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Jim Ruby, Executive Secretary
Environmental Quality Council

Cynthia C. Dougherty
Director
Office of Ground Water and Drinking Water
U. S. Environmental Protection Agency
1200 Pennsylvania Ave., NW.
Washington, DC 20460

Re: Proposed Rule for Geologic Sequestration, Docket EPA–HQ–OW–2008–0390

Dear Director Dougherty:

The organizations identified by the signatures at the end of this letter have been participating in multi-stakeholder group (MSG) discussions regarding the proposed rule for geologic sequestration (GS) of carbon dioxide under the Safe Drinking Water Act (SDWA), 73 Fed. Reg. 43491-541 (July 25, 2008). We have achieved consensus on specific rule language recommendations for all of the issues addressed in this letter.

As noted in previous letters, the consensus recommendations presented in this letter address only the objective of protecting underground sources of drinking water (USDWs) under the SDWA and do not address verification requirements for carbon credits.[1/]

1. Basalts, Coal Seams, Salt Caverns, and Shales

We agree that EPA has ample basis for adopting rules to regulate GS in hydrocarbon reservoirs and in deep saline formations under the SDWA. For these types of geologic formations, there is a widespread technical consensus on how to assess and manage risks, what data is needed to characterize sites, how to select sites, how to conduct injection operations, how to model the behavior of CO_2 in the reservoir, and how to monitor project performance.

There is less technical support on the ability to conduct GS in basalts, coal seams, salt caverns, and shales. As compared with deep saline formations and hydrocarbon reservoirs, the trapping/containment mechanisms of CO_2 and/or operational engineering involved in basalts, coal seams, salt caverns and shales may be significantly different and using identical regulatory language might not be appropriate. In fact, it is not known at this time whether GS (or even injection in some cases) can be done at commercial scale in each of these types of formations – GS efforts in these formations are still in the experimental stage. Wells in basalts, coal seams, salt caverns and shale formations

1/ The recommendations presented in this letter reflect a consensus among the signatories on the specific issues addressed; however, some of the signatories note that their participation should not be interpreted as an express or implied change in views on other issues that may be related to the issues addressed. In particular, CATF, EDF and NRDC reserve the respective views they have expressed regarding the appropriate legal authority for the rule, the definition of geologic sequestration, and necessary requirements needed if injection is to be allowed above the lowermost underground source of drinking water (*see* comments to EPA dated December 24, 2008 and letters dated March 17, 2009).

should be treated as experimental wells under Class V, recognizing that completing the process of research, development and demonstration likely will require initial full scale experimental projects in addition to pilot projects.

Keeping these wells under Class V would allow EPA and the states to gain enough experience to develop suitable permitting requirements for such wells and to tailor those requirements at both the pilot and commercial scales until the agencies are ready to regulate such wells under an appropriate class.

To implement this approach, sections 144.6(f), 144.80(f), 146.5(f) and the definition of sequestration in 146.81 should be revised. The proposed 144.15 provision that the construction, operation or maintenance of any non-experimental Class V GS well is prohibited should be retained, but only with the understanding that this prohibition is not intended to limit the size or scale of any experimental GS operation.

> "Class VI. Wells used for geologic sequestration but not including those wells used for geologic sequestration that are regulated under another Class. Wells used for geologic sequestration in basalts, coal seams, salt caverns or shales are regulated under Class V as experimental wells until such time as the Administrator establishes separate requirements by rule for the specific type of formation or determines, following public notice and opportunity for comment, that wells used for geologic sequestration of carbon dioxide streams into the specific type of formation should be regulated under another class."

2. <u>Non-interference principle</u>

EPA notes in the preamble (page 43506), "it is ... possible that multiple owners or operators will be injecting CO_2 into formations that are hydraulically connected and thus the elevated pressure zones may intersect or interfere with each other." We have agreed that this possibility should be addressed through a revision to the regulations. Until more comprehensive approaches to basin-scale management are developed and based on the proposed definition of "pressure front", we recommend the adoption of the following addition to §146.94:

> "(e) If an owner or operator obtains evidence that a pressure front associated with one geologic sequestration project intersects or will more likely than not intersect the pressure front or area of review associated with another project, the owner or operator obtaining such evidence must notify the Director. The Director shall notify the owner or operator of the other geologic sequestration project. If the Director determines that the pressure front associated with one project interferes or will more likely than not interfere with the ability of another project to comply with the terms of its permit(s), the Director may require the owners or operators of

> the interfering or potentially interfering projects to modify operations as necessary to mitigate or avoid such interference. Such modifications may also include modifications mutually agreed upon by the respective owners and operators and approved by the Director."

3. Transmissive faults or fractures

The proposed rule in §146.83(a)(2) requires a confining zone(s) that is free of transmissive faults or fractures, while §146.81 defines this term as "A fault or fracture that has sufficient permeability and vertical extent to allow fluids to move between formations". We recommend the following modification to the definition in §146.81(d) in order to avoid unduly restricting movement that is merely between formations:

> "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."

4. Definition of confining zone

The proposed definition of confining zone in §146.81(d) requires that the formation act as "a barrier" to fluid movement, which may be unnecessarily strict. The definition also fails to recognize that it is movement through and beyond the confining zone that needs to be limited. We recommend retaining the current UIC program definition of confining zone as preferable to the proposed definition with one revision to address the possibility that a confining zone for a particular project may be beneath rather than above the injection zone.

> "*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."

5. Area of review definition and basis

We also suggest that the second sentence of the proposed definition of GS project be transferred to the definition of area of review as recommended below. This language also reflects a change from "brine" to "formation fluids."

> "*Area of review* means the subsurface three-dimensional extent of the carbon dioxide stream plume and the associated pressure front, as well as the overlying formations, [any USDWs underlying an injection zone along

with any intervening formations,][2/] and the surface area above that delineated region."

In addition, we recommend that the second sentence included both in EPA's proposed definition of area of review and in section 146.84(a) be dropped from the definition and retained in section 146.84(a) but modified to read as follows:

> "(a) The area of review is based on computational modeling, as well as monitoring and other operational data, that account for the physical and chemical properties of all phases of the injected carbon dioxide stream."

