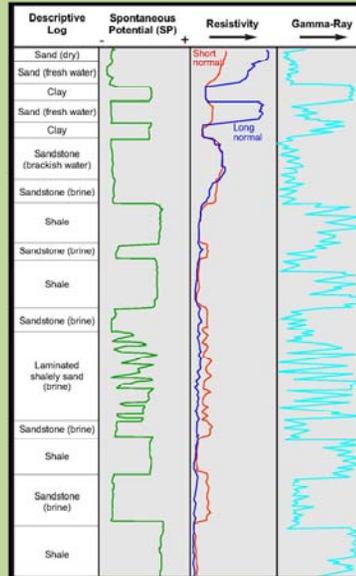




Underground Injection Control Geologic Sequestration Rule Training Workshop: Testing and Monitoring (40 CFR 146.90)

Purpose: Testing and Monitoring



- Provide information about site performance
- Verify injection proceeding as planned

Testing and monitoring are important components of the Class VI Program that ensure that USDWs are not endangered. Information generated through a rigorous testing and monitoring regime will provide information about site performance that can be compared against baseline information or previous monitoring results.

Monitoring data can demonstrate whether the GS project is performing as predicted. For example, these data can verify that the injectate is confined in the target formation; identify potential corrosion of well materials; signal the need for mechanical integrity adjustments; show changes in the formation fluid geochemistry; or verify the predicted direction of the carbon dioxide plume and *area of pressure front*.

Testing and Monitoring: UIC Program Director Review

- Testing and Monitoring Project Plan
 - With permit application
 - Periodic review throughout the operational phase
 - Approved changes to the plan constitute permit modification
- Results of monitoring and testing
 - Periodic review throughout operational and PISC phases

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The Testing and Monitoring Plan is one of the five plans required in the Class VI permit application to verify the project is operating as permitted and not endangering USDWs

The UIC Program Director will review the required site-specific Testing and Monitoring Plan submitted in the owners' or operators' Class VI injection well permit application. Any subsequent amendments to the Plan (triggered for any reason) will also be reviewed and approved by the UIC Program Director. Changes to the Testing and Monitoring Plan constitute a permit modification.

At a minimum of every five years, the owner or operator will perform periodic reviews of the submitted results of the monitoring and testing done at the injection site – both during the operational phase and during the post-injection phase. These periodic reviews are submitted to the Director.

Testing and Monitoring Plan

- Describes all planned logging, sampling, and testing activities
- UIC Program Director ensures that planned testing and monitoring:
 - Is site-specific
 - Uses most suitable technologies

40 CFR 146.90

Project
Plan

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The Class VI Testing and Monitoring Plan describes all the planned logging, sampling, and testing for the site.

Owners or operators of other well classes must submit monitoring plans; however, the Testing and Monitoring Plan required of Class VI owners or operators must incorporate all of the requirements at 40 CFR 146.90, and are envisioned to be more comprehensive.

The Testing and Monitoring Plan requirements allow for site specificity and selection of the most suitable monitoring technologies.

The UIC Program Director will review the Testing and Monitoring Plan to ensure that the planned testing meets the requirements in the Rule while appropriately accounting for site-specific circumstances (e.g., testing frequencies or access to areas in the extended AoR).

Sample Testing and Monitoring Plan Table of Contents

- a) Carbon Dioxide Stream Analysis
- b) Continuous Recording of Operational Parameters
- c) Corrosion Monitoring
- d) Ground Water Quality Monitoring
- e) External Mechanical Integrity Testing
- f) Pressure Fall-Off Testing
- g) Carbon Dioxide Plume and Pressure Front Tracking
- h) Surface Air Monitoring &/or Soil Gas Monitoring (if required)
- i) Additional Monitoring (if required)
- j) Periodic review of the Monitoring Plan
- k) Quality Assurance and Surveillance Plan

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This is a sample table of contents for a Testing and Monitoring Plan that the UIC Program Director may receive. It incorporates all the required elements of the plan that need to be reviewed.

