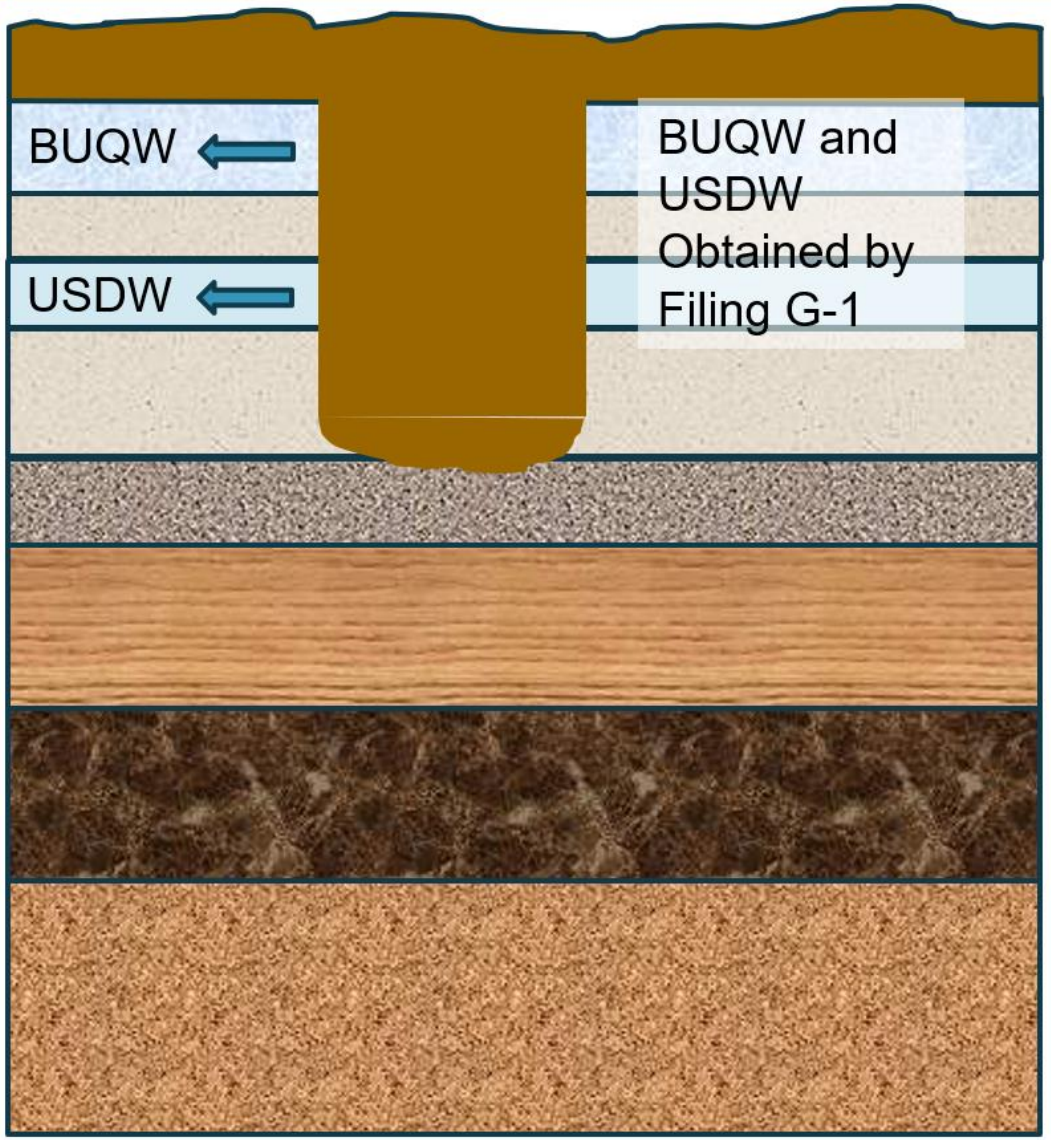
CLASS VI ENGINEERING REVIEW
Well Construction
Testing and Monitoring
Stimulation
Emergency Response
Quality Assurance

Leo Castro

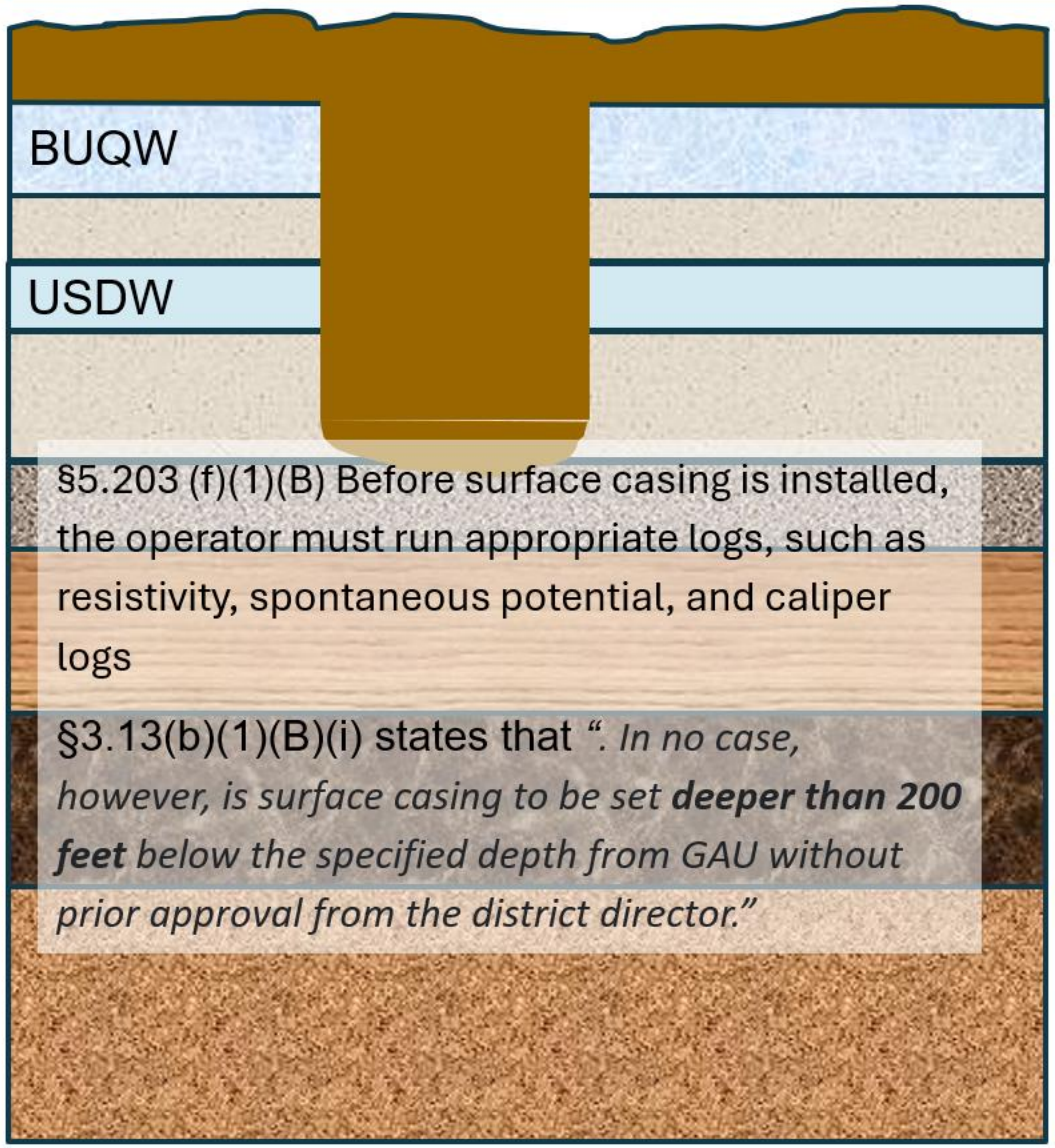
Well Construction

- Well Construction Governed By
  - Title 16 Part 1 Chapter 5 Subchapters A & B, §§5.101, 5.102, 5.201, 5.202, 5.203, 5.204, 5.205, 5.206, 5.207 and 5.208

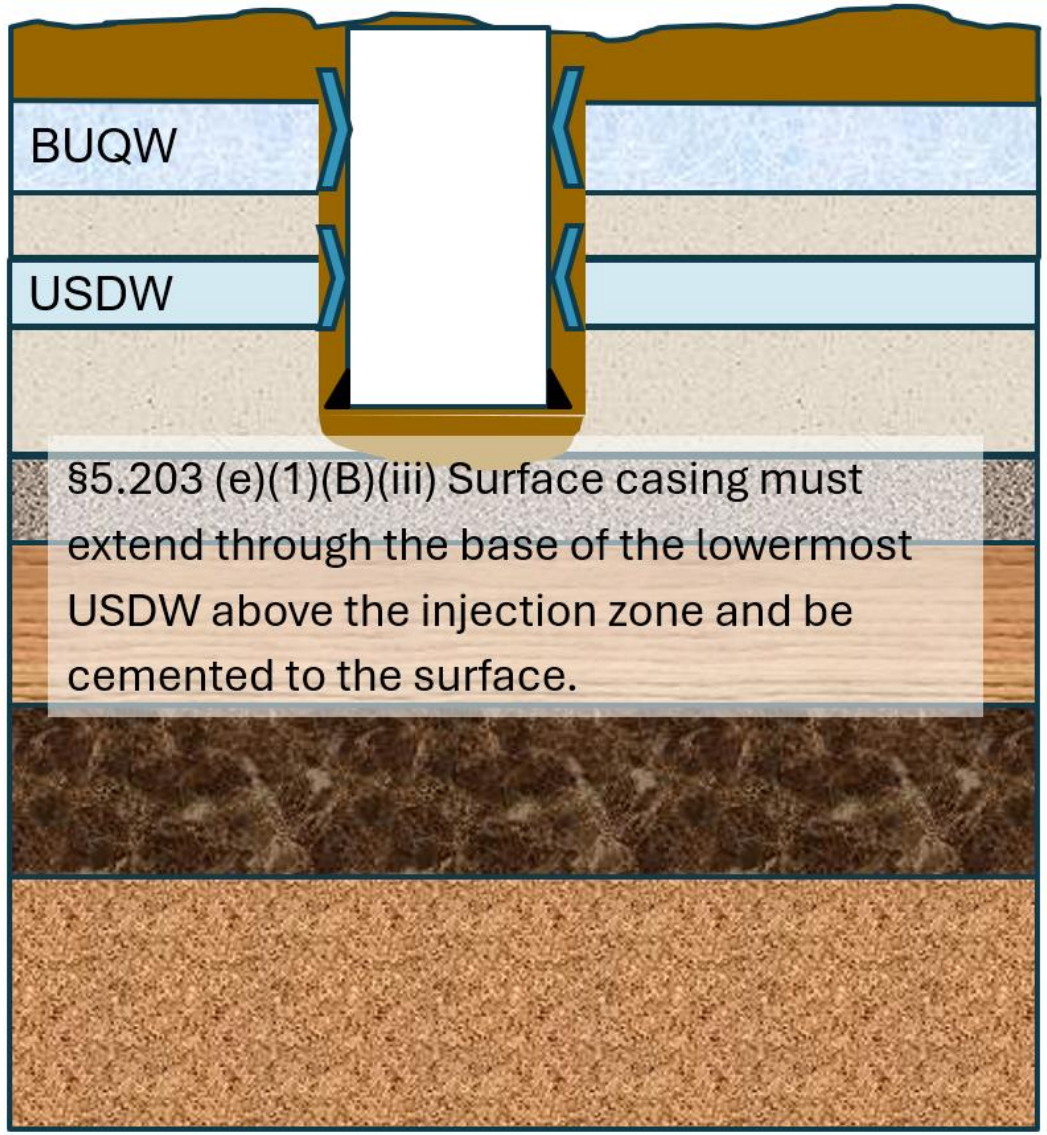
- Major Tripping Point
  - 16 TAC Chapter 5 §5.203 (e)(1)(B)(i) which states that, *"(i) The operator must ensure that injection wells are cased and the casing cemented in compliance with* ***§3.13*** *of this title (relating to Casing, Cementing, Drilling, Well Control, and Completion Requirements), in addition to the requirements of this section."*