The first sentence of section 146.84(a), which duplicates the definition of area of review, should be deleted from section 146.84(a) and retained in the definition with the modifications presented above.

6. <u>Area of review and corrective action requirements</u>

In proposed §144.55(a) the rule would require Class I, II (other than existing), III or VI permit applicants to identify the location "of all known wells within the injection well's area of review which penetrate the injection zone" or, in the case of Class II wells operating over the fracture pressure of the injection formation, "all known wells within the area of review penetrating formations affected by the increase in pressure."

Since injection in deep saline formations will result in an area of elevated pressure (above the original reservoir pressure) that will be larger than the CO_2 plume and could conceivably affect overlying or underlying formations, we have agreed that the requirement for Class II wells operating above the fracture pressure should also apply to Class VI wells. This would help prevent the unwanted migration of reservoir fluids from the injection zone as a result of the pressure increase. We therefore recommend that §144.55(a) be revised to read as follows, with revisions shown in blue:

> "(a) Coverage. Applicants for Class I, II, (other than existing), or III, injection well permits shall identify the location of all known wells within the injection well's area of review which penetrate the injection zone. In the case of Class II wells that operate over the fracture pressure of the injection formation, applicants shall also identify the location of all known wells within the area of review penetrating formations affected by the increase in pressure. For such wells which are improperly sealed, completed, or abandoned, the applicant shall also submit a plan consisting of such steps or modifications as are necessary to prevent movement of

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[2/] The bracketed language should be included to the extent that the regulations authorize GS above USDWs, an issue on which the signatories have expressed differing views in our respective comments on the proposed rule. *See* footnote 1 above.

fluid into underground sources of drinking water ("corrective action"). Where the plan is adequate, the Director shall incorporate it into the permit as a condition. Where the Director's review of an application indicates that the permittee's plan is inadequate (based on the factors in §146.07), the Director shall require the applicant to revise the plan, prescribe a plan for corrective action as a condition of the permit under paragraph (b) of this section, or deny the application. The Director may disregard the provisions of §146.06 (Area of Review) and §146.07 (Corrective Action) when reviewing an application to permit an existing Class II well. Applicants for permits for Class VI wells [or for wells in other classes that are used for geologic sequestration and do not meet the criteria for §144.6(b)(4)][3/] shall identify the location of all known wells within the area of review penetrating the injection zone and all known wells within the area of review which penetrate formations affected by the pressure front and shall perform corrective action as specified in §146.84."

7. **Well construction**

EPA's proposed §146.86(b)(3) would require the long string casing to be cemented by circulating cement to surface in one or more stages. Yet that may be hard to accomplish in some cases, such as very deep wells. There are also potential disadvantages of this approach with regard to the weight of the cement column and its relation to well integrity. Sealing this annulus also eliminates an approach for monitoring the integrity of the cement in that critical interval through the primary confining interval and above. We recommend that EPA not make this a mandatory requirement. The requirement should also recognize that there may be other technologies that could be as effective as cement and centralizers, which may not be feasible in some applications; furthermore, current research and development efforts are likely to yield additional technologies the use of which should not be foreclosed. Accordingly, we recommend the following language for §146.86(b)(3):

> "(3) At least one long string casing, using a sufficient number of centralizers, which at a minimum: must be sealed from within the injection zone upward through the overlying confining zone, and must provide adequate isolation of the injection zone and other intervals as necessary for protection of USDWs using cement and/or other isolation techniques. The Director may approve the use of packers or alternative isolation techniques, provided these are demonstrated to be equivalent to cement or more effective to provide adequate isolation and to protect USDWs."

[3/] The undersigned, except NRDC which does not support the Group's proposed bright line definition and language for §144.6(b)(4) (*see* MSG letter of Dec. 23, 2008), believe that this clause in brackets should be included.

8. Reevaluation of the Area of Review and Revision and Maintenance of Plans

Although the proposed §146.84(f) would require "reevaluation" of the AoR at a "minimum" fixed frequency of ten years or "when operational and monitoring conditions warrant," the specific language of §146.84 runs the risk that revisions will not be made on a timely basis. We recommend imposing a continual obligation on operators to assess whether the AoR itself, the AoR and corrective action plan and all other plans required by the regulations should be revised, requiring an annual certification stating that the owner or operator has reviewed the circumstances (including operating and monitoring data) during the preceding year to determine whether these circumstances warranted a revision of the AoR and any plans, and requiring that revisions be done when required by the Director as well as when the operator determines that conditions warrant. To accomplish this, it is useful to break down the concept of "reevaluation" into two ideas – "assessment" of the need to revise the AoR and all plans and the actual process of "revision." We believe that these suggestions will result in increased accuracy and reliability in the site performance data while avoiding work that is not warranted by the site data and site performance. Moreover, a continuous obligation to assess whether revisions are needed, when coupled with an annual certification requirement (see proposed §146.91(d) below) will create a clear accountability trail for both operator and Director in case of disputes. Given this annual certification process, we believe it is unnecessary to require a reevaluation on a fixed basis every 10 years in every case.

An annual certification requirement can also be used to enhance the ability of both Director and operators to keep track of which plans require updating and whether or not plans that ought to be updated have in fact been revised. Such a shared understanding is essential if there is to be the "ongoing dialogue" between regulators and operators that EPA anticipates. We considered the inclusion of an annual report as described in the preamble at 73 Fed. Reg. 43518, but concluded that the benefits of that particular report would be outweighed by the burden. The annual certification we are recommending would be much simpler. We recommend:

That §146.84(f) be revised to read as follows:

> "(f) (1) Notwithstanding the requirement in paragraph (2)(i) of this subsection to perform a reevaluation of the area of review at the frequency set forth in the area of review and corrective action plan, the owner or operator must also conduct the following whenever warranted by material change in the monitoring and operational data or in the evaluation of the monitoring and operational data by the owner or operator:
>
> "(i) reevaluate the area of review by performing all of the actions specified in paragraphs (c)(1) through (3) of this section to delineate the area of review and identify all wells that require corrective action;

"(ii) perform corrective action on wells requiring corrective action in the reevaluated area of review in the same manner specified in paragraph (d) of this section; and

"(iii) submit an amended area of review and corrective action plan or demonstrate to the Director through monitoring data and modeling results that no change to the area of review and corrective action plan is needed.

