113

McDonald, Jeffrey

From: Gilmore, Tyler J [Tyler.Gilmore@pnnl.gov]
Sent: Friday, January 17, 2014 4:06 PM
To: McDonald, Jeffrey
Cc: Greenhagen, Andrew
Subject: Re: Informal Request (IR) # 3 (IR3-01-10-14)
Attachments: EPA_IR3_for_FG-RPT-017-Final.pdf

Jeff,
Attached are our responses to the Informational request below, (IR) # 3 (IR3-01-10-14). Please call if you have any questions.
Thanks
Tyler

From: <McDonald>, Jeff McDonald <mcdonald.jeffrey@epa.gov>
Date: Friday, January 10, 2014 12:38 PM
To: Tyler Gilmore <tyler.gilmore@pnnl.gov>
Cc: "Greenhagen, Andrew" <Greenhagen.Andrew@epa.gov>
Subject: Informal Request (IR) # 3 (IR3-01-10-14)

Tyler,
Here are some comments/questions that we have for you and the applicant (FGA). I will gladly talk to you today, Monday, or whenever to clarify any questions you might have with these. As you can see, I copied this from our internal tracking. We will distinguish formal RAIs from informal requests (IRs), hence this being called IR #3. Do you think that a response to these could be sent back to us by the end of next week?
Thanks,
Jeff

RAI or item #	Subject	Appl. Page	Appl. Section.	EPA Comment / Question / Request	
01-10-14_1	Alternative PISC timeframe	7.1	7.0	It appears that FutureGen will not be making a demonstration for an alternative PISC period (other than the 50 year default). We assume that if FutureGen makes a demonstration for a PISC other than the 5o year default, this will happen in the future. Is this correct?	

01-10-14_2	Testing and Monitoring	5.25	5.2.3.3	This bullet point states that pressure gauges will be pulled and recalibrated during a well workover, when the injection and monitoring well tubing is pulled. Question: Is this frequency of pressure monitor calibration adequate? How often does Future Gen anticipate it will pull the tubing of the well? We think that redundant gauges should be run to provide confirmation of downhole pressure and temperature. If you agree, what frequency and/or duration will you have both gauges in place to support this?	
01-10-14_3			Fig. 2.11	Figure 2.11 shows a fracture gradient of 0.647 psi/ft for the Elmhust formation. Therefore, the maximum injection pressure must be calculated using the lowest fracture gradient of the Elmhust formation of 647psi/ft x 0.9=.5823 P max at the wellhead=[{0.5823-(.433)(.8322)}3867.9]-14.7=844psig Where: From table 4.2, the density of the CO2 is 51.95 #/ft3, therefore, the specific gravity = 51.95/62.42= 0.8322 The maximum injection pressure in the injection zone = (0.433)(0.8322)(3867.9)+844=2238psig From Table 4.3, the maximum bottom-hole injection pressure is 2358psi Please provide details information about the equation and parameters used to come up with a maximum injection pressure of 1847 psi	

01-10-14_4	PISC	7.1	7.1	The FGA plans to calibrate the computational modeling used for the AoR and PISC with monitoring data once operational, however it is unclear if there is a schedule that the FGA plans to use for this purpose. The regulations require reevaluations every 5 years, but will the FGA conduct model calibration prior to that anniversary or more frequently, and if so, when or with what frequency?	
01-10-14_5	PISC	3.27 to 3.34	7.1.3 and 3.1.6	The computational model results indicate that a small fraction of the injected CO2 will enter the lower part of the Lombard formation. If authorized under any UIC permits, the injection zone will need to include that lower part of the Lombard. Please determine what members or submembers of the Lombard are expected to receive CO2 and will therefore be part of any permitted injection zone.	
01-10-14_6	PISC and T&M	7.5	7.2 and 5.2	Specific locations of monitoring wells need to be identified for any permit decision including what specific parameters will be monitored for.	
01-10-14_7	PISC and T&M	7.5	7.2.2	Please state whether FGA will use a "multi-level monitoring system within a single casing string with multiple sample intervals" **or** a "multi-level piezometer installation."	
01-10-14_8	PISC and T&M	7.6	7.2.3 and 5.2	Please indicate which method the FGA intends to use to compy with the requirements for indirect CO2 plume monitoring (40 CFR 146.90(g)). Please ensure that this covers both the injection and post injection phases of the project.	
01-10-14_9	PISC and T&M	7.9	7.3.4	The site closure plan should name the specific agencies who will be notified of site closure and **verify that no tribal authorities** must be included per 40 CFR 146.93(f)(2).	

