UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SUBJECT: Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects – UIC Program Guidance (UICPG # 83)

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Introduction

This Guidance provides information for States and EPA Regions to consider when permitting pilot[1] projects designed to evaluate the technical issues associated with carbon dioxide (CO_2) injection as Class V experimental technology wells. Permitting such projects as Class V experimental technology wells—while maintaining the UIC Program's protective safeguards of underground sources of drinking water (USDWs) and public health—will assist future decision making and the development of a scientifically sound management framework for commercial-scale CO_2 injection projects, if needed, in the future. The purpose of this guidance is to assist UIC Program Directors[2] in evaluating these applications and setting appropriate Class V experimental technology well permit conditions for pilot CO_2 injection projects.

Geologic sequestration is the process of capturing CO_2 from an emission source (e.g., a power plant), transporting the CO_2, and injecting it into deep subsurface rock formations. Available evidence suggests that, worldwide, there is a likely technical potential storage capacity in geologic formations of perhaps 2,000 gigatons (Gts or a billion metric tons) of CO_2 *(IPCC Special Report: Carbon Dioxide Capture and Storage, Summary for Policymakers,* 2005). The potential for this mitigation technology is substantial, and "with appropriate site selection…, a monitoring program…, a regulatory system, and the appropriate use of remediation methods…, the local health, safety and environmental risks of geological storage would be comparable to risks of current activities. . . ." (*IPCC Special Report: Summary for Policymakers*, at page 11, 2005).

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[1] For the purposes of this Guidance, "pilot projects" include all CO_2 injection projects of an experimental nature that are designed to assess the efficacy of CO_2 injection for the purposes of long-term geologic sequestration (GS) that will come on-line in advance of a final decision by EPA on a management strategy for CO_2 injection for GS.
[2] "Director" means the Regional Administrator, the State Director or the Tribal Director as the context requires or an authorized representative. When there is no approved State or Tribal Program, and there is an EPA-administered Program, "Director" means the Regional Administrator. [40 CFR 144.3]

Planned GS Projects and EPA's Role

Research and development (R&D) on GS over the next several years will involve two phases of projects. CO2 GS wells constructed and operated as part of either phase may qualify as Class V "experimental technology" wells provided they meet the definition of that term found at 40 Code of Federal Regulations (CFR) 146.3 ("a technology which has not been proven feasible under the conditions in which it is being tested"). While injection of fluids, including CO_2 into the subsurface, e.g., for enhanced oil recovery (EOR) and enhanced gas recovery (EGR), is a long-standing practice, injection of CO_2 for GS is an experimental application of this existing technology.

The first phase – the "validation" phase – is slated to begin in the next year or two and will provide *in situ* tests of GS technology by injecting low volumes of CO_2. The validation phase projects include 25 field tests where CO_2 will be injected and its fate and transport will be monitored. Attachment 2 lists the Regional Partnerships, who have GS projects supported by the U.S. Department of Energy (DOE). To get up-to-date information on the progress being made by the DOE Regional Partnerships, please visit the web sites referenced in the attachment.

Deployment phase projects (the second phase) would follow, beginning around 2009. Drawing on the knowledge gained in the validation phase, these projects will involve higher volumes of CO_2. Full, commercial-scale deployment of GS technology is expected to commence around 2012, following the collection of sufficient data to inform a scientifically-sound management framework.

EPA anticipates that pilot projects will have a variety of objectives, including testing the effectiveness of various well materials and injection practices, assessing the usefulness of geophysical survey and monitoring techniques, testing failure scenarios, and/or validating models of the fate and transport of CO_2 in the subsurface. As they review permit applications, UIC Directors should keep in mind that a primary goal of the pilot projects is to collect data to support a scientifically-based framework for managing GS projects. Because the results of pilot experimental projects would benefit all future CO_2 injection operations, EPA strongly encourages gathering and sharing of data through the permitting process for pilot projects.

Several topics merit further evaluation through research and demonstration projects. These include the following topics:

- Potential impacts of CO_2 injection on ground water and USDWs;
- Potential impacts of CO_2 injection on human health and the environment;
- Integrity of CO_2 injection wells and other wells in the area of review;
- Fluid displacement and pressure impacts;
- Remediation technologies;
- Land surface deformation;
- Potential for large-scale CO_2 releases;
- Measurement, monitoring, and verification tools applicable to GS of CO_2;
- Potential impacts of CO_2 injection on geologic media (reservoir and seals); and
- Geochemical and geomechanical effects.

Research and demonstration projects focused on the above topics will provide useful information for developing a framework for commercial-scale CO_2 injection projects. To further this research goal, Directors should exercise reasonable and appropriate flexibility in evaluating permit applications and writing permit conditions that will allow well owners or operators[3] to achieve their project objectives.

