

COMMENT #3

First Draft language for WAC 173-218 Geologic Sequestration of Carbon Dioxide:

This should be considered a rough draft. Please focus your review and comments on the concepts, the format is likely to change to fit the required regulatory format.

Send comments by October 23, 2007 to:

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Referenced regulation:

Ch 173-218 WAC, Underground Injection Control Program:
<http://www.ecy.wa.gov/biblio/wac173218.html>

Ch 173-216 WAC, State Waste Discharge Permit Program:
<http://www.ecy.wa.gov/biblio/wac173216.html>

Ch 173-200 WAC, Water Quality Standards for Ground Waters of the State of Washington: <http://www.ecy.wa.gov/biblio/wac173200.html>

Minimum standards for construction and maintenance of wells:
<http://www.ecy.wa.gov/biblio/wac173160.html>

Oil and Gas Conservation Commission General Rules:
<http://apps.leg.wa.gov/WAC/default.aspx?cite=344-12>

Chapter 173-218 WAC Underground Injection Control Program

Additions to: **WAC 173-218 Definitions.**

“Caprock” means the geologic formation that prevents the upward migration of injected carbon dioxide.

“Geologic sequestration of carbon dioxide” means the injection of carbon dioxide, usually from human sources like burning coal or oil, into subsurface geologic formations intended to limit its release into the atmosphere for a defined length of time.

“Geologic sequestration target formation” means the geologic layer with sufficient porosity and permeability to inject the carbon dioxide for sequestration.

“Sequestration” means to set apart or remove.

WAC 173-218-040 UIC well classification including allowed and prohibited wells.

(5) Class V injection wells means all injection wells not included in Classes I, II, III, or IV.

(a) The following are examples of Class V injection wells that are allowed in Washington:

.....

(xv) Injection wells used to inject carbon dioxide for geologic sequestration.

WAC 173-218-090 Specific requirements for Class V wells to meet the nonendangerment standard.

- (3) Class V UIC wells not used for storm water management must:
- (i) Not directly discharge into an aquifer, except for wells listed in WAC 173-218-040 (5)(a)(ii) through (iv), (vii) through (xi), (xiii), ~~and (xiv)~~ and (xv).

NEW SECTION

WAC 173-218-XXX Specific requirements for Class V wells used to inject carbon dioxide for permanent geologic sequestration.

- (1) Class V wells used to inject carbon dioxide for geologic sequestration are not rule authorized and must obtain a state waste discharge permit under chapter 173-216 WAC State waste discharge permit program or chapter 173-226 WAC Waste discharge general permit program.
- (2) Class V wells used to inject carbon dioxide for geologic sequestration may directly discharge into an aquifer only if:
- (a) The aquifer contains “naturally non-potable ground water” as defined in WAC 173-200-020(18) and is deeper than any potable ground water within the project area;
 - (b) they have obtained a permit under the state waste discharge permit program or the waste discharge general permit program establishing enforcement limits which may exceed the ground water quality criteria, as allowed under WAC 173-200-050(3)(b)(vi); and
 - (c) they are in compliance with all conditions of their state waste discharge permit or their waste discharge general permit.

Permit Application

The application for a discharge permit authorizing the injection of carbon dioxide for geologic sequestration shall include information supporting the demonstration required by WAC 173-200-050(3)(b)(vi) and the following:

- (1) A current site map showing the ~~boundaries of the geologic sequestration target formation, the location and well number of all proposed CO₂ injection wells, including any subsurface observation wells and the location of all other wells including cathodic protection boreholes and the location of all pertinent surface facilities within the boundary of the project;~~
- (2) A technical evaluation of the proposed project, including but not limited to, the following:
- (a) The name and lithologic description of the ~~geologic sequestration target formation~~ reservoir(s) to be utilized for geologic sequestration of CO₂;
 - (b) ~~The name, description, and average depth of the reservoir or~~ A depth map showing the depth to the top of the target reservoir(s) within the area of review ~~reservoirs to be utilized for geologic sequestration of CO₂~~;
 - (c) A geologic and hydrogeologic evaluation of the ~~geologic sequestration target formation~~ target reservoir(s) within the area of review, including an evaluation of all

