Wellbore Integrity

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OIL & GAS
CONSERVATION COMMISSION

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RE: Wellbore Integrity

Summary

The Colorado Oil and Gas Conservation Commission (COGCC) currently has several rules, policies and procedures that, when implemented properly, are intended to result in wellbore integrity. “Wellbore integrity” is a system configuration, including casing, cement, annular fluid, and surface appurtenances (e.g., valves, piping, and emission control devices) to protect against infiltration and prevent the migration of oil, gas or water from one horizon to another, that may result in the degradation of ground water.

COGCC has an active pre-construction and post-construction wellbore review process. The engineering staff preforms a pre-construction review of the casing and cement design to verify that the wellbore will be able to isolate fresh water from hydrocarbons. Field inspections occur during the drilling and completions phase to monitor and observe well drilling and completion phases through unannounced and random inspections. Post construction, the engineering staff performs a review of the as constructed casing and cement to verify that the approved permit to drill design was built and meets the criteria to isolate both fresh water and hydrocarbons zones. Wellbore integrity monitoring continues throughout the well’s productive life through bradenhead and mechanical integrity testing.

COGCC takes wellbore integrity very seriously. The current rules contain approximately 22 rules related to assuring the well’s cement and casing can be properly constructed to isolate and protect the fresh waters. Along with rules to monitor and maintain a wells mechanical integrity, there are 11 policies, several studies, and defined procedures.

Wellbore Integrity

Introduction

The Colorado Oil and Gas Conservation Commission (COGCC) currently has several rules, policies and procedures that, when implemented properly, are intended to result in wellbore integrity. As discussed herein, "wellbore integrity" is defined as the ability of a wellbore system configuration, including casing, cement, annular fluid, and surface appurtenances (e.g., valves, piping, and emission control devices) to protect any potential oil or gas bearing horizons penetrated during drilling against infiltration of injurious waters from other sources, and to prevent the migration of oil, gas or water from one horizon to another, that may result in the degradation of ground water. These objectives of wellbore integrity are provided for in Rule 317.d.

An oil or gas well may be subjected to various stresses through the life of the well, and wellbore integrity must be maintained as these stresses are applied to the well. In general, there are four phases in the life of a well: drilling, completion, production and abandonment. COGCC has rules, policies and procedures to address wellbore integrity during each phase. The drilling phase commences after approval of a Form 2 (Application for Permit to Drill). COGCC engineering staff review Form 2's to verify that casing and cementing plans satisfy wellbore integrity criteria defined by Rule 317 and common industry practices specific to individual areas of the state.

Well Construction and Fluid Isolation

The COGCC engineering evaluation begins with a review of surface casing setting depths to ensure useable fresh water aquifers are isolated; and, well control is adequate per Rule 317.e. (areas with unknown subsurface conditions) or Rule 317.f. (areas with known subsurface conditions). For deep fresh water aquifers, cemented intermediate casing or production casing stage cement may be used to isolate the deep fresh water aquifers that are not otherwise isolated by cemented surface casing, Rule 317.g. Further, Rule 317.h. and Rule 317.i. require hydrocarbon producing zones to be isolated with cemented intermediate or production casing. Rule 317.h. and Rule 317.i. also require minimum strength standards and coverage intervals for surface, intermediate, and production casing cement.

A well is constructed with a combination of steel tubulars (casing) and cement to satisfy the wellbore integrity objective of zonal isolation. Steel tubulars (or "strings") are "telescoped" into the well as the wellbore is deepened. If necessary, a conductor pipe is used as the outermost string to keep the surface hole open while drilling and prevent collapsing (or "sloughing") of near-surface soil and unconsolidated rocks into the surface hole. Conductor pipe is not intended to provide isolation of fresh water aquifers. Conductor pipe is either driven into the ground or placed with cement in a drilled hole. The next smallest casing string is the surface casing, which is fully cemented and protects fresh water aquifers, except for deep fresh water aquifers that are otherwise protected by cemented intermediate casing or stage cement on production casing. Surface casing is also designed for sufficient depth to protect fresh water

aquifers during possible well control events and as a foundation for placement of blowout prevention equipment that is used during drilling and workover operations. Depending on subsurface conditions, a smaller diameter intermediate casing is sometimes set and cemented inside and below surface casing to provide well control for weak deeper formations; to protect deep fresh water aquifers; to isolate lost circulation, to stabilize heaving or unstable zones; or to provide a rigid framework for hanging deep production liners, particularly in horizontal wells. The smallest diameter, innermost string is a production casing, which runs to surface or hangs off the bottom of an intermediate string as a liner. The primary purpose of the production string is to isolate producing hydrocarbon formations with cement to prevent migration of hydrocarbons and other fluids (e.g., hydraulic fracturing fluids) from the producing formation up the wellbore outside of the production casing. Figures 1 through 7 depict the drilling and installation process along with the related COGCC rules related to wellbore integrity. A summary of the COGCC engineering Form 2 review is presented as an exhibit to this summary, *Engineering Wellbore Review Procedure.*

The combination of steel and cement not only isolates fluid flow, but provide the compression, tension, collapse, and buckling strength necessary to maintain wellbore integrity in response to induced pressures applied to the well during drilling, completion and production activities. COGCC cement strength criteria are based on industry standards for compressive strength at 8 hours and 72 hours. See Rule 317.h. and Rule 317.i. COGCC requires production casing to be pressure tested for conditions anticipated during completion and production operations, Rule 317.j.