While flexibility is important, the Safe Drinking Water Act (SDWA) focuses on the protection of USDWs and public health, and no project should be designed or operated in a way that endangers USDWs or the health of persons. If the project goal is to test failure scenarios, it is important that the project incorporate appropriate protections to safeguard USDWs and public health (e.g., proper casing and tubing materials, sufficient logging to ensure well integrity, and adequate monitoring to detect movement of CO_2). Well owners or operators should specify the objectives of the project and identify the data to be gathered; they should also demonstrate that the project meets the non-endangerment standard under the UIC Program (i.e., protection of USDWs).

An important goal of the pilot projects is to gather, evaluate, and share data on appropriate technologies and approaches for CO_2 injection to ultimately support national goals for addressing climate change.

Here are some important features of the CO_2 pilot phase:

- **Transitional nature of the pilot phase -** Over the next several years, EPA anticipates pilot CO_2 injection projects will be put into operation across the United States. This guidance and the Class V experimental technology well permits will bridge the gap between pilot and commercial-scale projects. EPA plans to evaluate options for permitting commercial-scale projects in the near future. Through this guidance, EPA encourages a case-by-case approach to permitting pilot projects to facilitate gathering the data needed to support decisions about future requirements for commercial-scale operations. On the basis of the data collected, the Agency may consider developing regulations tailored specifically for CO_2 injection. Development of such regulations would be a transparent and open process, and broad public and industry participation would be encouraged.

- **Scale of the pilot projects -** Initially, we expect the project permit applications to request authorization to inject very small volumes of CO_2 relative to commercial-scale projects. The relatively small volumes of CO_2 injected in these initial pilot projects should minimize any potential for adverse effects on USDWs and public health due to the movement or leakage of CO_2. As relevant siting, construction, and operational data from these smaller pilot projects is gathered and analyzed, EPA anticipates that Regional and State Directors will receive applications for larger

[3] "Owner or operator" means the owner or operator of any facility or activity subject to regulation under the UIC Program. [40 CFR 144.3]

operations, with the goal of furthering our understanding of how to mitigate any risks posed by commercial-scale operations.

- **Generation of data -** Permitting requirements for commercial-scale CO_2 injection projects will need to be based on sound science. The goal of the pilot projects is to generate data that will enhance our understanding of the fate and movement of, and risks associated with, injected CO_2. The knowledge and data gained from these pilot projects will allow the development of an effective approach to manage injection of CO_2, if needed, at the commercial scale.

- **Communication -** EPA encourages well owners or operators to share with the Director data collected throughout the siting, construction, and operation of the injection wells; operators may request protection of any confidential information that is submitted. In turn, Regional Direct Implementation Program Directors are expected to, and State Directors are encouraged to, share permit applications and other information related to permit issuance with EPA Headquarters.

Because of the complexities involved in successfully and safely achieving the goals of a pilot project, States and Regions may want to pool their resources and form multidisciplinary teams to process the pilot applications and collect/analyze the data. These teams could consist of:

- Geologists
- Reservoir Engineers
- Geophysicists
- Geochemists
- Hydrologists
- Statisticians
- Remote Sensing Scientists
- Modellers
- Atmospheric Scientists
- Biologists/Ecologists

Potential Impacts/Risk Associated with Geologic Sequestration

There may be risks to human health and safety from CCS technology implementation. Direct exposure to elevated levels of CO_2 can cause both chronic and acute health effects depending on the concentration and duration of exposure. Additionally, injected CO_2 and any impurities it may contain have the potential to endanger USDWs or adversely affect human health. Therefore, the injectate for pilot projects should be characterized prior to permit issuance. Furthermore, displacement of native fluids and chemical constituents, movement of possibly hazardous impurities in injected fluids, and potential leaching and mobilization of naturally occurring metals and minerals in the injection and confining formations associated with CO_2 injection may potentially endanger USDWs, if not properly managed. It is up to the Director to determine, on a case-by-case basis, whether endangerment of USDWs could occur as a result of the proposed injection. Authorities should make these determinations based on their knowledge of the specific geology in their States. In addition, we encourage permitting authorities to seek

UIC Program expertise, and request additional data on CO_2 injection from the owners or operators where appropriate and available.

Geologic Sequestration Authority Under the Safe Drinking Water Act

The UIC Program under the SDWA regulates injection of fluids, including solids, semi-solids, liquids, and gases (e.g., CO_2) to protect USDWs. The UIC regulations address the siting, construction, operation, and closure of wells that inject a wide variety of fluids, including those that are considered commodities or wastes. The natural gas exemption under the UIC regulations is not applicable to GS because, while CO_2 is a naturally occurring gas, the exclusion applies only to "natural gas as it is commonly defined" (e.g., gaseous hydrocarbons), and "not to other injections of matter in a gaseous state" (See House of Representatives Report 96-1348, reprinted in 1980 U.S. Code Congressional and Administrative News 6080).

The UIC Program defines five classes of underground injection wells; at least three of these are potential classifications for CO_2 injection:

- Class I wells are deep, technically sophisticated wells that dispose of waste below the lowermost USDW. The UIC regulations define three subcategories of Class I wells based on the fluids they inject, including wells used by generators of hazardous waste or hazardous waste management facilities, other industrial and municipal disposal wells, and radioactive waste disposal wells. Owners or operators of Class I hazardous waste disposal wells typically model the behavior of wastes in the subsurface to demonstrate long-term storage (i.e., 10,000 years). The large volumes of treated wastewater injected via Class I municipal disposal wells may provide some insight into the potential challenges presented by the large-scale injection of CO_2.