Comment [CLD1]: Does this imply the boundaries of the entire formation, or the extent of the area of the formation designated for storage in a given project (i.e., the maximum projected plume)? **This is where the Area of Review should be defined.**

Comment [CLD2]: The area of review for these required data / descriptions needs to be defined. See suggestions below.

existing information on all geologic strata overlying the geologic sequestration target formation target reservoir(s) including the immediate caprock containment characteristics and all designated subsurface monitoring zones. The evaluation shall include any available geophysical data and assessments of any regional tectonic activity, local seismicity and regional or local fault zones, and a comprehensive description of local and regional geologic real or and stratigraphic features. The evaluation shall focus on a description of the the proposed CO₂ sequestration target reservoir(s) or reservoirs and the a description of mechanisms of geologic confinement, including but not limited to rock properties, regional pressure gradients, structural features, and absorption characteristics with regard to the ability of that confinement to prevent migration of CO₂ beyond the proposed sequestration reservoir. The evaluation shall also identify any productive oil and natural gas zones occurring stratigraphically above, below, or within the geologic sequestration target formation and all water-bearing horizons known in the immediate vicinity of the geologic sequestration target formation. The evaluation shall include a method to identify unrecorded wells that may be present within the project boundary. The evaluation shall include exhibits and plan view maps showing the following:

- (i) All wells, including but not limited to, water, oil, and natural gas exploration and development wells, injection wells, and other man-made subsurface structures and activities, including surface or subsurface coal mines extending more than n meters below ground surface, within one mile of the outside boundary of the geologic sequestration target formation area of review;
- (ii) All manmade surface structures that are intended for temporary or permanent human occupancy within one mile of the outside project boundary area of review;
- (iii) Any known regional or local faulting within the sequestration project boundary;
- (iv) An isopach map of the proposed CO₂ storage reservoir or reservoir(s);
- (v) An isopach map of the primary and any secondary containment barrier(s);
- (vi) A structure map of the top and base of the storage reservoir or reservoirs;
- (vii) Identification of all structural spill points or stratigraphic discontinuities controlling the isolation of stored CO₂ or associated fluids;
- (viii) An evaluation of the potential displacement of in situ water and the potential impact on groundwater resources, if any; and
- (ix) Structural and stratigraphic cross-sections that describe the geologic conditions at the reservoir.

A licensed geologist or engineer shall conduct the geologic and hydrogeologic evaluation required under this paragraph. As appropriate The evaluation should reflect the best available data and, existing geologic, geophysical, or engineering data available on the proposed project area may should be incorporated into the evaluation as appropriate;

- (d) A review of the data of public record for any and all wells within the project area, which penetrate the reservoir or primary and/ or secondary seals overlying the reservoir designated as the CO₂ storage reservoir, and those wells that penetrate the

Comment [CLD3]: This may need to be more explicitly defined to include information on lithology, capillary entry pressure, etc

Comment [CLD4]: Does available mean "existing" or "free"? There may be geophysical data that can be purchased; are we requiring that these data be obtained? If so, will there be some cap on cost to ensure that data owners aren't scalping for seismic lines?

Comment [CLD5]: Active+inactive? Active within the last 1000 years? Active within the Quaternary? Only those faults which penetrate the formation and containment system, or all known faults? If the answer is th (... [1]

Comment [CLD6]: While I agree with the concept that we need to provide as much flexibility as possible to allow the proponent to prove contain (... [2]

Comment [CLD7]: Probably should be asking for all water-bearing reservoirs (along with geochemistries for each of them to (... [3]

Comment [CLD8]: Should we also include planned project wells here?