COGCC may require remedial cementing when a well is being deepened, re-entered, or recompleted. In existing wells, where newly-defined subsurface conditions have been identified, COGCC will require remedial cement across fresh water aquifer or hydrocarbon bearing zones prior to completion of any new objective hydrocarbon formations. COGCC may require specific tests during these phases of operation, Rule 207. As an example, formation integrity tests are required after drilling below the surface casing in the East Mamm Creek Area (refer to the *Notice to Operators Drilling Mesaverde Group or Deeper Wells in the Garfield County, Well Cementing Procedure and Reporting Requirements, revised February 9, 2007).*

Post Construction Verification

After the well has been drilled, cased and cemented, the operator is required by Rule 308A to submit a Form 5 (Drilling Completion Report) reporting how the well was constructed. Figure 4 depicts a cased and cemented well. Operators are required to submit documentation of the work completed with Form 5. COGCC engineering staff reviews the documentation (well log data, service company reports, and operator daily field reports) to confirm that the conductor (if any), surface, intermediate (if any) and production casings were placed and cemented in accordance with the approved Form 2 and applicable COGCC rules and policies. If cement coverage is not adequate to provide proper isolation of fresh water aquifers and hydrocarbon producing zones, then remedial cementing and/or other corrective action is required, and enforcement actions are considered. COGCC requires a Cement Bond Log (CBL) to verify

cement coverage behind the production casing or intermediate casing (if a production liner is used). Rule 317.o. Depending on the planned casing and cement configuration, COGCC staff may also require a CBL or temperature log for an intermediate casing string, even if a production casing string CBL is already required by rule. Figure 5 is an excerpt from a CBL showing the top of production casing cement. This geophysical log is a downhole tool run for the express purpose of evaluating the presence and quality of cement placed around casing.

COGCC also requires operators to file a Form 5A (Completed Interval Report). Rule 308B Form 5A includes information related to completed formations, depths, perforated intervals, and stimulation treatments. Figure 6 illustrates a graphic representation of a completed interval.

Well Integrity Monitoring

COGCC has several methods to monitor wellbore construction in the field during drilling, cementing, completion and production operations. COGCC engineering and field inspection staffs conduct unannounced and random inspections during all phases of these operations. Field inspections may also be conducted during specialized tests that are performed to demonstrate wellbore integrity, including bradenhead tests, mechanical integrity tests (MIT's) and formation integrity tests.

Surface casing cementing inspections may be performed to verify that cement is placed along the entire length of casing through observation of visible cement returns at the surface outside of the surface casing. With the cemented surface casing isolating the fresh water zones, drilling will continue for the intermediate or production hole.

During drilling, the production hole stability is maintained by the fluid weight of the drilling mud and the resulting mud cake that is formed on the borehole wall. After the target hydrocarbon zone has been reached in the production hole, the production casing is placed and cemented in the hole to isolate the hydrocarbon producing formations. COGCC staff may conduct unannounced and random field inspections while the production hole is being drilled, or while production casing is being run and cemented to monitor compliance with COGCC rules.

The next phase of monitoring is during the completion (a.k.a., stimulation or hydraulic fracture treatment). COGCC engineering and field inspection staffs conduct unannounced and random inspections to observe these operations. Rule 341 requires continuous bradenhead (the annulus between the surface casing and the production casing) pressure monitoring and recording during all stimulation operations. The rule further states that the stimulation fluids shall be confined to the objective formations during treatment. If the bradenhead annulus pressure increases more than 200 psig at any time during stimulation, the operator shall verbally notify COGCC as soon as practicable. Upon receipt of any high bradenhead pressure notices, COGCC engineering staff reviews the pressure data to determine if any remedial action is necessary. The operator is required to perform remedial work if wellbore integrity was compromised. Within the Wattenberg Field, COGCC has established an adjacent wellbore policy for bradenhead monitoring during hydraulic fracturing treatments of horizontal wells within 300 feet of an existing well.

Wellbore Integrity

Tests may be performed periodically during a well's productive life to monitor wellbore integrity. Bradenhead tests and MIT's are two examples. Bradenhead monitoring is an indirect method to verify wellbore integrity, and is defined by Rules 207.b. and 608.e. Bradenhead testing is the pressure monitoring of wellhead access to the annulus between the production and surface casing, as depicted in Figure 8. The wellhead annuli are equipped with fittings to allow safe and convenient access for pressure and fluid flow monitoring. The objective of the test is to check for pressure differential between the annular space and the casing and to observe any fluid flow (gas, oil, and/or water) up the annulus, which could be indicative of a casing leak. If a casing leak is suspected, then a MIT could be performed for verification.

Bradenhead monitoring of all coalbed methane (CBM) wells is required on a biennial basis. Rule 608 CBM bradenhead monitoring is performed per COGCC Orders in the San Juan and Raton Basins. Further, COGCC used Rule 207 to define special bradenhead areas. There are two Commission designated testing areas in addition to the San Juan and Raton Basins: Piceance Basin (refer to *Notice to Operators Drilling Wells in the Buzzard, Mamm Creek, and Rulison Fields, Garfield County and Mesa County, Procedures and Submittal Requirements for Compliance with COGCC Order Nos. 1-107, 139-56, 191-22, and 369-2, dated July 8, 2010*) and the *Special Bradenhead Testing Area in Weld County, established on December 16, 2009*.

MIT's, as described in Rule 326, are required for all shut-in, temporarily abandoned, or injection wells. The test is required at 5-year intervals. The test is performed by filling the casing (and/or the casing-tubing annulus on injection wells) with water or gas and applying a designated test pressure to the casing, as shown on Figure 9. The surface pressure is observed for 15 minutes to monitor for possible leak off. Wellbore integrity is confirmed if significant leak off is not observed. Conversely, if the test fails, the well is required to be repaired or abandoned. The requirement to maintain mechanical integrity is further enhanced by Rule 317.j., which requires the production casing to be pressure tested for the conditions anticipated during completion and production operations.

Wells lacking mechanical integrity or wells that are no longer capable of production are required to be abandoned per Rule 319 and Rule 326.d. The downhole abandonment procedure requires all water, gas or oil zones to be isolated and fluids to remain in their respective formations, as shown on Figure 10. To meet this requirement, mechanical or cement plugs are placed above and/or below hydrocarbon and fresh water aquifers. COGCC engineering staff reviews a Form 6 (Notice of Intent to Abandon) prior to plugging and abandonment to verify proper plug placement. This review is similar to a Form 2 engineering review, as discussed above, to identify all fresh water aquifers and hydrocarbon producing zones.