Useful information such as facility information and site access to the extended AOR may be included, but the regulations require:

- a. Analysis of the carbon dioxide stream
- b. Continuous recording of operational parameters, e.g. injection pressures, annulus pressure, annulus fluid volume
- c. Corrosion monitoring
- d. Periodic ground water quality monitoring
- e. Annual demonstration of external Mechanical Integrity Testing
- f. Pressure fall-off test at least once every five years
- g. Carbon dioxide plume and pressure front tracking
- h. Surface air monitoring &/or soil gas monitoring (if required by the Director)
- i. Any additional monitoring determined necessary by the Director based on that project's site specific

In addition the regulations require:

- a. Periodic review of the monitoring plan
- b. Quality assurance and surveillance plan for all testing and monitoring requirements

Testing and Monitoring Plan Updates

- Possible triggers for Plan amendments:
 - Model revisions
 - Plume and pressure front tracking data
 - Evidence of leaching or changes in subsurface geochemistry
 - Well data

40 CFR 146.90(j)

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As described earlier, the GS rule requires the owner or operator to periodically review the testing and monitoring plan in the context of the most recent AoR reevaluation and monitoring and operational data. The plan should be amended if needed in order to continue to ensure USDW protection.

Considerations for determining the need to amend the Testing and Monitoring Plan include:

1. Any needed model revisions. If the most recent AoR reevaluation necessitated a revision to the computational model, EPA recommends that the plan be amended to reflect any changes in the prediction of plume and pressure front movement.
2. Any changes in the size or shape of the AoR or indications that the plume is moving differently than predicted -- this may indicate the need for additional monitoring locations, pressure monitoring in more locations, or more frequent/extensive geophysical surveys.
3. Evidence of leaching/mobilization of metals or organic constituents in the subsurface which may indicate a need to modify ground water monitoring parameters or analyses.
4. Well construction, mechanical integrity, and corrosion testing data that indicates a need to modify the well testing regime, e.g., by revising MITs or corrosion monitoring activities.

Review Results of Monitoring and Testing

- Operational parameters
 - Injection pressure, rate and volume,
 - Annulus pressure, fluid volume
- Corrosion monitoring
 - Performed quarterly
 - Use coupons, corrosion loops, other approved method

40 CFR 146.90(b)-(c)

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On an ongoing basis, the UIC Program Director will need to review the results of testing and monitoring, which will be provided in the required semi annual reports. The owner or operator will submit semi-annual reports containing monthly average maximum and minimum values for injection pressure, flow rate and volume, and annular pressure and volume. The owner or operator is also required to provide a description of any event that exceeds operating parameters for annulus pressure or injection pressure. The UIC Program Director may request further information on any anomalous values if he or she is not satisfied with the explanation provided.

The UIC Program Director will also review the results of corrosion monitoring of well materials. Corrosion monitoring is needed to detect deterioration of well components (e.g., casing, tubing and packer) that may cause loss of mechanical integrity. The owner or operator must monitor for corrosion using coupons, corrosion loops, or another method approved by the UIC Program Director, quarterly and will submit the results of corrosion monitoring semi-annually [40 CFR 146.91(a)].

Review Results of Monitoring and Testing (cont'd.)

- Ground water and geochemical monitoring
- Geophysical surveys
- External MITs
 - Method described in Plan and approved
- Pressure fall-off test date and results
 - At least once every 5 years
- Surface air/soil gas monitoring

40 CFR 146.90(a) & (d)-(h)

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The UIC Program Director will also need to review monitoring data of the ground water quality and geochemical changes above the confining zone(s). The owner or operator will submit ground water quality data for a number of parameters that will likely include, pH, specific conductivity, temperature, carbon dioxide (%), major cations and anions, total dissolved solids, metals, and hydrocarbons. The UIC Program Director will compare ground water quality analyses to those provided in the past and as part of the baseline site characterization information. A significant change in major anion concentrations, total dissolved solids, pH, or concentration of trace constituents may be indicative of a breach of the confining zone.