Formatted:
Highlight

Comment [CLD9]: Is this really enough information, or are we really looking for some sort of modeling that will describe the dynamics over (... [4]

Comment [CLD10]: Because the UIC directive is to protect USDWs, can't we simply say "show no impact to current and potential source (... [5]

~~geologic CO₂ sequestration reservoir~~ within one mile of the Area of Review, or any other distance as deemed necessary by the department, ~~of the boundary of the project area~~. This review shall determine if all abandoned wells have been plugged in a manner that prevents the movement of CO₂ or associated native fluids from the geologic CO₂ sequestration reservoir. A licensed geologist or engineer shall conduct the review required under this paragraph;

(e) The proposed calculated maximum volume and areal extent for the proposed geologic sequestration target formation using a method acceptable to and filed with the department;

(f) The proposed maximum bottom hole injection pressure to be utilized at the reservoir. The maximum allowed injection pressure, measured in psig, shall be no greater than 90 percent of the formation fracture pressure as determined by a step-rate test or other method approved by the department. ~~The geologic sequestration target formation shall not be subjected to injection pressures in excess of the calculated fracture pressure even for short periods of time.~~ Higher operating pressures may be allowed if approved in writing by the department. ~~The application, if approved by department, shall be subject to any conditions established in the permit. The geologic sequestration target formation shall not be subjected to injection pressures in excess of the calculated fracture pressure for any length of time;~~

(g) The proposed maximum long-term geologic sequestration target formation pressure and the necessary technical data to support the proposed geologic sequestration target formation storage pressure request.

(3) The extent of the CO₂, determined by utilizing all available geologic and reservoir engineering information, and the projected response and storage capacity of the geologic sequestration target formation;

(4) A detailed description of the proposed project public safety and emergency response plan. The plan shall detail the safety procedures concerning the facility and residential, commercial, and public land use within one mile of the Area of Review, or any other distance as deemed necessary by the department, ~~of the outside boundary of the project area~~. The public safety and emergency response procedures shall include contingency plans for CO₂ leakage from any well, flow lines, or other permitted facility. The public safety and emergency response procedures also shall identify specific contractors and equipment vendors capable of providing necessary services and equipment to respond to such CO₂ injection well leaks or loss of containment from CO₂ injection wells or the CO₂ storage reservoir. These emergency response procedures should be updated as necessary throughout the operational life of the permitted storage facilities.

(5) A detailed worker safety plan that addresses CO₂ safety training and safe working procedures at the facility;

(6) A corrosion monitoring and prevention plan for all wells and surface facilities;

(7) A leak detection and monitoring plan for all wells and surface facilities. The approved leak detection and monitoring plan shall address:

(a) Identification of potential release to the atmosphere;

(b) Identification of potential degradation of all groundwater resources; and

(c) Identification of potential migration of CO₂ into any overlying oil and natural gas reservoirs.

Comment [CLD11]:
ould this define the area of review (or extent + XXXX meters, or ... ?)

Comment [CLD12]:
Why was 90% chosen here? Is this Washington State UIC requirement? If not, we might consider advocating for a lower % of fracture pressure since there is a provision for approval of higher pressures if the applicant so desires.

Comment [CLD13]:
eems like we should be more explicit?

Comment [CLD14]:
e should probably also ask for a discussion of uncertainty; the less data, the lower the confidence in the results.

Comment [CLD15]:
eaks to the surface?
Leaks to USDWs?
Leaks above the primary caprock? Will remediation be required if CO₂ migrates into potential USDWs that are not currently being used as drinking water supplies? Should the plan include mechanisms for remediation of CO₂ leakage into ground or surface water?

Comment [CLD16]:
ipelines?

Comment [CLD17]:
hat about surface water?