"(2) Except as provided in paragraph (3) of this subsection, the owner or operator shall also conduct a reevaluation by performing all of the actions specified in subparagraphs (1)(i) through (iii) of this subsection:

"(i) Within the time periods specified in the area of review and corrective action plan for conducting such a reevaluation of the area of review; or

"(ii) If an area of review evaluation or reevaluation has not been performed pursuant to §146.84(c) and (d) for the geologic sequestration project during the preceding ten (10) years, then within six months after the passage of that 10-year period.

"(3) The Director shall waive the requirement for a reevaluation pursuant to either §146.84(f)(2)(i) or (ii) if the owner or operator demonstrates to the Director through monitoring and operational data and modeling results, such as those reviewed annually pursuant to section 146.95, that such a reevaluation is not warranted by material change."

In addition, we recommend the following new §146.95:

"146.95 Plan Maintenance and Update

"(a) Owners or operators must submit an annual statement, signed by an appropriate company official, confirming that the company has:

"(i) reviewed the monitoring and operational data that are relevant to a decision on whether to reevaluate the area of review and the monitoring and operational data that are relevant to a decision on whether to update a plan identified in §146.82(p) or (u) through (x) or the quality assurance plan for all testing and monitoring requirements; and

"(ii) determined whether any updates were warranted by material change in the monitoring and operational data or in the evaluation of the monitoring and operational data by the owner or operator.

> "(b) Owners or operators must submit either the updated plan or a summary of the modifications for each plan for which an update was determined to be warranted pursuant to subsection (a) of this section. The Director may require submission of copies of any updated plans and/or additional information regarding whether or not updates of any particular plans are warranted.
>
> "(c) The Director may require the revision of any required plan whenever the Director determines that such a revision is necessary to comply with the requirements of this subchapter."

9. Emergency Response

With respect to the emergency and remedial response section, we propose two changes – change §146.94(b)(4) to read:

> "Implement the emergency and remedial response plan approved by the Director, and keep the Director apprized of the implementation."

and §146.94(d) to read:

> "The owner or operator must notify the Director and obtain his approval prior to conducting any well workover or other remediation measures not listed in the emergency and remedial response plan."

It should be noted that the language chosen here for §146.94(d) relates specifically to remediation measures and not to emergency responses, which should not be delayed to seek approval when immediate response action is necessary. Every effort should be taken to ensure that emergency responses are comprehensively addressed in the plan, including appropriate notification provisions and timeframes, but emergency responses should not be delayed when awaiting approvals could impair the effectiveness of the response.

Conclusion

The undersigned submit these recommendations with the request that the recommendations be considered for inclusion in a potential notice of data availability and as a basis for revising the respective provisions in the final rule. In addition, we are committed to continuing our discussions with an objective of developing additional specific recommendations for improvement of a final rule that could be adopted by no later than your scheduled date in late 2010 or early 2011.

Sincerely,

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Recommendation on
Requirements for Geologic Sequestration in Oil and Gas Reservoirs
where Class II(b)(4) Requirements Are Not Met
[Revised to incorporate additional MSD recommendations]
October 9, 2009

§ 146.25 Geologic sequestration in oil or gas reservoirs for wells classified under 146.6(b)(5).

Except as otherwise provided in this section, injection wells used for geologic sequestration and meeting the classification criteria of 40 CFR §146.5(b)(5) shall be subject to the following requirements in lieu of the requirements of 40 CFR §146.22-24:

(a) Minimum Criteria for Siting - The owner or operator must have demonstrated to the satisfaction of the Director that existing wells are, and new wells will be, sited in areas with a suitable geologic system. The geologic system must be comprised of:

(1) An injection zone of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream;

(2) A confining zone(s) that is laterally continuous and free of known transmissive faults or fractures over an area sufficient to prevent the movement of fluids that endangers an USDW;

(b) Area of Review and Corrective Action

(1) The area of review is based on computational modeling, as well as monitoring and other operational data, that considers the volumes and the physical and chemical properties of all phases of the injected carbon dioxide stream.

(2) The owner or operator must prepare, maintain, and comply with a plan to delineate the area of review for a proposed geologic sequestration project under this section, reevaluate the delineation, and perform corrective action that meets the requirements of this section in a manner and at a frequency acceptable to the Director. As a part of the permit application or revision, the owner or operator must submit an area of review and corrective action plan that includes the following information:

(i) The method for delineating the area of review that meets the requirements of §146.25(b)(1) and (3), including the model to be used, assumptions that will be made, and the site characterization and other data including any existing monitoring data on which the model will be based;

(ii) A description of:

(A) How monitoring and operational data (e.g., injection rate and pressure) will be used to inform an area of review reevaluation; and

(B) How corrective action will be conducted to meet the requirements of §146.25(b)(4), including what corrective action will be performed prior to injection and what, if any, portions of the area of review will have corrective action addressed on a phased basis and how the phasing will be determined; how corrective action will be adjusted if there are changes in the area of review; and how site access will be assured for future corrective action.

(3) The owner or operator must perform the following actions to delineate the area of review and identify all wells that require corrective action:

(i) Project, 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 carbon dioxide injection activities until the plume movement ceases or pressure differentials sufficient to cause the movement of injected fluids or formation fluids into an USDW are no longer present. The model must:

(A) Be based on detailed geologic data collected to characterize the injection and confining zones, available monitoring data, and on anticipated operating data, including injection pressures, rates and total volumes over the duration of injection;

(B) Take into account relevant geologic heterogeneities, and data quality, and their possible impact on model projections;

(C) Consider potential migration through faults, fractures, and artificial penetrations and beyond lateral spill points; and

(D) Consider the physical and chemical properties of all injected and formation fluids in the subsurface.

