ATTACHMENT 17

AR # 213

E-mail re: Addition of AoR “Triggers” and Pressure Monitoring Well

213

McDonald, Jeffrey

om: Gilmore, Tyler J [Tyler.Gilmore@pnnl.gov]
nt: Tuesday, March 04, 2014 6:00 PM
To: McDonald, Jeffrey
Cc: Bayer, MaryRose; Greenhagen, Andrew; Vermeul, V R (Vince); Bonneville, Alain; Appriou, Delphine; Lucinda Low Swartz
Subject: Addition of AoR "Triggers" and Pressure Monitoring Well
Attachments: AoR_Reevaluation_rev0.docx

Jeff and Molly,
Following our conference call on Monday we took two major actions; 1) we refined a list of events that would trigger a reevaluation of the Area of Review prior to the regularly scheduled reviews and 2) we added plans for constructing a new well within the first 5 years of operation that would monitor pressure in the reservoir outside the CO2 plume.

Attached is a write up that describes the frequency of the regularly scheduled AoR reviews along with "triggers" that would result a reevaluation prior to a scheduled review. We have identified 6 triggers and the details of which are provided in the attached file. In summary, the writeup states;

The Alliance will reevaluate the AoR on an annual basis for the first 5 years following the initiation of injection operations (Figure 23). Following the fifth year of injection, the AoR will be updated at a minimum of every 5 years as required by 40 CFR 146.84(b)(2)(i). An annual reevaluation in the first 5 years is intended to account for any operational variation during the startup period.

Some conditions would warrant reevaluation prior to the next scheduled cycle. To meet the intent of the regulations and protect underground sources of drinking water, the following six conditions would warrant reevaluation of the AoR:

1. *Exceeding fracture pressure conditions*
2. *Exceeding Established Baseline Hydrochemical/Physical Parameter Patterns*
3. *Compromise in Injection Well Mechanical Integrity*
4. *Departure in Anticipated Surface Deformation Conditions*
5. *Seismic Monitoring Identification of Subsurface Structural Features*
6. *Seismic Monitoring Identification of Unexpected Plume Pattern*

Central to our monitoring strategy is to use an "adaptive" or observational approach to monitoring. Using this approach we will identify a location for an additional well within the first 5 years of operation, which will be used for monitoring the pressure in the reservoir outside the CO2 plume. We added this discussion in the Testing and Monitoring Plan and the AoR plan but is also identified throughout each of the plans. As we send each of the plans we will highlight where in those plans we describe the approach.

Please let us know if this adequately addresses your comments on our plans.
Thanks
Tyler

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Area of Review Reevaluation Plan and Schedule

Proposed Reevaluation Cycle

The Alliance will reevaluate the AoR on an annual basis for the first 5 years following the initiation of injection operations (Figure 23). Following the fifth year of injection, the AoR will be updated at a minimum of every 5 years as required by 40 CFR 146.84(b)(2)(i). An annual reevaluation in the first 5 years is intended to account for any operational variation during the startup period.

Some conditions would warrant reevaluation prior to the next scheduled cycle. To meet the intent of the regulations and protect underground sources of drinking water, the following six conditions would warrant reevaluation of the AoR:

1. **Exceeding Fracture Pressure Conditons:** Pressure in any of the injection or monitoring wells exceeding 90% of the geologic formation fracture pressure at the point of measurement. This would be a violation of the permit conditions. The Testing and Monitoring plan provides discussion of pressure monitoring.

   Action: The computational model will be calibrated to match measured pressures. Model outputs that calculate the change in AoR would be provided to EPA.

2. **Exceeding Established Baseline Hydrochemical/Physical Parameter Patterns:** A statistically significant difference between observed and baseline hydrochemical/physical parameter patterns (e.g., fluid conductivity, pressure, temperature)within the Ironton Formation immediately above the confining zone(ACZ1 and ACZ2 wells). The Student's t-test statistical procedure will be used to compare background (baseline) with observed results. The Testing and Monitoring plan provides extended information regarding how pressure, temperature and fluid conductivity will be monitored within the Ironton Formation.