(8) A geologic sequestration target formation leak detection and monitoring plan utilizing subsurface observation wells to monitor any movement of the CO₂ volume outside of the permitted geologic sequestration target formation. This may include the collection of baseline information of CO₂ background concentrations in groundwater, surface soils, and chemical composition of in situ waters within the geologic sequestration target formation. The approved subsurface leak detection and monitoring plan shall be dictated by the site characteristics as documented by materials submitted in support of the application with regard to CO₂ containment and address:

- (a) Identification of potential release to the atmosphere;
- (b) Identification of potential degradation of any groundwater resources; and
- (c) Identification of potential migration of CO₂ into any overlying oil and natural gas reservoirs.

(9) The proposed well casing and cementing program

(10) A performance bond covering the surface facility to department in an amount established by department. The amount of the bond shall be sufficient to provide financial assurance to the department to cover the abandonment of the project or remediation of facility leaks should the operator not perform as required or cease to exist.

(11) A performance bond for each CO₂ injection and subsurface observation well to department in an amount established by the department. The amount of the bond shall be sufficient to provide financial assurance to the department to cover the plugging and abandonment or the remediation of a CO₂ injection and/or subsurface observation well should the operator not perform as required in accordance with the permit or cease to exist;

(12) The payment of the application fee;

(13) Any other information that the department requires; and

(14) A closure and post closure plan.

Geologic Sequestration Well Standards

Monitoring and injection wells used for Geologic Sequestration projects must meet the following standards (NOTE: In statutory references to chapter 344-12 RCW the word “gas” shall include injected supercritical carbon dioxide for geologic sequestration):

(1) Casing materials and cement must be designed and tested to withstand the reactive fluids and expected conditions encountered during the lifetime of the geologic sequestration projects

(2) Minimum Standards for Construction and Maintenance of Wells. Chapter 173-160 WAC,

(3) Drilling Fluid standards of WAC 344-12-098

(4) Directional or other appropriate surveys shall be completed for all wells to verify location at depth

(5) Wells must be logged with appropriate geophysical methods (ASK DNR FOR APPROPRIATE WORDS)

(6) All geologic data including: logs, surveys, cuttings and cores must be submitted to the DNR within XX days of well completion. (ASK DNR FOR APPROPRIATE WORDS)

(7) Project wells and other new wells that are completed within or below the geologic sequestration target formation within or below the primary containment formation (caprock) must meet these additional standards:

Comment [CLD18]:
re we making any provision for cosequestration of other gases? If so, do we need a mechanism here for requiring more stringent MMV and remediation plans in those cases?

Comment [CLD19]:
his needs to be much more specific.

Comment [CLD20]:
xclusive of other gases?

Comment [CLD21]:
ow long is CO₂ resistant cement resistant for? Does Schlumberger publish this info on their product? I would like to see this resistance requirement extend well beyond the lifetime of the project. If the cement loses integrity in year 100 and CO₂ escapes via this pathway, that's just as bad as if it had leaked in year 25. We need this standard to hold well beyond the P&A phase.

Comment [CLD22]:
eally? DNR is going to house all of the cores from all of the injection wells in the state? Probably plugs are enough unless DNR is planning to start a core “library” type facility.

- (a) Well casing and cementing standards of WAC -344-12-087
 - (b) The amount of cement behind casings shall be verified by a cement bond log, density log, cement evaluation log or any other evaluation method approved by the department.
 - (c) Blowout prevention standards of WAC 344-12-092
 - (d) Wells shall be tested annually to assess their structural integrity. Tests shall include corrosion logs, pressure test and other appropriate tests. Any finding of inadequate structural integrity shall be reported immediately to the department.
- (8) Notify the department 30 days prior to beginning any substantial work on wells including ~~-,~~ deepening, repair or closure. Advance notice period may be reduced by the department when the work is intended to address immediate threats to public health, safety or the environment.