Underground Injection Control Branch
U.S. EPA - Region 5
(312) 353-6288 [office]
(312) 408-2240 [direct fax]
mcdonald.jeffrey@epa.gov

01-10-2014: Email from Jeff McDonald (U.S. EPA Region 5) to Tyler Gilmore (Alliance): "Informal Request (IR) #3 (IR3_01-10-14)"

Requests based on the text application

IR #	Subject	Page	Doc. Sec.	Par.	EPA Comment / Question / Request	FutureGen Response	Footnote / Reference Citation
01-10-2014_1	Alternative PISC timeframe	7.1	7.0		"It appears that FutureGen will not be making a demonstration for an alternative PISC period (other than the 50 year default). We assume that if FutureGen makes a demonstration for a PISC other than the 50 year default, this will happen in the future. Is this correct?"	The FutureGen Industrial Alliance, Inc. (Alliance) is planning to conduct monitoring for 50 years after cessation of CO_2 injection, the default period in the regulations.	
01-10-2014_2	Testing and Monitoring	5.25	5.2.3.3		"This bullet point states that pressure gauges will be pulled and recalibrated during a well workover, when the injection and monitoring well tubing is pulled. Question: Is this frequency of pressure monitor calibration adequate? How often does FutureGen anticipate it will pull the tubing of the well? We think that redundant gauges should be run to provide confirmation of downhole pressure and temperature. If you agree, what frequency and/or duration will you have both gauges in place to support this?"	Mechanical strain gauges and thermocouples wires will be the primary monitoring devices for pressure and temperature and will be frequently re-calibrated (initially on a quarterly basis). In some wells a redundant fiber optic cable will also be installed as part of a comparison test with more standard gauges. A wireline-deployed multi-parameter probe to monitor pressure, temperature, and specific conductance (P/T/SpC) will be installed in each monitoring well to provide real-time parameter measurements. The probes will be installed via a dedicated wireline winch system that will also be used to collect pressurized fluid samples. As such, the sensors will be removed each time a well is sampled (initially on a quarterly basis) and more frequently if required for calibration purposes. Calibration frequency will be based on observed parameter response and on manufacturer recommendations, but it will be evaluated, at a minimum, each time the well is sampled. The two reservoir monitoring wells will also be instrumented with tubing-conveyed fiber-optic cables that continuously monitor changes in pressure and distributed temperature along the length of the monitoring interval. As such, this configuration will be redundant for pressure measurements but will provide additional capability for distributed temperature sensing. This redundant fiber-optic system would only be recalibrated or replaced when the monitoring well tubing string is pulled. The injection wells will be completed with a string of 3.5 in.-OD tubing that extends from the wellhead at the surface to near the top of the perforated interval. A tubing string that is 4,000 ft long will extend approximately 11 ft below the top of the perforations. The tubing string will be held in place at the bottom by a packer that is positioned just above the uppermost perforations (approximate measured depth of 3,975 ft). An optical or electronic pressure-and-temperature (P/T) gauge will be installed on the outside of the tubing string, approximately 30 ft above the packer, and ported into the tubing to continuously measure CO_2 injection P/T inside the tubing at this depth. Because the bottom-hole P/T gauge will be attached to the tubing string, the gauge will be recalibrated or replaced only when the injection well tubing string is pulled, which would occur only if warranted by a downhole issue that can only be addressed by performing a well workover. In addition, injection P/T will also be continuously measured at the surface via real-time P/T instruments installed in the CO_2 pipeline near the pipeline interface with the wellhead. The surface instruments will be checked, and if necessary, re-calibrated or replaced on a regular basis (e.g., semi-annually) to ensure they are providing accurate data. Because the surface instruments can be more readily accessed and maintained than the bottom-hole gauge, they will be used to control injection operations and trigger shutdowns.	