COGCC has an active pre-construction and post-construction wellbore review process. A field inspection program occurs during all phases of well and surface facility construction, operation, abandonment, decommissioning, and reclamation through unannounced and random inspections. Monitoring processes include a variety of downhole test procedures. The oil and gas extraction industry is dynamic with evolving technology. COGCC staff considers current rules and policies adequate to create, maintain, and demonstrate wellbore integrity. However,

periodic review of COGCC's wellbore integrity rules, polices, and procedures are necessary to keep in step with the oil and gas extraction industry.

WELL BORE DIAGRAM
DRILL OUT FOR SURFACE CASING
With fresh water to protect the aquifers

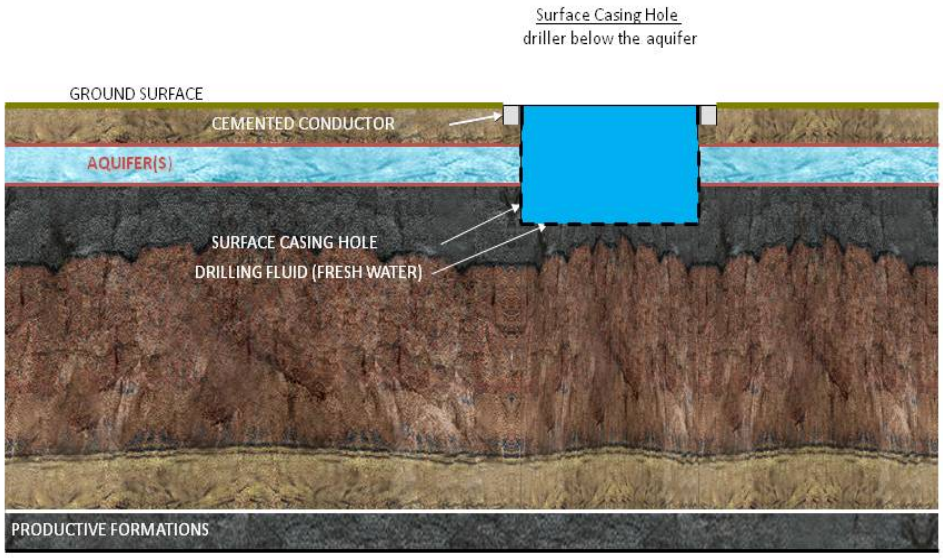

Figure 1

WELL BORE DIAGRAM
PLACE & CEMENT SURFACE CASING
To Protect Aquifers
Per COGCC Rules 317.e, f, g, & h