(ii) Using methods approved by the Director, identify all known or reasonably discoverable artificial penetrations into the confining zone, including active, inactive and abandoned wells and underground mines, in the area of review that may penetrate the confining zone. Provide a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information or evaluations the Director may require; and

(iii) Determine which abandoned wells identified in §146.25(b)(3)(ii) have been plugged in a manner that prevents the movement of carbon dioxide or displaced formation fluids that may endanger USDWs;

(iv) Determine which active and inactive wells identified in §146.25(b)(3)(ii) have been completed in a manner that prevents the movement of carbon dioxide or displaced formation fluids that may endanger USDWs.

(4) The owner or operator must perform corrective action using materials suitable for use with the carbon dioxide stream on all wells identified in §146.25(b)(3)(ii) that are determined to need corrective action in accordance with 146.25(b)(2)(ii)(B).

(5) (a) Notwithstanding the requirement in subparagraph (2)(i) of this paragraph to perform a reevaluation of the area of review at the frequency set forth in the area of review and corrective action plan, the owner or operator must also conduct the following whenever warranted by material change in the monitoring and operational data or in the evaluation of the monitoring and operational data by the owner or operator:

"(i) reevaluate the area of review by performing all of the actions specified in subparagraphs (3)(i) through (iii) of this subsection to delineate the area of review and identify all wells that require corrective action;

"(ii) perform corrective action on wells requiring corrective action in the reevaluated area of review in the same manner specified in paragraph (4) of this subsection; and

"(iii) submit an amended area of review and corrective action plan or demonstrate to the Director through monitoring data and modeling results that no change to the area of review and corrective action plan is needed.

"(b) Except as provided in subparagraph (c) of this subsection, the owner or operator shall also conduct a reevaluation by performing all of the actions specified in clauses (i)(A) through (C) of this subsection:

"(i) Within the time periods specified in the area of review and corrective action plan for conducting such a reevaluation of the area of review; or

"(ii) If an area of review evaluation or reevaluation has not been performed pursuant to §146.84(c) and (d) for the geologic sequestration project during the preceding ten (10) years, then within six months after the passage of that 10-year period.

"(c) The Director shall waive the requirement for a reevaluation pursuant to either §146.25(5)(b)(i) or (ii) if the owner or operator demonstrates to the Director through monitoring and operational data and modeling results, such as those reviewed annually pursuant to section 146.25(m), that such a reevaluation is not warranted by material change."

(6) The emergency and remedial response plan (as required by §146.25(l)) and a demonstration of financial responsibility (as required by §146.25(c)) must account for the entire area of review (as modified) regardless of whether or not corrective action in the area of review is phased.

(c) Financial Assurance

(1) The owner or operator must demonstrate the adequacy of existing financial responsibility or provide and maintain financial responsibility and resources for: corrective action (that meets the requirements of § 146.25 (b)), injection well plugging (that meets the requirements

of § 146.25(j)), and post-injection site care and site closure (that meets the requirements of § 146.25 (k) and emergency and remedial response (that meets the requirements of § 146.25(l) in a manner prescribed by the Director until:

(i) The Director receives a well plugging report identified in §146.25(j)(4) or completion of the post-injection site care and site closure plan as appropriate; and

(ii) The Director determines that the site has reached the end of the post-injection site care period.

(2) The owner or operator must provide to the Director, at a frequency determined by the Director, but no more frequently than annually, written updates or adjustments up or down to the cost estimate to account for any changes to the area of review and corrective action plan (§146. 25(b)(2)), the injection well plugging plan (§146. 25(j)(2)), and the post-injection site care and site closure plan (§146. 25(k)(1)) and for actions taken or changes in conditions that reduce the estimated costs of such plans.

(3) The owner or operator must notify the Director of adverse financial conditions that may affect the ability to carry out injection well plugging and post-injection site care and site closure.

(4) The owner or operator must provide an adjustment of the cost estimate to the Director if the Director has reason to believe that the most recent demonstration is no longer adequate to cover the cost of injection well plugging (as required by §146. 25(j)) and post-injection site care and site closure (as required by §146. 25(k)).

(5) In conjunction with the submission under (c)(2) and (m), the owner or operator may request, and the Director may approve, an adjustment to the financial responsibility required by (c)(1) to account for actions or changes in conditions that have reduced the estimated costs of the plans referenced in (c)(1).

(d) <u>Well Construction Requirements</u>

(1) Applicability

(i) the requirements of this subsection apply to newly drilled injection wells and any existing well except to the extent the well is exempted pursuant to (ii)

(ii) the Director may exempt an existing well from any of the provisions of (d)(2) if:

(A) the well meets the construction requirements of 40 CFR 146.22; and

(B) the Director determines, after evaluating the significance of any logs, surveys and tests which may be available for the well and the extent to which the well does or does not meet the provisions of (d)(2), that requiring the well to satisfy a particular provision is not necessary to avoid endangerment of an USDW.

(2) Construction Requirements for newly-drilled injection wells.

(i) General. The owner or operator must ensure that newly-drilled injection wells are constructed and completed to:

(A) Prevent the movement of fluids into any unauthorized zones or an USDW as a result of the planned injection operation;

(B) Permit the use of appropriate testing devices and workover tools; and

(C) Permit continuous monitoring of the annulus space between the injection tubing and long string casing.

(ii) Casing and cement or other materials used in the construction of each well to which this section is applicable must have sufficient structural strength and be designed for the life of the well. All well materials must be compatible with fluids with which the materials may be expected to come into contact and meet or exceed test standards or practices developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the Director. The casing and cementing program must be designed to prevent the movement of fluids that endangers USDWs. In order to allow the Director to evaluate and approve casing and cementing requirements, the owner or operator must provide the following information:

(A) Depth to the injection zone;

(B) Hole size;

(C) Size and grade of all casing strings (wall thickness, external diameter, nominal weight, length, joint specification and construction material);

(D) Predicted corrosive characteristics of the combined carbon dioxide stream and formation fluids;

(E) Down-hole temperatures and pressures;

(F) Lithology of injection and confining zones;

(G) Type or grade of cement and additives; and

(H) Quantity, chemical composition, and temperature of the carbon dioxide stream.