- Class II wells are used by the oil and gas industry for a variety of waste fluid disposal, enhanced recovery, and hydrocarbon storage needs. CO_2 is currently being injected for enhanced oil recovery (EOR) and enhanced gas recovery (EGR). Class II programs' decades of experience with injecting CO_2 and knowledge of oil and gas reservoirs are useful to those working on GS efforts.

- Class V experimental technology wells are intended to demonstrate unproven but promising technologies. EPA's rationale for allowing the use of Class V experimental technology wells is to encourage innovation. In other words, under EPA's regulations an injection well that is being used to demonstrate a developing technology may be subject to more flexible, yet fully protective, technical standards than those designed for commercially operating facilities. The designation as a Class V experimental technology well is generally considered only while the technology is experimental in nature. [See Attachment 1: *Appropriate Classification and Regulatory Treatment of Experimental Technologies (Ground Water Program Guidance No. 28)*; May 31, 1983 for additional information.]

EPA has determined that the Class V experimental technology well subclass provides the best mechanism for authorizing pilot GS projects. This guidance has been developed to assist UIC

Program Directors in permitting CO_2 injection wells as Class V experimental technology wells. Depending on the specific circumstances, for purposes of the pilot projects addressed in this guidance, permitting CO_2 injection into deep saline formations, depleted hydrocarbon reservoirs, or basalt formations through Class V experimental technology wells may be appropriate. In addition, depending on the particular facts, CO_2 injection wells of pilot GS projects that involve methane-depleted coalbeds, depleting natural CO_2 formations, and non-commercial gas fields (due to low BTU or productivity) may be appropriate for permitting as Class V experimental technology wells.

CO_2 injection for EOR or EGR operations is a long-established technology, and these wells may continue to be permitted as Class II wells, and Class II permitting requirements would apply. However, if the injection of CO_2 through those wells is not associated with the enhanced recovery of oil or gas, these operations would then be considered for re-permitting as Class V experimental technology wells. In other words, although CO_2 injection for EOR and EGR is a proven technology, CO_2 injection for long-term storage is still experimental and under development at this time. While there are similarities between CO_2 injection for the purposes of oil and gas extraction and for GS, there are important differences as well. For example, CO_2 injection for GS will eventually involve much greater volumes of $CO_{2,}$ which will be stored for very long periods of time. Owners or operators should be made aware that Class II EOR and EGR projects that transition to GS (either as pilot-phase Class V experimental projects or long-term commercial scale operations) may be subject to siting, well construction, or monitoring standards that could be different from those specified for a Class II well.

Additionally, wells with dual completions (e.g., where CO_2 is injected into one reservoir to produce oil and into another for GS) could be subject to permitting requirements under both Class II and Class V. Coordination will be essential where more than one permitting authority is involved (e.g., in States where Class II and Class V wells are overseen by different agencies); memoranda of agreement (MOAs) or memoranda of understanding (MOUs) between the authorities may be needed. Proactive communication about dual permitting requirements to owners or operators is important.

Purpose of this Guidance

This guidance applies to GS projects that are to be permitted as Class V experimental technology wells (based on available information from the pilot projects planned by DOE's Regional Partnerships and other GS projects developed for the purpose of increasing understanding of issues related to CO_2 injection). It provides suggested guidelines for permitting and operating near-term pilot GS projects prior to commercial-scale implementation of GS. This guidance is intended to address only pilot GS projects (i.e., the limited number of experimental projects anticipated to be brought online in advance of commercial-scale operations over the next several years). Owners or operators should be made aware of this, so that they may submit permit applications in a timely manner that allows them to meet pilot project goals.

Class V experimental technology permitting may be appropriate, as an interim measure, for CO_2 GS injection wells of a "pilot" or "demonstration" nature, regardless of the volumes injected. EPA's regulations at 40 CFR 146.3 state that, "experimental technology means a technology which has not been proven feasible under the conditions in which it is being tested." Such wells, which are anticipated to come on-line in the near term, will be drilled and operated to test various technologies and assumptions related to the safe and effective GS of CO_2. At some point in the future, EPA expects that the technology surrounding CO_2 injection for GS purposes will no longer be considered "experimental." By that time, EPA would expect to have made a decision on a management strategy to address CO_2 injection for commercial scale GS. Until then, EPA recommends that States or Regions review applications to construct and operate appropriately designed and operated "pilot" and "demonstration" CO_2 GS wells to determine whether they may be permitted as Class V experimental technology wells.

Proper operation of injection wells for GS projects is required under the SDWA to safeguard USDWs and protect public health. In addition, comprehensive oversight of CO_2 injection will build public confidence in an emerging technology that may ultimately be deployed at a large scale across the United States. Furthermore, a consistent oversight framework will allow Directors to permit pilot GS projects in an efficient and consistent manner, thus reducing unknowns and possible confusion among the pilot-project owners or operators, regulating entities, and the general public. EPA has begun evaluating and formulating a process for making decisions about commercial-scale GS projects and such a process may include specific regulatory options and technical requirements.