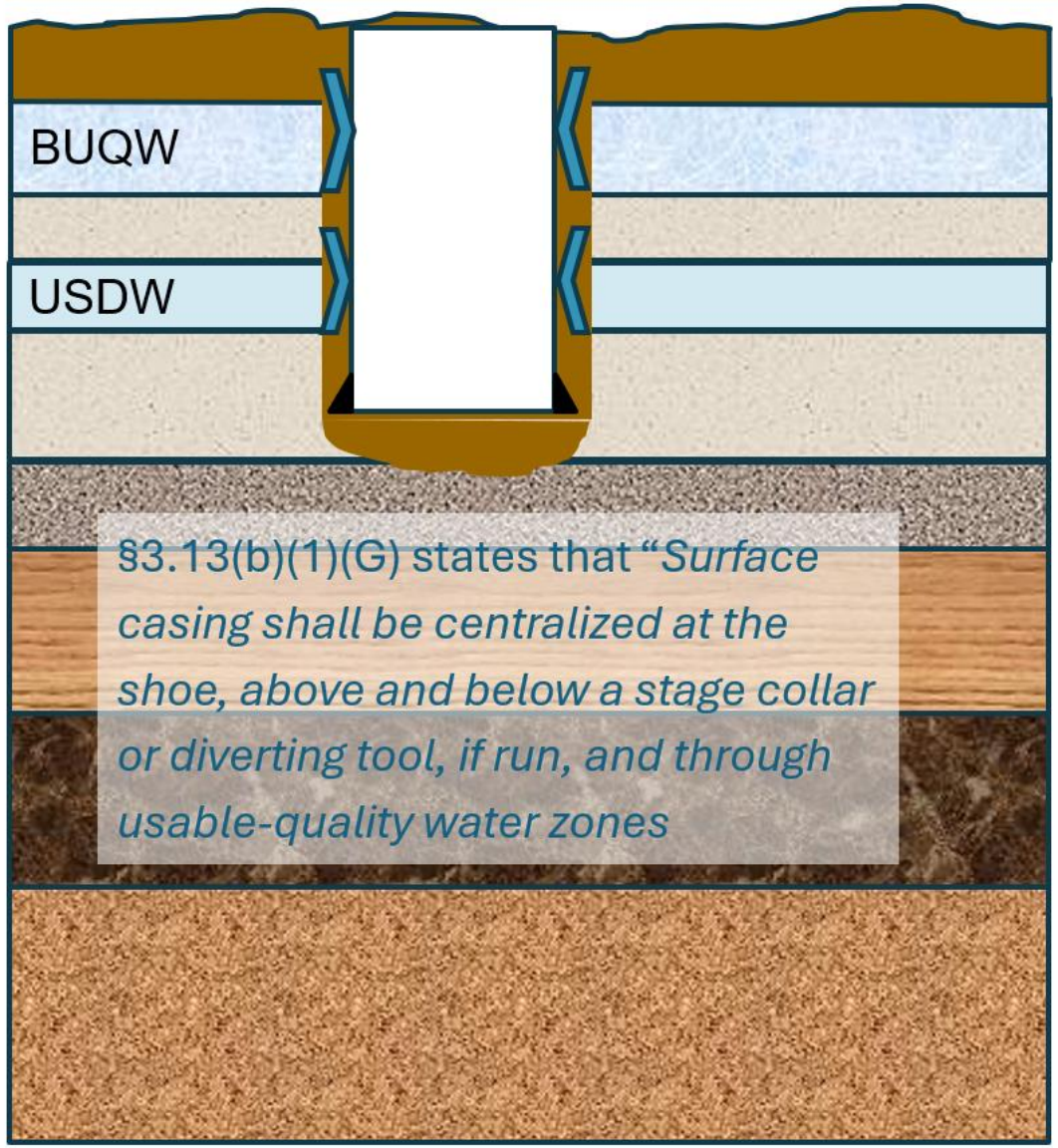
- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)



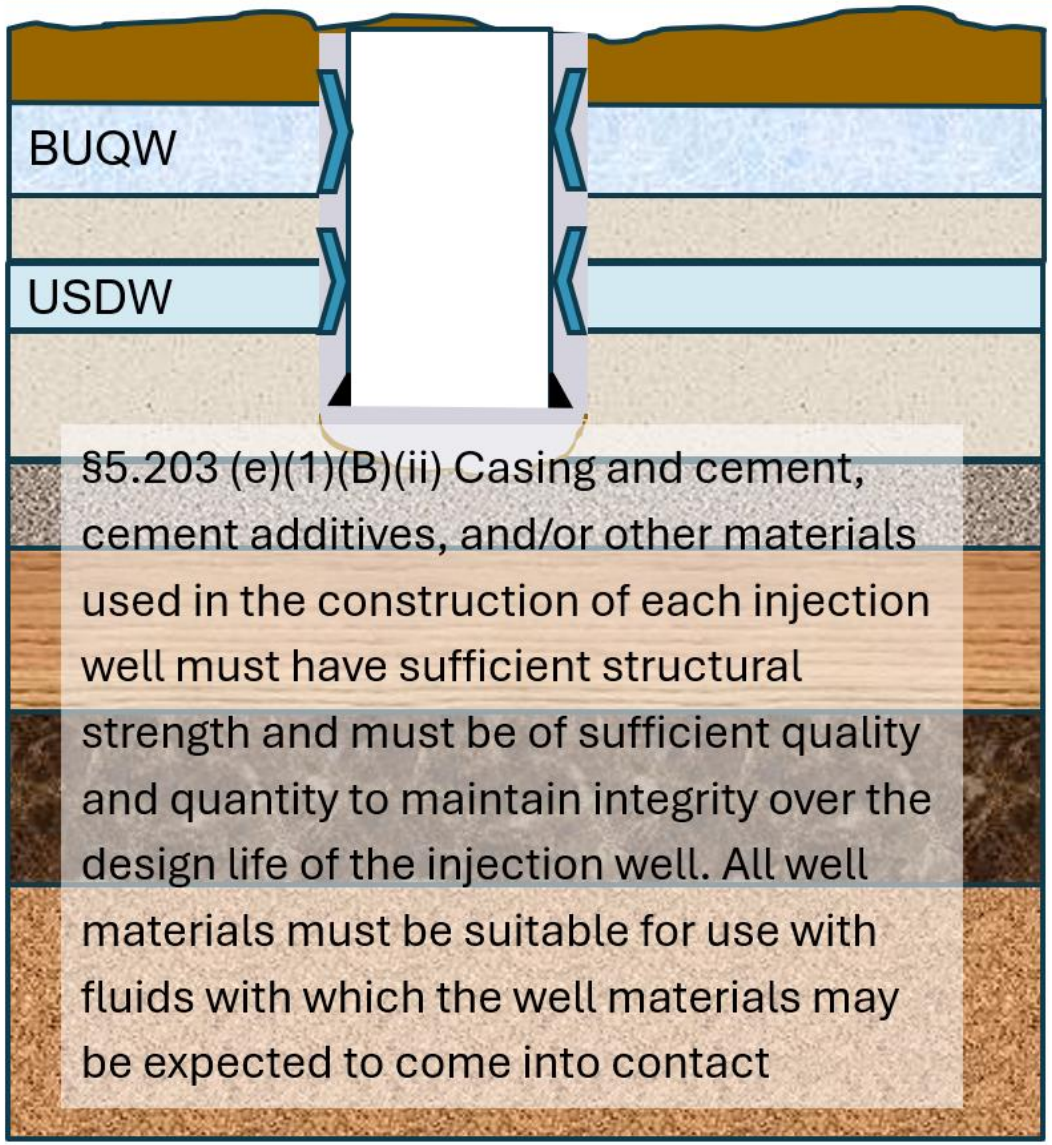
- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)
- Surface Open Hole Logging



