Geologic Sequestration Rules: A Multi-Stakeholder Perspective

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Carbon Sequestration Council

- American Electric Power
- Anadarko Petroleum Corporation
- BHP Billiton
- BP Alternative Energy
- ConocoPhillips
- Denbury Resources Inc.
- Duke Energy
- E.ON USA LLC

- Hydrogen Energy California
- Occidental Petroleum Corporation
- Salt River Project
- Schlumberger Carbon Services
- Shell Exploration and Production
- Southern Company
GS Multi-Stakeholder Discussion (GSMSD)

- Representing array of interests in geologic sequestration (GS) rulemaking – industry, state agencies and environmental NGOs
- Dynamic participation among interests
- Discussing interests and issues in an effort to reach consensus
- Presenting joint recommendations
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UIC Program Well Classes

- **Class I (a)** – Waste disposal (industrial hazardous and nonhazardous wastes – municipal wastewater)
- **Class II (b)** – Injection wells associated with oil and gas exploration and production
- **Class III (c)** – Solution mining wells (e.g., salt, uranium)
- **Class VI (d)** – Hazardous waste into underground sources of drinking water
- **Class V (e)** – All wells not included in other classes (includes pilot-scale GS experimental wells) (GSMSD proposes additional experimental well categories)
- **Class VI (f)** – Geologic sequestration wells
Class II Oil & Gas Wells

- Class II (b)(1) – Produced water (brine) disposal wells
- Class II (b)(2) – Enhanced oil recovery (EOR) wells
- Class II (b)(3) – Hydrocarbon storage wells
- Class II (b)(4) – Business as usual EOR with simultaneous geologic sequestration (GS)
- Class II (b)(5) – GS in oil and gas reservoirs that does not meet Class II(b)(4) requirements
UIC Regulatory Framework  
Currently Under Revision to Incorporate CCS

- **Class II(b)(2):** Business as Usual CO₂ EOR
- **Class II(b)(4):** BAU CO₂ EOR with Storage (& Monitoring Overlay)
- **Class II(b)(5):** Post EOR to Maximize Storage with Minimal Extraction and/or Increased Pressure
- **Class V:** Experimental Storage (Basalts, Coal Bed Methane, Shales, Salt Caverns, other pilot and demonstration projects)
- **Class VI:** Deep Saline Formation Sequestration
GSMSD General Approach

- Build on existing knowledge of technology and sites
- Preference for performance standards
- Allow for adaptation based on “learning by doing” from both specific projects and collective results
- Using plans to allow flexibility for site specific and progressive adaptations
- Recognition of important role modeling will play
- Iterative process to allow for use of data to verify and modify modeling as necessary and appropriate
Site Characterization

**USEPA**

- Injection zone of sufficient **areal extent, thickness, porosity, and permeability** to receive the total anticipated volume of the carbon dioxide stream;
- Confining zone(s) that is free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zone(s); and
- Possible additional zones that will impede vertical fluid movement

**Multi-Stakeholder**

- An injection zone of sufficient **areal extent, thickness, porosity, and permeability** to receive the total anticipated volume of the carbon dioxide stream;
- A confining zone(s) that is laterally continuous and free of known transecting, transmissive faults or fractures over an area sufficient to prevent the movement of fluids that endangers a USDW;
- **No requirement for additional zones**
Area of Review
(Project Envelope)

**USEPA**
- Delineation – computational modeling
- Prepare, maintain, and comply with a plan to delineate the area of review for a proposed GS project, periodically reevaluate the delineation, and perform corrective action

**Multi-Stakeholder**
- Delineation – computational modeling
- Prepare, maintain, and comply with a plan to delineate the area of review for a proposed GS project, reevaluate the delineation, and perform corrective action
Area of Review and Corrective Action Plan

**USEPA**
- Specify Delineation Method
- Fixed frequency for review (<10 years)
- Conditions that would warrant interim reevaluation
- How monitoring and operational data will be used to inform area of review reevaluation
- Corrective actions and timing

**Multi-Stakeholder**
- Specify Delineation Method
- Review data annually and revise to address material changes
- How monitoring and operational data will be used to inform area of review reevaluation
- Corrective actions and timing
Area of Review Delineation

- Predict, using computational modeling and available monitoring data, the projected lateral and vertical migration of the carbon dioxide plume and formation fluids in the subsurface from the commencement of injection activities until the plume movement ceases, pressure differentials sufficient to cause the movement of injected fluids or formation fluids into a USDW are no longer present, or after a fixed time period as determined by the Director.