This guidance assumes that adequate permitting procedures and enforcement authority are in place at the State and EPA Regional levels. Although there are no Federal requirements written specifically for Class V experimental technology wells, there are applicable requirements for Class V wells generally (see 40 CFR 144.12, 144.24 to 144.27, and 40 CFR 144.79 - .89). Among other things, Class V well owners or operators, including owners or operators of Class V experimental technology wells, must submit information to the Director regarding the nature of their injection operations (40 CFR 144.26). This Guidance identifies additional information that the Director may decide to request. UIC Program Directors are encouraged to request additional information, as needed for writing adequate permits, (40 CFR 144.27) and to require that the owner or operator obtain a permit (40 CFR 144.12 (c)). Federal UIC permitting requirements at 40 CFR Parts 144 and 146 should be thoroughly considered and implemented. Permit issuers should follow the requirements for public participation (40 CFR Part 124), which are an important part of promoting public confidence in CO_2 injection and an open decision-making process.

Guidance for Setting Permit Requirements

Injection wells used for GS pilot projects may be permitted as Class V experimental technology wells if all applicable SDWA and UIC permitting requirements are met. For those pilot GS projects that inject CO_2 into depleting oil and gas reservoirs to enhance the recovery of oil or natural gas, permitting as Class II EOR and EGR wells may be appropriate, as long as oil and gas are being recovered (40 CFR 144.6(b)(2)).

Any Class V experimental permit issued to a pilot project should remain in effect for as long as necessary to cover the estimated timetable of the goals of the project. On an as-needed basis, Class V GS pilot project permits can be modified to extend the timetables or alter the goals of an evolving project, as long as State or Federal limits on permit duration are not exceeded.

The sections below present factors that Directors may wish to consider as they evaluate permit applications. Because the pilot projects will have a variety of experimental endpoints, the factors presented are not an exhaustive list, and may not necessarily be relevant to all projects.

Considerations for the Appropriateness of Injection Sites

The appropriateness of injection sites selected for pilot CO_2 injection will depend on the goals of the project. Possible experimental goals may include testing the effectiveness of various geologic formations in receiving or trapping CO_2 (e.g., short-term and long-term relations between trapping mechanisms, structural and stratigraphic considerations, and formation impacts such as solubility and mineralization); failure scenario testing; or testing or validating the accuracy of models in certain geologic conditions. In general, to prevent endangerment of USDWs, an adequate receiving and confining system for a CO_2 injection site should consist of:

- A receiving zone of sufficient depth,[4] areal extent, thickness, porosity, and permeability;

- A trapping mechanism that is free of major non-sealing faults;

- A confining system of sufficient regional thickness and competency; and

- A secondary containment system which could include buffer aquifers and/or thick, impermeable confining rock layers.

A site that is deemed to be appropriate for pilot CO_2 injection may not necessarily meet future requirements for commercial-scale operations. Therefore, owners or operators intending to eventually expand their pilot projects to commercial-scale operations should understand that additional UIC requirements may apply to the project after conversion to commercial operation.

Below are factors that EPA recommends Directors consider when assessing the appropriateness of proposed pilot CO_2 injection sites:

- Some leakage of CO_2 from the injection zone may occur, and in fact may be the experimental goal of certain research projects that are designed to test monitoring methods. However, in no case should leakage endanger USDWs or the health of persons.

- Potential reactions between injected CO_2 and the rocks and fluids in the injection zone may impact injectivity. Permeability may be reduced (by chemical precipitates blocking pore throats or coal swelling) or increased (if matrix minerals dissolve).

[4] To be stored above supercritical pressure, CO_2 should be injected at least 800 meters (2,625 feet) below the land surface.

Other types of reactions include gas release due to injectate-fluid reactions and selective adsorption and desorption reactions of the minerals in a reservoir.

- Pressures needed for injection of supercritical CO_2 (i.e., 1,070 psi/ 73.8 bars) may impact receiving and confining formations, e.g., they may exceed the fracture pressure of some formations.

- Thermal effects (e.g., thermal shock) can affect receiving formations and cement.

- Vertically transmissive geologic features (e.g., faults or fractures), which may facilitate the upward movement of CO_2, should be delineated. High-resolution surface and borehole geophysics may be useful for these delineations.

- If analytical or numerical models of CO_2 containment or transport are run, testing and validation of such models are necessary. (This model testing will provide valuable information on the selection of proper time frames for the modeling of commercial-scale projects. The modeled time frames may vary to reflect the project goals and objectives).

- The presence of underground voids and conduits, whether natural (e.g., karst) or artificial (e.g., mines and solution mining operations) may impact the appropriateness of a proposed injection site.