Permit Terms and Conditions

All terms and conditions listed in WAC 173-216-110, State Waste Discharge Permit Program, apply. In addition, the following standards shall apply to permits for the injection of carbon dioxide for geologic sequestration:

(1) Decision whether to issue a permit will be based on the ability of the applicant to demonstrate the following:

(a) That the geology of the site will:

(i) Hold carbon dioxide in the geologic sequestration target formation “permanently” as defined by **WAC XXX-XXX**, and

(ii) The caprock above the geologic sequestration target formation has the appropriate characteristics to provide an effective barrier that, **under operating and lifetime maximum pressures described in [Permit application (2)(f) and (2)(g)]**, prevents migration of carbon dioxide and/or non-potable water into shallower aquifers that would degrade the water quality in the shallower aquifers or impact beneficial use.

(b) A monitoring program has been developed that is likely to identify ground water quality degradation in shallower aquifers prior to degradation of any potable aquifer. The detection program will monitor ~~the two -migration to shallower-~~ **most closely as close stratigraphically to overlying** the geologic sequestration target formation ~~as practicable~~.

(c) Design and construction standards of all facility structures and wells are sufficient to prevent migration of carbon dioxide or non-potable water into ~~shallower aquifers~~ that will degrade water quality in the shallower aquifers or impact beneficial uses.

(2) The permit shall include a maximum working pressure in the geologic sequestration target formation, calculated from information provided in the application, that assures that the pressure in the injection zone does not initiate new fractures or propagate existing fractures in the injection zone or caprock. In no case shall the injection pressure **exceed capillary entry pressure in the confining zone**, initiate fractures in the confining zone or **otherwise** cause the movement of injected fluids or formation fluids into shallower aquifers.

(4) If the operator identifies water quality degradation in shallower aquifers or leaks to the surface, including those around wells or within well casing, the operator must:

(c) Immediately stop injecting.

Comment [CLD23]:
 nly aquifers or are we concerned with oil and gas fields, natural gas storage facilities, etc? Should probably be explicit about what we are requiring the operator to protect.

- (a) Immediately notify the department,
- (b) Take all necessary actions to protect public health, safety and the environment,
- ~~(e) Stop injecting~~
- (d) ~~Develop and implement~~ thea mitigation plan as described in the permit application to arrest and reverse environmental impacts. ~~The mitigation plan shall be developed in consultation with the department.~~

Comment [CLD24]:
lan should have already been developed for permit application.

(5) Monitoring for Geologic Sequestration projects shall include:

- (a) Characteristics of injected fluids
- (b) Continuous monitoring of injection pressure, flow rate and volume.
- (c) Continuous monitoring of pressure on annulus between tubing and long string casing

(d) Monitoring of shallower migration detection aquifer(s) identified in WAC XXX-XXX (1)(b) above.

(6) Quarterly reports shall be submitted to the department that include the following:

- (a) Physical, chemical and other relevant characteristics of the injected fluids
- (b) Monthly average, maximum and minimum values for injection pressure, flow rate, volume injected and annular pressure
- (c) Results from migration detection monitoring for shallower aquifers
- (d) Results from any other tests or work completed during the reporting period, such as mechanical integrity tests, geophysical surveys, acoustic monitoring, well repairs, etc...

Comment [BPM25]
uarterly reporting is really way way overboard. An annual report is more than sufficient. Notification requirements are triggered elsewhere as soon as any problem is detected via the monitoring program.

(7) Annual Reports

An annual report shall be submitted to the department that includes:

(WHAT?)

Closure

If carbon dioxide injections stop for a period of 90 days, the operator shall begin implementing the approved-closure plan submitted with the injection permit. The department may extend this 90 day period, in writing, upon the request of the operator, if the operator demonstrates that carbon dioxide injection will resume within one year. The operator shall review and amend the closure plan as needed, at a minimum the plan shall be reviewed at each permit renewal (5 years). Proposed amendments shall be effective only after approved in writing by the department. Approval of proposed amendments shall not delay the commencement of closure activities using the most recent approved closure plan. If the operator fails to begin closure, or is not able to begin closure, the department shall use the financial assurance instrument to begin closure activities.

