ATTACHMENT 27

AR # 497

Petitioners' Comments on FutureGen's UIC Draft Permits

(Excerpts)

Greenhagen, Andrew

From: Kristen Gale <kg@nijmanfranzetti.com>
Sent: Thursday, May 15, 2014 3:45 PM
To: FutureGenComments; McDonald, Jeffrey
Cc: Jennifer Nijman
Subject: Comments on FutureGen's UIC Draft Permit, Well 1, Permit No. IL-137-6A-0001
Attachments: Comments on FutureGen's UIC Draft Permit, Class VI UIC Well 1, Permit No. IL-137-6A-0001 With Exhibits (00020001xA9B67).pdf

Categories: Blue category

Mr. McDonald:

Attached please find Comments on the FutureGen Alliance 2.0 UIC Draft Permit, Well 1, Permit No. IL-137-6A-0001. We have also placed a hard copy in the mail.

Regards
-Kristen

Kristen Laughridge Gale
Nijman Franzetti, LLP
10 S. LaSalle St., Ste 3600
Chicago, IL 60603
Office: 312-251-5250
Cell: 217-390-0309
www.nijmanfranzetti.com
kg@nijmanfranzetti.com

NIJMAN · FRANZETTI LLP

10 South LaSalle Street • Suite 3600 • Chicago, Illinois 60603
312.251.5250 • fax 312.251.4610 • www.nijmanfranzetti.com

Jennifer T. Nijman
jn@nijmanfranzetti.com

Susan M. Franzetti
sf@nijmanfranzetti.com

FOR INCLUSION IN THE ADMINISTRATIVE RECORD

May 15, 2014

VIA E-MAIL & U.S. MAIL

Jeffrey McDonald
US EPA Region 5
77 W. Jackson Blvd. (WU-16J)
Chicago, IL 60604-3590

Re: Comments on FutureGen's Underground Injection Control Draft Permit, Morgan County Class VI UIC **Well 1, Permit No. IL-137-6A-0001**, dated March 2014[1]

Dear Mr. McDonald:

On behalf of the Leinberger family (Andrew H. Leinberger Family Trust and DJL Farm LLC), and the Critchelow family (William and Sharon Critchelow) (both families collectively referred to as "the Parties"), both of whom own property in the vicinity of the subject project, we are writing to submit the Parties' comments to the Underground Injection Control Draft Permit ("UIC Permit" or "Permit"), issued by the United States Environmental Protection Agency ("EPA"). EPA issued the draft Permit based on the UIC Permit Application/Supporting Documentation, March 2013 and Revised May 2013, and other material in the Administrative Record ("AR") that the FutureGen Industrial Alliance, Inc. ("FutureGen") submitted to the EPA. As set forth below and in the expert comments attached as Exhibits 1 and 2, the Permit is deficient in fundamental respects.

The FutureGen project is a "demonstration" and "first-of-a-kind" project. See U.S. Department of Energy Final Environmental Impact Statement ("Final EIS"), p. S-3, AR #411. The EPA stated that "[t]hese are the first Class VI permits for carbon sequestration in the United States." See FutureGen Fact Sheet, p. 1 (Public Comment on

[1] Because EPA has issued four separate permits for each of the four UIC wells, the Parties have submitted these comments for the Administrative Record in each permit proceeding.

First Carbon Storage Draft Permits), AR #16. Because it will set an important precedent, strict adherence to the applicable UIC regulations is imperative. The UIC regulations include "strict standards" for Class VI wells. See AR #411. Further, the Director of the EPA Region V Water Division ("Director") should use her discretion to require additional information regarding the project, as necessary, in order to properly assess the Permit. See, e.g. 40 CFR §146.82(a)(21), 146.84(c)(2).

The project involves the injection of millions of tons of carbon dioxide (1.1 million metric tons per year for 20 years) into an area where persons reside and private property is located. See AR # 16. Carbon dioxide is lethal to humans, animals and vegetation in the compressed liquid form that will be piped and injected underground.[2] Carbon dioxide is a supercritical fluid at temperatures greater than 31.1 degrees Celsius and 7.38 MPa. See Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. Ill. L. Rev. 363, 428 (2010) (citing *CRC Handbook of Chemistry and Physics* 6-39 (David R. Lide ed., 88th ed. 2008)), attached in Exhibit 3. "When released, supercritical CO_2 depressurizes into a gas and has the potential to asphyxiate humans at high concentrations, among other possible adverse health effects." Jeffrey W. Moore, *The Potential Law of on-Shore Geologic Sequestration of Co_2 Captured from Coal-Fired Power Plants*, 28 Energy L.J. 443, 470 (2007) (citing Eric J. Beckman, *Supercritical and Near-Critical CO_2 in Green Chemical Synthesis and Processing*, 28 J. of Supercritical Fluids 121, 123 (2003)), attached in Exhibit 3. EPA recognized the unique risks to underground sources of drinking water ("USDW") associated with geologic sequestration ("GS") in its Final rule, stating, "Large CO_2 injection volumes associated with GS, the buoyant and mobile nature of the injectate, the potential presence of impurities in the CO_2 stream, and its corrosivity in the presence of water could pose risks to USDWs…recognizing that an improperly managed GS project has the potential to endanger USDWs…the properties (of CO_2), as well as the large volumes that may be injected for GS result in several unique challenges for protection of USDWs in the vicinity of GS sites from endangerment." See 75 FR 77230, Section II.A. (3), AR# 330. Due to the high level of potential risk to USDW, EPA must make every effort to strictly adhere to UIC regulations and the Director should use her discretion to obtain sufficient information to ensure that the project will not adversely impact drinking water in Morgan County or otherwise adversely affect human health or the environment.

[2] The draft Permit and application have little to no discussion on the impact of the 30 miles of piping (and the related connection area where the piping meets the UIC well) on the aquifer closest to the surface (Drinking Water Aquifer). The Director should use her discretion pursuant to regulation to require information to establish that the Drinking Water Aquifer will not be impacted.

I. Introduction

The Parties own property located within the Area of Review of the FutureGen UIC project. The Critchelow Family's property is approximately four acres and is located

Ex. 6 at [redacted] in Jacksonville, Illinois ("Critchelow Property"). The Critchelow Property is located directly on the edge of the CO_2 plume modeled by FutureGen. See Permit map Figure 12, modified to show Critchelow and Leinberger Properties and wells, attached to the Declaration of Karl Leinberger, Exhibit 4. The Critchelow Family has a water well on their property, which the family uses for drinking and washing. The well is not identified in the Permit materials.[3] The Critchelow Family has lived on their property and used the well water for over 25 years. See Declaration of William Critchelow, attached as Exhibit 5.

The members and trusts of the Leinberger family own approximately 1,285 acres within the Area of Review ("Leinberger Property"). Portions of the Leinberger Property are on the edge of the CO_2 plume identified by FutureGen, with the remaining parcels very close to the CO_2 modeled plume. See Attachment A to Leinberger Declaration, Ex. 4. The draft permit for FutureGen's project identifies only one water well located on Leinberger Property. This water well is identified as Map ID Number 58. See Permit, Table 9, p. B34. There are two other water wells located on Leinberger Property. Neither of those two water wells is identified in the draft Permit. See Leinberger Declaration, Ex. 4, paras 9-10.

The Leinberger Property also has many oil and gas wells on their Property and within the Area of Review that are either mis-identified or not identified at all in the draft Permit. The draft Permit properly identifies only one oil/gas well (#118). The oil/gas wells identified as Map ID Numbers 116 and 119 appear to be located on Leinberger Property, but are misidentified in Table 9 on page B35 of the draft Permit as belonging to other owners. There are 17 non-producing oil/gas wells located on Leinberger Property that are reflected in the Illinois State Geological Survey ("ISGS") database, but are not reflected in FutureGen's draft Permit in Table 9 or Figure 12 on pages B33-B37. See Ex. 4, paras 6-8. There are also two non-producing natural gas wells located on Leinberger Property that are not reflected in the draft permit nor in the ISGS database. Id. One old natural gas well is located within 0.3 miles of FutureGen's projected carbon dioxide plume. The second old natural gas well is approximately 0.7 miles from the projected plume. Id.

---

[3] In fact, the Critchelows appear to have water two wells on their property, neither of which is identified by FutureGen. See Leinberger Declaration, attached as Exhibit 4.

The Parties' Properties will be directly impacted by the FutureGen project. Although the Properties are located on the edge of the CO_2 plume as currently modeled, as described below and in the expert reports, the projected plume as modeled is undersized. It is more than likely that the projected CO_2 plume will, when properly modeled, directly impact the pore space on the Properties. FutureGen does not have an option or any rights for the pore space on the Critchelow Property or Leinberger Property. See Leinberger Declaration, Ex. 4, para. 5.

The Parties have engaged two experts to review the draft Permit, and have attached the experts' technical comments as Exhibit 1 (Expert Report of Daniel J Price) and Exhibit 2 (Expert Report of Gregory Schnaar PhD). The experts' comments are incorporated by reference. Mr. Daniel J. Price is a Registered Geologist and a Principal Consultant with ENVIRON International Corporation. He has broad expertise in evaluating the geology and other factors necessary for underground injection wells. Dr. Gregory Schnaar is a Senior Environmental Scientist with Daniel B. Stephens & Associates, Inc. Dr. Schnaar helped write the Class VI UIC Permit regulations and EPA technical guidance, and has extensive expertise and experience in evaluating geologic sequestration projects. The experts' curriculum vitae are attached to their reports.

The Parties' comments fall within the following categories: geologic concerns; the under sizing of the projected CO_2 plume due to modeling inadequacies including incomplete modeled extent of the injected CO_2, overly large grid-cell spacing, inadequate sensitivity analysis, and incorrect assumption of no regional or local flow gradient; errors in input parameters for the model; inadequacy of the well survey; insufficient number of monitoring wells; insufficient showing of financial responsibility; and other less critical comments relating to Permit errors.

II. Comments to Draft UIC Permit

Pursuant to Section 1421 of the Safe Drinking Water Act (AR # 18, 477), the purpose of the of the Underground Injection Control Program is to prevent underground injection which endangers drinking water sources 42 U.S.C. 300h (b)(1). The UIC regulations must prevent contamination of drinking water and prevent the movement of fluids containing contaminants that "otherwise adversely affect human health." *In re NE Hub Partners, L.P.*, 7 E.A.D. 561, 567 (1998) (*citing* 40 C.F.R. § 144.12(a)). Due to the deficiencies in the materials submitted to EPA, FutureGen has not met this standard and the resulting draft Permit is based on erroneous findings.

A. <u>FutureGen Caused Movement of Fluid into Underground Sources of Drinking Water</u>

Already before construction, FutureGen has allowed the movement of contaminated fluid into underground sources of drinking water. In October 2011, FutureGen drilled a deep stratigraphic well to support the evaluation of the carbon storage location. The stratigraphic well is approximately 1 mile east of the intended injection site, at longitude 90.05228W, latitude 39.8067N. The drilling ceased in December 2011. See Supporting Documentation, 2.1.3, AR# 1, 2. At that same time, water pumped from one of the Critchelow's wells turned a yellowish/brown color for approximately one month. See Critchelow Declaration, Ex. 5. The Critchelows use the well water for washing and drinking, yet were unable to do so when it was so discolored. Moreover, the drilling caused the water in the well to overflow. Id. The discoloration and pressure impacts to the Critchelow's well only ceased when the drilling ceased. The water in the well has never changed colors or overflowed in the 25 years the Critchelows have lived on their property. Id.

The discoloration and pressure impacts of the drilling of the stratigraphic well were in clear violation of the mandates of the SDWA and the underlying regulations. Specifically, Section 144.12(a) of the general requirements for underground injection wells states:

> No owner or operator shall construct, operate, maintain, convert, plug, abandon or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR part 142 *or may otherwise adversely affect the health of persons*. **The applicant for a permit shall have the burden of showing that the requirements of this paragraph are met** (emphasis added).

By causing the Critchelow's well to overflow and the water in the well to be discolored, FutureGen has already failed in its burden of showing that it has not constructed and operated an injection activity that allows the movement of fluid into underground sources of drinking water or adversely affects the health of persons. The proposed injection well in the draft Permit will be about a mile closer to the Critchelow Property than the stratigraphic well. FutureGen has not conducted an investigation or provided any explanation for the impact on the Critchelow well. See also, Ex. 1, para. 6 (Price report).

Under its discretionary authority, the Director should require FutureGen to investigate this impact and refrain from issuing the Permit until the issues presented, including probable impacts to wells in the Survey Area and Area of Review, are resolved.