Considerations for the Area of Review

Studies to determine the area of review (AoR) and test modeling/monitoring of CO_2 movement can provide valuable data to guide commercial-scale efforts. Maps and data for the AoR study should incorporate accurate and reliable data to inform commercial-scale projects regarding movement of CO_2 and potential pathways for CO_2 in AoRs. While a fixed radius approach to determining the AoR may be appropriate for smaller pilot projects, it may not be appropriate for commercial-scale operations. Furthermore, given that the aim of pilot operations is to inform future decision-making, projects that test AoR study methods or identify which properties of CO_2 injection impact the size of the AoR are encouraged. The items below present aspects of the AoR that are relevant to CO_2 injection:

- It may be appropriate to base the size of the AoR on a zone of endangering pressure influence. CO_2 pressure buildup predictions may require adaptations of the pressure buildup equations used for aqueous fluid injection, along with considerations of some of the following:
  - Reservoir transmissibility
  - Injection rate
  - Duration of CO_2 injection
  - Total injection volume
  - Boundary conditions (e.g., pinchout or sealing fault)
  - Pressure-volume-temperature (PVT) behavior
  - Injection depth

- Relative permeability effects of CO_2 injection into a brine-filled reservoir.

- The maximum pressure buildup predicted at abandoned well locations may affect corrective action procedures.

- Given the buoyancy of CO_2, shallow wells in the buoyant plume area may also act as conduits for the upward migration of CO_2. (All wells and natural conduits within the AoR, regardless of depth, are potential conduits for CO_2 release). The volume of CO_2 injected, formation dip, and reservoir mobility can also impact the buoyant plume movement. Any data gathering or modeling that can help determine the upper limit and lateral extent of CO_2 plume movement in various geologic conditions should be encouraged.

- Certain geologic reservoirs that are potentially advantageous for CO_2 injection for geologic sequestration, such as depleted oil and gas reservoirs, are likely to be penetrated by active and abandoned wells. The Director may not have complete information on the location and condition of all abandoned wells. This has implications for successful CO_2 GS at a particular site.
  - The corrosive nature of CO_2 may have implications for selecting appropriate corrective action procedures. For example, cement with proven additives may be preferred
  - Older abandoned wells are likely to be constructed of traditional well materials and plugged with mud and cement, and may be susceptible to CO_2 contamination or corrosion
  - It may be useful to retain some "typical cement plugs" in a limited number of abandoned wells to collect data on cement performance

Considerations for Injection Well Construction

EPA expects that the objective of certain pilot projects may be to test the interactions between various well materials or cements and CO_2, and, therefore, wells for these projects should be constructed in accordance with the project goals. Construction materials, casing, and cement should be appropriate to the geologic environment, the properties of CO_2, and the anticipated life of the project. Owners or operators should describe the project goals, the planned construction procedures, and how USDWs will be protected from endangerment in their applications.

It is important that owners or operators be made aware that, if they intend to eventually convert a well used in a pilot project to a commercial-scale operation, the permit requirements for the commercial-scale project may be more stringent than those for the pilot project. This may impact decisions by owners or operators about construction materials or drilling methods.

Additional monitoring may be warranted if there are concerns or uncertainties about the pilot project, or where failure scenarios are being tested. Regional Directors are expected to, and State Directors should, encourage owners and operators to submit any data gathered or lessons learned about the effectiveness of certain materials or processes that can be of use in the development of standards and requirements for commercial-scale projects. Some of the considerations for well construction include:

- Requirements for surface and long-string casing, packer, tubing, cement, and other construction materials should take into account the properties of CO_2 and the subsurface formations. Where existing wells are being used, the Director should evaluate the adequacy of the existing well materials and cement. It is the owner or operator's responsibility to demonstrate that the existing well materials and cement are adequate.

- Directors may find owners and operators using new, non-traditional technologies (e.g., coil tubing, fiberglass liners, expandable casing, potassium cements, cathodic protection, laser drilling, and horizontal and slant injections) for the construction of CO_2 injection wells. It is the responsibility of the owner or operator to demonstrate how these technologies can ensure the protection of USDWs and public health from CO_2 injection activities.

- Non-traditional stimulation methods may be used for CO_2 injection projects. Depending on the project goals, some fracturing during stimulation may provide useful information. The Director should include appropriate permit conditions to ensure that fracturing of the confining zone does not endanger USDWs. It is important to note that fracturing may render the site unusable for long-term CO_2 storage, however. The owner or operator should describe the proposed stimulation program, and notify the Director when stimulation will be performed. Detailed geophysical and well logs should be maintained, and the Director should be informed of the results and be able to access and view any data collected.

Considerations for Injection Well Operation and Monitoring Program

Appropriate operating procedures for pilot projects may depend on the project goals. Owners or operators should demonstrate how the planned operating procedures meet the project goals and how USDWs will be protected. Monitoring parameters (e.g., injection pressure, volume, and rate) in the permit that help gather the data needed to understand the behavior and potential leakage of CO_2 and impacts of CO_2 injection on well materials and receiving formations are encouraged. Owners or operators should also be encouraged to share any data gathered or lessons learned during well operation with the Director. Appropriate emergency procedures (e.g., automatic shut-offs and contingency plans) should be incorporated into the operating permits.