(iii) Casing must extend through the base of the lowermost USDW above the injection zone and be cemented to the surface. Cement may be staged. Surface casing need not extend through the base of the lowermost USDW above the injection zone if a combination of cement around the surface casing and intermediate or long-string casing achieves continuous cement through the base of the lowermost USDW above the injection zone.

(iv) At least one long string casing, using a sufficient number of centralizers, which at a minimum must be sealed from within the injection zone upward through the overlying confining zone, and must provide adequate isolation of the injection zone and other intervals as necessary for protection of USDWs using cement and/or other isolation techniques. The Director may approve the use of packers or alternative isolation techniques, provided these are demonstrated to be equivalent to cement or more effective to provide adequate isolation and to protect USDWs.

(v) Cement and cement additives must be suitable for use with the carbon dioxide stream and formation fluids and of sufficient quality and quantity to maintain integrity over the life the well. The integrity and location of the cement shall be verified using technology capable of evaluating cement quality and identifying the location of channels to ensure that USDWs are not endangered.

(vi) Tubing and packer.

(A) Owners and operators must inject fluids through tubing with a packer set at a depth opposite a cemented interval at the location approved by the Director.

(B) In order to allow the Director to evaluate and approve tubing and packer requirements, the owner or operator must provide the following information::

(1) Depth of setting and the depth of the injection zone;

(2) Composition of the carbon dioxide stream.

(3) Maximum proposed injection temperature and pressure;

(4) Maximum proposed annular pressure;

(5) Maximum proposed injection rate (intermittent or continuous) and volume of the carbon dioxide stream;

(6) Size of casing; and

(7) Tubing tensile, burst, and collapse strengths.

(e) <u>Logging, sampling, and testing prior to new well operation</u> – The following requirements apply only to newly-drilled wells.

(1) During the drilling and construction of an injection well, the owner or operator must run appropriate logs, surveys and tests to determine or verify the depth, thickness, porosity, permeability, and lithology of, and the salinity of any formation fluids in, all relevant geologic formations to evaluate conformance with applicable injection well construction requirements and to establish accurate baseline data against which future measurements may be compared. The owner or operator must submit to the Director a descriptive report prepared by a knowledgeable log analyst that includes an interpretation of the results of such logs and tests. The Director may approve such additional or alternative logs and tests as may be requested by the owner or operator after taking into account the availability of similar data in the area of the drilling site, the construction plan, and the need for additional information as the construction of the well progresses and these may include the following:

(i) Deviation checks during drilling must be at sufficiently frequent intervals to determine the location of the borehole;

(ii) In conjunction with installation of the surface casing:

(A) Resistivity, gamma ray, and caliper logs before the casing is installed; and

(B) Cement evaluation log(s) after the casing is set and cemented and/or map(s) to evaluate cement quality with sufficient radial resolution to identify channels or missing cement that would prevent compliance with §146.25(d)(2).

(iii) Before and upon installation of the long string casing:

(A) Resistivity, spontaneous potential, porosity, caliper, gamma ray and any other logs the Director requires based on site specific conditions and risk-based factors for the given geology before the casing is installed; and

(B) Cement evaluation log(s) after the casing is set and cemented and/or map(s) to evaluate cement quality with sufficient radial resolution to identify channels or missing cement that would prevent compliance with §146.25(d)(2).

(iv) Test(s) designed to demonstrate the internal and external mechanical integrity of injection wells, which may include one or more of the following:

(A) A pressure test with liquid or gas;

(B) Oxygen-activation logging;

(C) Tracer surveys;

(D) A temperature or noise log; or

(E) A casing inspection log.

(v)Any alternative methods that provide reliable, equivalent or better information and that are required of and/or approved of by the Director.

(2) The owner or operator must submit to the Director a report describing whole cores or sidewall cores representative of the injection zone and confining system and formation fluid samples from the injection zone(s). The Director may accept data from cores and fluid samples from nearby wells if the owner or operator can demonstrate that such data are representative of conditions in the wellbore.

(3) Prior to injection well operation, the owner or operator must record the formation temperature, formation fluid pH and conductivity, and reservoir pressure of the injection zone(s).

(4) At any time prior to injection well operation, the owner or operator must determine fracture pressures of the injection and confining zones and conduct tests to verify hydrogeologic and geomechanical characteristics of the injection zone as necessary to satisfy the requirements of (f)(1).

(5) The owner or operator must provide the Director with the opportunity to witness all logging and testing required by this subpart. The owner or operator must submit a schedule of such activities to the Director upon spudding the well and submit any changes to the schedule 48 hours prior to the scheduled test.

(f) Injection well operating requirements

(1) The owner or operator must comply with a maximum injection pressure limit approved by the Director and specified in the permit. In approving a maximum injection pressure limit, the Director shall consider the results of well tests and, where appropriate, geomechanical or other studies that assess the risks of tensile failure and shear failure. The Director shall approve limits that, with a reasonable degree of certainty, will avoid initiation or propagation of fractures in the confining zone or cause otherwise non-transmissive faults transecting the confining zone to become transmissive. In no case may injection pressure cause movement of injection or formation fluids in a manner prohibited by 40 CFR §144.12(a).

(2) Injection of the carbon dioxide stream into any annulus or between the outermost casing protecting USDWs and the well bore is prohibited.

(3) The owner or operator must fill the annulus between the tubing and the long string casing with a corrosion inhibiting fluid approved by the Director and must maintain a positive pressure on the annulus.

(4) The owner or operator must install and use continuous recording devices to monitor: the injection pressure and the rate, volume, and temperature of the carbon dioxide stream. The owner or operator must regularly monitor the pressure on the annulus between the tubing and the long string casing. The owner or operator must install, test and use alarms and

automatic shut-off systems, designed to alert the operator and shut-in the well when operating parameters such as injection rate, injection pressure, or other parameters approved by the Director diverge beyond ranges and/or gradients specified in the permit.

(5) Mechanical integrity

(i) A well has mechanical integrity if:

(A) There is no significant leak in the casing, tubing or packer; and

(B) There is no significant fluid movement into an USDW through channels adjacent to the injection well bore.