B. The Geologic Formation Data is Incomplete

The draft Permit includes a finding that "The permittee has demonstrated to the satisfaction of the Director that the well is in an area with suitable geology in accordance with the requirements at 40 C.F.R. §146.83. See draft Permit, section I. As described in the attached Expert Report of Daniel J. Price, Exhibit 1, there are a number of inadequacies in FutureGen's assessment of the geology of the area.

FutureGen has not provided sufficient information concerning permeability values, and has not provided information concerning the potential change in hydraulic head based on the pressure change induced by injection into the Mt. Simon Sandstone. See Ex. 1, paras. 1-3. FutureGen should provide additional discussion that demonstrates the pressure change induced by injection into the Mt. Simon would not be great enough to allow brine migration and impact underground sources of drinking water. Significantly, the geologic data shows that there is a regional "dip" in the formation that is not reflected in the Permit analysis. See Ex. 1, para. 4. These data points have the potential to impact the results of the model of the CO_2 plume and should be more accurately discussed and, as set forth below, incorporated into the CO_2 model as part of its sensitivity analysis.

FutureGen is also required to provide information on geologic structure, including any known or suspect faults and fractures that may transect the confining zones in the Area of Review and a determination that they would not interfere with containment, and provide information on the seismic history including the presence and depth of seismic sources and a determination that the seismicity would not interfere with containment. See 40 CFR §146.82, AR # 18. FutureGen admits that the data provided on faults in the area of the injection well is inconclusive such that the Director has little information on which to rely. See Ex. 1, para 5 (Price report). Further, although the size of the Area of Review has been increased since the filing of FutureGen's permit application, FutureGen failed to then include the larger Area of Review in its assessment of the seismic data. Id. Finally, in light of the much larger Area of Review, the Director should also require additional analysis of the threat and resulting impact of a large earthquake in the general area, since this storage facility will persist for the long term.[4] See In re Stonehaven

[4] The New Madrid Fault is located in the Midwest and runs through a portion of southern Illinois. See Facts About The New Madrid Seismic Zone, Missouri Department of Natural Resources, located at https://www.dnr.mo.gov/geology/geosrv/geores/techbulletin1.htm. According to the U.S. Geological

Energy Mgmt, LLC (UIC Appeal No. 12-02, EAB March 28, 2013) (Region III failed to adequately support and explain its conclusion that earthquakes were not a risk for the UIC activity).

C. The Plume Size is Materially Understated and Incorrectly Configured

The model predicting the projected lateral and vertical migration of the CO_2, as required under 40 C.F.R. §146.84(c)(1), has resulted in a projected plume size that is materially understated. As described in the attached Expert Report of Dr. Gregory Schnaar, Exhibit 2, there are several issues have resulted in the under sizing of the CO_2 plume, including:

- FutureGen failed to follow EPA Guidance to use maximum-risk scenario simulation and conservative input parameter values;
- The carbon dioxide plume on maps in the permit application Supporting Documentation do not include the complete modeled extent of the injected carbon dioxide;
- The grid-cell blocks used in the model are too large, resulting in a smaller plume;
- FutureGen's modeling sensitivity analysis is inadequate, and does not provide for a full understanding of potential model under-prediction of carbon dioxide plume and pressure-front extent; and
- FutureGen's model assumption of no regional or local flow gradient in the injection zone is not valid and may have a significant impact on model results.

When properly modeled to address these factors, the projected CO_2 plume will be significantly larger than currently identified in the draft Permit. See Ex. 2, paras. 1- 6

Survey ("USGS"), there is an appreciable risk of a major earthquake affecting west central Illinois. *Earthquake Hazard In The New Madrid Seismic Zone Remains A Concern*, p. 2 (USGS 2009), located at http://pubs.usgs.gov/fs/2009/3071/pdf/FS09-3071.pdf. The USGS's 2008 National Seismic Map accords FutureGen's injection site a significant possibility of an earthquake. USGS National Seismic Map, p. 1 (USGS 2008), located at http://pubs.usgs.gov/fs/2008/3018/pdf/FS08-3018_508.pdf. Due to geology, earthquakes in the Midwest affect a larger area. "Due to the harder, colder, drier and less fractured nature of the rocks in the earth's crust in the central United States, earthquakes in this region shake and damage an area approximately 20 times larger than earthquakes in California and most other active seismic areas." See Facts About The New Madrid Seismic Zone, Missouri Department of Natural Resources, located at https://www.dnr.mo.gov/geology/geosrv/geores/techbulletin1.htm. These articles are attached as combined Exhibit 6.

(Schnaar report). In fact, FutureGen's own modeling sensitivity analysis resulted in a plume 120% larger in size. See Ex. 2, para. 1 and Figure 1. Dr. Schnaar, in Figure 1 of his expert report, shows the impact of the 120% plume, and explains that the 120% size is a *minimum* size for the projected plume given the deficiencies of the model. Id. Further, the 120% minimum projected plume size does not account for the significant differences in injection rates and well construction amongst the injection wells. Id at para 10. Thus, at an absolute minimum, the plume should be designated in the draft Permit as 120% larger than currently modeled.

The Director should also require that FutureGen provide additional information concerning the horizontal lateral injection wells. The injection wells are pointed towards the Critchelow Property and Leinberger Property. See Ex. 2, para. 10 (Schnaar report); draft Permit, p. B41. Yet, the size of the projected plume in the direction of the Properties is barely larger than the size of the plume in the directions where no lateral injection wells are directed. Additional information is necessary to justify this projected extent and configuration of the plume.

The Director is authorized to request additional information and should require that FutureGen fully address the undersizing of the plume and to explain why injection well length and injection rates have little to no influence on the lateral configuration of the plume and pressure front around the injection wells. Without this information, the Director is accepting a plume analysis that is poorly documented and potentially erroneous.

D. Inaccurate Well Identification and Information

Under the Class VI regulations, FutureGen must account for all wells in the Area of Review and must provide *any other information the Director may require*. 40 C.F.R. §146.82(a)(4) (emphasis added). EPA Guidance instructs permit applicants that resident interviews and well surveys may be used to identify area wells. See UIC Program Class VI Well Area of Review Evaluation and Corrective Action Guidance, Section 4, AR# 439. There is no indication that FutureGen performed a complete investigation of wells, especially after the Area of Review was enlarged subsequent to the permit application. Although FutureGen identifies the wells within the new Area of Review, it does not provide details or locations of those wells. See Ex. 1, paras. 6, 7 (Price report). As a result, the draft Permit fails to identify or mis-identifies the wells located in the project areas.[5]

[5] See *In re Bear Lake Properties*, LLC, 42 ELR 41361 (2012) (Class II well) (EAB remanded a permit where the Region did not adequately demonstrate that it surveyed all of the drinking water wells in the Area of Review).

The FutureGen draft Permit does not account for the Critchelow or Leinberger private wells, and, as noted above, it appears the Critchelow well was impacted by FutureGen's drilling activities. Given the much larger Area of Review, and the possibility that some of the water wells in the area could penetrate the confining zones, the Director should require a more thorough and aggressive approach, pursuant to recommendations of EPA Guidance, to identifying potential water wells based on updated modeling results.

FutureGen is considering use of three abandoned oil and gas wells completed at greater than 1,000 feet bgs for soil-gas monitoring because of their potential for providing a preferential pathway for CO_2 gas migration. See Ex. 1, para. 10 (Price report). The Director should require that FutureGen provide information concerning the wells, including integrity testing and the need for upgrading of these wells, given their potential use.

There are two wells located with the expanded Area of Review that penetrate the primary confining zone, and therefore could provide a potential preferential pathway between the injection zone and shallow USDW aquifers. See draft Permit, p. B3. FutureGen states that both wells are believed to have been sufficiently plugged and recompleted, but there does not appear to be any supporting documentation verifying that these wells are plugged as required. See Ex. 1, para. 8 (Price report).

Without complete data on area wells, the draft Permit discussion of well identification and information is based on significant errors in fact.

E. Insufficient Monitoring

FutureGen's proposed monitoring system is insufficient. As stated by EPA in the Preamble to the Class VI Rule, "GS is a new technology and there are a number of unknowns associated with the long-term effects of injecting large volumes of CO_2 …" Federal Requirements Under the Underground Injection Control Program for Carbon Dioxide Geologic Sequestration Wells ("E.P.A. Rule"), 75 Fed. Reg. 77230, 77261 (2010). Consequently, the monitoring and testing protocols must reflect the untested nature of the project.

EPA regulations require that Area of Review modeling be used to designate the number and placement of monitoring wells. See 40 C.F.R. §146.90 (d)(2). EPA guidance suggests that monitoring wells be cited based on modeling results, projected plume migration, dip direction, and presence of potential leakage pathways. See Geologic Sequestration of Carbon Dioxide: Underground Injection Control (UIC) Program Class

VI Well Testing and Monitoring Guidance p. 56/115, AR #441. In the initial (March 2013) permit application, monitoring wells were placed within the boundaries of the projected carbon dioxide plume, which at that time defined the Area of Review. See Permit App. Supporting Documentation p.C4/56. Subsequently, FutureGen significantly increased the size of the Area of Review to include the boundaries of the 10psi pressure increase. See Permit, Attachment B. However, no additional monitoring wells are included in the updated Testing and Monitoring plan to monitor in this area of elevated pressure. No discussion is included regarding any additional search for potential leakage pathways or sensitive areas in this now larger Area of Review. See Ex. 2, para. 11 (Schnaar report). The Director must obtain and review this additional information in order to ensure the monitoring system is adequate and the Permit is based on accurate data.

Because geologic sequestration is a new technology, methods for monitoring the location of the plume are largely untested. Neither the draft Permit nor the Supporting Documentation contain details on how the number, type, and proposed location of the five monitoring wells (three Reservoir Access Tubes [RATs] and two Single-Level in-Reservoir [SLR] wells) for the injection zone (Attachment C p.C4/56) satisfy the Class VI requirements. Further, and as set forth in Section II.C above, FutureGen's modeled CO_2 plume must be enlarged, including in the southerly directions due to injection well length, injection pipe directions, and injection rates, and the extent of the monitoring in those areas must be correspondingly increased to satisfy the regulations. Additional deep monitoring wells penetrating the confining zone and shallow monitoring wells are needed. The proposed monitoring configuration would be inappropriate in light of a material change to the size and shape of the projected plume.

F. <u>The Financial Responsibility Provided For In The Draft Permit Is Deficient</u>

The draft Permit fails to accurately demonstrate financial assurance for the FutureGen Class VI project. The Class VI UIC rules broadly require financial responsibility related to the creation, operation and closure of a Class VI well. 40 C.F.R. §146.85. The financial responsibility "must be sufficient to address endangerment of underground sources of drinking water. 40 C.F.R. §146.85(a)(3). Thus, FutureGen must demonstrate and maintain financial responsibility sufficient to cover the cost of four categories: the corrective action, injection well plugging, post injection site care and site closure, and emergency and remedial response.[6] 40 C.F.R. §146.85(a)(2). Moreover,

[6] The authorized financial instruments include trust funds, surety bonds, letter of credit and insurance. 40 C.F.R. §146.85(a)(1).

section 144.12(a) of the UIC regulations states that injection activity must be conducted in a manner that does not allow the movement of contaminants that may cause a violation of drinking water standards, or may otherwise adversely affect the health of persons.[7] 40 C.F.R. §144.12(a). Given the purpose of the SDWA in providing remedial protections, it would be inconsistent with the SDWA to narrowly construe the financial responsibilities set forth in §146.85(a). In addition to the language of the regulations, it is an important policy consideration to ensure that area properties and persons are not adversely affected by the underground injection of CO_2.

For this draft Permit, the financial responsibility is provided for *exclusively* by a trust fund funded with the following amounts:

Activity		**Estimated Cost**
Performing Corrective Action on Deficient Wells in AoR		$623,000
Plugging Injection Wells		$2,723,000
Post-Injection Site Care		$18,320,000
Site Closure		$3,402,000
Emergency and Remedial Response	Pre-Injection	$6,100,000
	Injection and Post Injection	$20,600,000

FutureGen will not fully fund the trust before construction of the wells begins, but instead will pay into the trust in a phased approach, which is reflected in Table 2 of Attachment H of the draft Permit.