The following are considerations relevant to developing operating and monitoring plans for CO_2 injection wells:

- CO_2 reacts with water to form carbonic acid, which is corrosive. Impurities in the CO_2 stream may also be a concern due to their potential impact on well materials or potential contamination of USDWs. Data on the occurrence of various chemical compounds in ground water can help identify these effects.

- Operating parameters for CO_2 injection include:
  - Maintaining records of:
    - Average and maximum injection rates and pressures
    - Daily and cumulative total injection volumes
  - The nature of the annulus fluid (e.g., its compatibility with CO_2)
  - The purity of injected CO_2 and the presence of any other pollutants (e.g., nitrogen oxides, sulfur oxides, and mercury)
  - The temperature of the injected CO_2 (for evaluation of thermal effects on well materials and integrity)
  - Limitations on injection pressure based on the fracture pressure, if fracturing is prohibited for the pilot project (Due to the reduced static fluid pressures expected from CO_2 injection, compensation for pump-induced injection pressures at the surface will be needed)

- Monitoring of pressure buildup and movement of fluids, both within and outside of the injection zone, is useful for understanding the movement and impacts of the CO_2 plume.

- If failure scenarios are being tested, appropriate protective contingencies are encouraged, such as additional monitoring, or the use of food-grade CO_2 (i.e., without impurities), because the behavior of co-constituents and their impacts are not well known.

- It may be the goal of certain pilot projects to monitor the movement of CO_2 out of the injection zone to understand the fate and transport of supercritical CO_2, or to compare actual movement to modeled predictions. The performance of sensitivity analyses to determine which operating parameters have the greatest effects on injectivity, containment, and storage capacity might be useful for future commercial-scale project designs and operations.

- The properties of CO_2 that differ from liquid injectate may affect mechanical integrity testing requirements and frequencies. Innovative alternatives (subject to approval by the Director), and expanded/custom logging suites that may be appropriate for various well types, geologic conditions, etc., are encouraged. For example:
  - Noise logs can detect gas flow, and other wireline logs, such as neutron-density logs and thermal decay time logs, may be useful in evaluating movement of CO_2 out of the injection zone
  - Temperature logs may detect temperature changes associated with degassing.
  - Oxygen Activation (OA) logs or other geophysical logging tools may be used to assess the movement of fluids behind the pipe due to poor cement bonding or cement deterioration and channeling effects
  - Cement evaluation logging, casing inspection logs, and coupon testing for corrosion can be used to evaluate well material integrity

- Monitoring plans that include collection of baseline ground water quality data will facilitate post-injection evaluations of the impacts of the injected CO_2 and other constituents.

Considerations for Site Closure

As with other injection operations, CO_2 injection projects must be closed and abandoned in a manner that is protective of USDWs (40 CFR 144.12). If projects are designed to test failure scenarios, CO_2 volumes must be low enough and protective measures must be put in place so that no endangerment of USDWs will result (40 CFR 144.12). In addition, most pilot projects are assumed to be small enough (low volumes and/or use of food-grade CO_2) that remediation would not be an issue. However, this should be confirmed by the Director.

For pilot projects, traditional financial assurance requirements for proper abandonment would generally apply. However, commercial-scale operations, including those that are converted from pilot projects, may have additional financial assurance requirements to ensure that issues arising from the larger CO_2 plumes, the unique nature of CO_2, and the long storage time frame are addressed.

Guidance Implementation

This document provides guidance to EPA Regional and State and Tribal Directors exercising responsibility under the SDWA concerning underground injection wells used for pilot CO_2 GS projects. This document also provides information to the public and those responsible for the oversight of pilot CO_2 injection projects, including Regional Carbon Sequestration Partnerships. It is designed to provide a timely and consistent framework to assist Regional and State Directors to permit pilot CO_2 injection wells. This guidance does not, however, substitute for the SDWA or EPA's UIC regulations; nor is it a regulation itself. Thus, it cannot change or impose legally binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. The use of non-mandatory words like "should," "could," "would," "may," "might," "encourage," "expect," and "can," in this guidance means solely that something is suggested or recommended, and not that it is legally required, or that the suggestion or recommendation imposes legally binding requirements, or that following the suggestion or recommendation necessarily creates an expectation of EPA approval.

Collaboration and communication between Headquarters, Regional UIC Program staff, and Primacy States is critical to achieving pilot GS project goals. Regional Directors are expected to, and State Directors are encouraged to, share permit applications and other information related to permit issuance with EPA Headquarters to assist with the development of a management framework for commercial-scale GS projects. The purpose of EPA Headquarters' involvement is to gather relevant and pertinent information for use in making decisions about commercial-scale CO_2 injection projects. Authority to access State UIC Program data is set forth in the Federal UIC regulations at 40 CFR 145.14(a) and can be used by EPA to request information from Program Directors. As with any other data gathering and management effort as part of UIC Program implementation, appropriate Confidential Business Information procedures must be followed (40 CFR 145.14(b)).