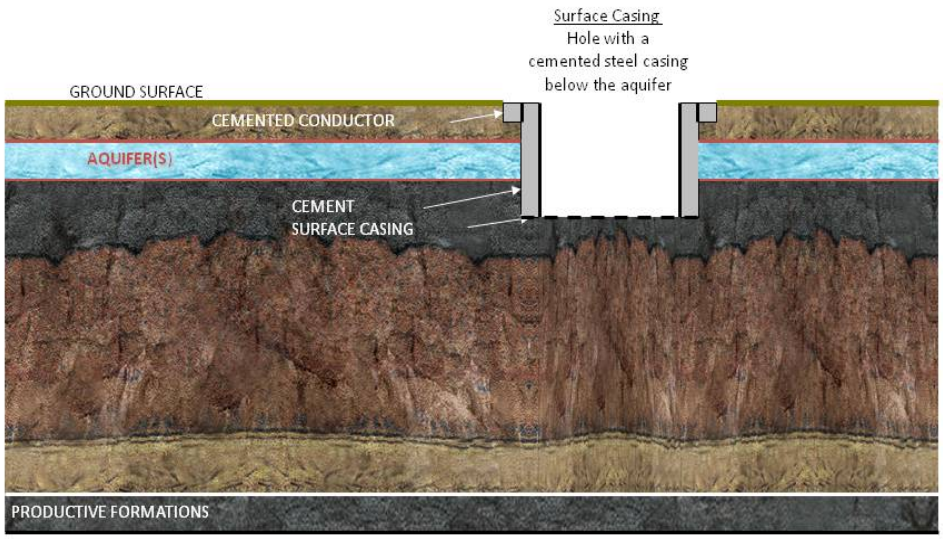

Figure 2

Wellbore Integrity

WELL BORE DIAGRAM

DRILL OUT FOR PRODUCTION HOLE

Fluid inflow control by drilling fluid weight

Per COGCC Rules 317.e, f, g, & h

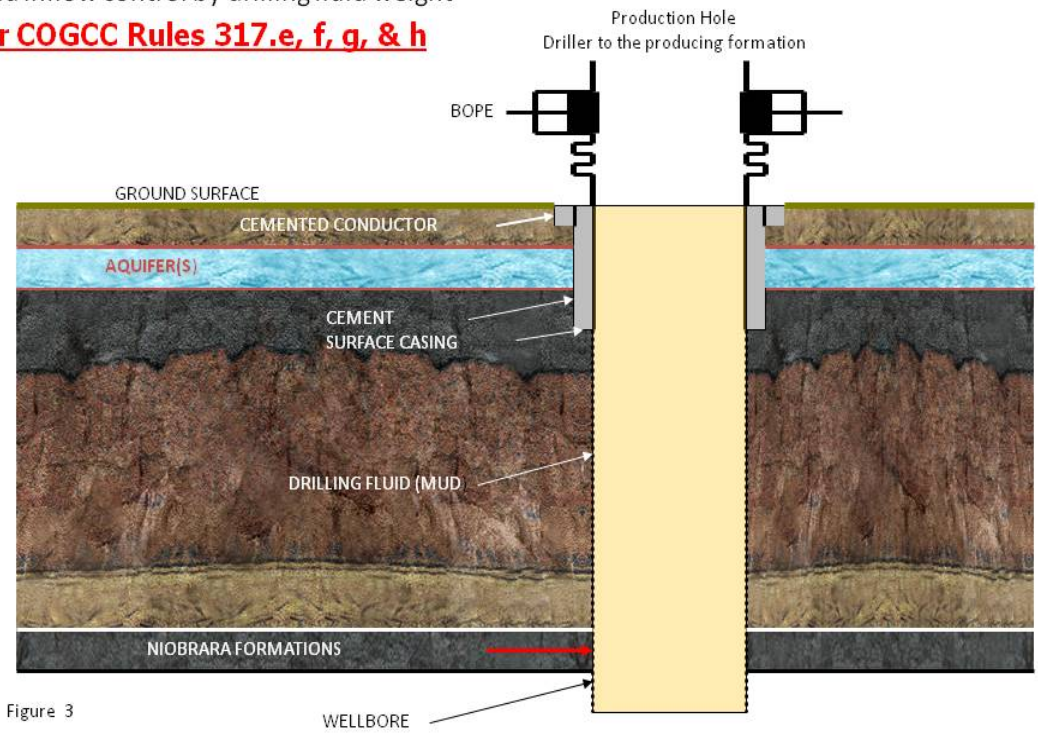

Figure 3

WELL BORE DIAGRAM

PLACE & CEMENT PRODUCTION CASING

Fluid inflow prevented by cement

Per COGCC Rules 317.i, j, & k and verified per Rule 308A

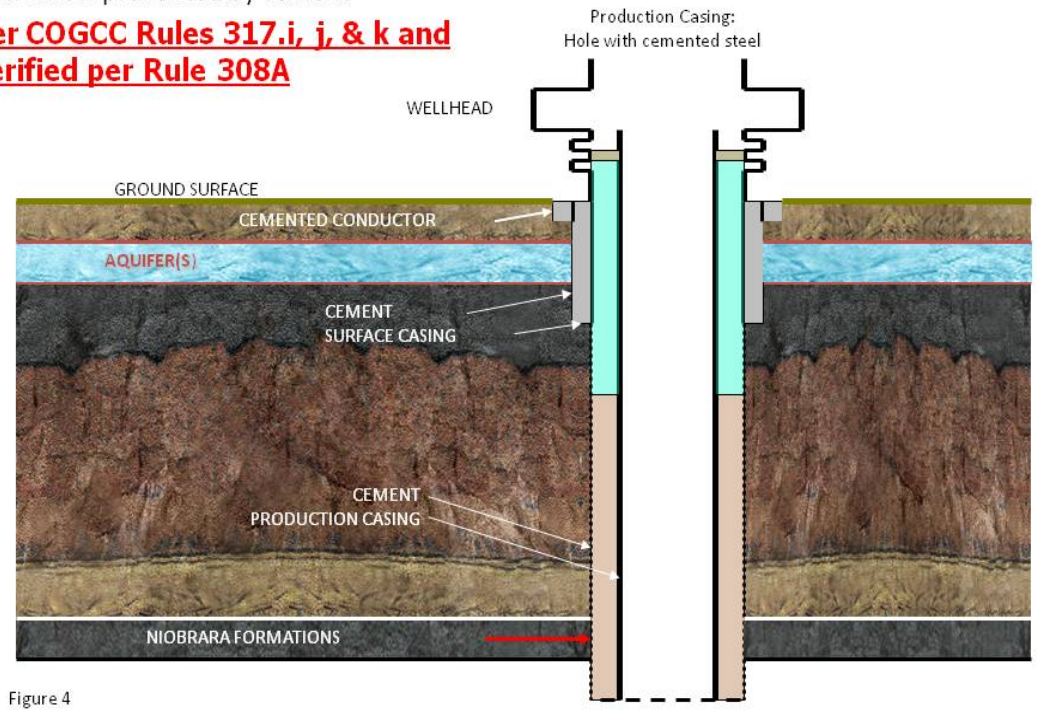

Figure 4

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Cement Bond Logs to verify placement of cement

Per COGCC Rule 317.o requires cement bond logs for all wells.