Red = GSMSD recommendation
Area of Review
Corrective Action

- Identify all artificial penetrations
- Well construction, completion and plugging status
- Determine need for and perform corrective actions
  - Corrective actions all relate to providing adequate plugging and securing of wells within the area of review that penetrate the confining or injection zones
  - Corrective actions can be phased to address later wells not affected by early injection operations
Area of Review Reevaluation

**USEPA**
- Fixed review period at least every 10 years
- Also when monitoring and operational conditions warrant
- Repeat area of review delineation and corrective action process

**Multi-Stakeholder**
- Annual review of monitoring and operational data
- Determine whether any updates are warranted by material change in the monitoring and operational data or in the operator’s evaluation of the monitoring and operational data
- Repeat area of review steps
- Statement with annual report
Injection Pressure Limit

**USEPA**

- Do not exceed 90 percent of injection zone fracture pressure
- Do not initiate new fractures or propagate existing fractures in the injection zone
- Fracturing of injection zone permitted during stimulation

**Multi-Stakeholder**

- Director approves pressure
  - Consider well tests
  - Where appropriate use geomechanical or other studies to assess risks of tensile and shear failure
- Do not initiate or propagate of fractures in confining zone
- Do not cause non-transmissive faults transecting the confining zone to become transmissive
Other GS Permitting Requirements

**USEPA**

- Generally oriented toward performance standards
- Include some prescriptive requirements
  - Corrosion monitoring
  - Injection pressure limit 90%
  - Long string casing cement
  - Logging tool requirements
  - 10-year AoR review
  - 50-year post closure

**Multi-Stakeholder**

- Promoting more use of performance standards
- Responses to prescriptive requirements
  - Only where corrosive fluids
  - Avoid defeating containment
  - Prevent fluid movement
  - Identify measurement object
  - Iterative review and revision
  - Meet specific standards
Promoting Flexibility

**USEPA**

- *Confining zone* means a geologic formation, group of formations, or part of a formation stratigraphically overlying the injection zone that acts as a barrier to fluid movement.

- *Transmissive fault or fracture* means a fault or fracture that has sufficient permeability and vertical extent to allow fluids to move between formations.

**Multi-Stakeholder**

- *Confining zone* means a geological formation, group of formations, or part of a formation that is capable of limiting fluid movement from an injection zone.

- Transmissive fault or fracture means a fault or fracture that has sufficient permeability and vertical extent to allow fluids to move beyond a confining zone.
GS Permit Plans = Adaptability

- Area of review and corrective action plan
- Testing and monitoring plan
- Injection well plugging plan
- Post-injection site care and site closure plan
- Emergency and remedial response plan
GS Plan Review/Revision

**USEPA**

- Prepare, maintain and comply with plans

**Multi-Stakeholder**

- Annual review of monitoring and operational data against model

- Determine whether any plan updates are warranted by material change in the monitoring and operational data or in operator’s evaluation of the monitoring and operational data

- Make and summarize revisions

- Operator’s statement with annual report
Closure Care

**USEPA**
- Conduct monitoring for at least 50 years following the cessation of injection.
- Monitoring will continue until the GS project no longer poses endangerment to USDWs.
- Director may reduce or extend site closure period from 50-yr presumption.