Given the regional differences across the United States and to foster national consistency in issuing Class V experimental technology well permits for GS pilot projects, DI Program Directors are encouraged to submit initial permit applications and proposed permits to Headquarters staff. Based on the anticipated number of applications, EPA expects that the submission to Headquarters staff of one permit application and proposed permit per EPA Region is likely to be sufficient. State Directors are strongly encouraged to enter into formal arrangements, such as MOAs, with their Regional Directors to share data related to pilot project permit applications and issuances.

Directors should make reasonable efforts to witness important field events throughout the life of the project. Directors should be notified in advance of drilling or completion activities so they have the opportunity to witness important events.

Directors who are responsible for traditional Class V shallow wells are encouraged to consult deep well experts (e.g., Class I or Class II well Directors) to ensure that appropriate standards and requirements are applied to the pilot CO_2 injection wells. EPA Headquarters can assist in identifying such experts.

This guidance supplements the guidance: *Appropriate Classification and Regulatory Treatment of Experimental Technologies (Ground Water Program Guidance No. 28)*; May 31, 1983. The specific guidance in that document continues to apply. (See Attachment 1)

<u>Contact Information for this Guidance</u>

For further information, or questions relating to this guidance, please contact Lee Whitehurst, EPA Office of Ground Water and Drinking Water, Prevention Branch, at 202-564-3896 or Whitehurst.Lee@epa.gov.

Contact information for UIC Program Directors can be found at:
http://www.epa.gov/safewater/uic/states.html

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Attachment 1

Appropriate Classification and Regulatory Treatment of Experimental Technologies (*Ground Water Program Guidance No. 28);* May 31, 1983

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

19,963

MAY 31 1983

MEMORANDUM

SUBJECT: Appropriate Classification and Regulatory Treatment of Experimental Technologies. Ground-Water Program Guidance No. 28 (GWPG # 28).

FROM: Victor J. Kimm
Director, Office of Drinking Water

TO: Water Division Directors, Regions I-X
Water Supply Branch Chiefs
UIC Representatives

BACKGROUND

On August 27, 1981 EPA promulgated technical amendments to the Underground Injection Control (UIC) Regulations, 40 C.F.R. Parts 144* and 146, under Part C of the Safe Drinking Water Act. These included an amendment to §146.05(e), adding "[i]njection wells used in experimental technologies" to the list of Class V wells. Without further explanation, it may be difficult to determine exactly what is an experimental technology for the purposes of this classification and what the regulatory treatment of that technology will be. This guidance is intended to clarify this issue.

DISCUSSION

According to the well classification system in the UIC regulations, Class V is intended to contain wells for which EPA needs further information or study to determine what regulatory treatment is appropriate. By placing "experimental technologies" in Class V, the regulations relieve any well that qualifies as experimental from the technical standards of the class into which it normally would fall. "Experimental technology" was defined in §146.03 of the February 3, 1982 UIC regulatory amendments (47 FR 4992) as "a technology which has not been proven feasible under the conditions in which it is being tested."

*/ These regulations were promulgated on May 19, 1980 (45 FR 33418) as Part 122 and amended on August 27, 1981 (46 FR 43156) and February 3, 1982 (47 FR 4992). Part 122 was subsequently reorganized and renumbered as Part 144 by technical amendment on April 1, 1983 (48 FR 1416).

Some of these wells would fall into Class V, according to EPA's well classification criteria, even if they were not experimental. Others fall in Class V solely because of their experimental status, and would otherwise fall under another well classification. With respect to this latter group, the regulations do not definitively state whether a technology, once proven feasible, "reverts" automatically to the class into which it originally would have fallen and is subject to the technical requirements for that class, or whether it is treated like all the other injection practices explicitly placed in Class V, i.e., remains in Class V until, if ever, appropriate standards are developed.

In view of the different types of experimental technologies that may exist, the Agency has determined, based on the reasoning set out below, that the appropriate interpretation is that some technologies will be considered to revert to their original class when the technology becomes commercially feasible, while others will remain in Class V pending any future regulation. This interpretation applies only to types of wells that are in Class V solely because they meet the general definition of an experimental technology. A type of well that meets any other definition of a Class V well will in all cases remain in that class until future regulations are developed, notwithstanding whether it also meets the general experimental technology definition.

As mentioned above, a type of injection practice placed in Class V because it is experimental usually would have fallen into some other class if it were not experimental. Some of these practices, though experimental, are sufficiently similar or analogous to the other wells contained in that other class that the standards of that class are still technologically appropriate to the new practice. This will usually be the case when, for example, the new practice is not truly a new technology but rather a variation on an existing technology.

The justification for treating this type of experimental well as Class V is that to encourage innovation, a developing technology arguably should not be burdened by strict technical standards designed for commercially operating facilities. This is especially justifiable since the wells are likely to be few in number and operate only intermittently, and under Class V would be bound by the general standard that they not endanger drinking water. This justification implies that the technology be considered Class V only while experimental. Once the technology proves feasible, the justification no longer applies.

