ATTACHMENT 6

AR # 68

Request for Additional Information Regarding FutureGen 2.0 Wells

68

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

NOV 14 2013

REPLY TO THE ATTENTION OF:
WU-16J

CERTIFIED MAIL 7001 0320 0005 8923 4123
RETURN RECEIPT REQUESTED

Kenneth K. Humphreys
Chief Executive Officer
FutureGen Industrial Alliance, Inc.
73 Central Park Plaza East
Jacksonville, Illinois 62650

Subject: Request for Additional Information Regarding FutureGen 2.0 Wells, United States Environmental Protection Agency Underground Injection Control (UIC) Permit Applications for Four Geologic Sequestration Wells; United States Environmental Protection Agency UIC Permit Nos. IL-137-6A-0001, -0002, -0003, & -0004

Dear Mr. Humphreys:

In order to complete our review of FutureGen's permit applications, we need additional information described in the enclosure with this letter. Please submit any information no later than 30 days from the receipt of this letter.

Inquiries concerning the contents of the enclosure may be directed to Jeffrey McDonald of my staff by telephone at (312) 353-6288 or by email to mcdonald.jeffrey@epa.gov.

Sincerely,

for Rebecca Harvey, Chief
Underground Injection Control Branch

cc: Stephen Nightingale, IEPA

Enclosure

Requests based on the text application

Section Number	Section Title	Request
3.1.2	Physical Processes Modeled	Page 3.3 of the permit application states that laboratory investigations for quantifying the importance of chemical reactions are being conducted. Are any results available? Modeling considering reactive transport may need to be conducted if the lab results indicate significant iron carbonate precipitation that changes injection zone porosity.
3.1.3.2	Intrinsic permeability in the Injection Zone	A "curve permKCal" is referenced, but the location of the curve isn't clear. Please provide a copy or further explain.
3.1.3.2	Intrinsic permeability in the Injection Zone	No hydrologic tests were conducted in the Elmhurst formation to measure a Permeability-Thickness Product and no ELAN calculation was given. How was a Permeability-Thickness Product determined for the Elmhurst formation?
3.1.3.2	Vertical Permeability	Kv/Kh measured in 20 core plug pairs; highly related to presence of mudstone/shale; sparse data led to use of literature values. Given that 20 ratios were successfully determined, how do they compare to the literature values?
3.1.3.2	Capillary Pressure and Saturation Functions	Data was used from the Manlove field to generate Brooks-Corey parameters for four different permeability ranges, shown in Table 3.5. Please provide a citation for this information.
3.1.3.3	Temperature	We believe 6.72^{-3} should be 6.72×10^{-3} °F/ft?
3.1.3.3	Temperature	Why is regression used rather than measured data?
3.1.5	Representative Case Scenario Description	Section 3.1.5 of the permit application notes that the design of the injection wells was chosen to "avoid sensitive areas" (p. 3.26). What are these "sensitive areas" and how were they identified? Is this the reason the horizontal well legs are not evenly distributed in a radial fashion?
3.1.6	Computational Model Results	It would be helpful to have a verbal description of the changes between figures in a series: e.g., the 70yr figure in 3.21 has a wide area in green but the other three do not: what does this tell us? It is extremely difficult to judge scale from these figures. Please provide dimensions of plume and pressure front over time, together. A map view, such as Fig. 3.25, would be ideal. What is the largest extent of the plume and when does this occur? Because these figures are not all at the same scale, they are hard to compare.
3.1.6	Computational Model Results	Please provide figures beyond year 70. We suggest figures to year 100.
3.1.10	Parameter Sensitivity and Uncertainty	32 cases were defined using "quasi Monte Carlo" approach. *This approach should be described and possibly cited.*
3.1.10	Parameter Sensitivity and Uncertainty	The permit application states that 32 cases were defined from the representative case model. The parameter values used for these 32 cases should be presented in a table.