**Multi-Stakeholder**
- Implement approved post-injection site care plan.
- Continue only until closure is approved.
- No fixed period required.
Closure Process

USEPA

- Demonstration, based on monitoring and other site-specific data, that
  - the carbon dioxide plume and pressure front have stabilized and
  - no additional monitoring is needed to assure that the geologic sequestration project does not pose an endangerment to USDWs

Multi-Stakeholder

- Demonstrate to the Director, based on monitoring, other site-specific data, and modeling that is reasonably consistent with site performance that no additional monitoring is needed to assure that the geologic sequestration project does not pose an endangerment to USDWs
Closure Standard

USEPA

- The carbon dioxide plume and pressure front have stabilized

Multi-Stakeholder

- Demonstrate, based on the current understanding of the site, including monitoring data and/or modeling, all of the following:
  - project footprint (CO2 plume and the area of elevated pressure);
  - detectable CO2 plume
  - no significant leakage
  - injected or displaced fluids are not expected to migrate to leakage pathway into a USDW
  - injection wells properly plugged
  - any remaining project monitoring wells are properly managed
The Iterative Review Process

- Site selection and characterization
- Area of review delineation with data and modeling
- Corrective action and plan development
- Monitoring
- Compare data with model
- Respond and revise plans

- No natural pathways (faults and fractures – transmissive)
- Search for natural and artificial pathways
- Identify and eliminate well pathways
- Injected plume performance not leak detection
- Confirm behavior of site and injected CO2 stream
Conclusions on EPA Proposal

- Excellent starting point for GS framework
- Need increased site and collective adaptability
- Multi-Stakeholder participants recommend improvements
- Concerns remained over potential gaps because protection of USDWs does not fully address all “leakage”
Background for EPA MR Rule

- Proposal published in the *Federal Register* on April 12, 2010 (at pages 18576-18606)
- Will be closely coordinated with the development of EPA’s final underground injection control (UIC) program rule for geologic sequestration (GS)
GHG Emissions Reporting for CO2 Injection

- Reporting for CO2 Injection for Geologic Sequestration
  - Total mass of CO2 received at facility annually
  - Total mass of CO2 injected annually
  - Obtain approval of monitoring, reporting and verification (MRV) plan
  - Total mass of CO2 emitted
  - Total mass of CO2 sequestered (stored) annually
  - Total mass of CO2 sequestered since GS initiated (GSMSD)

- Reporting for CO2 Injection for Enhanced Recovery (ER) of oil and natural gas
  - Total mass of CO2 received at facility annually
  - Total mass of CO2 injected annually
EPA GHG Reporting Proposal Addresses Perceived UIC Gaps

- Explicitly covers potential leakage (atmospheric emissions)
- Extends MRV requirements for “business as usual” ER operations not otherwise covered
  - EPA UIC proposal extended coverage to GS Class VI wells
  - GSMSD proposal would cover wells used for GS in oil and gas reservoirs that are not business as usual ER wells
  - Perceived gap in coverage for GS wells although most ER operations conduct extensive monitoring to retain CO2
- Provide official confirmation of CO2 volumes stored
- Covers off shore (outside UIC) as well as onshore (already UIC)
GS Operations Covered

- All GS for storage alone (primarily saline formations)
- ER operations choosing to be classified as GS facilities
  - Voluntarily participate to quantify CO2 storage amounts
  - Participate by submitting and obtaining approval of MRV plan
- Full GS facility reporting until injection ceases
- Continue MRV implementation and leakage reporting until closure approved
GS Facility

- A geologic sequestration (GS) facility includes all structures associated with injection located between the points of CO2 transfer onsite and the injection wells.

- GS with ER facility also includes all structures associated with production located between the production wells and the separators.

- GSMSD recommendation would expand definitions to specify all injection and monitoring wells, pipelines, compressors, valves and associated equipment and structures from receipt of CO2 to storage field through to injection wells and from production wells to separators.
Exclusions

- EPA would exclude research and development projects (but not demonstration projects) receiving federal funding

- GSMSD recommendation would exclude
  - All R&D projects injecting <25,000 tons of CO2 per year
  - Subsurface testing and characterization activities involving injection of <25,000 tons of CO2 total
  - Other subsurface testing and characterization activities upon demonstration
  - Reinjection of produced fluids with some CO2 in normal course of oil and gas exploration and production operations
MRV Plan Development

- Assess the risk of leakage of CO2 from various pathways
- Strategy for detecting and quantifying leakage
- Strategy for establishing pre-injection environmental baselines
- Monitoring plan
- Site-specific mass balance equations for reporting
  - can reflect specifics of CO2 stream(s) received for GS
  - can reflect production of oil and gas
  - can reflect operational cycles
- Use UIC MRV plans to satisfy GHG reporting MRV rules
GSMSD View of MRV Plan

- Purpose is primarily to confirm anticipated CO2 behavior and results at sites that have been carefully selected and characterized to meet the applicable siting requirements.