Comment [CLD26]:
his isn't long enough. Permits should run at least a ten-year cycle. If the department needs assurance that all is well once injection has begun, perhaps the initial quarterly report should have additional reporting requirements, but a 5-year cycle is much too short. Also, I think we're really interested in lifetime project info for the permitting process regardless of the length of time the permit is issued for, so the data requirements should already be built into the application.

Post Closure Activities

The operator is obligated to renew and be covered under permit and pay all appropriate permit fees throughout the post closure period. The operator shall continue all required monitoring and reporting throughout the closure and post closure period. The post closure period shall continue until monitoring demonstrates that conditions in the geologic sequestration target formation have stabilized so that there is little or no risk of future environmental impacts. (WHAT DOES THIS LOOK LIKE?) (ANY SUGGESTIONS FROM THE EXPERTS?) (MAY BE DEFINED IN PERMIT APPLICATION.) The post closure period shall be complete only after the operator has

Comment [CLD27]:
orever? How long must the operator monitor? I think defining this "temporal area of review" is key here.

received written approval from the department. . If the operator fails to or is not able to continue the post closure activities as required, the department shall use the financial assurance instrument to complete post closure activities. Any funds remaining in the financial assurance account shall be released to the operator upon the department's approval of the completion of the post closure period.

Financial Assurance

The owner or operator shall establish a closure and post closure account to cover all closure and post closure expenses. The operator may fund the account with a trust fund, surety bond, letter of credit, insurance or corporate guarantee that meets the specification of XXXXX. The value of the closure and post closure account shall cover all costs of closure and post closure care identified in the closure and post closure plan. The closure and post closure cost estimate shall be revised annually to include any changes in the facility and to include cost changes due to inflation. The obligation to maintain the account for closure and post closure care survives the termination of any permits and the cessation of injection. The requirement to maintain the closure and post closure account is enforceable regardless of whether the requirement is a specific condition of the permit.

Mitigation

(IS MORE NEEDED?)

Comment [CLD28]:
losure is not where the real teeth of the financial assurance and liability bonding requirements should live. P&A costs are relatively low, and it's industry standard to post a bond to cover these expenses. This is not where the letter of credit, etc should be exercised. Those instruments should be used to address leakage and associated liability.

Comment [CLD29]:
lans really need to be submitted as part of the permit. The public needs to know that there is a plan in place if the CO₂ starts leaking, instead of the operator calling a meeting to discuss options while their formation is venting.

| | | |
|--|-------------------------|------------------------------|
| Page 3: [1] Comment [CLD5] | Casie L Davidson | 10/4/2007 3:04:00 PM |
| Active+inactive? Active within the last 1000 years? Active within the Quaternary? Only those faults which penetrate the formation and containment system, or all known faults? If the answer is this last option, proponent should specify recurrence rates and movement per time. | | |
| Page 3: [2] Comment [CLD6] | Casie L Davidson | 10/4/2007 3:04:00 PM |
| While I agree with the concept that we need to provide as much flexibility as possible to allow the proponent to prove containment, capacity and reliability, I think that if we mean "tell us what the effective porosity of the formation is", we can be explicit about that. Same thing with other key engineering parameters like fracture pressure, thickness, etc. | | |
| Page 3: [3] Comment [CLD7] | Casie L Davidson | 10/24/2007 3:32:00 PM |
| Probably should be asking for all water-bearing reservoirs (along with geochemistries for each of them to determine which are USDWs) above the fmn and any USDWs underlying the fmn (which there shouldn't be given the requirements presented here. | | |
| Page 3: [4] Comment [CLD9] | Casie L Davidson | 10/9/2007 10:04:00 AM |
| Is this really enough information, or are we really looking for some sort of modeling that will describe the dynamics over the lifetime of the project? | | |
| Page 3: [5] Comment [CLD10] | Casie L Davidson | 10/24/2007 3:45:00 PM |
| Because the UIC directive is to protect USDWs, can't we simply say "show no impact to current and potential sources of underground drinking water?" | | |