confirmed outliers (section 5.3).

- End of 1st paragraph - It would be helpful if the text on page 51 discussing why there will be no significant environmental impact during possible flow-back is cited here.

✓ Text now reads, "Details of the flow-back procedure that is planned for the end of the stimulation are given in section 4.6. Because flow-back is planned after hydroshearing, flow-back as a seismic mitigation measure will have no additional environmental impact. In either case, the water fraction will be flowed to sumps and then evaporated using spray systems positioned over the sumps. The steam fraction will be flowed to the atmosphere. Other than the temporary visual impact of the steam plume, flow-back will have no detrimental impact on the environment."

- Will a volume capacity of 10-12% of the total injected fluid volume be a sufficient safety factor?

It was noted that 10% of the injected fluid was released during the first day of back flow at Basel. There is some mention on p. 51 that excess water could be reinjected (but this really isn't an option on the first well, when the entire point would be to remove water from the reservoir), or could be spread out on roads if the chemistry permits this type of surface disposal. This issue might warrant additional study.

✓ Flow back does not need to complete, just sufficient to drop the reservoir pressure. In addition some flow back will be in the form of steam, so will not require sump space.

- Change "least principle stress" to "least principal stress"

✓ Changed in this ISMP.

- Pg. 42 - For Fig. 3-9, it would be useful to add arrows for parts A and C that denote the orientation of Hmin.

✓ Changed in this ISMP. Arrows added to all three subfigures.

- Pg. 43-44 - How can you predict the b value for Newberry if there are almost no prior events for this area? Isn't this needed to estimate the seismogenic index? Also, how good is the assumption that b values determined from natural seismic events are the same as those for induced seismic events?

✓ All good questions. The Fugro report, Appendix E of the ISMP, provides further background and caveats on how the Shapiro approach was used to *a-priori*. As stated in the text, we plan to track and update the seismogenic index as the Demonstration proceeds, starting as soon as a Newberry-induced seismicity b-value can be determined.

- Pg. 44 - Change "minimum principle stress" to "minimum principal stress"

✓ Changed in this ISMP.

- "It may be necessary to exceed 2500 psig to create a robust EGS reservoir." Lots of assurances elsewhere in the report that hydroshearing is different from hydrofracking, but then they say we might need to hydrofrac?

✓ The following sentence was deleted, "The upper bound of 2500 psig is to initiate hydroshearing or hydrofracturing in the well." The following sentences were added, "As the EGS reservoir grows it may be necessary to exceed 2500 psig in order to overcome frictional losses (in the wellbore and fracture network) and deliver fluid pressure to the margins of the reservoir sufficient to cause hydroshearing. At higher wellhead pressures, the tensile failure pressure may be exceeded near the wellbore; however, the near wellbore flow network developed early in the stimulation should remain self-propped due to initiation in the hydroshearing regime."

- Pg. 45 - Excellent graph

✓ Thanks!

- Pg. 46 - "If our current understanding of the stress regime is correct." See issue raised above about confidence level of stress model.

✓ See response to same question on page 34.

- The model looks at the horizontal extent of fracture generation. How much vertical growth is expected? Fractures may not propagate downwards very much (as they may be impeded by the brittle-ductile boundary), but they may shear upwards. How might this be impacted by variations in stratigraphy and hydrothermal alteration?

- ✓ The vertical limits on growth are discussed in Section 4.4. The following sentence was added in section 4.4, "The vertical growth boundary will be monitored by both microseismicity (see Section 4.5 below) and by real-time fiber optic temperature and pressure monitoring in the well bore."

- Pg. 47 - There appears to be a bit of a seismic monitoring station gap in the NW quadrant (between stations TG19, TG17, ND03, and NN24). Is this a concern?
- ✓ No. As explained on the call, the stations to the northwest will all be more sensitive borehole seismometers, while several of those to the east (near and in the NNVM) will include less sensitive surface seismometers.