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IR #	Subject	Page	Doc. Sec.	Par.	EPA Comment / Question / Request	FutureGen Response	Footnote / Reference Citation
01-10-2014_3	Testing and Monitoring		Table 2.11		"Figure 2.11 shows a fracture gradient of 0.647 psi/ft for the Elmhust formation. Therefore, the maximum injection pressure must be calculated using the lowest fracture gradient of the Elmhust formation of 647psi/ft x 0.9=.5823 P max at the wellhead=[{0.5823-(.433){.8322}}3867.9]-14.7=844psig Where: From table 4.2, the density of the CO2 is 51.95 #/ft3, therefore, the specific gravity = 51.95/62.42= 0.8322 The maximum injection pressure in the injection zone = {0.433}{0.8322}(3867.9)+844=2238psig From Table 4.3, the maximum bottom-hole injection pressure is 2358psi Please provide details information about the equation and parameters used to come up with a maximum injection pressure of 1847 psi"	**1) Determination of the fracture gradient** Triaxial tests were conducted on eight vertical samples from the cored interval of the stratigraphic well. Triaxial tests provide information regarding the geomechanical properties of samples. However, these data cannot be used to properly determine the fracture gradient of a formation. Only in situ measurements with hydraulic fracturing tests provide an accurate estimate of this parameter. At the time the UIC permit application was submitted, no hydraulic fracturing tests had been conducted in the Mount Simon Sandstone at the Morgan County site. Therefore, a realistic regional value of 0.65 psi/ft was considered to be representative of the fracture gradient in the Mount Simon Sandstone. In November and December 2013, hydraulic tests were conducted in the Mount Simon Sandstone and in the Precambrian basement. The first results of these tests verify that the fracture gradient used in the model for the injection zone remains conservative and appropriate. **2) Determination of the maximum injection pressure** The regulation requires that *"The owner or operator must inject carbon dioxide at a pressure less than 90 percent of the identified formation fracture pressure, except during stimulation."* Therefore, a value of 0.585 psi/ft (90% of 0.65 psi/ft) was used to calculate the maximum injection pressure that was specified in the numerical model. 2,252.3 psi was specified as the maximum injection pressure that the model would allow. This limiting value was assigned at the top of the open interval (depth of 3,850 ft bgs) based on the following calculation: 0.585*3,850=2,252.3 psi. The pressure of 1,847 psi to which the EPA is referring to is not related to the maximum pressure allowed in the injection interval, but was a preliminary estimate of the CO_2 pressure that the pipeline will be capable of delivering at the wellhead. The maximum pressure allowed in the injection interval will determine the actual maximum wellhead pressures.	
01-10-2014_4	PISC	7.1	7.1		"The FGA plans to calibrate the computational modeling used for the AoR and PISC with monitoring data once operational, however it is unclear if there is a schedule that the FGA plans to use for this purpose. The regulations require reevaluations every 5 years, but will the FGA conduct model calibration prior to that anniversary or more frequently, and if so, when or with what frequency?"	The Alliance will conduct model calibration at least every 5 years. Model calibration may also occur when actual operational data differ significantly from initial estimated operational values that were used for model inputs, or when monitoring data and model results differ significantly as per specified in the regulation.	