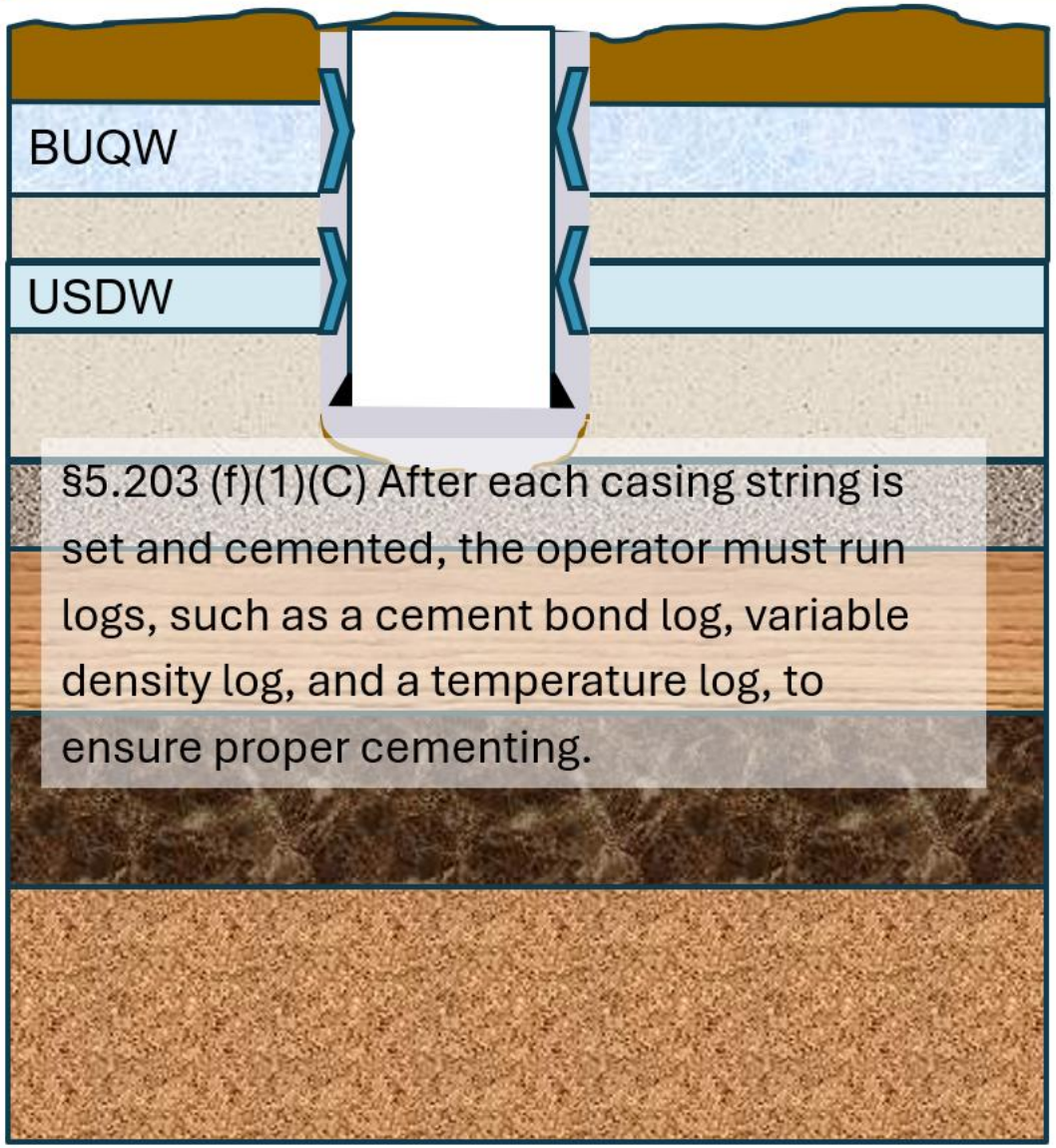
- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)
- Surface Open Hole Logging
- Casing Setting Depth



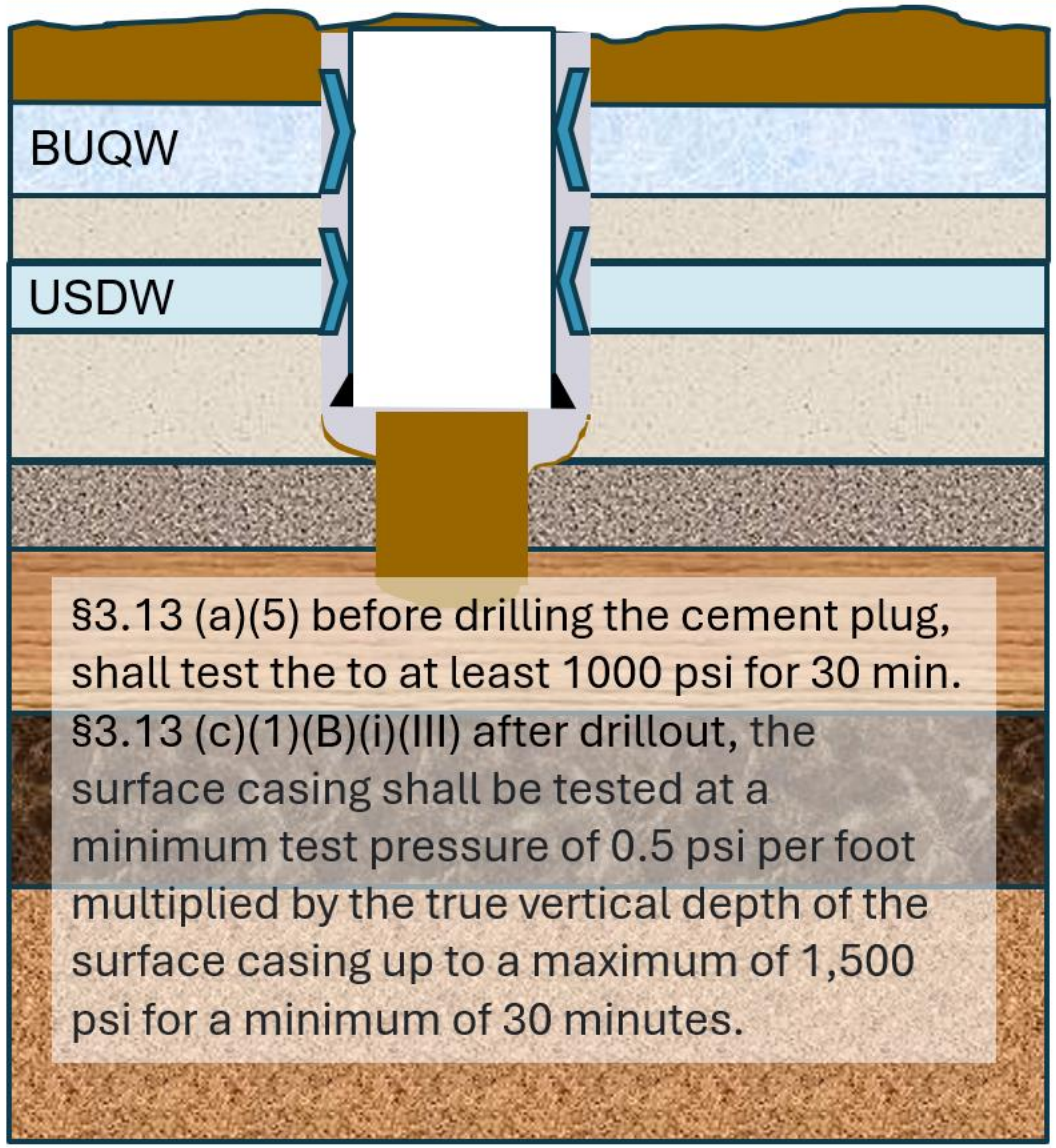
- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)
- Surface Open Hole Logging
- Casing Setting Depth
- Centralizers



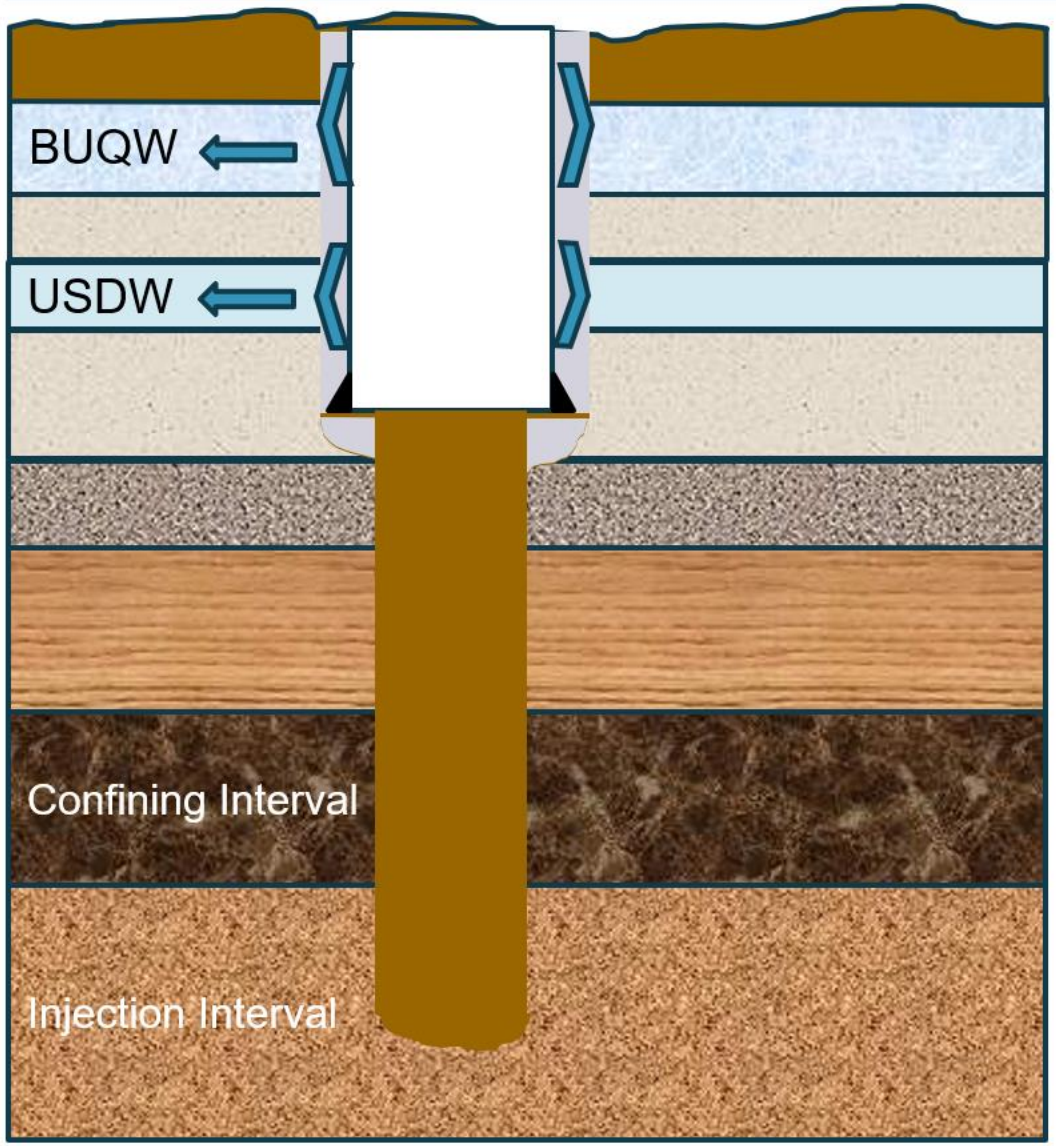
- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)
- Surface Open Hole Logging
- Casing Setting Depth
- Centralizers
- Cement Type



- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)
- Surface Open Hole Logging
- Casing Setting Depth
- Centralizers
- Cement Type
- CBL



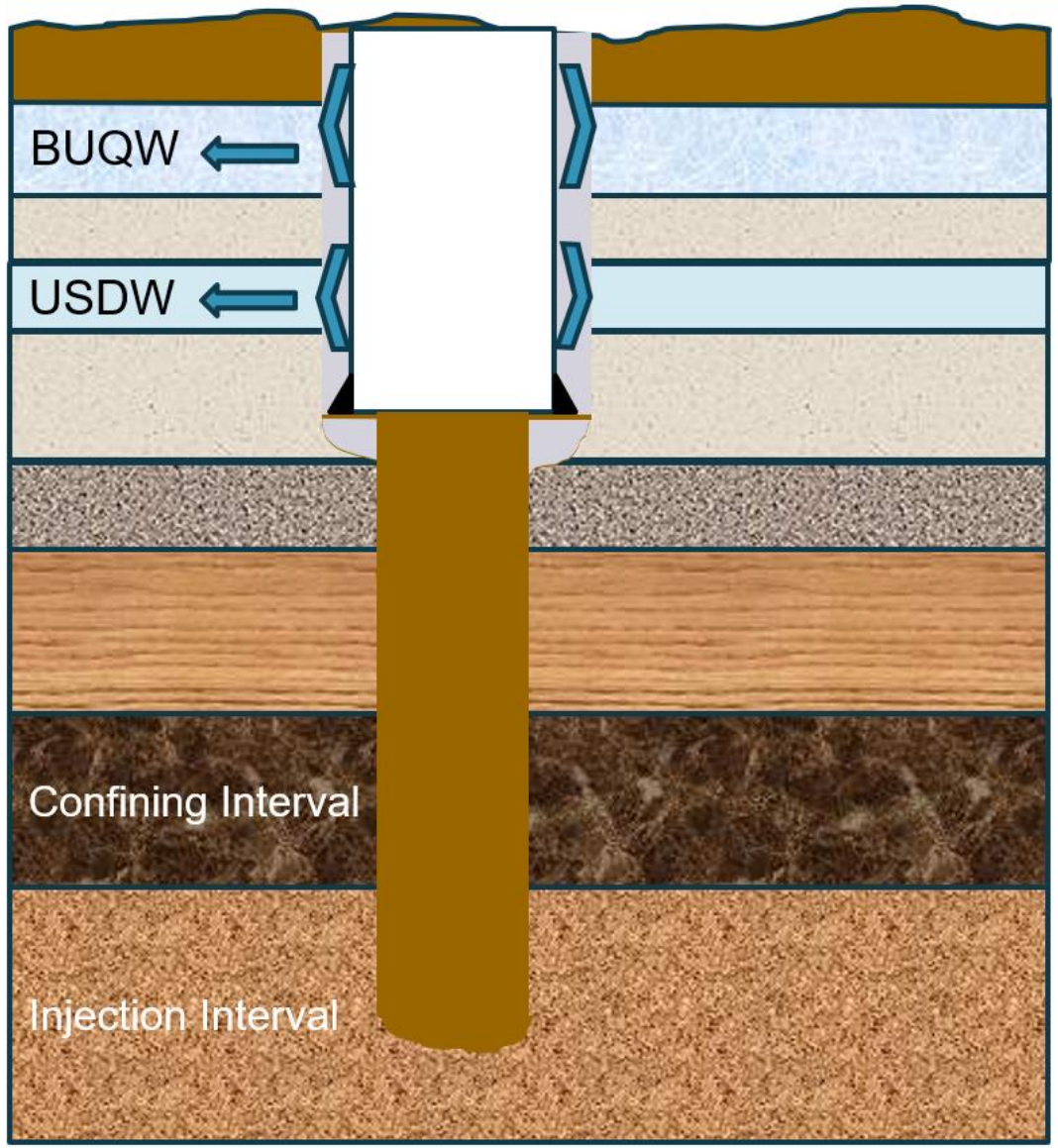
- Base of Usable Quality Water (BUQW)
- Underground Source of Drinking Water (USDW)
- Surface Open Hole Logging
- Casing Setting Depth
- Centralizers
- Cement Type
- CBL
- MIT



- Production Logging

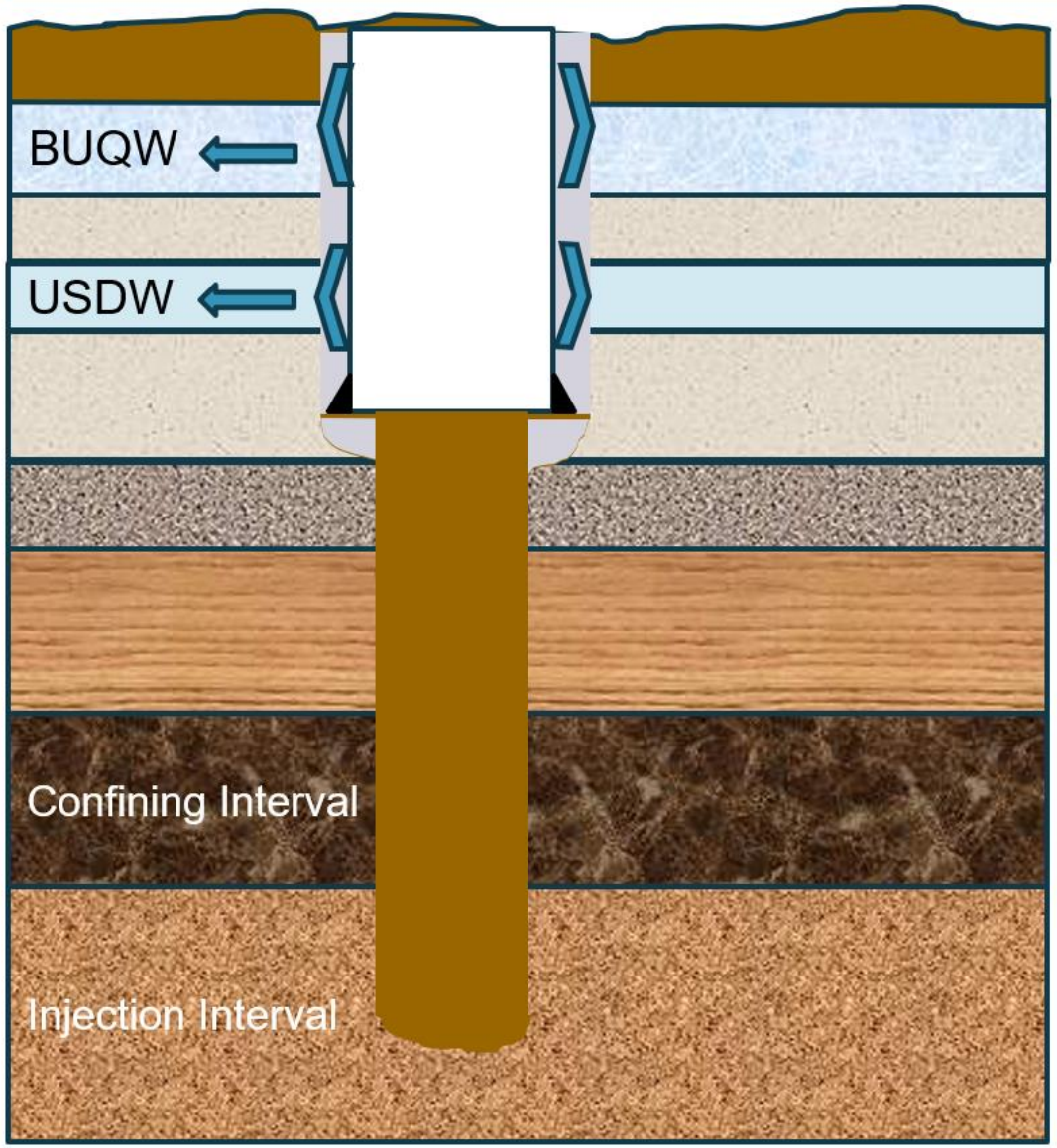
§5.203 (f)(3)(B) The operator must submit analyses of whole cores or sidewall cores representative of the injection zone and confining zone and formation fluid samples from nearby wells or other data

§5.203 (e)(2)(A) Depth to the injection zone(s);
§5.203 (e)(2)(H) Lithology of injection and confining zone(s)