The financial assurance provided for in Section H and Attachment H of the draft Permit is deficient because it does not reflect important policy considerations in connection with the UIC regulations and does not strictly adhere to the regulations, thus thwarting the purposes of the SDWA. Foremost, the emergency and remedial response

[7] 40 C.F.R. §144 applies to the UIC programs and should be read in conjunction with 40 C.F.R. §146. 40 C.F.R. §146.1(A).

financial assurance should not be a trust fund, but should be an insurance policy as originally proposed in the Permit Application. Because of the switch to a trust fund, the emergency and remedial response is now a quarter of the amount of coverage FutureGen originally proposed. Even if FutureGen is allowed to use a trust fund for the emergency and remedial response, the amount is insufficient to account for and remedy all possible exigencies. Due to last minute changes regarding the emergency and remedial response financial assurance, the cost estimate is not based upon a detailed written estimate as required under the regulations. It is also improper to allow FutureGen to fund the trust fund in a phased-approach because of the risks to the instrument and the potential for insufficient coverage later. Finally, the draft Permit fails to provide that the trust fund may not terminate until the Director has approved the completed post-injection site care and site closure plan and the final site closure. To resolve these deficiencies, the Director should require that FutureGen make the changes proposed herein, at minimum, so that the final Permit is legally sufficient.

i. A Trust Fund is Improper for the Emergency Remedial Response

A trust fund to cover the emergency and remedial response financial assurance is improper and FutureGen should be required to obtain a pollution insurance policy as originally provided for in its Permit Application. The U.S. EPA Underground Injection Control (UIC) Program Class VI Financial Responsibility Guidance ("UIC Guidance Document") does not recommend a trust fund for emergency responses. "For activities of uncertain frequency and cost, such as emergency and remedial responses, the trust will likely not have the right amount of funds—too little is a partial failure of the instrument and too much represents an inefficient use of funds that unnecessarily raises GS costs. See U.S.EPA Underground Injection Control (UIC) Program Class VI Financial Responsibility Guidance, July 2011 p. 21, AR #438. Instead, the UIC Guidance Document states that "[i]nsurance policies are best suited for diversifying environmental risk. Insurance is the ideal instrument for handling the numerous possible scenarios associated with uncertain events such as emergency and remedial response demonstrations." Id at p. 22.

In the permit application Supporting Documentation, FutureGen proposed to include a $100 million insurance policy with a term of 3 to 5 years for the emergency and remedial response actions. See Sections 9.4.2.2, 9.4.2.5 and App. D. In FutureGen's November 2013 response to U.S.EPA's Request for Additional Information, FutureGen stated that it "intends to obtain third party insurance for costs related to any required emergency and remedial response action." See FutureGen Response, November 2013, p. 4, AR# 3. FutureGen further stated that it would obtain a $10 million insurance policy for the drilling phase and increase the coverage to a $100 million policy for the injection phase as well as "various other insurance policies including Control of Well and General Liability insurance and Umbrella/Excess coverage." Id.

Yet, the draft Permit as issued only provides for a trust fund of $26.7 million. The draft Permit does not explain this last minute change in the financial assurance and nor does the "Summary of Financial Responsibility Estimates for FutureGen Based on Cost Tool Options" submitted on March 28, 2014 (the "March 2014 Estimate"). See AR# 320. The March 2014 Estimate merely states that FutureGen decided it would use a trust fund/agreement to cover the emergency and remedial response costs. Id at p. 7. As explained by the Guidance Document, insurance policies are the best financial mechanisms to provide for the virtually infinite possible emergency scenarios that may occur. This is particularly true for a first of its kind project such as this one. Thus, the Director should require FutureGen to reinstate an insurance policy to provide for all of the possible environmental risks associated with such a new project. The insurance policy must have a limit of at least $100 million and must not contain exclusions that render the policy inadequate for its purpose.

ii. Improper Reduction of The Emergency Response Estimate And Insufficient Amount

The proposed $26.7 million for the emergency and remedial response for the entire project was improperly reduced from the originally proposed estimate and is insufficient to cover all possible risks and exigencies for this project. As stated above, FutureGen originally proposed to include a $100 million insurance policy with a term of 3 to 5 years for the emergency and remedial actions as well as various other insurance policies including Control of Well and General Liability insurance and Umbrella/Excess coverage. See Sections 9.4.2.2, 9.4.2.5 and App. D Supporting Documentation; FutureGen Response to U.S. EPA p. 4. Attachment H to the Permit does not provide for any insurance but instead states that there will be $26.7 million in the trust fund for the emergency and remedial response. This is a significant reduction in financial assurance for the multiple possible scenarios that may arise in an emergency. Instead of $100 million to cover all possible environmental risks, now there is a quarter of the coverage originally provided. This is clearly insufficient, particularly in light of the multiple unknowns involved in this first of its kind project. The Director has no basis to approve this reduction and should require FutureGen, to obtain, prior to permit issuance, an insurance policy with coverage up to $100 million as originally proposed to cover the emergency and remedial response costs.

In the event EPA allows FutureGen to use a trust fund for the emergency and remedial response financial assurance, the allocated amount should be significantly increased. The proposed $26.7 million is an insufficient amount for the emergency and remedial response costs. In the March 2014 Estimate, FutureGen states that the range of estimates for the emergency and remedial response costs are from $14.7 million to $77.9 million, and the proposed $26.7 million is the middle range of the estimated costs. See March 2014 Estimate, p. 8. The largest gap between the middle cost estimate, $26.7 million, and the high end cost estimate, $77.9 million, is the estimated cost to treat contaminated water from USDW. See March 2014 Estimate, Ex. B-2. In the middle cost estimate, FutureGen estimates that treating contaminated water will cost $14.4 million dollars, whereas the high end cost estimate is $62.8 million. Id. There is no explanation or accounting for the vast differences in amounts for treating contaminated groundwater. Because of the high degree of risks and the numerous unknowns, the emergency and remedial response cost estimate should be increased to the high cost estimate of $77.9 million thus ensuring that FutureGen will have sufficient funds to cover all potential emergency and remedial situations particularly as it relates to treating contaminated drinking water.

iii. Failure to provide detailed cost estimate

A detailed written estimate is missing from the draft Permit and supporting materials for the injection and post-injection emergency and remedial response trust fund amount. Under 40 C.F.R. §146.85(c), "The owner or operator must have a detailed written estimate, in current dollars, of the cost of performing corrective action on wells in the Area of Review, plugging the injection well(s), post-injection site care and site closure, and emergency and remedial response." Section 146.85(c) further provides: "The cost estimate must be performed for each phase separately and must be based on the costs to the regulatory agency of hiring a third party to perform the required activities. A third party is a party who is not within the corporate structure of the owner or operator." 40 C.F.R. §146.85(c)(1)

In Attachment H of the draft Permit, Tables 1 and 2 show the cost estimates for the activities that are covered by the Financial Responsibility. In support of these estimates, the draft Permit refers to the third-party cost estimates submitted by FutureGen in Appendix C of the permit application and EPA's independent evaluation of the cost estimates. See Attachment H, draft Permit, p. 11. Yet, Appendix C of the permit application Supporting Documentation is outdated and has inaccurate information. See App. C "Cost Estimate to Demonstrate Financial Responsibility for Class VI UIC Permit," March 2013 ("2013 Cost Estimate"). The 2013 Cost Estimate does not contain an accounting for the proposed emergency and remedial response trust fund amount for the injection and post-injection activity. At that time, FutureGen was proposing two insurance policies for the emergency and remedial response financial assurance. See permit application Supporting Documentation, Section 9.4.2.2 and Appendix D. Now, without explanation, the emergency and remedial response trust fund amount is $26.7 million. See Attachment H, draft Permit, p. 12.

The additional financial responsibility documents submitted by FutureGen to the AR also do not include a detailed cost estimate for emergency and remedial response. FutureGen submitted to EPA its March 2014 Estimate which proposed $26.7 million for emergency and remedial response. FutureGen's only explanation was that it was the middle range of costs generated by its "Cost Tool." See March 2014 Estimate, p. 8. According to the Cost Tools Output Table, Exhibit B-2, the estimated cost of treating contaminated water from a USDW ranged from $3.2 million to $62.8 million. Id at p. B-2. The March 2014 Estimate did not give any additional details on the basis for the contaminated water estimates, but merely stated that the proposed $14.4 million was in the middle range of the estimate. Id. As required by the regulations, a detailed cost estimate is necessary to effectuate one of the important goals of the SDWA in protecting drinking water sources. Similarly, there is no explanation for the total costs for emergency and remedial response as proposed in Exhibit B-2.

The draft Permit is equally opaque in its basis for the emergency and remedial response action cost estimates. The draft Permit breaks down the emergency and remedial response action cost estimates by assigning $6.1 million to the pre-injection emergency and remedial response, and $20.6 million for the injection and post-injection emergency and remedial response. See Attachment H of draft Permit, Table 2. There is no accounting or breakdown of the injection and post-injection emergency and remedial response cost estimate of $20.6 million.

The cost-estimate for performing corrective actions on deficient wells in the Area of Review is also improper. As explained above, the Area of Review for the project significantly increased in the draft Permit, yet FutureGen did not reevaluate the wells in the Area of Review. Nor did FutureGen reevaluate the cost estimate for the wells in the Area of Review. Because FutureGen did not reconsider the additional deficient wells in the increased Area of Review, the proposed cost estimate for performing corrective actions is insufficient. The Director should require FutureGen to increase the cost estimate accordingly.

The absence of explanation of the significant reduction in emergency and remedial response cost estimate is contrary to the regulatory requirements in 40 C.F.R. §146.85(c) which requires a detailed written estimate of the cost of emergency and remedial response. To remedy this legal deficiency, the Director should require FutureGen to provide a detailed explanation of the cost estimate for all of the emergency and remedial response cost estimates, particularly the cost estimate proposed for the injection and post-injection emergency and remedial response.

iv. Improper Pay-in Period

The draft Permit allows FutureGen to incrementally pay into the trust fund for each task. See Attachment H, Schedule C, entitled the "pay-in-periods." The Director should require that Future Gen fully fund the trust fund to ensure it has sufficient funds for the entire project. As the UIC Guidance Document states, "A fully funded trust fund or escrow account minimizes the risk of instrument failure. While longer pay-in periods reduce the up-front financial burden for the owner or operator, longer pay-in periods also increase the risk that the instrument will fail if the owner or operator cannot meet its obligations." See U.S. EPA Underground Injection Control (UIC) Program Class VI Financial Responsibility Guidance, July 2011 p. 23, AR# 438. As this is a first of its kind project, FutureGen should have all of the funds available to minimize the risk of instrument failure.[8]

Alternatively, the Director should shorten the pay-in-period to minimize the risk of instrument failure. Id. at 23. In particular, the incremental funding of the emergency and remedial response fund is too long. The draft Permit provides that FutureGen will only have $6.1 million in emergency response during the drilling period, and will add $20.6 million when it begins to inject CO_2. Because emergency and remedial response costs often have a large one-time cost, (see p. 23 of UIC Guidance Document), the Permit should require that FutureGen have all of its emergency and remedial response costs in the trust fund before drilling begins. Further, if the Director requires that FutureGen have an insurance policy for the emergency and remedial response financial assurance per the recommendation above, then the Insurance policy should be fully funded to account for an unexpected scenario that will have a large on-time cost. Id at 23.

v. The Draft Permit Improperly Authorizes the Trustee and FutureGen to terminate the Trust Fund

Section 17 of the Trust Agreement in Attachment H of the draft Permit states that the trust is irrevocable and "shall continue until terminated by the Grantor and Trustee, with the concurrence of the EPA Water Division Director." This language is inconsistent with the regulations and should be revised. Under 40 C.F.R. §146.85(b)(1), the owner or operator must maintain financial responsibility and resources until the Director "approves the completed post-injection site care and site closure plan" and "approves site closure."

[8] It should also be noted that the Permit does not state that the Director approved the use and length of the pay-in-periods for the trust fund, as required by 40 C.F.R. §146.85(f).

To ensure that the draft Permit follows the requirements under the regulations, the Permit should explicitly state that the Trust Fund will not terminate until the Director approves the completed post-injection site care and site closure plan and approves the site closure. In light of the fact that this is a first-of-its-kind commercial-scale Class VI well, it is important that proper financial safeguards be in place.

vi. Proposed Changes to the Financial Assurance

As detailed above, there are multiple deficiencies in the financial assurance portion of the Draft Permit. The following are proposed remedies for these deficiencies:

1) In light of the unproven nature of the project and the high risks associated with this first-of-its-kind project, FutureGen should have a $100 million pollution policy as originally planned as well as various other insurance policies including Control Well and General Liability insurance and Umbrella/Excess coverage as provided for in FutureGen's November 2013 Response to U.S.EPA's comments.

2) If FutureGen continues to use a trust fund for the emergency and remedial response cost estimate, the trust fund amount should increase to the high end cost estimate of $77.9 million presented in the March 2014 Estimate.

3) The Director should require FutureGen to provide a written detailed estimate from third-parties regarding the emergency and remedial response for the injection and post-injection. The Director should require those detailed estimates to be supported with working papers showing the analysis for each item. The Director should also require FutureGen to increase the cost estimate for performing the corrective actions on deficient wells to accurately account for the increased Area of Review.

4) The pay-in-period provisions should be eliminated, and instead, FutureGen should fully fund the Trust Fund before the project starts. At the very least, the pay-in-period should be reduced to the shortest time possible. This is equally true should FutureGen acquire an insurance policy for the emergency and remedial response financial assurance. Regardless, the final Permit should positively state that the Director approved the pay-in-period for the trust fund.