- Monitoring requirements should be tailored to each site and project and should reflect an understanding of what is already required and what is being implemented (even if not required).

- EPA should review whether an MRV plan is adequate to assure leakage is not occurring and to quantify whatever leakage does occur.

- UIC MRV plans may include all or most of what is needed, but that demonstration will need to be made explicitly by operators.
GSMSD Comments

- Need to meet the additional MRV plan requirements under this subpart does not necessarily require the use of atmospheric or soil monitoring methods.

- Most effective manner for protecting USDWs and for preventing leakage will be containment of injected CO2 stream and displaced formation fluids within injection and confining zones.

- Monitoring methods and procedures adopted under the UIC permit – along with additional monitoring procedures already being implemented – could be sufficient for MRV approval.

- This determination must be made on a case-by-case basis.
GSMSD Recommendations

- Monitoring plans must be site-specific
- Monitoring of potential leakage pathways would be conducted as necessary and feasible
- MRV plans should be reviewed annually against operational and monitoring data and would be reevaluated and revised as necessitated by material change either in the monitoring and operational data or in the evaluation of the monitoring and operational data
- EPA should recognize that the monitoring process likely would have at least two stages, with the latter stage being triggered by leakage
Leakage Response

Actions triggered by actual leakage would be:

(1) to determine and implement appropriate response pursuant to the UIC emergency and remedial response plan and

(2) to quantify that release for subpart RR emission reporting purposes.

Any additional monitoring and measurement steps and MRV plan revisions would be taken on a “fit for purpose” basis as necessary to locate and/or address the type of release.
Closure Standard

- The owner or operator of the facility must notify EPA that the CO2 plume and pressure front have stabilized and the GS facility has been closed in compliance with the facility’s Underground Injection Control permit.

- The owner or operator of the facility must notify EPA that the GS facility has been closed in compliance with the facility’s Underground Injection Control permit requirements.

- EPA shall approve discontinuation of reporting if the owner or operator has demonstrated, based on the current understanding of the site, including monitoring data and/or modeling, all of the following:
A. The estimated magnitude and extent of the project footprint (CO2 plume and the area of elevated pressure);
B. The estimated location of the detectable CO2 plume;
C. That there is no significant leakage of CO2;
D. That the injected or displaced fluids are not expected to migrate in the future in a manner likely to result in leakage;
E. That the injection wells at the site completed into or through the injection zone or confining zone are plugged and abandoned in accordance with applicable requirements; and
F. Any remaining project monitoring wells at the site are being used and managed pursuant to a plan approved by the applicable Underground Injection Control program Director.
Remaining Concerns

- EPA proposal prescriptive on metering locations and operation
- Reporting total CO2 injected for ER operations creates a number requiring qualification because of CO2 recycled in ER operations
- Annual reporting for ER operations can cause confusion because some years will have negative values without leakage
- Likewise, some years may imply greater mass of CO2 sequestered while field is pressured up for ER
- ER operations can vary significantly site-to-site
GSMSD Proposed Solutions

- Metering requirements should be performance based and reflect the realities of desirable field operations.
- Allow ER operations to provide optional additional data to reflect the injected mass of CO\textsubscript{2} that is injected annually.
- Have GS operations report the cumulative mass of CO\textsubscript{2} sequestered since the facility became subject to reporting requirements.
- GSMSD recommending comprehensive study of CO\textsubscript{2} use in ER operations.
For more information

- For information on the Multi-Stakeholder Discussions and Recommendations
  www.carbonsequestrationcouncil.org “Information”
  or
  www.CSCouncil.org “Information”

Recommendation Letters available under
“MSD Recommendations”
For other information, contact:

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