(ii) To evaluate the absence of significant leaks under this subsection, owners or operators must, following an initial annulus pressure test, continuously monitor and record at least daily injection pressure, rate, injected volumes, and pressure on the annulus between tubing and long stem casing and annulus fluid volume as specified in §146.25(g)(2)(ii);

(iii) At least once per year, the owner or operator must confirm the absence of significant fluid movement under paragraph (5)(i)(B) of this section using a method acceptable to the Director (e.g. including diagnostic surveys such as oxygen-activation logging or temperature or noise logs).

(iv) The Director may require any other test to evaluate mechanical integrity under paragraph (i)(A) or (i)(B) of this section. Also, the Director may allow the use of a test to demonstrate mechanical integrity other than those listed above with the written approval of the Administrator. To obtain approval, the Director must submit a written request to the Administrator, which must set forth the proposed test and all technical data supporting its use. The Administrator must approve the request if it will reliably demonstrate the mechanical integrity of wells for which its use is proposed. Any alternate method approved by the Administrator will be published in the Federal Register and may be used in all States in accordance with applicable State law unless its use is restricted at the time of approval by the Administrator.

(v) In conducting and evaluating the tests enumerated in this section or others to be allowed by the Director, the owner or operator and the Director must apply methods and standards generally accepted in the industry. When the owner or operator reports the results of mechanical integrity tests to the Director, he/she shall include a description of the test(s) and the method(s) used. In making his/her evaluation, the Director must review monitoring and other test data submitted since the previous evaluation.

(vi) The Director may require additional or alternative tests if the results presented by the owner or operator under paragraph (d) of this section are not satisfactory to the Director to demonstrate that there is no significant leak in the casing, tubing or packer or significant movement of fluid into or between USDWs resulting from the injection activity as stated in paragraphs (i)(A) and (i)(B) of this section.

(g) Testing and Monitoring

(1) Based on a site-specific assessment of the potential for fluid movement from the injection well or injection zone, and on the potential value of monitoring wells to detect such movement, the owner or operator of a well must prepare, maintain, and comply with a testing and monitoring plan to verify that the geologic sequestration project is operating as permitted and is not endangering USDWs. The testing and monitoring plan must be submitted with the permit application for Director approval, and must include a description of how the owner or operator will meet the requirements of this section.

(2) The testing and monitoring plan must, at a minimum, include:

(i) analysis of the carbon dioxide stream with sufficient frequency to yield data representative of its chemical and physical characteristics;

(ii) Installation and use, except during well workovers as defined in section 146.88(d), of continuous monitoring devices (including digital devices capturing periodic data) to monitor injection pressure, rate and volume; and to record at least daily the pressure on the annulus between the tubing and the long strong casing;

(iii) demonstration of external mechanical integrity pursuant to §146.25(f)(5) until the well is plugged;

(iv) monitoring of the pressure buildup in the injection zone annually, including at a minimum, a shut down of the well for a time sufficient to conduct a valid observation of the pressure fall-off curve at least once every five years; and

(v) quality assurance provisions.

(3) Where appropriate, the testing and monitoring plan shall also include:

(i) Monitoring for pressure changes in an appropriately porous and permeable formation overlying the confining zone;

(ii) The use of indirect, geophysical techniques to determine the position of the carbon dioxide stream front, the water quality in a designated formation, or to provide other site specific data;

(iii) Periodic monitoring of water quality for constituents specified in the plan in an appropriately porous and permeable formation overlying the injection zone;

(iv) Periodic monitoring of water quality for constituents specified in the plan in one or more USDWs;

(v) Corrosion monitoring of the well materials that will come into contact with water for loss of mass, thickness, cracking, pitting and other signs of corrosion performed and recorded at least quarterly which may be modified to be less frequent as approved by the Director based on construction materials, operating conditions, and monitoring history to ensure that the well components meet minimum standards for material strength and performance by:

(A) Analyzing coupons of the well construction materials placed in contact with the carbon dioxide stream; or

(B) Routing the carbon dioxide stream through a loop constructed with the material used in the well and inspecting the materials in the loop; or

(C) Using an alternative method, materials, or time period approved by the Director;

(vi) Any additional monitoring, as required by the Director, based on site-specific conditions and risk-based factors, necessary to support, upgrade, and improve computational modeling of the area of review evaluation required under § 146.25(b)(2); and

(vii) Any additional testing and monitoring necessary to determine whether fluid movement is occurring that would endanger an USDW.

(h) <u>Reporting Requirements</u>

The owner or operator must, at a minimum, provide the following reports to the Director, for each permitted well:

(1) Semi-annual or less frequently as determined by the Director reports containing:

(i) Any significant changes to the physical, chemical and other relevant characteristics of the carbon dioxide stream from the proposed operating data;

(ii) Monthly average, maximum and minimum values for injection pressure, flow rate and volume, and annular pressure;

(iii) A description of any event that significantly exceeds operating parameters for annulus pressure or injection pressure as specified in the permit;

(iv) A description of any event which triggers a shutdown device required pursuant to §146.25(f)(4) and the response taken;

(v) The monthly volume of the carbon dioxide stream injected over the reporting period and project cumulatively;

(vi) Monthly annulus fluid volume added; and

(vii) The results of monitoring prescribed under §146.25(g).

(2) Report, within 30 days the results of:

(i) Periodic tests of mechanical integrity;

(ii) Any other test of the injection well conducted by the permittee if required by the Director; and

(iii) Any well workover.

(3) Owners or operators must submit reports in an electronic format acceptable to the Director. At the discretion of the Director, other formats may be accepted.

(4) The owner or operator must prepare, maintain, and update required plans in accordance with the provisions of this section.

(i) Owners or operators must submit an annual statement, signed by an appropriate company official, confirming that the company has:

(A) reviewed the monitoring and operational data that are relevant to a decision on whether to reevaluate the area of review and the monitoring and operational data that are relevant to a decision on whether to update a plan identified in §146.25(i)(16) or (20) through (23); and

(B) determined whether any updates were warranted by material change in the monitoring and operational data or in the evaluation of the monitoring and operational data by the owner or operator.