5) The final Permit should positively state that FutureGen may not terminate the financial assurance instruments until the Director approves the completed post-injection site care and site closure plan and approves site closure.

G. <u>EPA Should Address Policy Considerations Resulting from an Increased Plume Size</u>

Section A of the draft Permit states: "issuance of this permit does not convey property rights of any sort or any exclusive privilege; nor does it authorize any injury to persons or property, any invasion of other private rights, or any infringement of State of local laws or regulations." Despite this statement, by allowing the draft Permit to proceed in its current state, EPA is establishing a policy through which it is authorizing a trespass and/or a regulatory taking of property. Although FutureGen has obtained the pore space ownership rights within various properties directly impacted by the CO_2 plume as modeled, FutureGen has *not* executed an option to acquire such rights from properties impacted by a larger plume, including the Critchelow Property or Leinberger Property. See Leinberger Declaration, Ex. 4, para. 5. As described above, using reasonable bounding values, FutureGen's modeling resulted in a plume 120% larger than identified on Figure 12. According to the expert, this 120% is the *minimum* size of the CO_2 plume and the plume is expected to be even larger than the 120% given the many errors in the plume model. See Ex. 2 (Schnaar report). Even the 120% larger plume size impacts many additional properties in the area, including the entire Critchelow Property and portions of the Leinberger Property.

The Director, through her discretionary authority and as an important policy matter, should require FutureGen to establish that it is not impacting additional properties through the projected CO_2 plume or the pressure front created by that plume, and that it has the appropriate pore space ownership rights. Although EPA generally does not include individual property rights in its permit review, EPA is required to determine the extent of the CO_2 plume, and has previously sought information from FutureGen regarding pore space rights. See December 10, 2013 Response to Comments, p. 2/41, AR # 4 (EPA requests information re "sensitive areas" and FutureGen explains that "sensitive areas" are properties to which the project has not acquired pore space rights. These properties were avoided by orienting the horizontal legs of the injection wells.") FutureGen should not be permitted to present an inaccurate approach to its model and projected plume simply to allow it to avoid having to purchase options for pore space on impacted properties. FutureGen must establish that additional "sensitive areas" are not impacted by a more likely and larger plume. The location of the CO_2 plume directly impacts the analysis of whether there is sufficient monitoring and whether underground drinking water supplies are endangered due to the location of the plume, which are squarely within the permit review.

Without information confirming that these additional "sensitive areas" are not impacted by the larger projected plume, the Director is allowing FutureGen to trespass, and thus subjecting itself to potential liability. A person can be liable for trespass for an intrusion by a third party if he acts with knowledge that his conduct will, with a substantial degree of certainty, result in the intrusion, or aids, abets or directs the commission of the trespass. *Sak v. CitiMortgage, Inc.*, 940 F.Supp.2d 802, 804 (N.D.Ill. 2013), *citing Dietz v. Ill. Bell Tel. Co.*, 154 Ill.App.3d 554, 107 Ill.Dec. 360, 507 N.E.2d 24, 26.[9] Here, the EPA's actions with regards to allowing the project to proceed with an under sized plume model will result in the intrusion on the Critchelow Property and Leinberger Property (as well as others) and the potential to adversely affect human health. In other words, the EPA is aiding and abetting the commission of a trespass that impacts human health. This is a significant policy issue that warrants EPA consideration prior to issuing the permit.

Similarly, by permitting a Class VI underground injection well that will have a projected plume at a minimum 120% greater than the projected model, and thus allowing the plume to enter onto other sensitive areas including the Critchelow Property and Leinberger Property, the EPA is "taking" the properties for a public purpose without just compensation. U.S. Const. amend. V, *Lingle v. Chevron*, 544 U.S. 528, 543, 125 S.Ct. 2074, (2005) ("The Takings Clause presupposes government interference with one's property rights in pursuit of a public purpose"). While a typical taking involves a government appropriating some interest in a person's property for the use of the government, a private party taking may be attributable to the government.[10]

Here, the U.S. is giving FutureGen a billion dollars to construct a power plant, a 30-mile pipeline, and a carbon sequestration well. See www.futurealliance.org/faqs/. In fact, the U.S. is the primary source of funding for the project, contributing 60% of the funds required for the project. See "Feds pledge $1 billion to FutureGen 2.0 in Morgan County," State Journal Register, January 16, 2014, attached as Exhibit 7. Importantly, this billion dollar grant is not described as a "loan," signifying that FutureGen would have to repay the U.S., but instead the U.S. states it is "providing" the money

---

[9] Under the Federal Tort Claims Act (FTCA), the United States (U.S.) is liable "in the same manner and to the same extent as a private individual under like circumstances…" 28 U.S.C. §2674. The U.S. Supreme Court has recognized that the U.S. may be sued on a claim of trespass under the FTCA. *Hatahley v. United States*, 351 U.S. 173, 181, 76 S.Ct. 745, 100 L.Ed. 1065 (1956). Since then other courts have upheld the notion that actions in trespass are actionable under the FTCA. *Black v. Sheraton Corp. of America*, 564 F.2d 531 (D.C.Cir.1977), *Simons v. U.S.*, 413 F.2d 531, 534 (C.A.Tex. 1969). See also *Anderson v. U.S.*, 259 F.Supp. 148 (E.D.Penn 1966).

[10]A government "can be held responsible for a private decision when it has exercised coercive power or has provided such significant encouragement, either overt or covert, that the choice must in law be deemed to be that of the [government]." *San Francisco Arts & Athletics, Inc. v. U.S. Olympic Committee*, 483 U.S. 522, 546, 107 S.Ct. 2971, 2986; *citing Yaretsky*, supra, 457 U.S., at 1004, 102 S.Ct., at 2786; *Rendell-Baker v. Kohn*, 457 U.S. 830, 840, 102 S.Ct. 2764, 2771 (1982) (emphasis added).

appropriated under the American Recovery and Reinvestment Act. See 79 FR 3577; Record of Decision and Floodplain Statement of Findings for the FutureGen 2.0 Project; January 22, 2014, attached as Exhibit 8. By permitting an undersized plume, EPA will allow FutureGen to appropriate additional "sensitive areas," including the Critchelow Property and Leinberger Property, without just compensation. This constitutes a taking. EPA should not engage in a policy of supporting a private party taking another person's property for the public use, especially when that use is high risk and has the potential to impact human health.

It cannot be EPA's policy to knowingly allow the undersized plume in the Permit that would result in a trespass or a taking. The policy issue can easily be avoided by ensuring that FutureGen has the adequate pore-storage ownership agreements in place to account for a more realistic plume size, before the Permit is granted. In the alternative, the Director should require FutureGen to submit additional information to establish that the increased plume size will not impact additional properties and will not impact human health.

III. Conclusion

We appreciate the amount time and effort EPA has expended to consider this unprecedented Class VI UIC Permit, and its extensive record. Nevertheless, the above summarized facts, along with the attached expert reports, reveal significant deficiencies in the FutureGen UIC draft Permit. If these deficiencies are not corrected and EPA issues the permit, EPA will have made its permit decision based on erroneous findings of fact and conclusions of law, and an erroneous exercise of discretion. Moreover, EPA, in considering the draft Permit, should address the important policy issues relating to the impact of a larger plume. Finally, the comment period should be reopened to allow for public comment on the various additions and corrections noted herein.

Thank you for your consideration.

Sincerely,

Jennifer Nijman

Jennifer T. Nijman

For and on behalf of the Leinberger family
and the Critchelow family

INDEX OF EXHIBITS

1) Expert Report by Mr. Daniel J. Price, RG Providing Comments on USEPA's Proposed Permit for the FutureGen Alliance Class VI Injection Wells in Morgan County, IL.

2) Expert Report by Dr. Gregory Schnaar Providing Comments on FutureGen Alliance UIC Draft Permit for FutureGen 2.0 Morgan County Class VI UIC Wells 1, 2, 3, and 4.

3) Combined Exhibit 3: Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. Ill. L. Rev. 363, 428 (2010); Jeffrey W. Moore, *The Potential Law of on-Shore Geologic Sequestration of Co2 Captured from Coal-Fired Power Plants*, 28 Energy L.J. 443, 470 (2007).

4) Declaration of Karl Leinberger.

5) Declaration of William Critchelow.

6) Combined Exhibit 6: *Facts About The New Madrid Seismic Zone*, Missouri Department of Natural Resources, located at https://www.dnr.mo.gov/geology/geosrv/geores/techbulletin1.htm; *Earthquake Hazard In The New Madrid Seismic Zone Remains A Concern*, p. 2 (USGS 2009), located at http://pubs.usgs.gov/fs/2009/3071/pdf/FS09-3071.pdf; *USGS National Seismic Map*, p. 1 (USGS 2008), located at http://pubs.usgs.gov/fs/2008/3018/pdf/FS08-3018_508.pdf.

7) *Feds pledge $1 billion to FutureGen 2.0 in Morgan County*, State Journal Register, January 16, 2014.

8) Record of Decision and Floodplain Statement of Findings for the FutureGen 2.0 Project; 79 FR 3577, January 22, 2014.

Expert Report of

Gregory Schnaar, Ph.D.

Comments on FutureGen Alliance UIC Draft Permits for FutureGen 2.0 Morgan County Class VI UIC Wells 1, 2, 3, and 4

May 15, 2015

G. Schnaar

Gregory Schnaar

Daniel B. Stephens & Associates, Inc.

Table of Contents

Section **Page**

List of Figures

Figure

List of Appendices

Appendix

Expert Report of
Gregory Schnaar, Ph.D.

1. Introduction

I have reviewed the FutureGen Alliance permit materials for the FutureGen 2.0 site in Morgan County, Illinois ('the Site'). My comments, listed below (Section 3), relate to FutureGen's computational modeling of plume and pressure-front migration, Area of Review (AoR) delineation, and planned Site monitoring activities. I have reviewed and commented on the following documents:

- FutureGen Alliance, 2013. Underground Injection Control Permit Applications for FutureGen 2.0 Morgan County Class VI UIC Wells 1, 2, 3, and 4; Supporting Documentation, Prepared for U.S. EPA Region 5. March 2013 (revised May 2013).

- FutureGen Alliance draft Permit, 2014a. Attachment B: Area of Review and Corrective Action Plan.

- FutureGen Alliance draft Permit, 2014b. Attachment C: Testing and Monitoring Plan.

2. Qualifications

I specialize in geologic sequestration of carbon dioxide (CO_2), contaminant transport evaluation, environmental chemistry, field monitoring programs, and numerical groundwater and vadose zone modeling. As a post-doctoral fellow with the U.S. EPA Underground Injection Control (UIC) program I was a key member of the regulatory development team for U.S. EPA's geologic sequestration Class VI rulemaking (U.S. EPA, 2010). Subsequently, I was an expert technical contractor for development of several technical guidance documents published by U.S. EPA regarding geologic sequestration projects, including *UIC Program Class VI Well Area of Review Evaluation and Corrective Action Guidance* (U.S. EPA, 2013a) and *UIC Program Class VI Well Testing and Monitoring Guidance* (U.S. EPA, 2013b).

I am also the author of several technical papers and presentations regarding geologic sequestration, including a review article on modeling of CO_2 plume and pressure migration at geologic sequestration projects (Schnaar and Digiulio, 2009). I have given numerous technical presentations and trainings on geologic sequestration and associated UIC regulations. My complete Curriculum Vitae is included as Appendix A.

3. Comments

1.) FutureGen should revise plume and pressure-front delineations with maximum-risk scenario simulations and conservative input parameter values (Permit Section: Attachment B, p.B37/46).

EPA modeling guidance states (U.S. EPA, 2013a, p.38/83):

> *The use of an a priori AoR delineation based on computational modeling predictions highlights the need for uncertainty and sensitivity analyses for the initial prediction. Conservative predictions will be needed prior to the commencement of injection and the availability of any site-specific data on carbon dioxide migration paths and rates. EPA recommends conducting sensitivity analyses as the principal evaluation tool for characterizing the most and least important sources of error in computational models (USEPA, 2003). Based on these results, maximum-risk scenario simulations can be conducted considering plume extent and pressure perturbation predictions that account for uncertainties in the model.*

FutureGen modeling and AoR delineation is not consistent with this EPA modeling guidance. Using “reasonable bounding values” for input parameters, FutureGen’s existing modeling sensitivity analysis resulted in a plume as much as 120 percent larger in size than their base case model runs (FutureGen, 2013, p.3-42, 3-43). I have included a map (Figure 1) with the FutureGen estimated supercritical CO_2 plume, and a plume area 120 percent larger. The 120-percent larger plume is likely *a minimum* for how much larger the FutureGen projected CO_2 plume should be given limitations in FutureGen’s sensitivity analysis, and other FutureGen modeling limitations as discussed below. It is essential for FutureGen to provide a conservative estimate of the extent of the supercritical CO_2 plume in order to effectively manage project risk and design the site monitoring network.