   Action: If in the event that hydrochemical/physical parameter trends suggest that leakage may be occurring, either the computational model or other models may be used to understand the observational parameter behavior.

3. **Compromise in Injection Well Mechanical Integrity:** A significant change in pressure within the protective annular pressurization system surrounding each injection well that , indicates a loss of mechanical integrity at an injection well.

   Action: Injection wells suspected of mechanical integrity issues would be shut down and the cause of the pressure deviation determined. Mechanical integrity testing would be conducted and in conjunction, the computational model will be updated with mechanical integrity results to determine the severity and extent of the loss of containment. The Testing and Monitoring plan provides extended information regarding the mechanical integrity tests that will be conducted in the injection wells.

4. **Departure in Anticipated Surface Deformation Conditions:** Surface deformation measurements that indicate an asymmetric or otherwise heterogeneous evolution of the reservoir pressure front, resulting in larger than predicted surface deformation outside the CO_2 plume.Areal surface deformation will be monitored using several technologies

including DINSAR, which is a radar-based method that can measure very small changes in ground-surface elevation (in the millimeter range) linked to pressure variations at depth. The area surveyed will extend beyond the predicted maximum extent of the CO_2 plume. If a measurable rise in the ground surface occurs outside the predicted extent, the AoR will be re-evaluated. The Testing and Monitoring plan provides extended information regarding surface deformation monitoring.

Action: The computational model will be calibrated to match calculated pressures if they vary from the predicted deformation/pressure calculations and a new AoR may be delimited.

5) **Seismic Monitoring Identification of Subsurface Structural Features:** Seismic monitoring data indicates the possible presence of a fault or fracture near the CO_2 reservoir in the sedimentary cover or in the basement (Concentration of microearthquakes of M<<1 in elongated clusters). The Testing and Monitoring plan provides extended information regarding the microseismic monitoring network.

   Action: The cause of the indicated microseismicity patterns would be evaluated. In conjunction, various operational parameters will be tested using computational model to determine if the microseismic activity can be controlled to acceptable levels

6) **Seismic Monitoring Identification of Unexpected Plume Pattern:** Seismic monitoring data indicates a CO_2 plume migration outside the predicted extent. The observation of microearthquakes (M<<1) may also help define the actual shape of the maximum pressure field associated with the plume extensions.

   Action: The computational model will be calibrated to match the location of observed microseismicity patterns indicative of plume extensions.

Re-evaluation Strategy

If any of these conditions occurs, the Alliance will re-evaluate the AoR as described below. Ongoing direct and indirect monitoring data, which provide relevant information for understanding the development and evolution of the CO_2 plume, will be used to support re-evaluation of the AoR. These data include 1) the chemical and physical characteristics of the CO_2 injection stream based on sampling and analysis; 2) continuous monitoring of injection mass flow rate, pressure, temperature, and fluid volume; 3) measurements of pressure response at all site monitoring wells; and 4) CO_2 arrival and transport response at all site monitoring wells based on direct aqueous measurements and selected indirect monitoring method(s). The Alliance will compare these observational data with predicted responses from the computational model and if significant discrepancies between the observed and predicted responses exist, the monitoring data will be used to re-calibrate the model (Figure 23). In cases where the observed monitoring data agree with model predictions, an AoR re-evaluation will consist of a demonstration that monitoring data are consistent with modeled predictions. As additional characterization data are collected, the site conceptual model will be revised and the modeling steps described above will be repeated to incorporate new knowledge about the site.