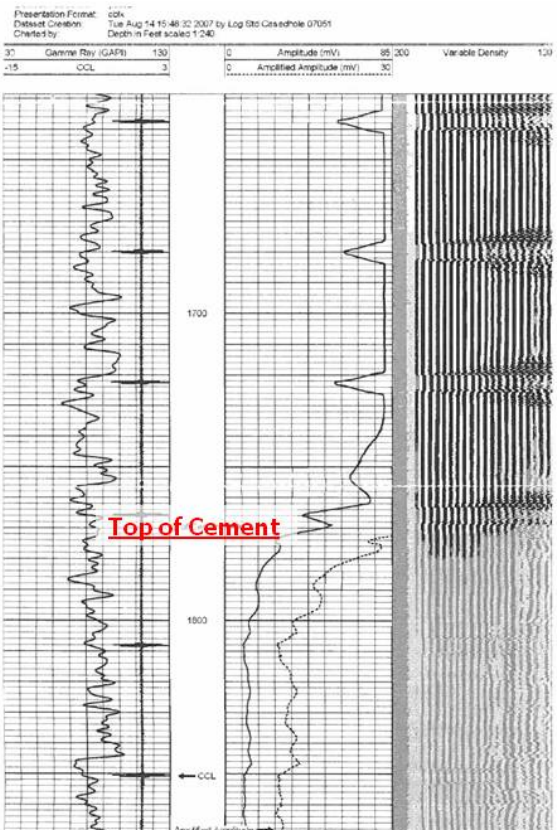

Figure 5

WELL BORE DIAGRAM
PREPARE FOR PRODUCTION
Perforate and run tubing

Per COGCC Rule 308B

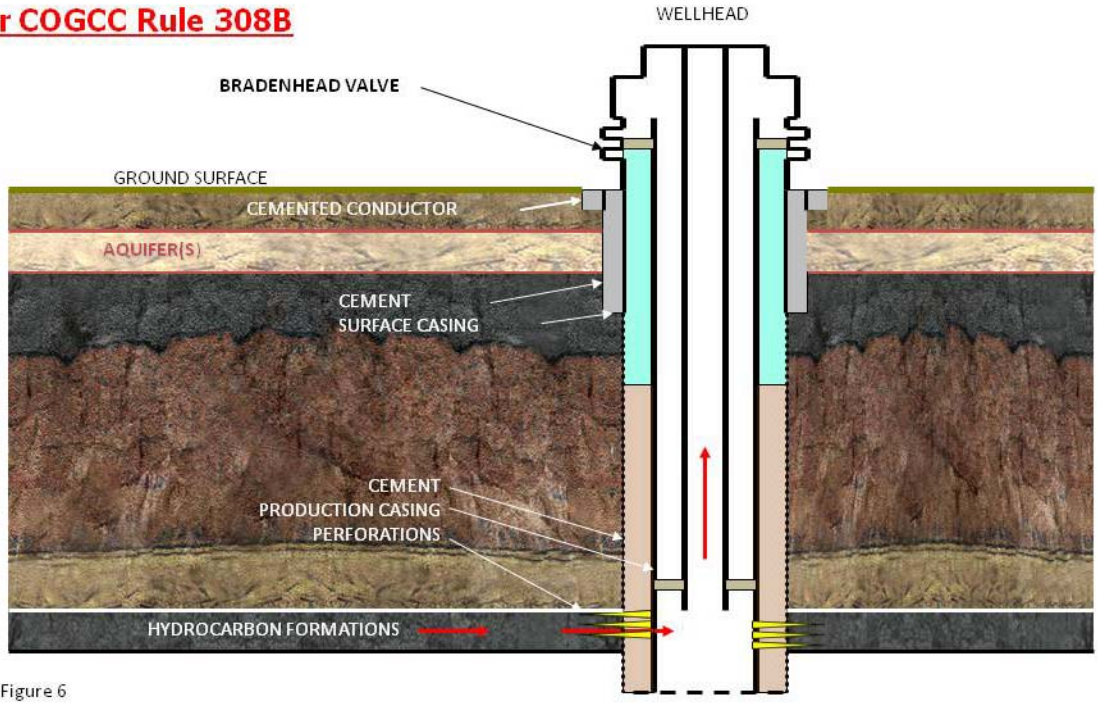

Figure 6

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WELL BORE DIAGRAM
STIMULATION – Hydraulic Fracture

Per COGCC Rule 341

Bradenhead valve monitoring during stimulation treatment per Rule 341

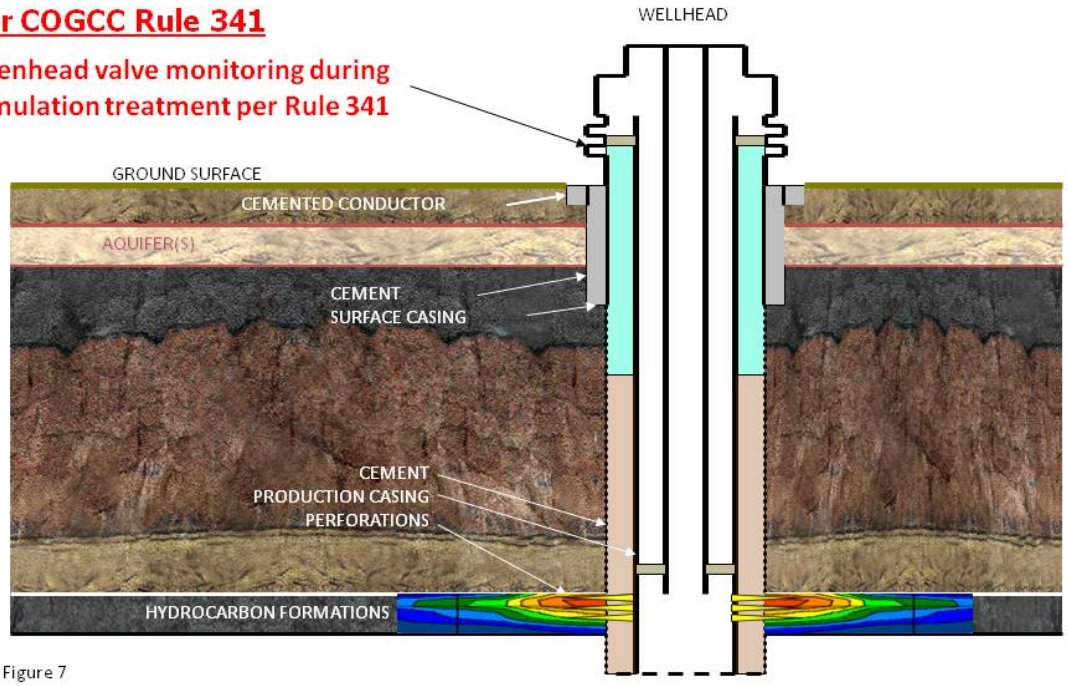

Figure 7

BRADENHEAD MONITORING TEST
Monitoring for internal annulus pressure

Per COGCC Rules 207.b. and 608.e.