Consequently, at any time that such injection wells are to begin commercial operation, EPA will no longer consider this type of injection to be in Class V. The injection practice would "revert" to the class into which it would have fallen originally had it not been experimental, and therefore would be subject to the technical requirements of that class.

Some experimental practices, however, will be "truly new technologies," so different from the other types of wells in the class into which they otherwise would have fallen that the standards of that other class are technologically inappropriate. Existing standards might be impossible to apply, or might fail to address the environmental hazards of the practice even when fully met. Some of these technologies have already been identified by EPA, and have been placed in Class V not by virtue of the general "experimental technology" category at issue here, but because they have been explicitly identified by regulation. Examples include the technologies listed in 40 CFR §146.05(e)(16): the in-situ mining of lignite, coal, tar sands, and oil shale.

For this type of well, treatment as Class V is justified not only by the aim of encouraging innovation, but also because it is undesirable to require compliance with technical standards that are inappropriate to the new technology. In addition, many of these new technologies are closely monitored by other federal agencies to collect information on and guard against threats to drinking water. Where these additional reasons for treatment as Class V exist, the wells should remain in Class V not only during the period they are experimental but even after commercial feasibility is demonstrated, until EPA determines appropriate treatment.

This is already the case for those experimental wells referred to above that have been explicitly placed in Class V by regulation. The same treatment should be afforded "truly new technologies" that EPA may have been unable to anticipate when promulgating the regulations. As a result, any experimental technology for which the standards of the class into which it would otherwise fall are technologically inappropriate will continue to be treated as Class V after it becomes commercially feasible. EPA may in the future determine other appropriate treatment for such wells, and may reclassify the wells at that time. An example of such a "truly new technology" is the slurry borehole mining of phosphate, which ordinarily would fall in Class III but which the Class III technical requirements do not fit.

Of course, all wells, whether in Class V or any other class, must comply with 40 CFR §144.12, the broad prohibition of any injection that may cause the violation of primary drinking water standards or otherwise adversely affect the health of persons. Even "truly new technologies," therefore, must comply with this basic standard. In addition, the long development period likely to to be associated with a "truly new technology" should allow EPA to develop technologically appropriate regulations for any such type of well, where appropriate, before substantial commercial production begins.

EPA will presume that any experimental technology can be appropriately regulated under the class into which it otherwise would have fallen, and will treat the operation as falling under that class once feasibility is demonstrated, unless the owner or operator demonstrates to EPA or the state agency administering an approved state program that the practice should be treated as a "truly new technology." EPA does not intend that treatment as a "truly new technology" be used as a vehicle for avoiding compliance with appropriate technical requirements. Such treatment will be reserved for cases where it clearly is technologically infeasible to apply the technical standards of the class into which it otherwise would fall, or where those standards clearly fail to provide protection for drinking water.

IMPLEMENTATION

Regional offices are instructed to use this guidance in operating UIC programs where EPA has primary enforcement responsibility. They are further instructed to make this guidance available to states working towards primacy and to advise the State Director that these interpretations represent EPA policy.

For further information on this guidance contact:

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Attachment 2

Summary Table of U.S. Department of Energy (DOE) Geologic Sequestration Regional Partnerships

Name and Web site	Area Covered	Contact Person(s)
Big Sky Regional Carbon Sequestration Partnership www.bigskyco2.org/	MT, WY, SD, ID, eastern WA, eastern OR	Susan Capalbo, Big Sky Principal Investigator, Office of VP for Research, Creativity and Technology. 406-994-5619, scapalbo@montana.edu Pamela Tomski, Big Sky Outreach Director, 202-822-6120 ext. 11, ptomski@erols.com
Midwest Geological Sequestration Consortium-Illinois Basin www.sequestration.org/	IL, KY, portions of IN	Link to all project staff: http://www.sequestration.org/staff.htm
Midwest Regional Carbon Sequestration Partnership http://198.87.0.58/default.aspx	MD, MI, OH, PA, WV, and portions of IN, KY	David Ball, balld@battelle.org
Plains CO2 Reduction Partnership www.undeerc.org/pcor/default.asp	ND, SD, MN, MT, WY, NE, IA, MO, WI, & Canadian provinces of Alberta, Manitoba, and Saskatchewan	Link to all project staff: http://www.undeerc.org/pcor/contactus.asp
Southeast Regional Carbon Sequestration Partnership www.secarbon.org/	GA, FL, NC, SC, VA, TN, AL, TN, MS, AR, LA, southeast TX	call 770.242.7712, or email sseb@sseb.org
Southwest Regional Partnership for Carbon Sequestration www.southwestcarbonpartnership.org/	NM, OK, KS, CO, UT, portions of TX, WY, AZ	Brian McPherson - brian@nmt.edu New Mexico Institute of Mining and Technology, 505.835.5834
West Coast Regional Carbon Sequestration Partnership www.westcarb.org/	AK, CA, NV, British Columbia, and portions of AZ, OR, and WA	Larry Myer, West Coast Regional Carbon Sequestration Partnership's technical director, Larry.Myer@ucop.edu.