- It might be worthwhile to depict the location of the John Day formation in the cross section, as it is mentioned as a key barrier between the geothermal system and the shallow freshwater aquifer.
- ✓ Text changed to reflect evidence of impermeable rock below depth of 1000 feet is related more to conductive gradients than presence of John Day formation. Text now reads, "NWG 55-29 penetrated volcanic rocks correlated to the Newberry, Deschutes and John Day formations, and, below about 8500 feet TVD, subvolcanic intrusives presumed to be related to the Newberry Volcano (AltaRock, 2010). In temperature profiles of NWG 55-29 and other deep wells, the base of permeability is characterized by a transition from isothermal temperatures above to conductive thermal gradients below, indicating limited groundwater flow below a depth of 1000 feet (Figure 4-2; Dames and Moore, 1994). Thus, setting a vertical growth boundary at 6000 feet TVD in NWG 55-29 (horizontal orange line in **Error! Reference source not found.**) will provide a buffer of 5000 feet (1.5 km) of impermeable rock between the EGS reservoir and local groundwater resources. The vertical growth boundary will be monitored by both microseismicity (see section 4.5 below) and by real-time fiber optic temperature and pressure monitoring in the wellbore."

- Pg. 48 - "After review, if the event location is confirmed as an outlier, a mitigation action will be triggered." How long is the review and concurrence of DOE, BLM, FS, PNSN, and LBNL expected to take?
- ✓ Text clarified to read that onsite personnel will perform mitigation without any need for concurrence.

- Pg. 51 - Regarding liquid storage capacity, is 11.6/12% enough? There is no discussion of how risk flow would exceed the storage capacity.
- ✓ See response above for Pg. 41 comment.

- Pg. 53 – re: outlier mitigation, here it says mitigation is to occur before the report is sent to DOE, BLM, USFS. Maybe I missed something but on page 48 it suggests there is review and concurrence of outlier before mitigation.
- ✓ Text clarified to read that onsite personnel will perform mitigation without any need for concurrence.

- Pg. 54 - One of the triggers is the presence of events at depths < 6000 feet. Given that the casing shoe is at 6462 feet, there isn't much leeway if any fractures start opening up near this point. If the vertical error is similar to the horizontal error for locating seismic events (~400 m), then any events that were located shallower than 7200 feet depth would presumably cause this trigger threshold to be reached.

- ✓ The vertical limits on growth are discussed in Section 4.4. The following sentence was added to section 4.4, "The vertical growth boundary will be monitored by both microseismicity (see Section 4.5 below) and by real-time fiber optic temperature and pressure monitoring in the well bore."

- Pg. 54 - no information on proven performance of diverters and thus likely effectiveness of diverters in mitigation.
- ✓ See response above for Pg. 8 comment

- Pg. 55 - "any ground motion… that can be correlated in time to a seismic event within 3 km." A more conservative approach would be to halt if any 0.028g is measured, whether correlated or not. Sticky wicket here is that if you halt for a natural event, in an abundance of caution, it could be interpreted as admitting that the stimulation was to blame. Still, I can see outcry if operations continued after a 3.5+, even if the scientific correlation with EGS stimulation was nil.
- ✓ On the teleconference, reviewers agreed that some way of filtering out false positives (i.e. a large truck passing the SMS) was necessary.

- Pg. 56-57 - Who will choose the "independent" civil engineer to evaluate damage claims? Will the BLM or FS play a role in this process?
- ✓ Text added, "chosen with concurrence of all stakeholders".

- Pg. 57 - Given that induced seismicity can continue after injection has ceased, the signs warning about possible rock falls should probably be not taken down after the flow tests, but should remain up for a short while (perhaps 1 month) longer.
- ✓ Changed in this ISMP to "for at least two months after."

- Pg. 65 - Correct error reference in Table C1. Update section numbers/titles in both tables so that they correspond to the revised section headings in the report.
- ✓ Changed in this ISMP.

Other Comments

Following is my review of AltaRock responses to the questions raised in the May, 2011 letter from DOE to AltaRock, Subject: DOE comments to AltaRock Energy's Induced Seismicity Mitigation Plan for award number DE-EE0002777, entitled "Recovery Act: Newberry Volcano EGS Demonstration"

- Comment 8 partially responded to
- ✓ This comment was discussed on the teleconference and all reviewers agreed that the AltaRock response was sufficient.

- Comment 9 responded to but maybe not sufficiently
- ✓ This comment was discussed on the teleconference and all reviewers agreed that the AltaRock response was sufficient.

- Comments 33 through 36 are responded to but perhaps not in sufficient detail
- ✓ This comment was discussed on the teleconference and all reviewers agreed that the AltaRock response was sufficient.