(ii) Owners or operators must submit either the updated plan or a summary of the modifications for each plan for which an update was determined to be warranted pursuant to subparagraph (i) of this paragraph. The Director may require submission of copies of any updated plans and/or additional information regarding whether or not updates of any particular plans are warranted.

(iii) The Director may require the revision of any required plan whenever the Director determines that such a revision is necessary to comply with the requirements of this subchapter.

(i) <u>Required permit application information</u>

This section sets forth the information which the owner or operator must submit to the Director in order to be permitted. The application for a permit for construction and operation of an injection well or for authorization to operate an existing well must include the following:

(1) Information required in 40 CFR 144.31(e)(1) through (6);

(2) A surface map showing the proposed locations for the injection well(s) for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number, or name and location of all known injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State or EPA approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells and other pertinent surface features including structures intended for human occupancy and roads. Only information of public record is required to be included on this map;

(3) A map delineating the area of review based upon modeling, using all available data including data available from any logging and testing of wells.

(4) Information on the geologic structure and reservoir properties of the proposed storage site and overlying formations, which may include:

(i) Isopach maps of the proposed injection and confining zone(s), a structural contour map aligned with the top of the proposed injection zone, and at least two geologic cross sections of the area of review reasonably perpendicular to each other showing the geologic formations from the surface to total depth of the well.

(ii) Location, orientation, and properties of known or suspected subsurface faults that may transect the confining zone(s) in the area of review and a determination that they would not interfere with containment;

(iii) Information on seismic history that have affected the proposed area of review including knowledge of previous seismic events and history of these events, including the presence and depth of seismic sources and a determination that the seismicity would not compromise containment;

(iv) Data sufficient to demonstrate the effectiveness of the injection and confining zone(s), including data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability reservoir pressure and of the injection and confining zone(s) within the area of review; including geologic changes based on field data which may include geologic cores, outcrop data, seismic surveys, well logs, capillary pressure tests and names and lithologic descriptions;

(v) Geomechanical information representative of the confining zone(s) in the area of review, such as information on fractures, stress, ductility, rock strength, and in situ fluid pressures; and

(vi) Geologic and topographic maps and cross sections illustrating geology, hydrogeology, and the geologic structure of the area of review.

(5) A compilation of all artificial penetrations within the area of review which penetrate the injection or confining zone(s). Such data should include a description of each well's type, construction, date drilled, location, depth, record of plugging and/ or completion, and any additional information the Director may require;

(6) Maps and stratigraphic cross sections indicating the general vertical and lateral limits of all USDWs, the location of water wells and perennial springs within the area of review, their positions relative to the injection zone(s) and the direction of water movement, where known;

(7) A compilation of available baseline geochemical data on the proposed injection zone and nearest adjacent porous and permeable formation to the confining zone, existing utilized water supply aquifers and any other USDWs designated by the Director.

(8) Proposed operating data:

(i) Average and maximum daily injection rate and volume of the carbon dioxide stream;

(ii) Average and maximum surface injection pressure;

(iii) The source of the carbon dioxide stream; and

(iv) An analysis of the chemical and physical characteristics of the carbon dioxide stream;

(9) Proposed formation testing program to obtain an analysis of the chemical and physical characteristics of the injection zone and confining zone;

(10) The compatibility of the carbon dioxide stream with fluids in the injection zone and minerals in both the injection and the confining zone(s), based on the results of the formation testing program or other data, and with the materials used to construct the well;

(11) Proposed stimulation program and a determination that stimulation will not compromise containment;

(12) The results of the formation testing program as required in paragraph (j) of this section;

(13) Proposed procedure to outline steps necessary to conduct injection operation;

(14) A wellbore schematic of the subsurface construction details and surface wellhead construction;

(15) Injection well construction procedures that meet applicable requirements;

(16) Proposed area of review and corrective action plan required by §146.25(b)(2);

(17) All available logging and testing program data on the well required by §146.25(e)(1);

(18) The proposed demonstration method for mechanical integrity pursuant to §146.25(j)(5);

(19) A demonstration, satisfactory to the Director, that the applicant has met the financial responsibility requirements under §146.25(c);

(20) Proposed testing and monitoring plan required by §146.25(g);

(21) Proposed injection and monitor well(s) plugging plan required by §146.25(j)(2);

(22) Proposed post-injection site care and site closure plan required by §146.25(k);

(23) Proposed emergency and remedial response plan required by § 146.25(l); and

(24) Any other information requested by the Director necessary to ensure protection of USDWs.

(j) <u>Injection and monitor well plugging</u>

(1) Prior to the well plugging, the owner or operator must flush each injection well with a buffer fluid, determine bottomhole reservoir pressure, and perform a final external mechanical integrity test.

(2) Well Plugging Plan. The owner or operator of a well must prepare, maintain, and comply with a well plugging plan for injection and monitor wells that is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The well plugging plan must be submitted as part of the permit application and must include the following information:

(i) For injection wells and any monitor wells that penetrate the injection zone:

(A) Appropriate testing or determination of bottomhole reservoir pressure;

(B) Appropriate testing or determination of reservoir pressure (including, for example, through additional perforations) in other formations only if required by the Director;

(C) Appropriate testing methods to ensure final external mechanical integrity as specified in §146.25(f)(5);

(D) The type and number of plugs to be used;

(E) The placement of each plug including the elevation of the top and bottom of each plug;

(F) The type and grade and quantity of material to be used in plugging. The material must be suitable for use with the carbon dioxide stream, reservoir and fluid conditions; and

(G) The method of placement of the plugs.

(ii) For monitor wells that do not penetrate the injection zone, information to demonstrate that the wells will be plugged in compliance with applicable state requirements.

(3) Notice of intent to plug. The owner or operator must notify the Director at least 60 days before plugging of a well. At this time, if any changes have been made to the original well plugging plan, the owner or operator must also provide the revised well plugging plan. At the discretion of the Director, a shorter notice period may be allowed.

(4) Plugging report. Within 60 days after plugging the owner or operator must submit a plugging report to the Director. The report must be certified as accurate by the owner or operator and by the person who performed the plugging operation (if other than the owner or operator.)