The Director must also review results of pressure front monitoring and carbon dioxide plume tracking, which may include geophysical surveys. This information is needed to verify the extent of the pressure front associated with the injection of carbon dioxide and can provide information useful in assessing confinement of the plume within the injection zone. The owner or operator must also submit the results with either pressure measurements of the first formation overlying the confining zone or indirect monitoring (i.e., geophysical surveys or carbon dioxide detection tools) above the injection zone. This information will show the extent of the carbon dioxide plume and confirm that it is not moving laterally or vertically in a manner contradictory to site understanding and the AoR delineation model.

The Director will need to review the results of annual external mechanical integrity tests to demonstrate that there is no fluid movement behind the casing. The owner or operator may have selected a radioactive tracer survey, temperature log, or noise log. Alternative external MITs may be allowed if the owner or operator described these in their Testing and Monitoring Plan and the Director approves their use.

A pressure fall-off test, including the results, must be submitted and will be reviewed by the UIC Program Director. The test must be performed at least once every 5 years, unless required more frequently by the Director. The proposed pressure fall-off test must be described in the Testing and Monitoring Plan, including the type of pressure fall-off test to be employed, associated quality assurance and surveillance measures, anticipated testing dates, and how data and test results will be recorded and reported.

Surface air monitoring and/or soil gas monitoring must also be reviewed if they are required by the UIC Program Director. The Director has discretion to determine whether this monitoring is necessary based on risk of endangerment to USDWs. Surface air and/or soil gas monitoring can serve as a warning that carbon dioxide has migrated vertically out of the injection formation and may have endangered a USDW. If the Director has reason to believe, (i.e., based on site-specific conditions,) that additional monitoring is needed to sufficiently assess progress of the GS project or protect against USDW endangerment, it is within his or her authority to request that this additional monitoring be included in the Testing and Monitoring Plan.

Monitoring Record Retention

- Data on nature and composition of injectate collected pursuant to 146.90 (a) must be retained by the owner or operator until 10 years after site closure
- Monitoring Data collected pursuant to 146.90 (b) – (i) must be retained by the owner or operator for 10 years after data collection

40 CFR 146.91(f)(2)-(3)

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Data collected under 40 CFR 146.82 for Class VI permit applications, and data collected on the nature and composition of the injected fluids must be retained by the owner or operator throughout the lifetime of the project and for 10 years following site closure. After this retention period, the records must be provided to the UIC Program Director, who will designate a location where the records will continue to be retained, and may require all records to be delivered to the Director at the conclusion of the retention period. The Director also has the authority to require the owner or operator to retain any records for longer than 10 years after site closure if he or she deems it necessary.

Monitoring Data collected must be retained by the owner or operator for 10 years after it is collected.

EPA recommends that the UIC Program Director confirm that submitted information is both accurate and complete.