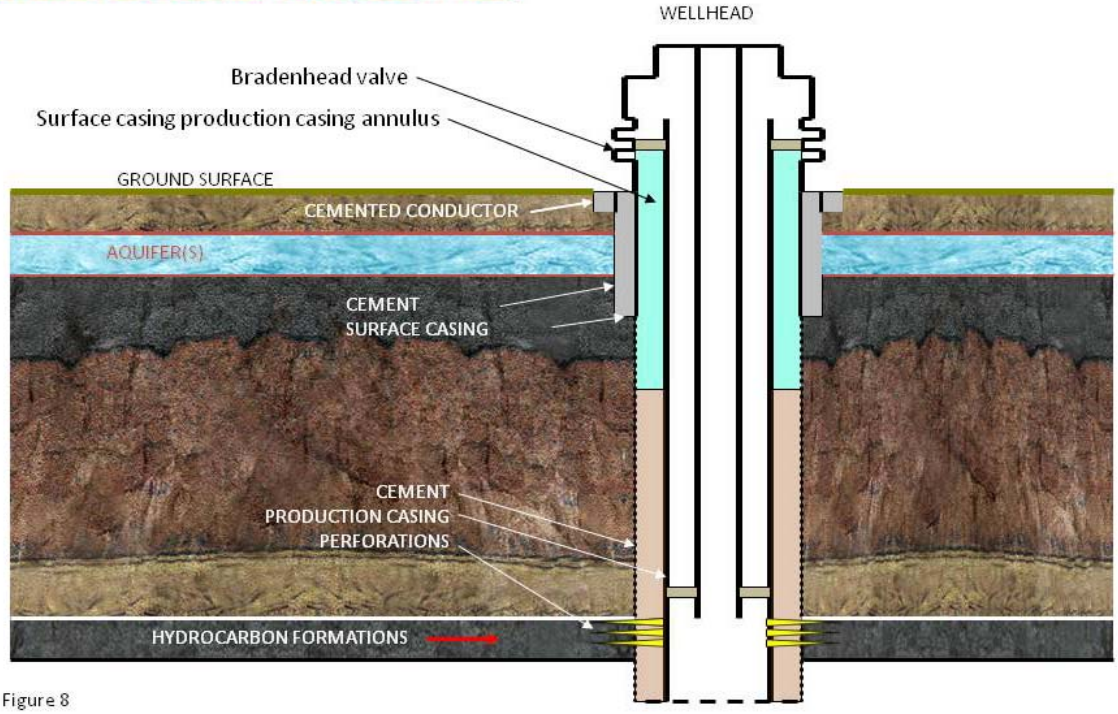

Figure 8

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MECHANICAL INTEGRITY TEST

Applied pressure monitoring of internal casing pressure

Per COGCC Rule 326

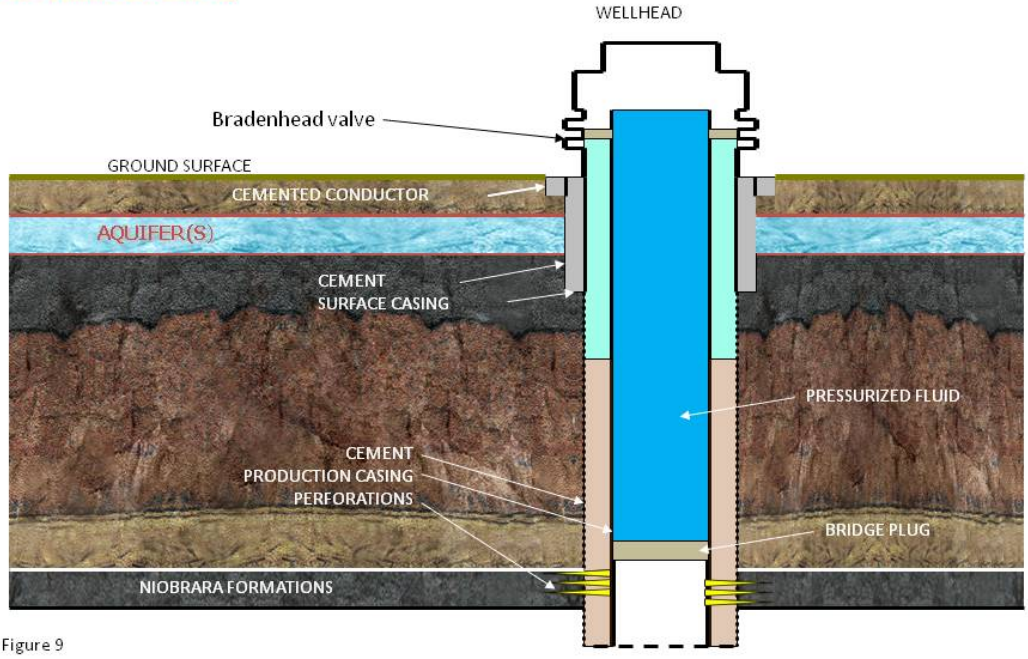

Figure 9

WELL ABANDONMENT

Rule 319: Isolation of fresh water and hydrocarbon zones

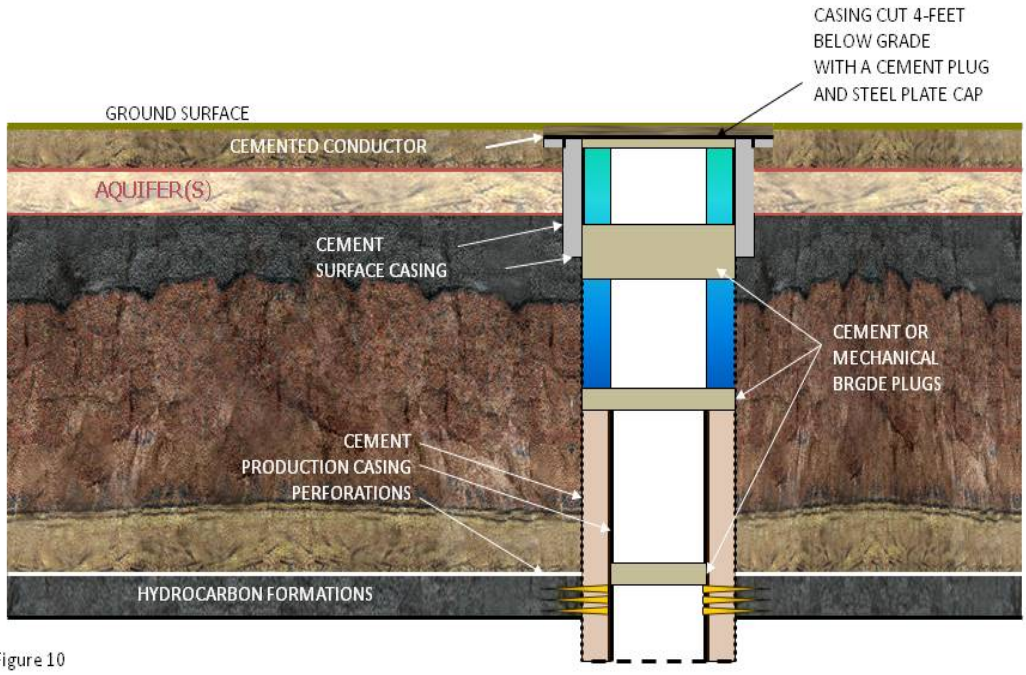

Figure 10

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CURRENT COGCC RULES RELATED TO WELLBORE INTEGRITY:

This section provided a list of most of the current COGCC rules related to wellbore integrity.