Requests based on the online GS data tool modeling input

Tab	Request
Model Domain	In the permit application and the Input Advisor submission, subsurface locations are referred to both in terms of depth (with respect to the ground surface or the kelly bushing) and elevation (with respect to sea level). For example, the top of the open interval is described as 3,850 ft below ground surface on p. 3.26 of the permit application, while the Input Advisor submission refers to this location as having an elevation of -3,220 ft. Is it correct to assume that all of the Z coordinate values submitted in the Input Advisor represent elevations relative to sea level and are consistent (e.g., z coordinates provided for well intervals)?
Rock Properties	The saturation function/relative permeability spreadsheet submitted via the Input Advisor defines the Brooks-Corey function for the relative permeability and saturation functions and provides corresponding parameters for different layers. It would be helpful if the functional forms of Brooks-Corey for the relative permeability and saturation functions were also provided in the spreadsheet.
Rock Properties	*Horizontal intrinsic permeabilities of the confining zones* (see p. 3.7 of the permit application). Because of the reliability issues associated with ELAN log-derived permeabilities below a certain limit (0.01 mD), FutureGen used the horizontal Klinkenberg permeabilities for each model layer. Was there any correction applied to the Klinkenberg permeabilities used for the confining zone layers, particularly because these may represent tight porous formations?
Rock Properties	*Residual saturation.* As shown in the "Sat-function-rel-perm" spreadsheet, residual aqueous saturation values used in the FutureGen AoR model range from 0.0597 to 0.0810. Residual aqueous saturation values found in the literature for the Mt. Simon Sandstone range from approximately 0.2 to 0.4 (Zhou et al., 2010; Bandilla et al., 2012b; Krevor et al., 2012; Matthias et al., 2013). It is expected that site-specific capillary pressure and residual aqueous saturation data for the FutureGen site will be generated after pre-injection testing of the proposed wells. However, an explanation of the effects of this selection on plume and pressure-front development may need to be provided.
Model Output	*Surface flux.* For the flux output files, two areas (4 mi x 4 mi and 8 mi x 8 mi) were selected and fluxes were defined across the east, west, north, and south boundaries of both of those areas, as well as the top of the Franconia and the top of the Proviso. What are the i, j, k indexes that define the 4 mi x 4 mi and 8 mi x 8 mi areas?
AoR Pressure Front Delineation	*Critical pressure calculation.* As mentioned in the previous Request for Additional Information from EPA, it is recommended that FutureGen explores alternative methods as well for the critical pressure determination, such as such as those described by Nicot et al. (2008) Birkholzer et al. (2011); or Bandilla et al. (2012).
AoR Pressure Front Delineation	*Pressure differential/simulation time.* Despite not calculating a critical pressure with respect to the lowermost USDW, FutureGen did apply a pressure differential of 31.45 psi to determine simulation times—this value is described as "the pressure differential needed to force fluids from the injection zone into the surficial alluvial aquifer system through a hypothetical conduit" (p. 3.25). In other words, it was not calculated with respect to the lowermost USDW, but rather the aquifer currently in use as a drinking water source. The footprint of this pressure front indicates a larger area that may be impacted by injection compared to the footprint of the separate-phase plume. FutureGen acknowledged this pressure effect when identifying artificial penetrations and evaluated two wells that penetrate the Mt.

	Simon outside of the delineated AoR, about 16 mi south-southwest of the proposed storage site, noting "Although these wells are well outside the AoR, they are within the region where increased pressures in the injection zone are expected and were therefore considered for additional review" (p. 3.43).What calculations were used to determine this value of 31.45 psi?
AoR Pressure Front Delineation	*Temperature in St. Peter (USDW).* Is 73°F, determined at the subsea elevation of -1,129 ft, measured at the stratigraphic well (API#12-137-22132-00)? This value does not match the resulting temperature for this elevation based on the linear-regression relationship given in Figure 3.13 – which indicates a temperature of about 82°F at a depth of 1,762.96 bkb (-1,129 ft subsea elevation).

Suggested References:

Bandilla, K.W., S.R. Kraemer and J.T. Birkholzer. 2012a. Using semi-analytic solutions to approximate the area of potential impact for carbon dioxide injection. International Journal of Greenhouse Gas Control 8: 196-204.

Birkholzer, J.T., Q. Zhou, A. Cortis and S. Finsterle. 2011. A sensitivity study on regional pressure buildup from large-scale CO_2 storage projects. 10th International Conference on Greenhouse Gas Control Technologies, 19-23 September 2010, Amsterdam. Energy Procedia 4(2011): 4371-4378.

Nicot, J.-P., C.M. Oldenburg, S.L. Bryant and S.D. Hovorka. 2008. Pressure perturbations from geologic carbon sequestration: Area-of-review boundaries and borehole leakage driving forces. 9th International Conference on Greenhouse Gas Control Technologies, 16-20 November 2008, Washington, D.C.