In my opinion, the plume as currently modeled is undersized and more likely than not to be greater than 120 percent larger when the model is run to include the appropriate conservative input parameter values.

FutureGen should update plume and pressure-front delineation maps using maximum-risk scenario simulations, addressing each parameter that could significantly affect plume and pressure extent, and based on conservative parameter values determined through sensitivity analysis, consistent with EPA guidance as cited above.

2.) FutureGen should revise their modeling sensitivity analysis to account for all relevant parameters and incorporate reasonable scaling factors (Permit Section 3.1.10, p.3-41).

FutureGen's modeling sensitivity analysis is inadequate, and does not provide for a full understanding of potential model under-prediction of CO_2 plume and pressure-front extent. Sensitivity analysis is the primary way to evaluate modeling uncertainty (U.S. EPA, 2013a, p.23/83). FutureGen's sensitivity analysis did not include varying of parameters that were based on literature values and/or prone to significant uncertainty, and are likely to have a large impact on model results (FutureGen, 2013, p.3-42). Additional parameters necessary for the sensitivity analysis include, but are not limited to the following: permeability-saturation relationships; capillary pressure-saturation relationships; anisotropy of intrinsic permeability; gas entry pressure; regional hydraulic gradient; and formation dip.

As stated by FutureGen, they have selected a "parsimonious" set of parameters upon which to conduct the sensitivity analysis (FutureGen, 2013, p.3-41). This approach is not one that would, by design, rigorously evaluate model uncertainty resulting from data limitations, and provide a conservative estimate of plume migration.

Additionally, scaling factors used in the existing sensitivity analysis are also too small given the range of possible input values (FutureGen, 2013, p.3-42). For example, estimates of intrinsic permeability for the Lower Mt. Simon varied by approximately a factor of 4.0 (i.e., 400 percent), for the wireline ELAN log testing and field hydraulic packer tests (FutureGen, 2013, p.3-6). However, the 'scaling factor' for testing the sensitivity of this parameter was only ±25 percent (FutureGen, 2013, p.3-42).

FutureGen should revise the modeling sensitivity analysis to include all relevant model parameters, and larger scaling factors that reflect the true range of reasonable values (including a scaling factor of 400 percent for intrinsic permeability of the Lower Mt. Simon). Discussion should be added to justify the chosen values of the scaling factors.

3.) FutureGen should provide maps of the extent of the dissolved-phase plume (Permit Section: Attachment B, p.B37/46).

The "CO_2 plume" plotted on maps in the permit application is missing a significant portion of the injected CO_2 mass. According to FutureGen modeling, 20 percent of the injected CO_2 occurs in the dissolved phase at the end of the simulation period, and the remaining 80 percent occurs in the supercritical phase (FutureGen, 2013, p. 3-27). For the purpose of the FutureGen permit application, the 'CO_2 plume' is defined as 99 percent of the supercritical CO_2 mass (FutureGen, 2013, p.3-25), and does not include the dissolved phase. Therefore, the FutureGen 'plume' includes only 99 percent of 80 percent (equal to 79 percent) of the total injected mass. The dissolved-phase plume likely extends much farther horizontally than the plotted 'plume maps.' The presence of dissolved-phase CO_2 poses potential risks to groundwater, including geochemical changes and potential leaching of inorganic constituents. For this reason, the extent of the projected dissolved-phase plume should be clear to EPA and stakeholders.

FutureGen should submit maps of the extent of the dissolved-phase CO_2 plume overlaid with the supercritical plume, the pressure boundary that defines the AoR, model boundaries, and the proposed FutureGen monitoring network.

4.) FutureGen should include 100 percent of the supercritical CO_2 mass in their delineation of the supercritical plume (Permit Section: Attachment B, p.B37/46).

FutureGen's inclusion of only 99 percent of the total supercritical mass in the 'plume boundary' is not consistent with EPA guidance, which states that the extent of the supercritical mass should be delineated, not the extent of 99 percent of the supercritical mass (U.S. EPA, 2013a, p.45/83). FutureGen's "VIMPA" analysis (FutureGen, 2013, p.3-37) effectively removes the thin leading edge of the supercritical plume from their delineation.

FutureGen should re-delineate the supercritical CO_2 plume to include 100 percent of the supercritical mass, such that it is clear to EPA and all stakeholders the complete projected horizontal extent of supercritical CO_2.

5.) FutureGen should demonstrate that model grid block sizes are sufficiently small (Permit Section: Attachment B, p.B37/46).

AoR and CO_2 plume modeling is clearly impacted by overly large grid-cell spacing. It is likely that the modeled CO_2 plume would extend farther horizontally if the model used smaller grid-cell blocks. FutureGen's modeled CO_2 plume shows a 'stair-stepped' shape around the edges, with long 'flat' sections (e.g., FutureGen, 2014a, p.B37/46). The stair-stepped geometry is a sign that grid cell block sizes are too large. EPA's modeling guidance discusses limitations of using overly large grid cell blocks, including results from Yamamoto and Doughty (2009) demonstrating that grid refinement may have a substantial effect on overall simulated plume extent (U.S. EPA, 2013a, p.21/83).

FutureGen should demonstrate that grid cell blocks used in AoR modeling are adequately small through rigorous model testing, and present detailed results of this testing to EPA and stakeholders. If necessary, all modeling figures should be revised based on the finer grid mesh model.

6.) FutureGen should incorporate regional hydraulic gradients into model simulations (Permit Section: Attachment B, p.B41/46).

FutureGen's model assumption of no regional or local flow gradient in the injection zone is not valid and may have a significant impact on model results. FutureGen model simulations assume hydrostatic conditions and no regional or local flow conditions (FutureGen, 2014a, p.B30/46). However, regional hydrogeologic maps clearly show a regional hydraulic gradient at the project location (FutureGen, 2014a, p.B27/46).

FutureGen model simulations should be conducted to test the assumption of no background gradient on plume and pressure-front migration. If this assumption is found to have an observable impact on model results, model simulations should be re-run considering a realistic regional gradient.

7.) FutureGen should present critical pressure calculations for all USDWs (Permit Section: Attachment B, p.B40/46).

FutureGen presents the results of pressure calculations for the lowermost USDW, but does not consider additional USDWs located above the proposed project (FutureGen, 2014a, p.40/46). FutureGen pressure calculations should be performed for all overlying USDWs, not only the lowermost USDW. If the critical pressure for another USDW is found to be less than 10 psi, the AoR boundary should be re-delineated based on the smaller critical pressure value.

8.) FutureGen should account for fluid impurities in computational modeling (Permit Section: Attachment B, p.B10/B46).

FutureGen's model assumes fluid injectate is pure CO_2, while in reality it may have up to 3 percent impurities (FutureGen, 2014a, p. B10/46). Fluid transport properties may be impacted by the presence of impurities, and model simulations must be conducted to test the assumption of 100 percent pure CO_2. If accounting for fluid impurities has an observable impact on model results, the modeling should be updated to account for representative fluid properties.

9.) FutureGen should provide detailed justification that model boundary conditions have no observable impact on modeling results (Permit Section Attachment B p.B31/46).

FutureGen states the following in regards to Boundary Conditions of their model domain (FutureGen, 2014a, p.B31/46): "The lateral and top boundary conditions were set to hydrostatic pressure using the initial condition with the assumption that each of these boundaries is distance enough from the injection zone to have minimal to no effect on the CO_2 plume migration and pressure distribution." FutureGen, however, provides no basis for this important assumption. EPA's modeling guidance discusses the necessity of model testing to ensure that boundary conditions are set sufficient far to avoid numerical error (U.S. EPA, 2013a, p.37/83).

Model testing should be presented to demonstrate that the model boundary conditions are sufficiently far from the injection point and projected pressure boundary as to not impact model results, especially in light of the more recently delineated AoR equal to 10 psi pressure increase.

10.) FutureGen should provide explanation for the approximately symmetrical plume and pressure delineation based on their modeling given significant differences in injection rates and well construction amongst the four injection wells, and the regional formation dip (Permit Section: Attachment B, p.B37/46).

FutureGen's modeled plume and pressure front delineations are approximately symmetrical in the horizontal plane around the four planned injection wells (FutureGen, 2014a, p.B41/46). However, the two horizontal injection wells directed towards the southwest (Well No. 3) and southeast (Well No. 2) include a significantly longer perforated interval (2,500 ft. versus 1,500 ft.) and larger injection rates (0.35 MMT/yr versus 0.19-0.21 MMT/yr) compared to the two wells directed towards the north. Additionally, the formation dips approximately 0.25 degrees in the east-southeast direction (FutureGen, 2014a, p. B7/46), which would be expected to cause preferential plume migration in the east-southeast direction.

FutureGen should provide a narrative explanation for why formation dip, injection well length, and injection rates appear to have a minor influence on the lateral configuration of the plume and pressure front around the four injection wells.

11.) FutureGen should present a detailed justification for monitoring well placement and add additional monitoring wells as necessary based on the more-recently delineated AoR (Permit Section: Attachment C).

FutureGen's monitoring network includes two "early-detection" wells completed in the first permeable unit above the confining zone (FutureGen 2014b, p.C1-C2/56). FutureGen has not demonstrated that these two monitoring wells alone will be adequate to detect potential leakage consistent with EPA guidance and regulations.

EPA regulations require that AoR modeling be used to designate the number and placement of monitoring wells above the primary confining zone, and monitoring well placement be based on specific information about the project, including injection rate and volume, geology, the presence of artificial penetrations, and baseline geochemical data (U.S. EPA, 2010; 146.90[d]).

EPA guidance recommends that monitoring wells be placed strategically to maximize the ability of the monitoring well network to detect potential leakage, and suggests that monitoring wells be cited based on modeling results, projected plume migration, dip direction, and the presence of potential leakage pathways (U.S. EPA, 2013b, p.56/115). EPA's monitoring guidance also states the following (U.S. EPA, 2013b, p.56-57/115):

> *The number of required monitoring wells may be greater for projects with larger predicted areas of elevated pressure and/or plume movement, or in cases of more complex or heterogeneous injection/confining zone hydrogeology. If the predicted area of impact of a given project increases in size as indicated during an AoR reevaluation, additional monitoring wells may be necessary...*
>
> *The number of monitoring wells placed above the confining zone should be determined such that any leakage through the confining zone that may endanger a USDW will be detected in sufficient time to implement remedial measures. The number of monitoring wells above the confining zone may be determined based on a modeling and/or statistical analysis, which may be documented in the Testing and Monitoring Plan. Considerations that may be included in this analysis are the regional hydraulic gradient, flow paths, transmissivity, and baseline geochemistry.*

In the initial FutureGen permit application, monitoring wells were placed within the boundaries of the projected carbon dioxide plume, which at that time defined the AoR (FutureGen, 2013). Subsequently the AoR size was significantly increased to include the boundaries of the 10 psi pressure increase (FutureGen, 2014a). However, additional monitoring wells were not added in the updated Testing and Monitoring Plan within this much larger area of elevated pressure.

FutureGen has provided no analysis regarding additional search for potential leakage pathways or sensitive areas in this now larger AoR that may require additional monitoring wells above the primary confining zone. Further, FutureGen has not provided any modeling or statistical analysis to demonstrate that two monitoring wells above the confining zone are adequate to detect leakage in sufficient time to implement remedial measures based on site-specific conditions, as suggested in EPA guidance as cited above.

FutureGen should present a detailed analysis justifying the placement of monitoring wells, in consideration of the most recently updated AoR, and including a search for all potential leakage pathways within the expanded AoR. Additional monitoring wells may be necessary in order to be consistent with EPA guidance.

References

FutureGen Alliance, 2013. Underground Injection Control Permit Applications for FutureGen 2.0 Morgan County Class VI UIC Wells 1, 2, 3, and 4; Supporting Documentation, Prepared for U.S. EPA Region 5. March 2013 (revised May 2013).

FutureGen Alliance, 2014a. Draft Permit Attachment B: Area of Review and Corrective Action Plan.

FutureGen Alliance, 2014b. Draft Permit Attachment C: Testing and Monitoring Plan.

Schnaar, G. and D.C. Digiulio. 2009. *Computational modeling of the geologic sequestration of carbon dioxide*. Vadose Zone Journal 8: 389-403.

U.S. EPA, 2003. Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models. Prepared by The Council for Regulatory Environmental Modeling.