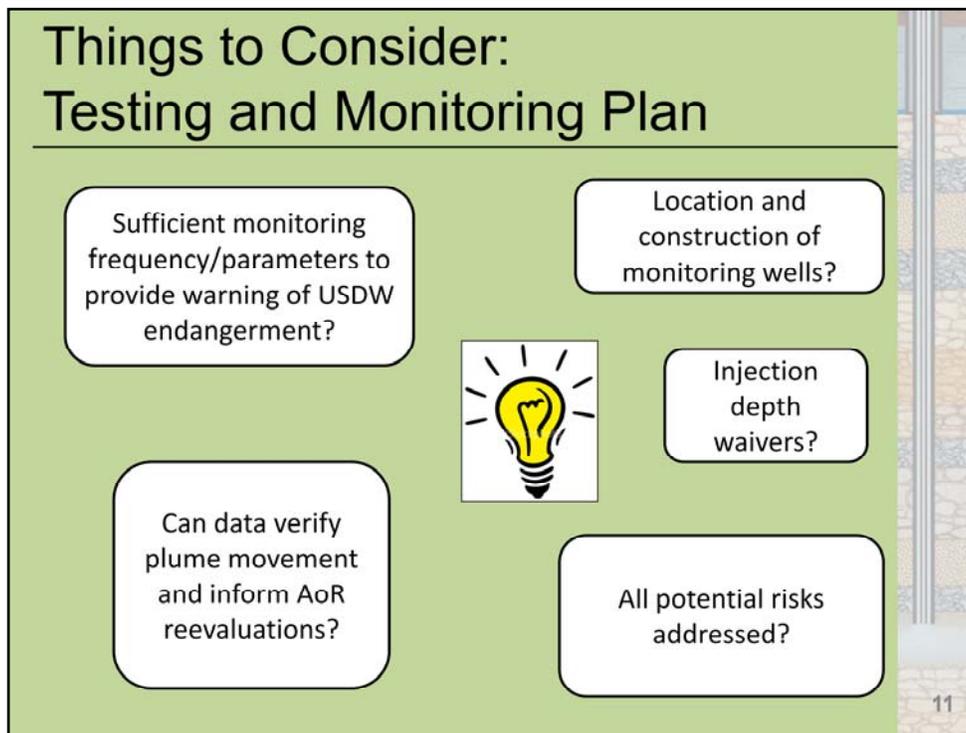
Some Class VI Program Testing and Monitoring Resources

- For more information on testing and monitoring, refer to:
 - Draft Final UIC Class VI Primacy Application and Implementation Manual
 - Draft UIC Class VI Testing and Monitoring Guidance (anticipated to be available for public comment in 2011)
 - EPA's Class VI Web site:
<http://water.epa.gov/type/groundwater/uic/class6/gclass6wells.cfm>

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Some Class VI Program testing and monitoring resources that are currently available are:

- The Draft UIC Program Class VI Primacy Application and Implementation Manual.
- The Draft UIC Program Class VI Testing and Monitoring Guidance.
- And EPA's Class VI website:
<http://water.epa.gov/type/groundwater/uic/class6/gclass6wells.cfm>.



Director's Evaluation of the Testing and Monitoring Plan

Note: a thorough evaluation should include reviewing final data and results of all planned tests described in the permit application.

Questions to consider:

- Is the planned testing and monitoring sufficiently robust (e.g., the proposed frequency, location, parameters) to provide early warning if USDWs are endangered?
- Does the proposed testing and monitoring plan address all potential risks identified in the site characterization process, e.g., all nearby USDWs or non-transmissive faults or fractures?
- Will the proposed plan provide the necessary data and model inputs on which to verify predictions of carbon dioxide plume movement and to reevaluate the AoR?
- Is monitoring appropriate to address the additional risk associated with injection into non-USDWs that are below/between USDWs if an injection depth waiver is sought?
- Are the planned monitoring wells located and constructed in a way to ensure they do not provide a conduit for fluid movement to USDWs?
- How could future activities (e.g., changes in land access) create impediments to testing and monitoring? What assurances would you want to see that the owner or operator can guarantee site access?

Open Discussion

We'll open the floor for questions, experience sharing, comments on the slides, etc.

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You are free to ask questions, provide examples of your experiences to date, or provide comments on the slides.

More Discussion Questions (if needed):

1. What extra detail or resolution in monitoring would you expect to see provided for areas of greater concern (potentially non-sealing faults, thinned beds, population centers, etc.)?
2. How would you expect applicants address the potential limits (e.g., detection limits, site suitability) of the monitoring technologies they plan to use?
3. If the extent of the AoR changes based on reevaluations/re-modeling, what should be done to ensure that any new hazards or special areas (e.g., state boundaries, historic landmarks) included in the new AoR are appropriately addressed?