207. TESTS AND SURVEYS
301 RECORDS, REPORTS, NOTICES-GENERAL
303 REQUIREMENTS FOR FORM 2, APPLICATION FOR PERMIT-TO-DRILL, DEEPEN, RE-ENTER, OR RECOMPLETE, AND OPERATE; FORM 2A, OIL AND GAS LOCATION ASSESSMENT.
308A COGCC Form 5. DRILLING COMPLETION REPORT
308B COGCC Form 5A. COMPLETED INTERVAL REPORT
309 COGCC Form 7. OPERATOR'S MONTHLY PRODUCTION REPORT
311 COGCC Form 6. WELL ABANDONMENT REPORT
314 COGCC Form 17. BRADENHEAD TEST REPORT
316A COGCC Form 14. MONTHLY REPORT OF NON-PRODUCTED WATER FLUIDS INJECTED
316B COGCC Form 21. MECHANICAL INTEGRITY TEST
316C NOTICE OF INTENT TO CONDUCT HYDRAULIC FRACTURING TREATMENT
317 GENERAL DRILLING RULES
- a. Blowout prevention equipment (“BOPE”).
- c. Requirement to post permit at the rig and provide spud notice
- d. Casing program to protect hydrocarbon horizons and ground water.
- e. Surface casing where subsurface conditions are unknown.
- f. Surface casing where subsurface conditions are known
- g. Alternate aquifer protection by stage cementing
- h. Surface and intermediate casing cementing.
- i. Production casing cementing.
- j. Production casing pressure testing.
- k. Protection of aquifers and production stratum and suspension of drilling operations before running production casing.
- m. Protection of productive strata during deepening operations.
- n. Requirement to evaluate disposal zones for hydrocarbon potential
- o. Requirement to log well
- p. Remedial cementing during recompletion.

317A SPECIAL DRILLING RULES - D–J BASIN FOX HILLS PROTECTION AREA
- a. Surface Casing - Minimum Requirements for Well Control.
- b. Surface Casing - Aquifer Protection.
- c. Exploratory Wells.

319 ABANDONMENT
321 DIRECTIONAL DRILING
325 UNDERGROUND DISPOSAL OF WATER
326 MECHANICAL INTEGRITY TESTING
327 LOSS OF WELL CONTROL
341 BRADENHEAD MONITORING DURING WELL STIMULATION OPERATIONS
404 CASING AND CEMENTING OF INJECTION WELLS
603 DRILLING AND WELL SERVICING OPERATIONS AND HIGH DENSITY AREA RULES
608e. COALBED METHANE WELLS Bradenhead testing.

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CURRENT COGCC POLICIES:

1. COGCC Policy for Bradenhead Monitoring During Hydraulic Fracturing Treatments in the Greater Wattenberg Area, dated May 29, 2012
2. Practices and Procedures, UIC Mechanical Integrity Tests, dated March 17, 2011
3. Notice to Operators Drilling Williams Fork Formation Wells in Garfield County, Surface Casing Depth and Modification of Leakoff Test Requirements, revised June 23, 2006
4. Notice to Operators Drilling Mesaverde Group or Deeper Wells in the Mamm Creek Field Area in Garfield County, Well Cementing Procedure and Reporting Requirements, revised February 9, 2007
5. Notice to Operators Drilling Wells in the Buzzard, Mamm Creek, and Rulison Fields, Garfield County and Mesa County, Procedures and Submittal Requirements for Compliance with COGCC Order Nos. 1-107, 139-56, 191-22, and 369-2, dated July 10, 2010
6. Notice to All Oil and Gas Operators Active in the Denver Basin, Colorado Oil and Gas Conservation Commission Approved Wattenberg Bradenhead Testing and Staff Policy, dated December 16, 2009
7. Drilling Completion Report - Cement Documentation Policy, February 17, 2009
8. Clarification on Procedures for Filing Changes to Applications for Permit-to-Drill, revised January 18, 2011
9. Conductor Pipe Setting Policy, April 6, 2006
10. Approval of Casing Repairs Policy
11. Northwest Colorado Notification Policy, Effective for Notices Received On or After January 1, 2010, Revision No. 3, May 10, 2012

COGCC STUDIES:

1. COGCC Mamm Creek Area Cementing and Bradenhead Pressure Monitoring Practices, staff presentation to Commission dated September 19, 2011
2. COGCC Response to the conclusions and recommendations in the June 20, 2011 *East Mamm Creek Project Drilling and Cementing Study*, memorandum dated September 19, 2011
3. East Mamm Creek Project Drilling and Cementing Study, consultant report dated June 20, 2011

COGCC Engineering Wellbore Review Procedure:

Surface Casing Review:

The following is a general outline of COGCC engineering staff's review process for evaluating sufficient surface casing setting depths for fresh water aquifer protection and well control.

1. Initially, our engineers review the Form 2 (Application for Permit-to-Drill) for the well location, total depth, objective formations, and proposed casing and cementing program.
2. From the well's proposed location the engineers utilize their knowledge of the geologic basin and local fresh water aquifers, which is derived from experience, literature, COGCC records

and geophysical log data, Colorado Geologic Survey (CGS) reports and Division of Water Resources (DWR) water well records to determine an appropriate surface casing setting depth to protect fresh water aquifers. Intermediate casing or production casing stage cement is considered for deep fresh water aquifer protection. Data from offset logs or wells is corrected for differences in ground surface elevation prior to approving required casing setting depths and cement coverage intervals.