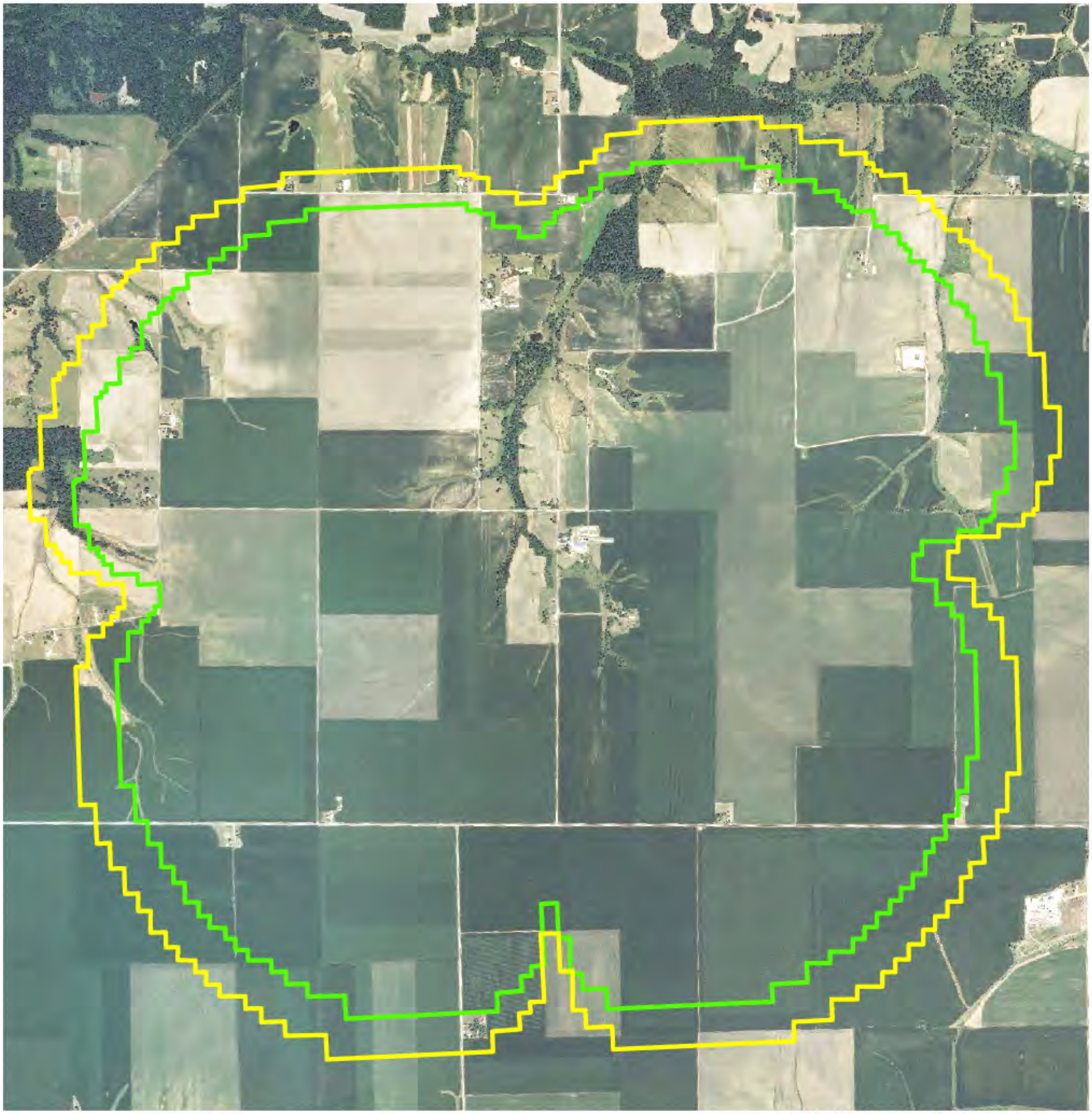
U.S. EPA, 2010. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells. U.S. Federal Register, Vol. 75, No. 237, Friday, December 10, 2010, p.77230-77303).

U.S. EPA, 2013a. UIC Program Class VI Well Area of Review Evaluation and Corrective Action Guidance. EPA 816-R-13-005.

U.S. EPA, 2013b. UIC Program Class VI Well Testing and Monitoring Guidance. EPA 816-R-13-001.

Yamamoto, H. and C. Doughty, 2009. Investigation of gridding effects for numerical simulation of carbon dioxide geologic sequestration. Proceedings of TOUGH Symposium, LBNL, September 2009, Berkeley, CA.

Figure



2012 NAIP aerial photography from USDA.

Explanation

FutureGen modeled supercritical carbon dioxide plume, 99% of total supercritical mass

Area 120% larger than FutureGen's plume area, based on FutureGen sensitivity analysis with reasonable bounding values

N

0 1300 2600 Feet

Source: FutureGen, March 2013 permit application, pg. 3.43.

Q:\PROJECTS\LT14.0099 FUTUREGEN\GIS\MXDS\PLUME AREA.MXD

Daniel B. Stephens & Associates, Inc.
5/13/2014 JN LT14.0099

FUTUREGEN
Plume Area

Figure 1

Appendix A

Curriculum Vitae of Gregory Schnaar, Ph.D.

Gregory Schnaar, Ph.D.

Specialization

Dr. Schnaar specializes in geologic sequestration of carbon dioxide, underground injection control (UIC), contaminant transport evaluation, environmental chemistry, field sampling, numerical groundwater and vadose zone modeling, and watershed-scale hydrologic studies. Previously with the U.S. Environmental Protection Agency, Dr. Schnaar developed the UIC Class VI geologic sequestration regulations and associated technical guidance published on U.S. EPA's website. Dr. Schnaar has given numerous technical presentations and trainings on geologic sequestration and associated UIC regulations, and is an Associate Editor for the peer-reviewed journal *Groundwater*.

Academic Degrees

Ph.D., Soil, Water, and Environmental Science, University of Arizona, 2006

B.S., Environmental Science and Policy, University of Maryland, 2002

Representative Professional Assignments

Geologic Sequestration of Carbon Dioxide and Energy Resources

- ***Carbon Dioxide Geologic Sequestration Rulemaking, Underground Injection Control Program (UIC), U.S. EPA, Washington, D.C.:*** Key member of the regulatory development team for the rulemaking: *Federal Requirements Under the Underground Injection Control Program for Carbon Dioxide Geologic Sequestration Wells* published in the Federal Registrar July 15 2008 (draft) and December 10 2010 (final). Regulation establishes a new well UIC Class (Class VI) for geologic sequestration projects. Crafted overall regulatory approach for geologic sequestration facility integrated groundwater monitoring and multi-phase fluid modeling. Performed extensive outreach on behalf of U.S. EPA to educate regulators and stakeholders on rule requirements.
- ***Geologic Sequestration Technical Guidance Documents, The Cadmus Group/U.S. EPA Office of Ground Water and Drinking Water, Washington, D.C***.: Expert technical contractor for five technical guidance documents published by U.S. EPA Underground Injection Control program regarding geologic sequestration of carbon dioxide. The technical guidance documents provide permitting support to owners and operators of geologic sequestration facilities and State regulators as related to monitoring, multi-phase numerical modeling, operation, and injection well integrity testing. Worked closely with U.S. EPA staff, contractors, and external peer reviewers to develop technically accurate guidance documents that are also consistent with the U.S. EPA policy objectives. Guidance documents are available at the following U.S. EPA website: http://water.epa.gov/type/groundwater/uic/class6/gsguidedoc.cfm
- ***Review of Archer Daniels Midland Company Underground Injection Control Permit Application for Class VI, Geologic Sequestration, The Cadmus Group/U.S. EPA Office of Ground Water and Drinking Water, Washington, D.C.***: Provided assessment of permit application submitted to U.S. EPA Region 5 for injection of carbon dioxide for geologic sequestration for proposed facility in Decatur, Illinois. Evaluated completeness of permit application as compared to Underground Injection Control regulations and identified discrepancies in technical submittals. Specifically evaluated documentation of numerical modeling conducted to demonstrate non-endangerment of groundwater resources.
- ***Review of Christian County Generation, LLC Underground Injection Control Permit Application for Class VI, Geologic Sequestration, The Cadmus Group/U.S. EPA Office of Ground Water and Drinking Water, Washington, D.C.***: Provided assessment of permit application submitted to U.S. EPA Region 5 for injection of carbon dioxide for geologic sequestration for proposed facility in Christian County, Illinois. Evaluated completeness of permit application and technical submittals.

Gregory Schnaar, Ph.D.

- ***Lecturer for Energy Course, Department of Geography, George Washington University, Washington, D.C.*:** Lectured upper-division undergraduate course, "Energy Resources." Course covered energy production and consumption trends in the U.S. and globally, evaluated technical aspects of fossil-fuel based, nuclear, and renewable energy systems, as well as environmental, geopolitical, and social implications of energy use.

Environmental Services and Litigation Support

- ***Evaluation of remediation options for non-point watershed legacy contaminants in lakebed sediment, Private Land Owner, McGrath Lake, Ventura County, California***: Project manager and consulting expert for compliance with a total maximum daily load regulation regarding legacy pesticides and polychlorinated biphenyls bound to lakebed sediments. Support private land owner and their legal counsel in relations with the Regional Water Quality Control Board (RWQCB), and related litigation. Additionally, provided substantial peer review comments on field methods and data analysis approaches currently being used to characterize the lakebed sediment contamination by University of California researchers and the RWQCB.
- ***Hydrogeologic Characterization, Groundwater Balance, and Selenium Transport Evaluation, Newport Bay Watershed, Orange County Public Works, Orange County, California***: Technical lead on watershed-scale assessment of selenium loading to surface water channels leading into Upper Newport Bay. Project includes watershed modeling of recharge from deep percolation, groundwater/surface water balance determination, selenium loading evaluation, stakeholder coordination, identification of data gaps and recommendations for next steps for control of selenium loading. Results will be used to develop approaches for compliance with a selenium total daily maximum load regulation. Presented results of the groundwater balance and selenium loading evaluation to the project stakeholder funding group, which includes the Los Angeles Regional Water Quality Control Board, local cities and water providers, CalTrans, and Orange County Watersheds.
- ***Vapor Intrusion Risk Assessment, San Roque Cleanup Trust, Former Dutchmaid Cleaners Perchloroethylene Site, Santa Barbara, California***: Technical lead for vapor intrusion risk assessment for 22-acre chlorinated-solvent contaminated site with contribution from three separate dry-cleaning facilities. Risk assessment was conducted consistent with California EPA (CalEPA) and U.S. EPA guidance, relied on data from over 60 soil vapor monitoring probes, and included development of site-specific screening objectives using the Johnson/Ettinger model. Oversaw field-testing for soil vapor diffusivity and soil moisture, which was used to justify a lower risk of vapor intrusion compared to default CalEPA assumptions. Vapor intrusion risk assessment reviewed by California state regulators with the Regional Water Quality Control Board (RWQCB), Department of Toxic Substances Control (DTSC), and Office of Environmental Health Hazard Assessment (OEHHA), who approved of the analysis.
- ***Groundwater Monitoring Program, San Roque Cleanup Trust, Former Dutchmaid Cleaners Perchloroethylene Site, Santa Barbara, California***: Task manager for groundwater monitoring program at chlorinated solvent-contaminated site. Semi-annual monitoring program for standard volatile-organic compounds (VOCs), remedial performance indicator parameters, 1,4-dioxane and groundwater levels from a network of over fifty monitoring wells. Responsible for staff and sub-contractor management, data analysis, budgeting, and reporting.
- ***Evaluation of chromium leaching from industrial disposal to surface water channel, Confidential Client, Los Angeles, California***. Project manager for evaluation of historical chromium contamination to groundwater from waste-water disposal in a channelized tributary of the Los Angeles River. Historical documents and aerial imagery used to develop timeline of channel construction and industrial operations from the 1920s to the 1960s. HYDRUS vadose zone modeling used to evaluate chromium leaching to groundwater. Results will be implemented in a larger groundwater model of the basin to evaluate allocation of responsibility for existing chromium impacts to groundwater.

Gregory Schnaar, Ph.D.