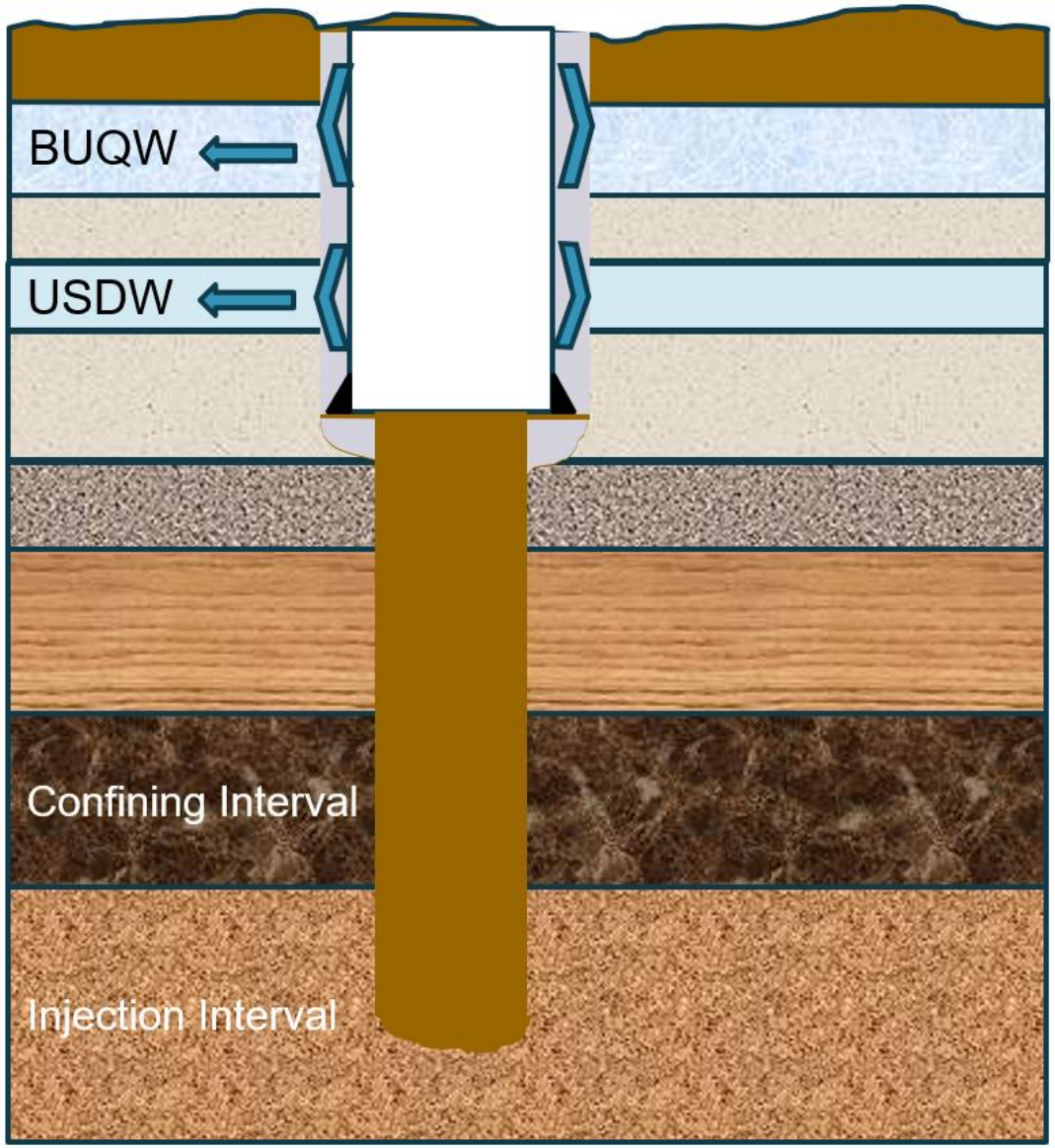
- Production Logging

§5.203 (f)(3)(A) The operator must record the formation fluid temperature, pH, conductivity, reservoir pressure, and static fluid level of the injection zone.



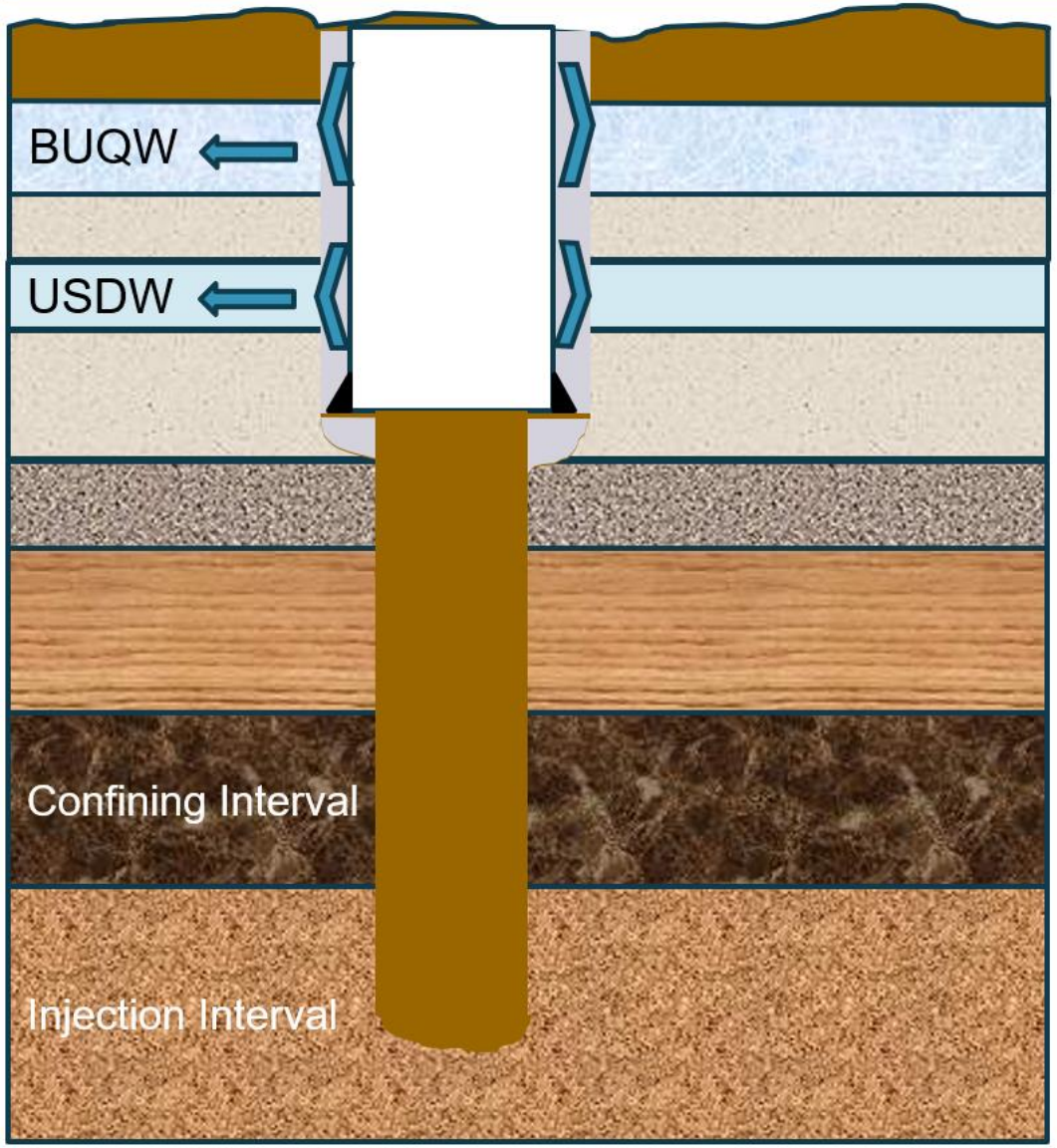
- Production Logging

§5.203 (f)(1)(D) Before **long string** casing is installed, the operator must run logs appropriate to the geology, such as resistivity, spontaneous potential, porosity, caliper, gamma ray, and fracture finder logs, to gather data necessary to verify the characterization of the geology and hydrology.



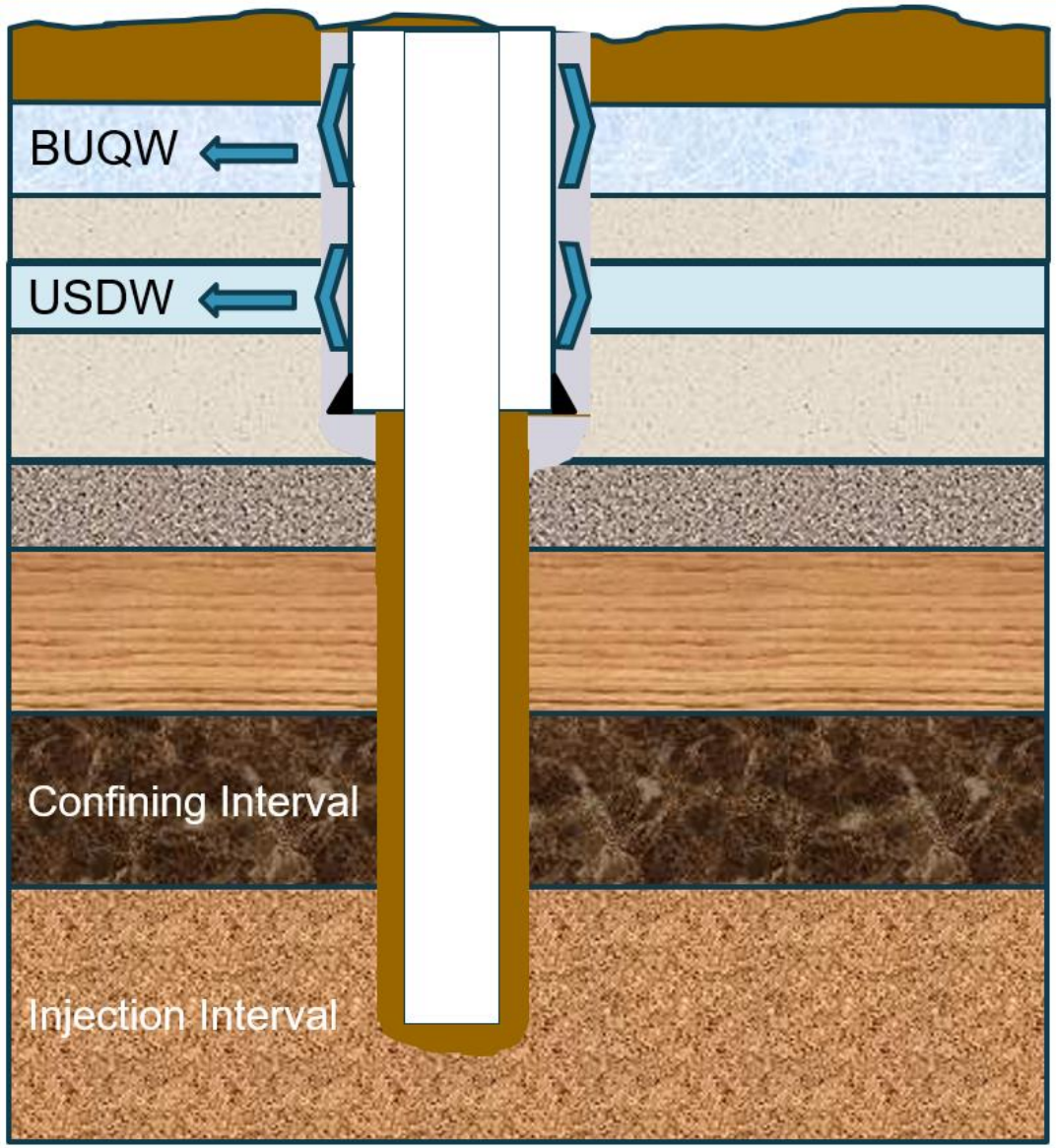
- Production Logging

§5.203 (f)(2)(C) The operator must determine or calculate the fracture pressures for the injection and confining zone. The Commission will include in any permit it might issue a limit of **90% of the fracture pressure** to ensure that the injection pressure does not exceed the fracture pressure of the injection zone