(k) <u>Post-injection site care and site closure</u>

(1) The owner or operator of a well must prepare, maintain, and comply with a plan for post-injection site care and site closure that meets the requirements of paragraph (1)(ii) of this section and is acceptable to the Director.

(i) The owner or operator must submit the post-injection site care and site closure plan as a part of the permit application to be approved by the Director.

(ii) The post-injection site care and site closure plan must include the following information:

(A) The projected pressure differential between pre-injection and projected post-injection pressures in the injection zone;

(B) The projected position of the carbon dioxide plume and associated pressure front at site closure as demonstrated in the area of review evaluation required under §146.25(b)(1), (3) and (5);

(C) A description of post-injection monitoring location, methods, and proposed frequency; and

(D) A proposed schedule for submitting post-injection site care monitoring results to the Director.

(iii) Upon cessation of injection, owners or operators of wells must either submit an amended post-injection site care and site closure plan or demonstrate to the Director through monitoring data and modeling results that no amendment to the plan is needed.

(iv) The owner or operator may modify and resubmit the post-injection site care and site closure plan for the Director's approval within 30 days of such change

(2) The owner or operator shall perform monitoring following the cessation of injection as follows:

(i) The owner or operator shall continue to conduct monitoring as specified in the Director-approved post-injection site care and site closure plan, pursuant to the performance based criteria described in §146.25(k)(2)(iii).

(ii) The owner or operator may request and demonstrate to the satisfaction of the Director that the post-injection site care and site closure plan should be revised to reduce the frequency of monitoring.

(iii) Prior to authorization for site closure, the owner or operator must 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. The owner or operator must demonstrate, 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 (carbon dioxide plume and the area of elevated pressure) ; (B) the estimated location of the detectable carbon dioxide plume ; (C) that there is no significant leakage of either carbon dioxide or displaced formation fluids that is endangering USDWs; (D) that the injected or displaced fluids are not expected to migrate in the future in a manner that encounters a potential leakage pathway into an USDW; (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 these requirements; and (F) any remaining project monitoring wells at the site are being used and managed pursuant to a plan approved by the Director in accordance with §146.25(k)(4).

(3) Notice of intent for site closure. The owner or operator must notify the Director at least 120 days before site closure. At this time, if any changes have been made to the original post-injection site care and site closure plan, the owner or operator must also provide the revised plan. At the discretion of the Director, a shorter notice period may be allowed.

(4) After the Director has authorized site closure, the owner or operator must plug all monitoring wells in a manner which will not allow movement of injection or formation fluids that endangers an USDW except that designated wells may remain unplugged pursuant to §146.25(k) (2)(iii)(F) with the consent of the owner and operator and pursuant to a post-closure monitoring and plugging plan approved by the Director which shall provide for, and designate the person responsible for, operating and plugging all such monitoring wells in a manner which will not allow movement of injection or formation fluids that endangers an USDW.

(5) Once the Director has authorized site closure, the owner or operator must submit a site closure report within 90 days after completion of all closure operations. The report must include:

> (i) Documentation of appropriate injection and monitoring well plugging as specified in §146.25(j) and paragraph (4) of this section. The owner or operator must provide a copy of a survey plat which has been submitted to the local zoning authority designated by the Director. The plat must indicate the location of the injection well(s) relative to permanently surveyed benchmarks. The owner or operator must also submit a copy of the plat to the Regional Administrator of the appropriate EPA Regional Office;
>
> (ii) Documentation of appropriate notification and information to such State, local and tribal authorities as have authority over drilling activities to enable such State and local authorities to impose appropriate conditions on subsequent drilling activities that may penetrate the injection and confining zone(s); and
>
> (iii) The volume of fluid injected, the injection zone or zones into which it was injected, and the period over which injection occurred.

(6) Each owner or operator of a injection well must provide notification to the designated state authority of the following information:

> (i) The fact that land has been used to sequester carbon dioxide;
>
> (ii) The name of the State agency, local authority, and/or tribe with which the survey plat was filed, as well as the address of the Regional Environmental Protection Agency Office to which it was submitted; and
>
> (iii) The volume of fluid injected, the injection zone or zones into which it was injected, and the period over which injection occurred.

(7) The owner or operator must retain for three years following site closure, records collected during the post-injection site care period. The owner or operator must deliver the records to the Director at the conclusion of the retention period, and the records must thereafter be retained at a location designated by the Director for that purpose.

(l) Emergency and Remedial Response Plan

(1) As part of a permit application or request for revision to operate under this section, the owner or operator must provide the Director with an emergency, risk-based remedial response plan that describes actions to be taken to address movement of the injection or formation fluids that may cause an endangerment to an USDW during construction, operation, closure and post-closure periods.

(2) If the owner or operator obtains evidence that the injected carbon dioxide stream, displaced formation fluids or an associated pressure front endangers an USDW, the owner or operator must:

(i) Cease injection in a prudent manner considering circumstances.

(ii) Take all steps reasonably necessary to identify and characterize the endangerment posed;

(iii) Notify the Director or the designated representative within 24 hours of becoming aware of the endangerment; and

(iv) Implement the emergency and remedial response plan approved by the Director and keep the Director apprized of the implementation.

(3) The Director may allow the operator to resume injection prior to remediation if the owner or operator demonstrates that the injection operation will not endanger USDWs.

(4) The owner or operator must notify the Director and obtain his approval prior to conducting any well workover or other remediation measures not listed in the emergency and remedial response plan.

(5) If an owner or operator obtains evidence that a pressure front associated with one geologic sequestration project intersects or will more likely than not intersect the pressure front or area of review associated with another project, the owner or operator obtaining such evidence must notify the Director. The Director shall notify the owner or operator of the other geologic sequestration project. If the Director determines that the pressure front associated with one project interferes or will more likely than not interfere with the ability of another project to comply with the terms of its permit(s), the Director may require the owners or operators of the interfering or potentially interfering projects to modify operations as necessary to mitigate or avoid such interference. Such modifications may also include modifications mutually agreed upon by the respective owners and operators and approved by the Director."