- ***Dry Cleaner Investigation, San Roque Cleanup Trust, Former Dutchmaid Cleaners Perchloroetheylene Site, Santa Barbara, California***. Managed investigation of soil contamination impacts from an active dry-cleaning facility that historically used tetrachloroethene in operations (One-Hour Martinizing). Limited access direct-push drill rig selected based on site reconnaissance and project requirements for soil sampling to depths of 30 feet below ground surface and grab groundwater sampling. Responsible for staff and sub-contractor management, site access and property manager/business owner coordination, budgeting, reporting, and soil sampling from direct-push soil cores. Results will be used to inform remedial options for the multi-party contaminated 22-acre site.
- ***Evaluation of groundwater impacts from coal fly-ash disposal in former gravel mine and associated numerical modeling, Confidential Client, Anne Arundel County, Maryland***. Evaluated potential downgradient groundwater impacts by sulfate, aluminum, and other inorganic constituents from leaching through fly-ash disposal pits. Previous numerical modeling was reviewed to assess assumptions regarding regional hydrogeology, groundwater flow and transport, and applicability of the model for assessing downgradient impacts. Developed radial diagrams of inorganic chemistry at downgradient monitoring wells to elucidate sources.
- ***Environmental Permitting Support and Evaluation of Salt and Nutrient Loading, Hollandia Produce LLC, Ventura County, California:*** Managed environmental permitting support for hydroponic lettuce production operation, including Conditional Use Permit (CUP) for Ventura County and a Waste Discharge Requirement/Water Recycling Requirement (WDR/WRR) for the Regional Water Quality Control Board (RWQCB). Successfully obtained Ventura County CUP permit, and RWQCB WDR/WRR permit approved December 2013. Facilitated collaborative process with client and County and State regulators in order to obtain permits and address regulator comments, and testified on behalf of client at Board hearings. Technical lead for quantitative evaluation of potential salt and nutrient impacts to groundwater. Hydroponic lettuce-growing facility will use local groundwater and harvested rain water to meet water needs, and apply spent process water to a rain garden and other on-site landscaping. Salt and nutrient loading methodology based on a modification of the published U.S. EPA two-dimensional mixing-model approach that incorporates salt and nutrient contribution from upgradient areas of the watershed.
- ***Numerical Model Design, Hexcel, Kent, Washington:*** Designed numerical groundwater model for investigation of groundwater flow and transport of chlorinated solvents at a facility located in Kent, Washington. The model was used to predict well capture zones associated with a pump-and-treat remedial effort and evaluate alternative remedial strategies. Groundwater modeling was conducted with the USGS MODFLOW model, and follow-up particle tracking was performed with MODPATH. Model results were submitted to the Washington State Department of Ecology in support of lowering pump-and-treat operational extraction rates.
- ***Evaluation of natural attenuation of chlorinated solvents in groundwater, Confidential Client, Contra Costa County, California:*** Evaluated groundwater geochemistry in regards to favorability for reductive dechlorination of chlorinated solvents released from a former landfill, in order to assess impacts to downgradient properties. Analysis was based on U.S. EPA guidance on the use of monitored natural attenuation at Superfund sites, and evaluated groundwater redox geochemistry, isotope analysis, the presence of degradation daughter products, and analytic biodegradation modeling.
- ***Development of Remedial Cost Allocation for Multi-party Contaminated Site, Confidential Client, Santa Clara County, California:*** Project manager for development of allocation for remedial costs associated with vadose zone and groundwater contamination. Contaminants of concern include trichloroethylene and 1,1,1-trichloroethane and their respective degradation products. Allocation analysis also included assessment of previous remedial actions that likely exacerbated contamination and increased long-term remedial costs. Multi-party allocation based on both area and mass of contribution for each party.

Gregory Schnaar, Ph.D.

- ***Vapor Intrusion Assessment, Confidential Client, Dayton, Ohio:*** Evaluated vapor intrusion at residential and commercial properties downgradient of a large chlorinated solvent contaminated site, and several smaller sites contributing minor plumes, in support of a class-action lawsuit. Performed extensive data analysis of indoor air and sub-slab vapor data collected from hundreds of residences, and groundwater data from a network of over fifty monitoring wells. Directed importing analytical results from thousands of laboratory reports and field monitoring reports into a comprehensive database for the site. A multiple-lines-of-evidence approach was used to demonstrate that elevated chlorinated solvent levels in residential indoor air is the direct result of groundwater contamination and vapor intrusion, including: a similar spatial distribution of VOC concentrations in indoor air, soil vapor, and groundwater was observed; the chemical signature (aka "chemical fingerprint") was also found to be similar for groundwater, soil vapor, and indoor air monitoring results; and Johnson/Ettinger vapor intrusion modeling predictions compared well to observed indoor air impacts from field monitoring.

- ***Aquifer testing and analysis and ambient groundwater monitoring program, Freeport-McMoRan Sierrita Mine, Green Valley, Arizona:*** Conducted multiple aquifer tests in vicinity of properties impacted by copper mine tailings. Analyzed current and historic aquifer test results in order to develop a three-dimensional understanding of the variability of hydraulic conductivity and storage parameters downgradient of mine tailings.

- ***Collection of groundwater, surface water, and vadose zone samples, various sites in California, Arizona, and Washington State:*** Significant experience in collection of groundwater, surface water, and vapor-phase samples for analysis of volatile organic carbon, metals and general geochemistry. Conducted a large-scale ambient groundwater monitoring program from privately owned wells located in neighborhoods and ranches downgradient or a large mine-tailings impoundment.

- ***Vapor Intrusion Assessment, Confidential Client, Los Angeles County, California:*** Project manager and technical lead in vapor intrusion assessment at a low-income housing complex in Los Angeles County. Site assessment and vapor intrusion modeling conducted in support of a class-action lawsuit. Vapor intrusion modeling involved development of a spreadsheet based partitioning model to predict multi-component vapor concentrations in presence of liquid petroleum hydrocarbons, and Johnson-Ettinger modeling of sub-slab vapor transport to indoor air.

- ***Non-aqueous phase liquid infiltration modeling, Confidential Client, Orange County, California***. Developed numerical model to evaluate infiltration of PCE and other chlorinated solvents for conditions representative of a contaminated property, and subsequent volatile organic carbon (VOCs) migration in vapor and pore-water. Modeling was used to evaluate the fate of Non-aqueous phase liquid NAPL in the subsurface and potential groundwater impacts, and support client in a multi-party litigation. Sensitivity analyses included the thickness and properties of clay lenses, release timing and volume, chemical properties, and the presence or absence of a surface 'cap' restricting upwards vapor migration. Model platform was TOUGH2-T2VOC.

- ***Numerical model design for evaluation of vadose zone contamination, Confidential Client, Philadelphia, Pennsylvania***. Designed a multiphase flow vadose zone model to evaluate impacts from release of large quantities of petroleum hydrocarbons from a large gasoline refinery. The model was used to examine the behavior of light non-aqueous phase liquid (LNAPL) in the vadose zone and at the groundwater table over a period of several decades in support of allocating contribution from separate facilities to LNAPL contamination. Model platform was TOUGH2-T2VOC.

- ***Pore-Scale Imaging Research, National Institute of Environmental Health Sciences Superfund Basic Research Program, University of Arizona, Tucson, Arizona:*** Designed and conducted experiments for pore-scale imaging of non-aqueous phase liquid (NAPLs) in natural sands. Research project included use of a cutting-edge optical technique for imaging of pure-phase chlorinated solvents in natural sandy media in order to observe NAPL migration and dissolution at the pore scale. Project also involved coordination of data collection and analysis among researchers at several universities and Argonne National Laboratory. Results have been published in several peer-reviewed journals and presented at various international scientific meetings.

- ***Research on Non-Ideal Sorption of Volatile Organic Compounds in Soil, University of Arizona, Tucson Arizona:*** Conducted physical and numerical experiments investigating the impact of non-ideal sorption on low-concentration elution tailing of chlorinated solvents and pesticides. Research involved conducting laboratory column flushing experiments, sample chemical analysis, and data interpretation with a numerical model. Results have been published in several peer-reviewed journals and presented at various international scientific meetings.

Water Resources and Watershed-Scale Groundwater Modeling

- ***Hydrogeologic Assessment and numerical watershed/groundwater flow model design, San Antonio Creek Watershed, Ojai Basin Groundwater Management Agency, Ojai, California:*** Project manager and lead modeler for development of a watershed-scale linked distributed parameter watershed-groundwater model. Project funded by a Local Groundwater Assistance grant administered by the California Department of Water Resources (DWR). Model calibration included transient effects of recharge from deep percolation, groundwater pumpage, and groundwater recharge from and discharge to San Antonio Creek and smaller tributaries. Groundwater levels in the Ojai Basin respond dramatically to rainfall cycles; therefore, groundwater recharge was estimated by use of an advanced distributed parameter watershed model. Numerical groundwater modeling platform was MODFLOW-SURFACT, which allowed for accurate modeling of groundwater level rise/decline cycles and associated aquifer dewatering. The model has been used for groundwater resource planning, watershed protection efforts, and design of an aquifer storage and recovery (ASR) project. Model development summarized in a detailed technical report submitted to Ojai Basin Groundwater Management Agency (OBGMA) and DWR, and also presented model results to OBGMA board members and stakeholders on several occasions.
- ***Evaluation of Numerical Model Estimates of Aquifer Recharge, Indio Water Authority, Indio, California:*** Project manager for review of the Coachella Valley Groundwater Model, a MODFLOW model that has been used for groundwater management planning and estimates of groundwater recharge from several water spreading pond facilities. Provided Indio Water Authority with independent evaluation of model assumptions and implementation, and resulting limitations of conclusions regarding groundwater recharge assessments.
- ***Indio Water Authority Aquifer Storage and Recovery Program, Indio Water Authority, Indio, California:*** Developed a preliminary project approach and cost assessment for development of an aquifer storage and recovery (ASR) program using blended wastewater treatment plan (WWTP) effluent and surface water supplies. Project scope includes feasibility evaluation, water resource impact assessment, injection well siting and design, permitting, injection well construction, development of a monitoring and reporting program, design and siting of monitoring wells, and a tracer test study.
- ***Groundwater Level and Water Quality Sampling Program, Ventura County Watershed Protection District, Ventura County, California:*** Project manager for field sampling program initiated to satisfy California State requirements regarding groundwater monitoring, and gather important data for understanding transient groundwater levels, geologic occurrence, and groundwater quality in the Ojai Groundwater Basin. Authored monitoring plan, quality assurance project plan (QAPP), and semi-annual monitoring reports.
- ***Development of Hydrogeologic Groundwater Budget and Approach to Development of a Groundwater Management Plan for Watershed Protection, Upper and Lower Ventura River Groundwater Basin, Ventura County Watershed Protection District, Ventura County, California:*** Project manager and technical lead for development of an estimated groundwater budget based on available data regarding

watershed infiltration, groundwater flow between different geologic formations, irrigation, pumpage, groundwater discharge, and surface water-groundwater interactions. Identified several data gaps and outlined recommendations for constraining estimates of the groundwater budget.

- ***Peer Review, Ventura River Watershed Management Plan, Ventura River Watershed Council, Ventura County, California***. Asked to provide a peer review of the Ventura River Watershed Management Plan by the watershed coordinator and stakeholder group. Reviewed sections related to groundwater, surface water, geology, soils, and previous studies conducted in the watershed.
- ***Hydrologic Investigation of Groundwater Flow, Salt River Pima Maricopa Indian Community, Scottsdale, Arizona:*** Managed a hydrologic investigation of groundwater flow at Salt River Landfill in Scottsdale, Arizona. Project entailed predicting the change in groundwater levels at the landfill as impacted by the Granite Reef Recharge basin and flow in the Salt River. Project work included hydrological analysis, data collection and organization, numerical modeling, preparation of reports, and presentations to project clients.
- ***Hydrologic and Water Quality System Project, U.S. EPA, Washington, D.C.:*** Provided support related to management of the Hydrologic and Water Quality System project, which aims to provide U.S. EPA with a state-of-the-art water quality computational model that is national and regional in scope. Project work entailed review of project reports, coordination with partner agencies at U.S. EPA and the U.S. Department of Agriculture, and development of project scopes and timelines.
- ***Dairy-Facility Nitrate Loading Study, University of Maryland, College Park, Maryland:*** Assisted in watershed-scale study of nitrate contamination associated with intensive dairy grazing at farms in Maryland. Responsible for collection of groundwater and unsaturated-zone water samples, and preparation of samples for laboratory analysis.

Professional Affiliations

American Association for the Advancement of Science, 2007-present

Soil Science Society of America, 2006-present

American Geophysical Union, 2004-present

American Chemical Society, 2004-present

Additional Professional Training

OSHA 40-hour HAZWOPER Training

MSHA New Miner 24-hour Training

TOUGH2, including T2VOC

ESRI ArcGIS

MODFLOW, MODPATH, MT3D and Groundwater Vistas

Soil Water Assessment Tool (SWAT)

Professional Experience

Daniel B. Stephens & Associates, Goleta, California, 2009 to Present
Senior Environmental Scientist/Hydrogeologist

U.S. EPA Office of Ground Water and Drinking Water. Washington D.C., 2007 to 2008
AAAS Science and Technology Policy Fellow

HydroGeoChem, Inc., Tucson, Arizona, 2006 to 2007
Environmental Scientist

Publications and Presentations

Peer-Reviewed Publications

Associate Editor, *Groundwater*, 2012 to present

Schnaar, G., T. Umstot, and S.J. Cullen. 2013. Correction TO: "Birkholzer, J.T. et al., 2011, Brine flow up a well caused by pressure perturbation from geologic carbon sequestration: Static and dynamic evaluations. International Journal Greenhouse Gas Control; Vol. 5: 850-861." International Journal of Greenhouse Gas Control, 17: 542-543.