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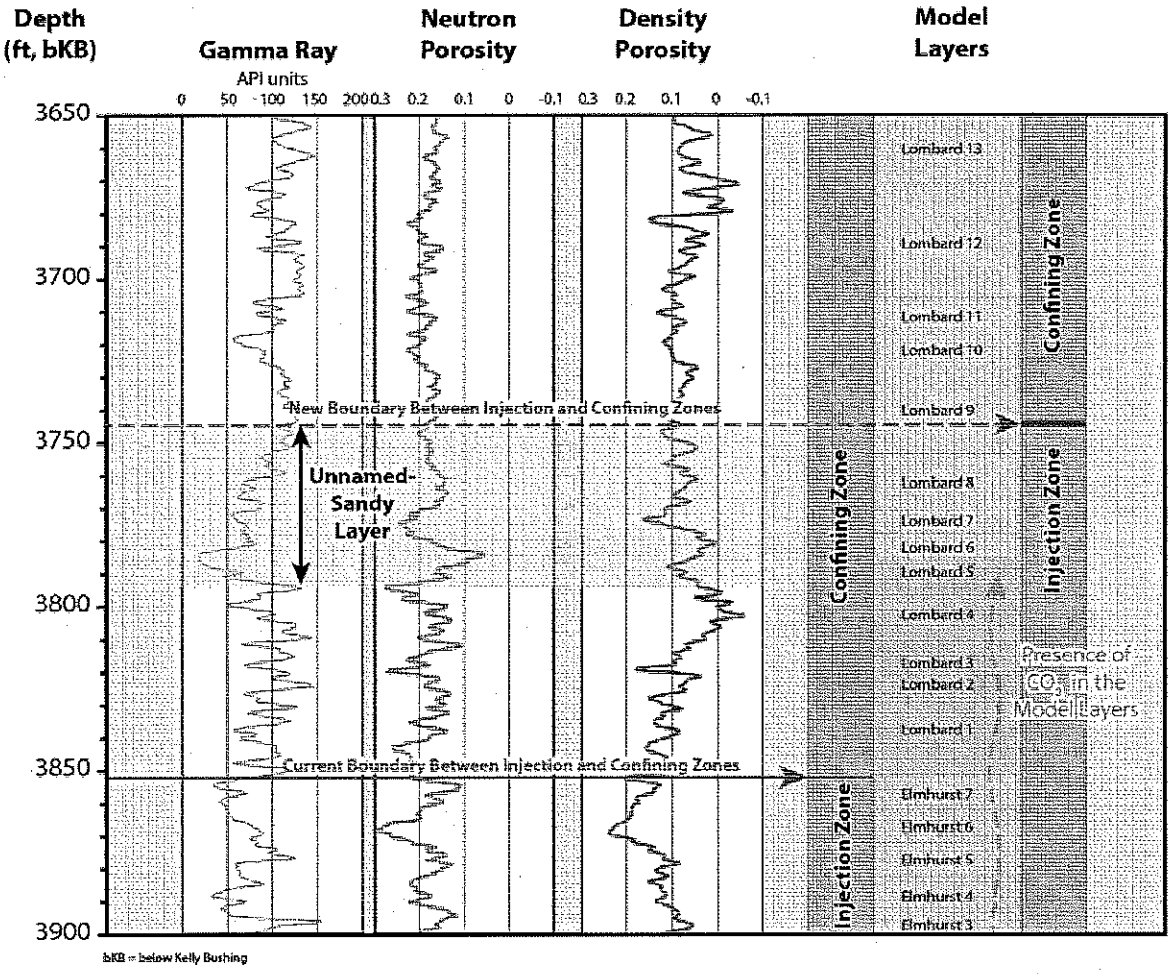
IR #	Subject	Page	Doc. Sec.	Par.	EPA Comment / Question / Request	FutureGen Response	Footnote / Reference Citation
01-10-2014_5	PISC	3.27 to 3.34	7.1.3 and 3.1.6		"The computational model results indicate that a small fraction of the injected CO2 will enter the lower part of the Lombard formation. If authorized under any UIC permits, the injection zone will need to include that lower part of the Lombard. Please determine what members or submembers of the Lombard are expected to receive CO2 and will therefore be part of any permitted injection zone."	The computation model results indicate that the Model Layer "Lombard 5" is the top unit containing a fraction of injected CO_2 during the 100-year simulation. However, because geophysical logs indicate the presence of an unnamed thin sandy layer above Lombard 5 (see graphic in Appendix A), the Alliance determined that this thin sandstone should also be part of the injection zone. In conclusion, based on the current knowledge of the geology at the FGA1 stratigraphic well, the top of the injection zone is set at 3,745 ft bKB (or 3,731 ft below ground surface), which is in the lower part of the model layer "Lombard 9" (Appendix A) KB = below Kelly Bushing	
01-10-2014_6	PISC and T&M	7.5	7.2 and 5.2		"Specific locations of monitoring wells need to be identified for any permit decision including what specific parameters will be monitored for."	The Alliance has modified the monitoring network design since the UIC permit application was submitted. A discussion, which includes monitored parameters, and a location map showing the updated and revised monitoring well network are provided in Appendix B.	
01-10-2014_7	PISC and T&M	7.5	7.2.2		"Please state whether FGA will use a "multi-level monitoring system within a single casing string with multiple sample intervals" **or** a "multi-level piezometer installation."""	The Alliance has modified the monitoring network design since the UIC permit application was submitted by eliminating this "multi-level monitoring well". The previously planned multi-level completion has been replaced by two fully cased reservoir access tubes (RATs) that will be installed within the boundaries of the simulated 5-year CO_2 plume. The RATs will extend to the base of the reservoir and into the Precambrian bedrock. The RATs will be non-perforated, cemented casings used to monitor CO_2 arrival and quantify saturation levels via downhole pulsed-neutron capture (PNC) geophysical logging across the reservoir and confining zone. A discussion and location map showing the updated and revised monitoring well network is provided in Appendix B.	
01-10-2014_8	PISC and T&M	7.6	7.2.3 and 5.2		"Please indicate which method the FGA intends to use to comply with the requirements for indirect CO_2 plume monitoring (40 CFR 146.90(g)). Please ensure that this covers both the injection and post injection phases of the project."	A suite of indirect geophysical monitoring methods were evaluated to assess their efficacy and cost-effectiveness for monitoring the areal extent, evolution, and fate and transport of the injected CO_2 plume under site-specific conditions. Technologies that were retained for implementation in the monitoring program include PNC logging, passive seismic monitoring, integrated surface deformation monitoring, and time-lapse gravity surveys. These methodologies will be applied during both injection and post-injection phases of the project.	
01-10-2014_9	PISC and T&M	7.9	7.3.4		"The site closure plan should name the specific agencies who will be notified of site closure and **verify that no tribal authorities** must be included per 40 CFR 146.93(f)(2)."	Sections 7.3 and 7.3.4 of the UIC permit supporting documentation were updated and are provided in Appendix C. It was verified that no tribal authorities must be included per 40 CFR 146.93(f)(2) and that the agencies notified of site closure will be the EPA Region 5 UIC Branch who will be notified at least 120 days before site closure. In addition, state and local agencies including the Illinois State Geological Survey and Illinois Department of Natural Resources, as well as City of Jacksonville and Morgan County agencies will be notified prior to the scheduled site closure.	