- Production Logging

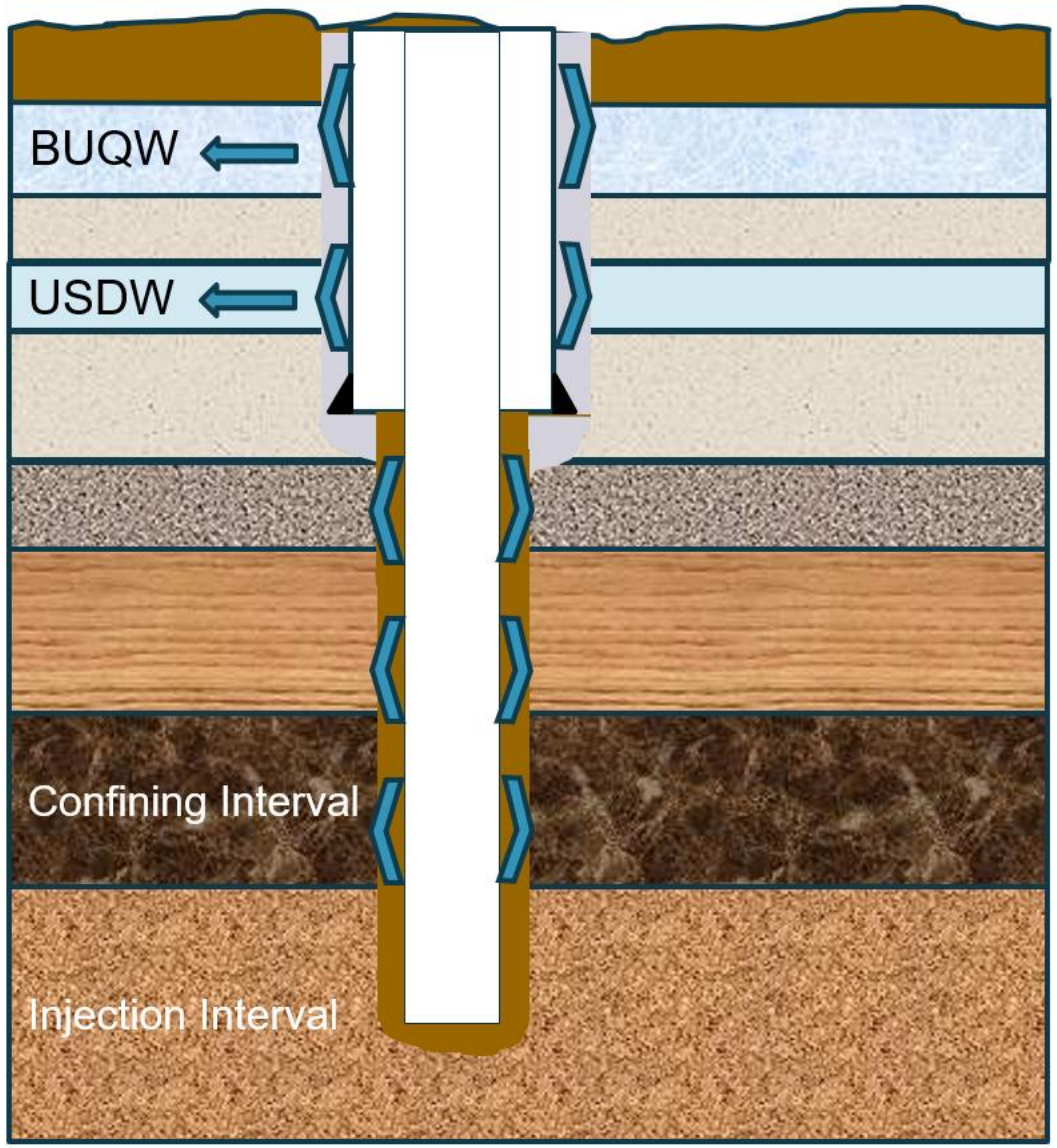
§5.203 (e)(1)(B)(ii) Casing and cement, cement additives, and/or other materials used in the construction of each injection well must have sufficient structural strength and must be of sufficient quality and quantity to maintain integrity over the design life of the injection well. All well materials must be suitable for use with fluids with which the well materials may be expected to come into contact



- Casing String Installation

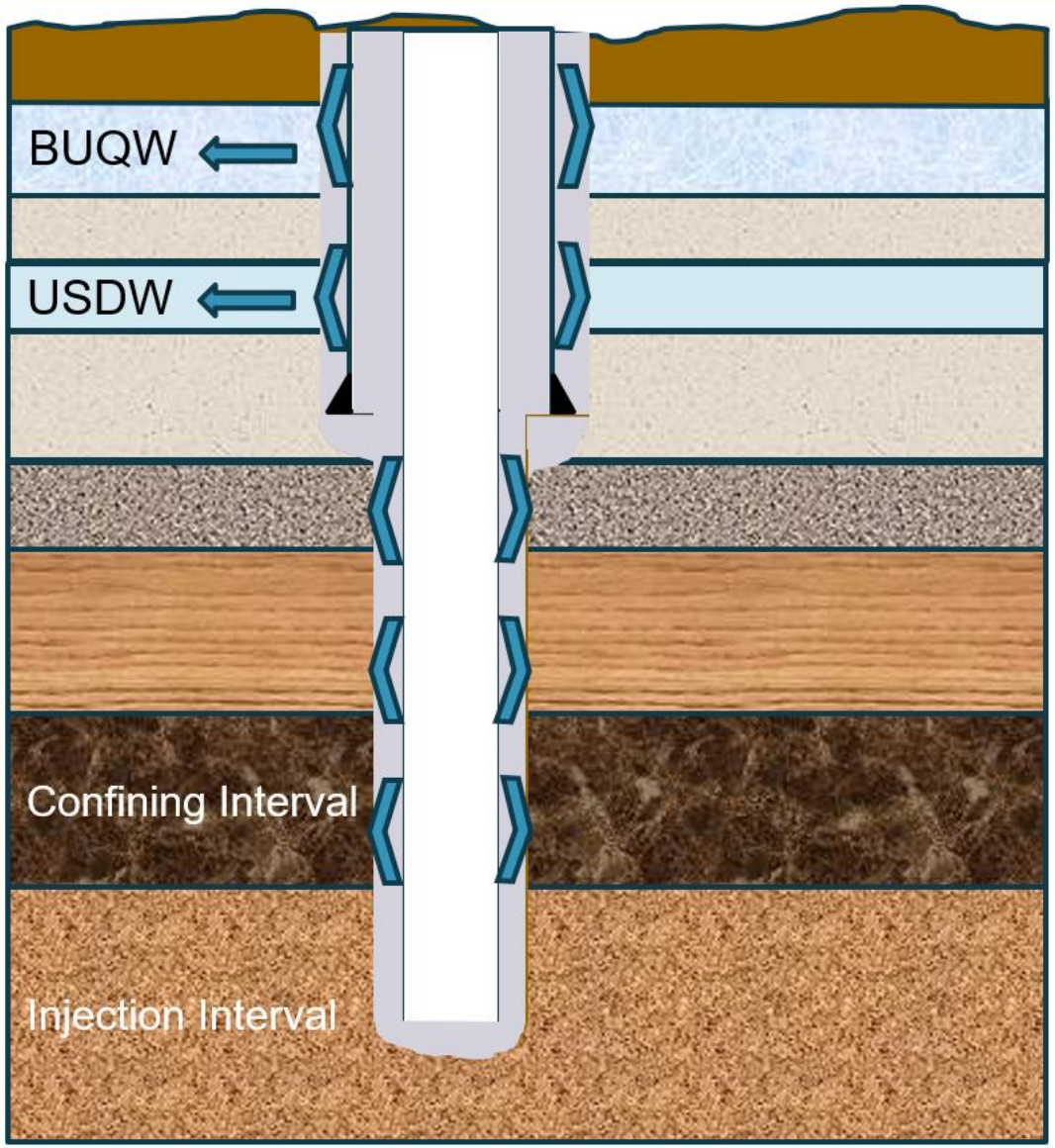
§5.203 (e)(2)(C) size and grade of all casing and tubing strings (e.g., wall thickness, external diameter, nominal weight, length, joint specification and construction material, tubing tensile, burst, and collapse strengths);

§5.203 (e)(2)(F) a description of the capability of the materials to withstand corrosion when exposed to a combination of the CO2 stream and formation fluids;
§5.203 (e)(2)(B) Hole size
§5.203 (e)(2)(A) Depth to the injection zone