Schnaar, G., and M.L. Brusseau. 2013. Measuring equilibrium sorption coefficients with the miscible-displacement method. Journal of Environmental Science and Health, Part A, 48: 355-359.

Brusseau, M.L., G. Schnaar, G.R. Johnson, and A.E. Russo. 2012. 10 - Impact of co-solutes on sorption of tetrachloroethene by porous media with low organic-carbon contents. Chemosphere, 89: 1302-1306.

Brusseau, M.L., A.E. Russo and G. Schnaar. 2012. Nonideal transport of contaminants in heterogeneous porous media: 9 - Impact of contact time on desorption and elution tailing. Chemosphere, 89: 287-292.

Russo, A., Johnson, G.R., Schnaar, G., and M.L. Brusseau. 2010. Nonideal transport of contaminants in heterogeneous porous media: 8. Characterizing and modeling asymptotic contaminant-elution tailing for several soils and aquifer sediments. Chemosphere, 81(3): 366-371.

Schnaar, G. and D.C. Digiulio. 2009. Computational modeling of the geologic sequestration of carbon dioxide. *Vadose Zone Journal* 8: 389-403.

Brusseau, M.L., Narter, M., Schnaar, G. and Marble, J. 2009. Measurement and Estimation of Organic-liquid/Water Interfacial Areas for Several Natural Porous Media. *Environmental Science & Technology*, 43(10): 3619-3625.

Brusseau M.L., Janousek H., Murao A., and G. Schnaar. 2008. Synchrotron X-ray microtomography and interfacial partitioning tracer test measurements of NAPL-water interfacial areas. *Water Resources Research*. 44, W01411.

Brusseau, M.L., Peng, S., Schnaar, G., and A. Murao. 2007. Measuring air-water interfacial areas for a sandy porous medium: comparing X-ray microtomography and partitioning tracer tests. *Environmental Science and Technology*. 41(6) 1956-1961.

Schnaar, G. and M.L. Brusseau. 2006. Characterizing pore-scale dissolution of organic immiscible liquid in natural porous media using synchrotron X-ray microtomography. *Environmental Science and Technology*. 40(21) 6622-6629.

Schnaar, G. and M.L. Brusseau. 2006. Characterizing pore-scale configuration of organic immiscible-liquid in multi-phase systems with synchrotron X-ray microtomography. *Vadose Zone Journal* 5: 641-648.

Gregory Schnaar, Ph.D.

Brusseau, M.L., Peng S., Schnaar, G., and M. Costanza-Robinson. 2006. Relationships among air-water interfacial area, capillary pressure, and water saturation for a sandy porous medium. *Water Resources Research.* 42, WO3501.

Schnaar, G. and M.L. Brusseau. 2005. Pore-scale characterization of organic immiscible-liquid morphology in natural porous media using synchrotron X-ray microtomography. *Environmental Science and Technology*. 39(21) 8403-8410.

Government Support Documents

Woodward N.B., Levine, A. D., Singer, M., Kobelski, B.J., Fries, J.S., Schnaar, G., Burruss, R.C., Duncan, D., Glynn, P., Neuzil, C., Huntsinger, R., Osvald, K.S., Carlson, C.P. 2008. Water Resources Research Needs Associated with Implementation of Geologic Sequestration of Carbon Dioxide. A report to the White House Office of Science and Technology Policy, Committee on Environment and Natural Resources, Subcommittee on Water Availability and Quality.

Schnaar, G. and D.C. Digiulio. 2008. Computational modeling of underground injection of carbon dioxide for determination of area of review and potential risk to underground sources of drinking water. Supporting document to: *Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO2) Geologic Sequestration (GS) Wells; Proposed Rule.* Federal Register Vol. 73, No. 144, Friday, July 25, 2008.

Professional Trade Magazines

Schnaar G., and S.J. Cullen. 2009. The Hydrology of Geologic Sequestration. *Southwest Hydrology*, 8: 20-21.

Schnaar, G. 2008. U.S. EPA Development of a Proposed UIC Rule for Geologic Sequestration of CO2. National Ground Water Association, *AGWSE Newszine*, July 16 2008.

Conference Presentations

Dodge, J.J., G. Schnaar, S.J. Cullen and J. Peng. 2014. Drainage Channels Remobilize Selenium, Swamp of the Frogs, Newport Bay Watershed, Orange County, California. Groundwater Resources Association of California/U.S. Society for Irrigation and Drainage Professionals. Groundwater Issues and Water Management - Strategies Addressing Challenges of Sustainability and Drought in California, March 4-5, Sacramento, California.

G. Schnaar, J. J. Dodge, , S. J. Cullen, and J. Peng. 2012. Water Balance Development to Characterize Selenium Flux, Newport Bay Watershed, Orange County, California. Groundwater Resources Association of California-Salt and Nitrate in Groundwater: Finding Solutions for a Widespread Problem, June 13-14, Fresno, California.

Molina, April, G. Schnaar, P. Kaiser, and Stephen J. Cullen, 2012. Preparing Geospatial Data for Use in Watershed and Groundwater Models. ESRI, Southwest Users Group, Albuquerque, New Mexico, October 8-11, 2012.

Kaiser, Phil, T. Umstot, G. Schnaar, Stephen J. Cullen, 2012. The Distributed Parameter Watershed Model for Predicting Recharge in Southern California. California Groundwater Association, 21st Annual Meeting and Conference, "California Groundwater: Data, Planning and Opportunities" October 4-5, 2012, Rohnert Park, California.

G. Schnaar. Federal UIC Regulations for Geologic Sequestration: An Integrated Approach of Site Characterization, Modeling, and Monitoring. American Association of Petroleum Geologists (AAPG) Rocky Mountain Section Annual Convention, June 2010. Durango, Colorado.

G. Schnaar. CO_2 Geologic Storage: Simulation for Regulators. International Energy Agency (IEA) CO2 Geological Storage Modeling Meeting, February 2010. Salt Lake City, Utah.

G. Schnaar. Geologic Sequestration of Carbon Dioxide: Models, Codes, and Federal Regulations. TOUGH Symposium, September 2009. Berkeley, California.

N. Sweetland. P. Schauwecker, and G. Schnaar. MTBE Products Liability Litigation: The Role of Hydrogeologic Investigation. International Network of Environmental Forensics Conference, September 2009. Calgary, Alberta.

G. Schnaar. Federal Regulations for Geologic Sequestration of Carbon Dioxide. Air & Waste Management Association, Carbon Sequestration 101 (via webinar), February 2009.

G. Schnaar. Standards for Geologic Sequestration of Carbon Dioxide, EPA Proposed Rulemaking, Signed July 15, 2008.

- Big Sky Regional Carbon Sequestration Partnership Annual Meeting, October 2008. Spokane, Washington.
- EPA Region 8 State UIC Workshop, October 2008. Salt Lake City, Utah.
- WESTCARB Regional Carbon Sequestration Partnership Annual Meeting, October 2008 (via webinar). Anchorage, Alaska.
- EPA Region 7 UIC Manager's Meeting, September 2008 (via webinar). Kansas City, MO.
- Ground Water Protection Council Annual Meeting, September 2008. Session: Underground Injection Control (UIC) and Geosequestration Seminar.
- Electric Power Research Institute Fall Environment Council Meeting, September 2008. Baltimore, Maryland.
- Edison Electric Institute Global Climate Change Subcommittee Meeting, July 2008. Savannah, Georgia.

G. Schnaar and N. Sweetland. Geologic Sequestration of Carbon Dioxide: Potential impacts to groundwater resources, the U.S. regulatory framework, and lessons learned from previous injection activities. Groundwater Resources Association of California Climate Change: Implications for California Groundwater Management, August 2008. Sacramento, California.

Brusseau, M.L., Janousek H., Murao A., and G. Schnaar. Synchrotron X-ray microtomography and interfacial partitioning tracer test measurements of NAPL-water interfacial areas. American Geophysical Union Fall Meeting, December 2007. Session: Pore-Scale Modeling and Imaging of Multiphase Flow, Solute Transport, and Biogeochemical Processes in Porous Media. San Francisco, California.

Marble, J.C., Narter M., Schnaar G., and M.L. Brusseau. Characterizing air-water interfacial area for variably saturated porous media. American Geophysical Union Fall Meeting, December 2007. Session: Pore-Scale Modeling and Imaging of Multiphase Flow, Solute Transport, and Biogeochemical Processes in Porous Media. San Francisco, California.

Schnaar, G. and M.L. Brusseau. Characterizing pore-scale dissolution of organic immiscible liquid in natural porous media using synchrotron X-Ray microtomography. American Geophysical Union Fall Meeting, December 2006. Session: Quantitative Pore-Scale Investigations of Multiphase Bio/Geo/Chemical Processes. San Francisco, California.

Brusseau, M.L., Schnaar, G., Marble J. Measured air-water and NAPL-water interfacial areas for sandy porous media: comparing X-ray microtomography and partitioning tracer test methods. American Geophysical Union Fall Meeting, December 2006. Session: Quantitative Pore-Scale Investigations of Multiphase Bio/Geo/Chemical Processes. San Francisco, California.

Brusseau, M.L., Schnaar, G., Peng S., Marble J. Relationship between air-water interfacial area and water saturation for sandy porous media. Soil Science Society of America International Meeting, November 2006 (Oral Presentation by G. Schnaar). Session: NRI's Soil Processes Program: Reports, Assessments and Future Directions. Indianapolis, Indiana.

Schnaar, G. and M.L. Brusseau. Pore-scale characterization of organic immiscible-liquid morphology in natural porous media using synchrotron x-ray microtomography.

- University of Arizona Dept. of Hydrology and Water Resources Student Showcase, 2006 (Oral Presentation). Tucson, Arizona.
- Superfund Basic Research Program Annual Meeting, 2006. New York, New York.
- American Geophysical Union Fall Meeting, 2005 (Oral Presentation). Session: Advances in Characterizing and Remediating Nonaqueous Phase Liquid Source Zones: From Pore Scale to Field Scale. San Francisco, California.

Brusseau, M.L., Peng, S., Schnaar, G., and M. Costanza-Robinson. Relationships among air-water interfacial area, capillary pressure, and water saturation for a sandy porous medium. American Geophysical Union Fall Meeting, 2005. Session: Pore-Scale Processes and Their Effect on Continuum and Field-Scale Hydrology. San Francisco, California.

Schnaar, G. and M.L. Brusseau. The impact of non-ideal sorption on low-concentration tailing behavior for chlorinated solvents in aquifer material.

- University of Arizona Water Sustainability Program Fall Forum, 2005. Tucson, Arizona.
- American Geophysical Union Fall Meeting, 2004 (Oral Presentation). Session: Mass Transfer and Mass Flux Processes in Source-Zone Systems. San Francisco, California.

- University of Arizona Superfund Basic Research Program and Southwest Environmental Health Sciences Center 8th Annual Science Fair, 2004. Tucson, Arizona.
- Arizona Hydrological Society Annual Symposium, 2004 (Oral Presentation). Tucson, Arizona.

STATE OF ILLINOIS)
) SS:
COUNTY OF MORGAN)

DECLARATION OF WILLIAM CRITCHELOW

William Critchelow, being first duly sworn on oath, states that he has personal knowledge of the information contained in this declaration, and if called as witness, he could competently testify as follows:

1. I am over the age of 18 and not under any legal disability.

2. My wife and I currently own the parcel of land that is approximately four acres in Ex. 6 size located at [redacted] Jacksonville, Illinois 62650. This land is located approximately 1.64 miles from FutureGen Alliance's ("FutureGen") proposed injection site.

3. I live in a house located on this land. I have lived in that house for over 25 years. There is a water well located on this land, which has been there for over 25 years.

4. When FutureGen drilled the test (characterization) well ("Test Well") from October through the first part of December in 2011, it caused the water in my well to turn yellowish/brownish for approximately one month. It also caused the water in my well to overflow during a portion of that period.

5. In the years that I have lived at in my house on that land, the water in my well has never changed colors or overflowed, except for when FutureGen drilled the Test Well.

Under penalties as provided by law pursuant to 28 U.S.C. § 1746, the undersigned certifies that the statements set forth in this instrument are true and correct, except as to matters therein stated to be on information and belief and as to such matters the undersigned certifies as aforesaid that he verily believes the same to be true.

Dated: May 7, 2014

William Critchelow
WILLIAM CRITCHELOW