Appendix A

IR 01-10-2014_5

Additional Information Regarding

Post-Injection Monitoring Plan and Monitoring Activities



Determination of the Top of the Injection Zone, based on Geophysical Logs and Modeling Results

Appendix B

IR 01-10-2014_6

Additional Information Regarding

Post-Injection Monitoring Plan and Monitoring Activities

Location of Monitoring Wells

The monitoring well network (Figure 1) has been updated in accordance with discussion in the UIC application supporting documentation.

> Chapter 5 of the UIC Supporting Documentation, Section 5.1, p. 5.2: The monitoring network design was developed based on the current conceptual understanding of the Morgan County CO_2 storage site and was used to guide development of the testing and monitoring approaches described in Section 5.2. The technical approaches described in Section 5.2 should be considered working versions that over time will be updated and modified as required in response to changes in the site conceptual model and/or operational parameters.

The objective of the monitoring program is to select and implement a suite of monitoring technologies that are both technically robust and cost-effective and provide an effective means of 1) evaluating CO_2 mass balance and 2) detecting any unforeseen containment loss.

The application proposed two single-level in-reservoir (SLR) wells, one above confining zone (ACZ) well, one underground source of drinking water (USDW) well, and a one multi-level in-reservoir (MLR) well within the injection reservoir for a total of five monitoring wells.