- Casing String Installation
- Centralizer Installation

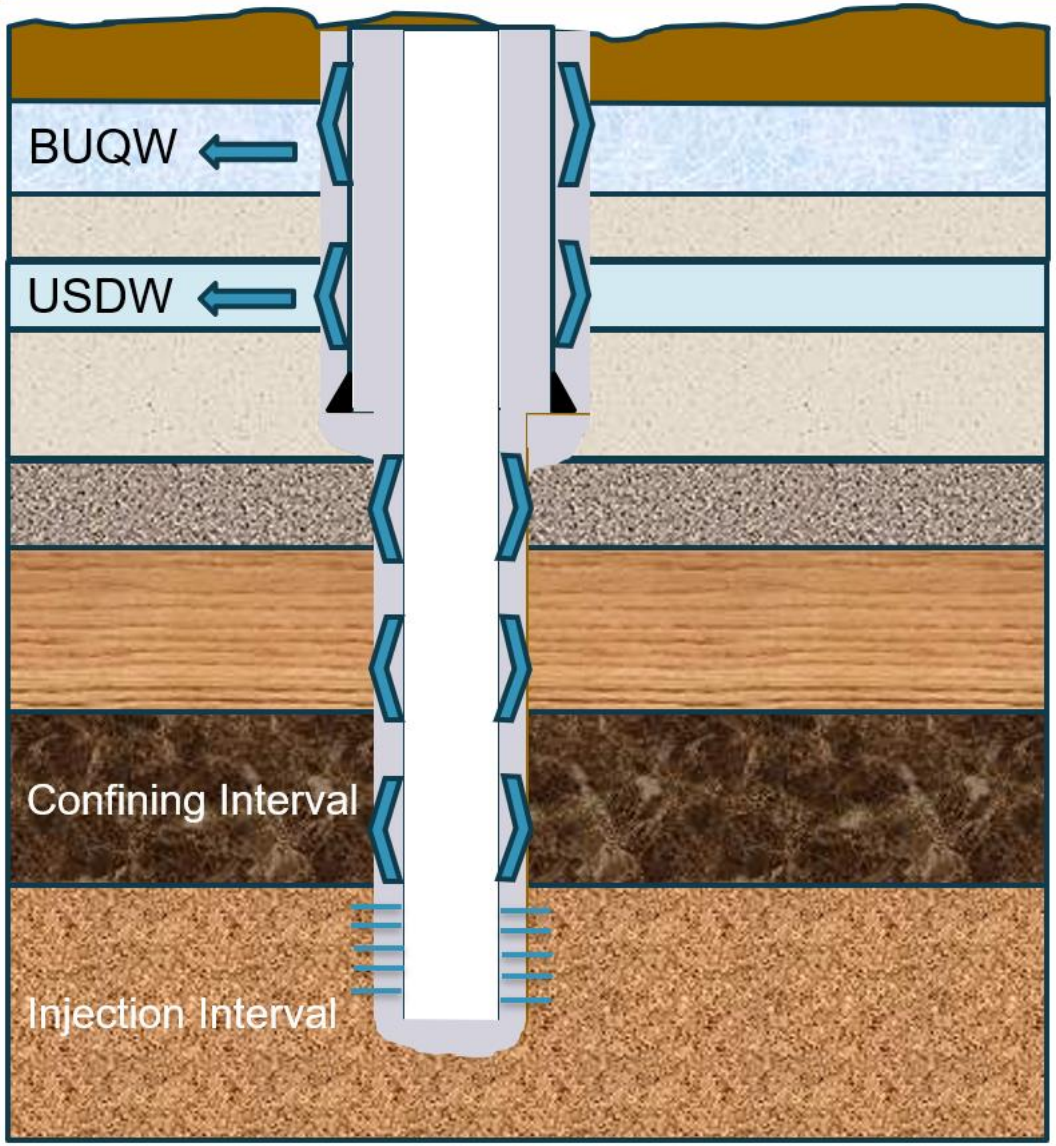
§5.203 (e)(1)(B)(v) long string casing, using a sufficient number of centralizers, must extend to the injection zone cemented by circulating cement to the surface in one or more stages. Must isolate the injection zone and other intervals as necessary for the protection of USDWs and to ensure confinement of the injected and formation fluids to the permitted injection zone. §3.13(b)(1)(G) recommends 1 centralizer every fourth joint



- Casing String Installation
- Centralizer Installation
- CBL, VDL Temp Logs

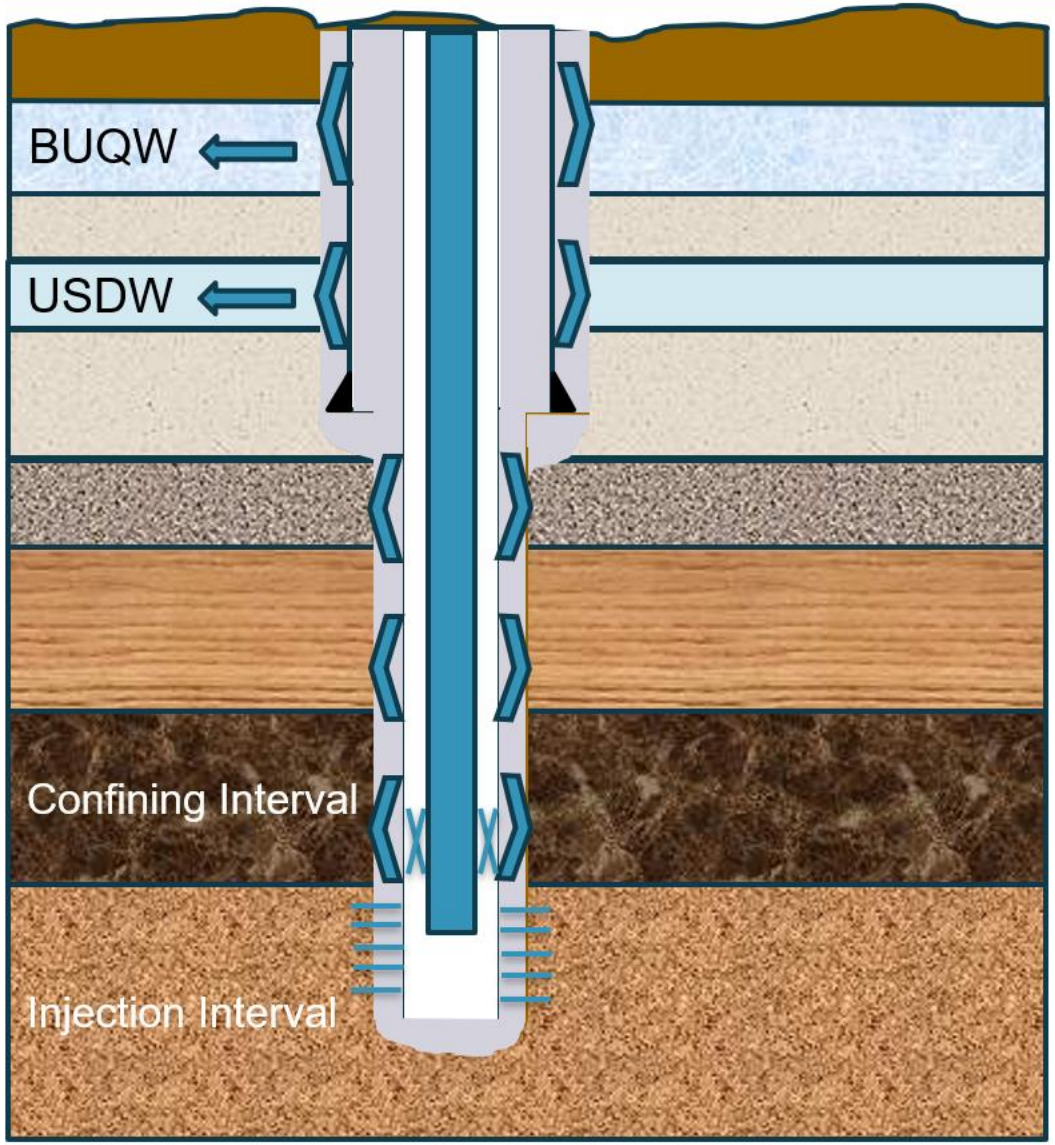
§5.203 (f)(1)(C) After each casing string is set and cemented, the operator must run logs, such as a cement bond log, variable density log, and a temperature log, to ensure proper cementing.

Prior to perforating, a Mechanical Integrity Test (MIT) must be performed



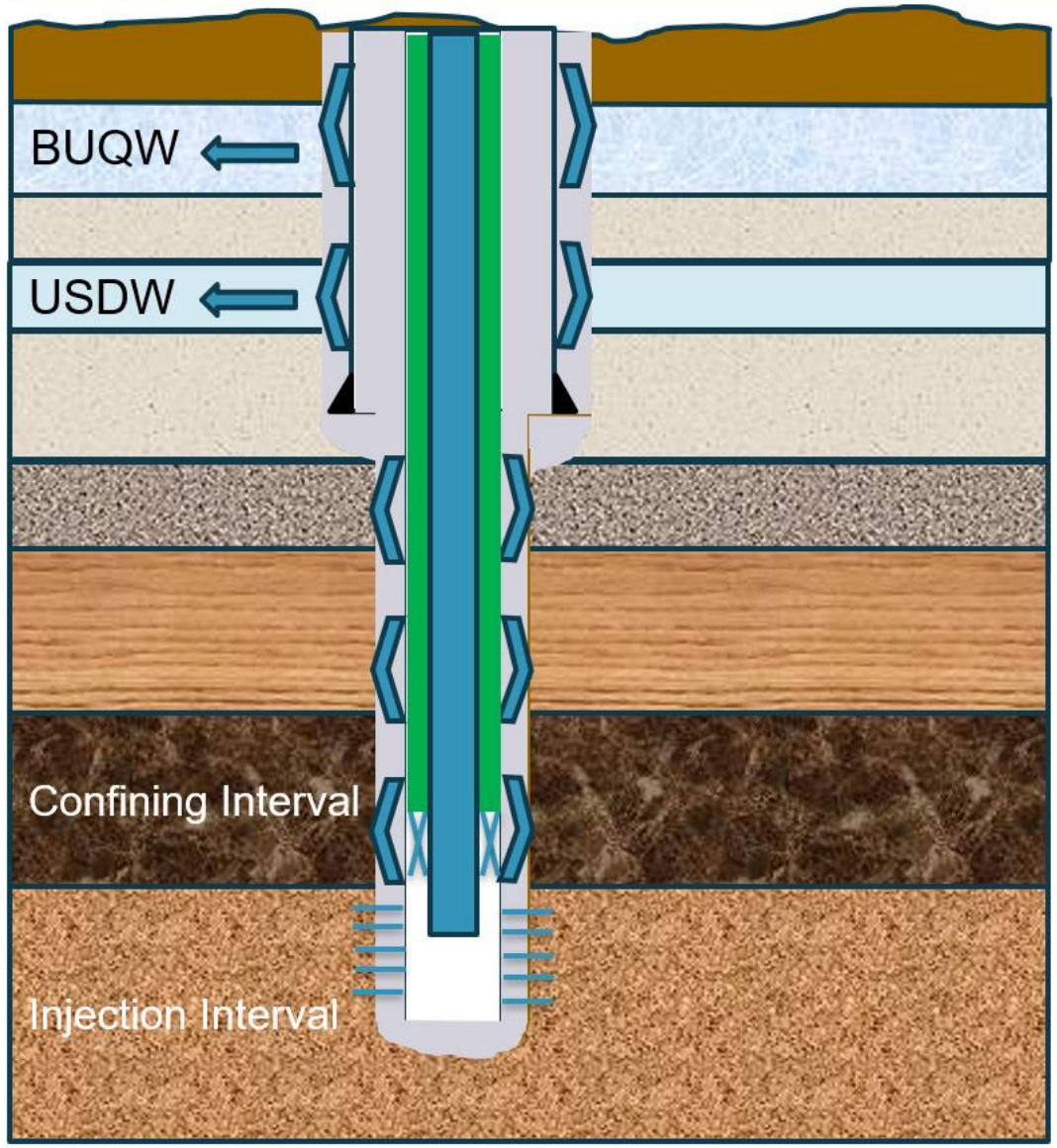
- Casing String Installation
- Centralizer Installation
- CBL, VDL Temp Logs