3. Engineers review COGCC well records to identify and compare the surface casing setting depths for any nearby oil and gas wells.
4. Engineers review the DWR water well records for aquifer protection beginning with all water wells within a one mile radius of the proposed oil or gas well. If deeper aquifers are not observed on offset geophysical logs, the minimum required surface casing depth must be at least 50 feet below the top of a confining shale layer underlying the fresh water aquifer in which the deepest permitted water well is screened or 50 feet below the total depth of the deepest permitted water well, whichever is deeper. In many cases, water wells are drilled into the confining layer to provide wellbore storage or additional room for a submersible pump, and therefore, water well total depth may be a more stringent criterion compared to the threshold of 50 feet below the confining layer top. Confining layer log tops from offset well logs and water well total depths are adjusted for elevation differences compared to the proposed oil or gas well when performing this evaluation. If there are no water wells, or if there are not enough water wells for a representative sample set within one mile then the area of review is expanded until a representative sample set is achieved.
5. If deep fresh water aquifers are observed on offset geophysical logs and water wells are not completed in those fresh water aquifers, then our engineers will consider more stringent casing and cement programs to protect the deep fresh water aquifers, including: deeper surface casing, intermediate casing, or production casing stage cement.
6. When geophysical log data and/or water well data is limited, engineers may consult with COGCC environmental staff, CGS, DWR, the Bureau of Land Management (BLM), the operator and local hydrogeologists to obtain additional information.
7. In certain areas of the state, minimum surface casing setting depths are required to account for possible high pressures that may be encountered during drilling. In most areas of the state, five (5) percent of the total vertical depth of the well is acceptable, but in certain areas of the Piceance Basin, ten (10) percent or fifteen (15) percent of the total vertical well depth is required.
8. After reviewing appropriate data, as discussed above, engineers then apply their professional knowledge, experience, and engineering judgment to either accept the operator-proposed casing and cement program or require a more stringent casing and cement program to provide proper fresh water aquifer protection and well control.
9. If the surface casing setting depth appears deeper than necessary, such that an aquifer may be exposed for an extended period while drilling the surface hole, or if hydrocarbon zones are expected in the proposed surface hole interval prior to reaching the surface casing setting depth, the engineer will engage with the operator to understand the intention of deep surface casing. The engineer's objectives will remain to protect fresh water aquifers and provide wellbore stability while drilling and to provide an adequate seal to protect fresh water aquifers with cement.

10. Following completion of the well, our engineers review the well log data, and service company and operator records of work completed to confirm that the surface casing was set and cemented to surface in accordance with the approved casing and cement plan on the Form 2. If proper fresh water aquifer coverage is not present, then remedial cementing and other corrective actions may be required.

Production Casing Review:
The following is a general outline of COGCC engineering staff's review process for evaluating sufficient production casing cement coverage:

1. Engineers review the Form 2 for the well location, total depth, objective formations, and proposed casing and cementing program.
2. From the well's proposed location the engineers utilize their knowledge of the geologic and production history, which is derived from experience, literature, COGCC records, and Colorado Geologic Survey (CGS) reports to review the Form 2 to determine appropriate cement coverage for isolation of the objective hydrocarbon producing zones.
3. The engineer reviews our well records and geophysical logs to identify any known productive hydrocarbon zones from nearby oil and gas wells. Cement coverage will be required for all known productive horizons. COGCC's statewide Rule 317.i. requires cement coverage across producing zones, and the cement top must extend at least two hundred (200) foot above the shallowest known producing horizon. Required production casing cement tops are more stringent in certain areas of the state (e.g., cement to surface in shallow coalbed methane plays and cement to 200' above the Mesaverde Group top in certain parts of the Piceance Basin). More stringent cement coverage may be specified where necessary for adequate hydrocarbon zone isolation as a Condition of Approval on Form 2.
4. Engineers then apply their professional knowledge, experience, and engineering judgment to either accept the operator-proposed casing and cement program or require a more stringent casing and cement program to provide proper zonal isolation and protection against fluid migration along uncemented portions of the wellbore, if any.
5. Following completion of the well, our engineers review the well log data and service company and operator records of work completed to confirm that the production casing was placed and cemented in accordance with the approved casing and cement plan on the Form 2. If required cement coverage is not present, remedial cementing and other corrective actions may be required.

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Wellbore Abandonment Review:

The following is a summary of the Engineering Staff review process for well abandonment, which begins with an operator submitted request to abandon, a *Notice of Intent to Abandon*. The *Notice of Intent to Abandon* is reviewed and approved with any necessary changes. Upon completion of the approved abandonment procedure the operator must submit a Subsequent of Abandonment Report, including contractor plugging verification reports, which document materials used and work performed.

The engineer reviews the operator's *Notice of Intent to Abandon*, with specific consideration given to fresh water aquifers and hydrocarbon producing zones to determine where plugs should be set in the well. Evaluation of these zones is similar to the evaluation described above for casing and cement program reviews for new oil or gas wells. Engineers require that plugs be set above the perforations for each hydrocarbon formation completed in the well. We also require plugs above hydrocarbon zones that are generally produced in the nearby vicinity even if not perforated in the particular well being plugged and abandoned. In dry holes, we require plugs to be set above drill stem tests (DST's) or other significant oil & gas shows observed while drilling. Shows are typically reported on the Form 5 or on a mud log. A stub plug is required if casing is to be cut and recovered. Plugs are required across previously repaired casing leaks and cementing stage tools. Plugs are required below and/or above fresh water aquifers (if any) that are not covered by surface casing or stage cement. A plug is required across the surface casing shoe, and another plug is required from 50' to surface.

Engineers consider the operator's proposed procedures, zones in need of isolation and documentation of existing cemented intervals in the wellbore. The engineer reviews important wellbore conditions as disclosed in the well record or on the *Notice of Intent to Abandon*, such as holes in casing (wellbore integrity), stuck tubing, packers, or other fish in the hole, previously undocumented perforations and cemented intervals (cement squeezes, casing repairs, or recompletions), and information from past workover operations, etc.

If the operator's *Notice of Intent to Abandon,* as submitted, is not adequate or the engineer has other questions, the engineer contacts the operator to resolve issues and make changes before approving the *Notice of Intent to Abandon*.

Subsequent Report of Abandonment:

After plugging the operator is required to provide a *Subsequent Report of Abandonment* of the well, including contractor plugging verification reports, which document materials used and work performed. Engineers review the submittal to confirm that plugs were set as required on the approved *Notice of Intent to Abandon*. If the job was not carried out substantially in accordance with the approved *Notice of Intent to Abandon* or it did not result in adequate isolation because of unanticipated changes in the field, necessary corrective action such as re-entry and re-plugging of the well, is required.