As part of the project's design optimization, the monitoring well network design has been revised (Figure 2) to increase its effectiveness, simplify its engineering design, and hopefully eliminate any permitting challenges that might have been associated with the MLR. The revisions include eliminating the MLR well in favor of adding two fully cased reservoir access tube (RAT) wells. The revised design includes a total of seven monitoring wells summarized in Table 1 and as follows:

- **Two ACZ wells**

  These wells will be used to monitor immediately above the Eau Claire caprock in the Ironton Sandstone. **Monitored Parameters: pressure, temperature, and hydrogeochemical indicators of CO_2.**

- **Two SLR wells** (one of which is a reconfiguration of the previously drilled stratigraphic well)

  These wells will be used to monitor within the injection zone beyond the east and west ends of the horizontal CO_2-injection laterals. **Monitored Parameters: pressure, temperature, and hydrogeochemical indicators of CO_2.**

- **Two RAT wells**

  These are fully cased wells, which allow access for monitoring instrumentation in the reservoir via pulsed-neutron logging equipment. The wells will not be perforated so as to avoid two-phase flow near the borehole, which can distort the CO_2 saturation measurements. **Monitored Parameters: quantification of CO_2 saturation across the reservoir and caprock.**

- **One USDW well**

  This well will be used to monitor the lowermost USDW (St. Peter Sandstone). **Monitored Parameters: pressure, temperature, and hydrogeochemical indicators of CO_2.**

Note that the specific geographic coordinates of each well remain "proposed" because the project is in the process of finalizing legal agreements with surface landowners. Also, we believe this proposed network should substantially exceed the intent of the regulations. Thus, we respectfully ask that only those wells required to meet the minimum permit requirements be included in the permit as prerequisite permit conditions.