§5.203(j)(2)(G) Must perform a pressure falloff test prior to start of injection



- Casing String Installation
- Centralizer Installation
- CBL, VDL Temp Logs
- Tubing String & Packer

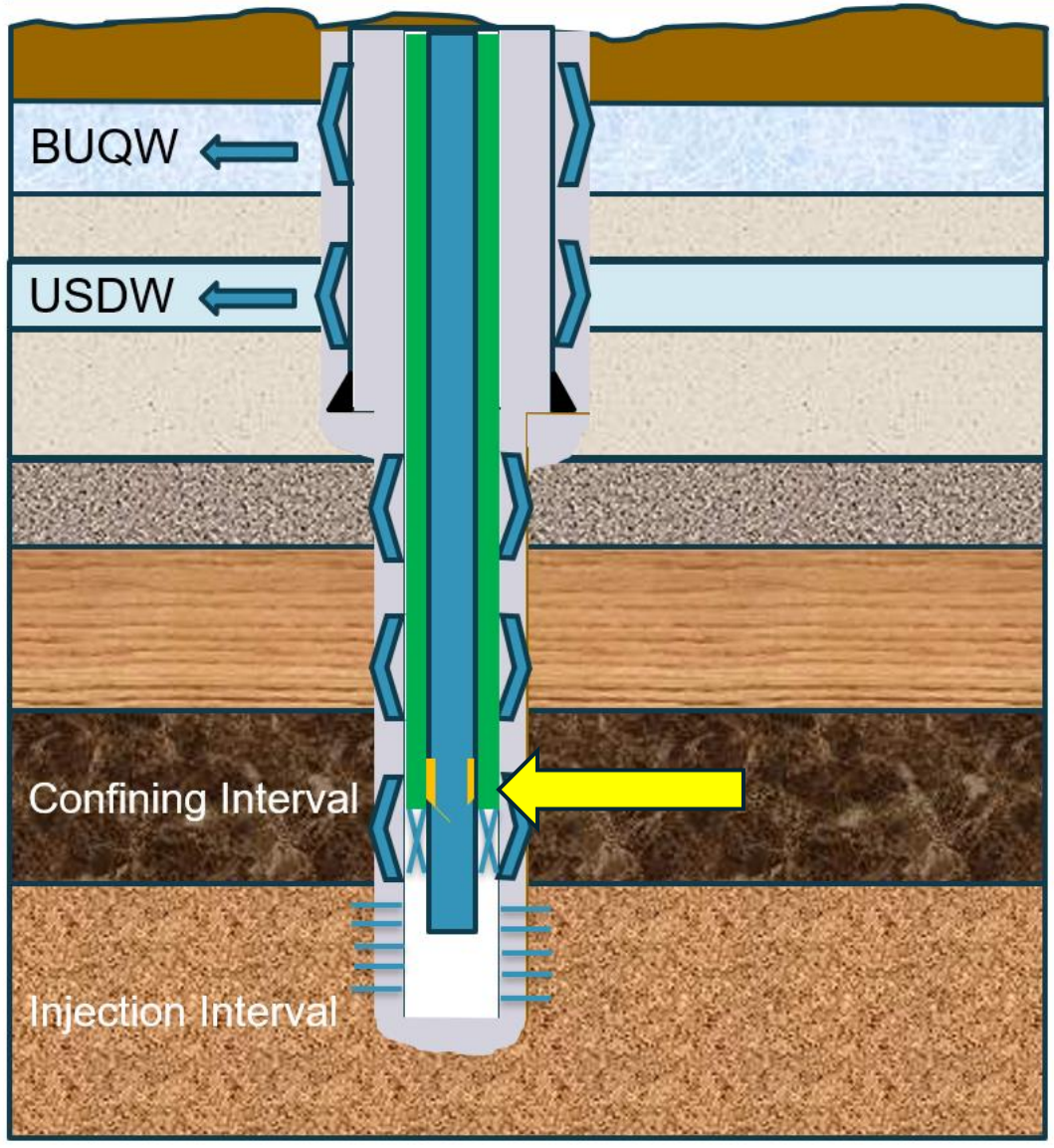
§5.203 (e)(1)(C)(i) All injection wells must inject fluids through tubing set on a mechanical packer. Packers must be set no higher than 100 feet above the top of the permitted injection interval



- Casing String Installation
- Centralizer Installation
- CBL, VDL Temp Logs
- Tubing String & Packer
- Monitoring

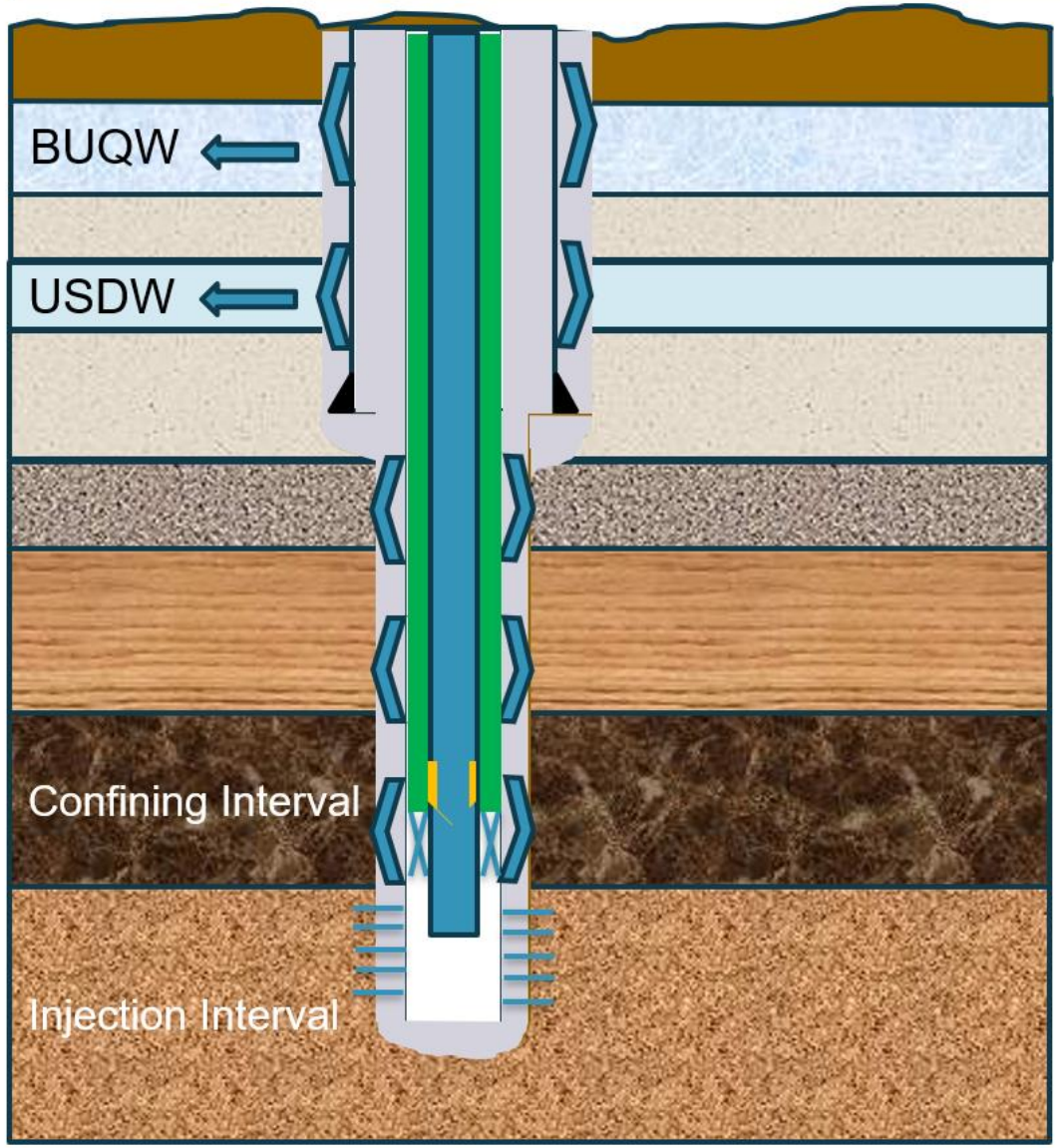
§5.206 (d)(2)(D) The owner or operator must fill the annulus between the tubing and the long string casing with a corrosion inhibiting fluid approved by the Director

§5.203 (e)(1)(A)(iii) Allow continuous monitoring of the annulus space between the injection tubing and long string casing.



- Casing String Installation
- Centralizer Installation
- CBL, VDL Temp Logs
- Tubing String & Packer
- Monitoring

§5.206 (d)(2)(F)(i) The operator must install and use alarms and automatic shut-off systems



- Casing String Installation
- Centralizer Installation
- CBL, VDL Temp Logs
- Tubing String & Packer
- Monitoring
- Stimulation

5.203(e)(4)
Well stimulation plan. The applicant must submit a description of the proposed well stimulation program

Other Key Requirements

- §5.203 (e)(2)(G) Down-hole temperatures and pressures
- §5.203 (e)(2)(K) Schematics of Downhole AND Surface Equipment
- §5.203(j)(2)(A) analysis of the CO2 stream prior to injection
- §5.203(j)(1) The applicant must submit a monitoring, sampling, and testing plan
- §5.203 (a)(4) must include in the application a quality assurance and surveillance plan for all testing and monitoring plan
- §5.203 The applicant must submit an emergency and remedial response plan

7. Emergency Response and Remediation Plan

- §5.203(l) the applicant must submit an emergency and remedial response plan
- Specify Response actions to coordinate activities
- Fill in internal call lists
- Monitoring discussed in application must be present in Testing and Monitoring plan
- Application must reference proper appendices and file names
- Prevent unauthorized access
- Identify soft and hard infrastructure
- Provide updated contact lists for all relevant parties