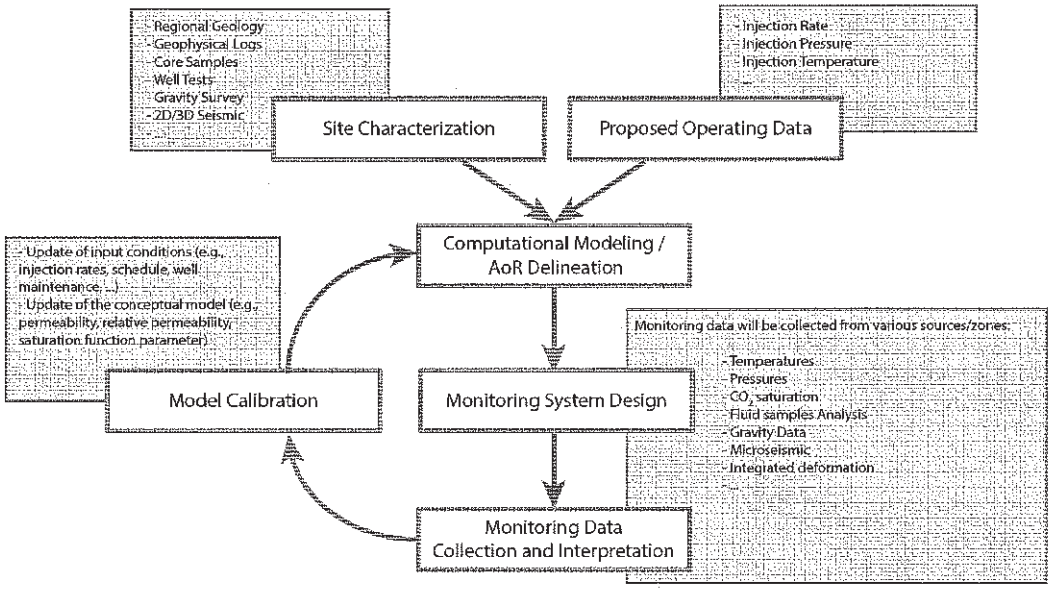
The Alliance will submit a report notifying the UIC Program Director of the results of this re-evaluation within 90 days of detection. At that time, the Alliance will either 1) submit the monitoring data and modeling results to demonstrate that no adjustment to the AoR is required, or

2) modify its Corrective Action, Emergency and Remedial Response and other plans to account for the revised AoR. All modeling inputs and data used to support AoR re-evaluations will be retained by the Alliance for the period of the project.

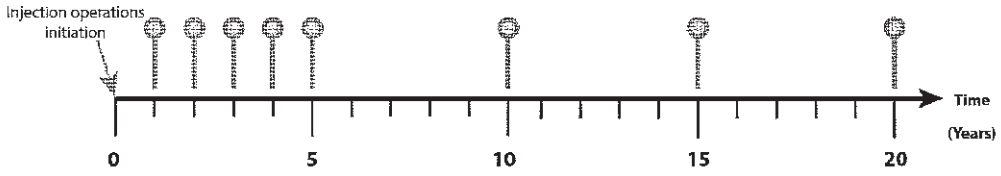
To the extent that the re-evaluated AoR is different from the one identified in this supporting documentation, the Alliance will identify all active and abandoned wells and underground mines that penetrate the confining zone (the Eau Claire Formation) in the reevaluated AoR and will perform corrective actions on those wells. As needed, the Alliance will revise all other plans, such as the Emergency and Remedial Response Plan, to take into account the reevaluated AoR and will submit those plans to the UIC Program Director for review and approval.

Note that seismic events are covered under the Emergency Response and Remediation Plan. A tiered approach to responding to seismic events will be based on magnitude and location. A notification procedure is provided in that plan.

Area of Review Reevaluation Plan and Schedule



Proposed Reevaluation Schedule



Proposed Reevaluation Schedule Prior to the Next Scheduled Reevaluation

Report notifying the UIC Program Director of the results of the AoR reevaluation

Triggers:

- Exceeding Fracture Pressure Conditions: Pressure exceeding 90% of the geologic formation fracture pressure at the point of measurement
- Exceeding Established Baseline Hydrochemical/Physical Parameter Patterns above theconfining zone
- Compromise in Injection Well Mechanical Integrity
- Departure in Anticipated Surface Deformation Conditions: larger than predicted surface deformation outside of the CO_2 plume
- Seismic Monitoring Identification of Subsurface Structural Features
- Seismic Monitoring Identification of Unexpected Plume Pattern

AoR Reevaluation

AoR_Reevaluation - 3/3/2014