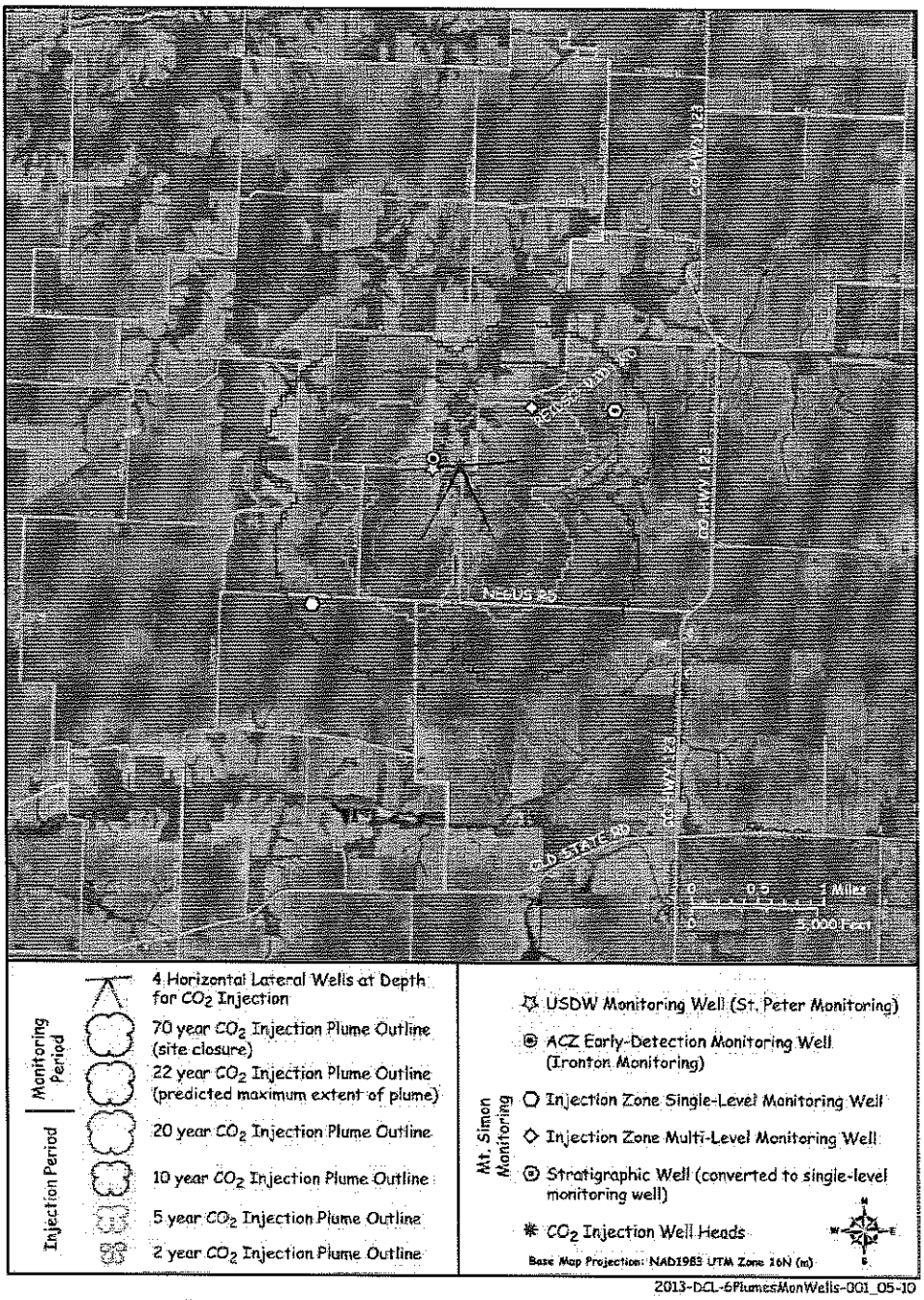


Figure 1. Monitoring Well Network as Presented in Testing and Monitoring Plan (Chapter 5.0) of the UIC Permit Supporting Documentation as Submitted in May 2013

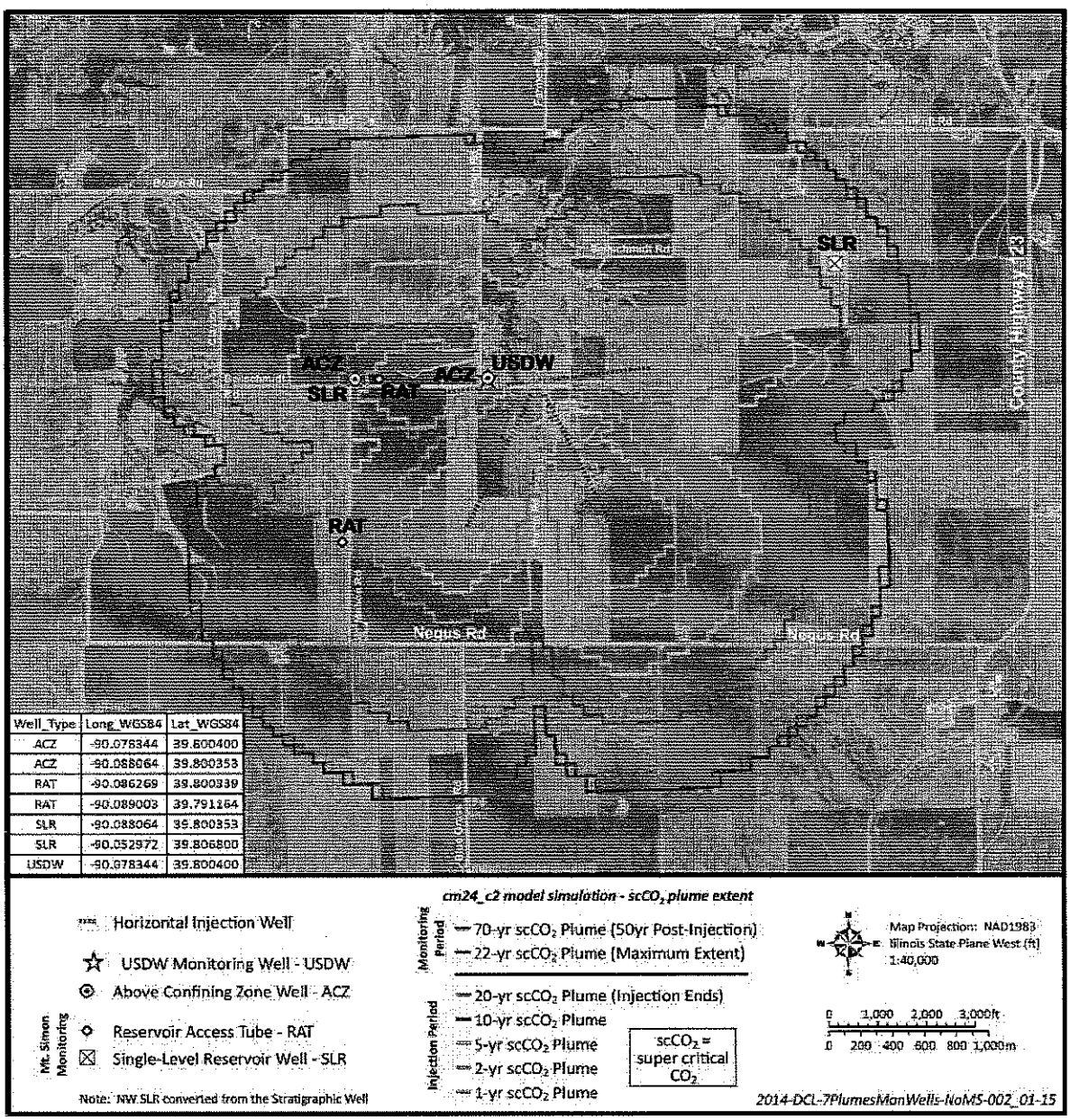


Figure 2. Updated and Revised Plan for Monitoring Wells.

The most recent monitoring well design includes five deep monitoring wells and two RAT wells as listed in Table 1.

Table 1. Planned Monitoring Wells within the FutureGen Site Network

	Single-Level In-Reservoir (SLR)	Above Confining Zone (ACZ)	USDW	Reservoir Access Tube (RAT)
# of Wells	2	2	1	2
Total Depth (ft)	4,150	3,470	2,000	4,465
Monitored Zone	Mount Simon SS	Ironton SS	St. Peter SS	Mount Simon SS
Monitoring Instrumentation	Fiber-optic P/T (tubing conveyed)[b]; P/T/SpC probe in monitored interval[(a)]	Fiber-optic (microseismic) cable cemented in annulus; P/T/SpC probe in monitored interval[(a)]	P/T/SpC probe in monitored interval[(a)]	Pulsed-neutron logging equipment

(a) The P/T/SpC (pressure, temperature, specific conductance) probe is an electronic downhole multi-parameter probe incorporating sensors for measuring fluid P/T/SpC within the monitored interval. The probe is installed inside tubing string, which is perforated (slotted) over the monitoring interval. Sensor signals are multiplexed to a surface data logger through a single conductor wireline cable.

(b) Fiber-optic cable attached to the outside of the tubing string, in the annular space between the tubing and casing.

SS = sandstone.

Appendix C

IR 01-10-2014_9

Additional Information Regarding

Post-Injection Site Care and Site Closure Plan

The following text replaces Sections 7.3 and 7.3.4 of the UIC permit Supporting Documentation:

7.3 Site Closure Plan

Site closure will occur at the end of the post-injection site care period. Site-closure activities will include decommissioning surface equipment, plugging monitoring wells, restoring the site, and preparing and submitting site closure reports. The EPA Region 5 UIC Branch will be notified at least 120 days before site closure. In addition, state and local agencies including the Illinois State Geological Survey and Illinois Department of Natural Resources, as well as City of Jacksonville and Morgan County agencies will be notified prior to the scheduled site closure.

At this time, there are no federally recognized Native American Tribes located within the AoR or the State of Illinois (http://www.ncsl.org/research/state-tribal-institute/list-of-federal-and-state-recognized-tribes.aspx). If a federally recognized Native American Tribe exists in the AoR or the State of Illinois at the time of site closure, it will be notified of site closure at that time.

A revised site-closure plan will be submitted to the EPA Region 5 UIC Branch and state and local (and tribal) governmental agencies, if any changes have been made to the original site-closure plan. After site closure is authorized, site-closure field activities will be completed.

7.3.4 Site Closure Reporting

A site-closure report will be submitted to the EPA Region 5 UIC Branch and the previously notified state and local regulatory agencies within 90 days of site closure. The site-closure report will include the following information:

- documentation of appropriate well plugging, including a survey plat of the injection well location
- documentation of the well-plugging report to Illinois and local agencies that have authority over drilling activities at the facility site
- records reflecting the nature, composition, and volume of the CO_2 injected in UIC wells.

In association with site closure, a record of notation on the facility property deed will be added to provide any potential purchaser of the property with the following information:

- notification that the subsurface is used for CO_2 storage
- the name of the Illinois and local agencies and the EPA Region 5 Office to which the survey plat was submitted
- the volume of fluid injected, the injection zone, and the period over which injection occurred.