STATE OF COLORADO
OIL & GAS
CONSERVATION COMMISSION

DEPARTMENT OF NATURAL RESOURCES
John W. Hickenlooper, Governor
1120 Lincoln St. Suite 801
Denver, CO 80203
Phone: (303) 894-2100
FAX: (303) 894-2109
www.colorado.gov/cogcc

Memorandum

September 19, 2011

To: David Andrews, COGCC Western Colorado Engineering Supervisor

CC: Stuart Ellsworth, COGCC Engineering Manager
David Neslin, COGCC Director

From: Kevin King, COGCC Northwest Area Engineer

Subject: COGCC Response to the conclusions and recommendations in the June 20, 2011 *East Mamm Creek Project Drilling and Cementing Study*, prepared by Crescent Consulting, LLC et al.

Executive Summary

The *East Mamm Creek Project Drilling and Cementing Study* ("EMC Study") finds that the *Notice to Operators Drilling MesaVerde Group or Deeper Wells in the Mamm Creek Field Area in Garfield County, Well Cementing Procedure and Reporting Requirements ("*Cementing NTO"), originally released in 2004, along with updated Standard Operating Procedures ("SOP") established by the operator, have made significant improvements in drilling and cementing practices in the Mamm Creek Field Area. The EMC Study identifies several recommended areas for improvement that may warrant a revision of the Cementing NTO. Considering that the EMC Study was primarily limited to the East Mamm Creek Area, which is a smaller subset of the field-wide area that is defined in the Cementing NTO, most of the recommended changes discussed herein would be limited to well pads permitted within the East Mamm Creek Area, likely through the use of COA's on individual Applications for Permit to Drill. COGCC is evaluating the adequacy of the geographic extent of the current East Mamm Creek Area and the larger Mamm Creek Field Area, and a revision of the Cementing NTO is not likely until COGCC's evaluation is complete.

Based in part on the preliminary review of the conclusions and recommendations in the EMC Study, COGCC staff recently approved drilling permits for wells on two pads in the East Mamm Creek Field with several additional Conditions of Approval which address these recommendations. The EMC Study was also used in the development of the Mamm Creek Field Casing and Cementing Guidance Matrix, which summarizes the advantages and disadvantages of different drilling practices as they apply to the East Mamm Creek Field Area.

Below you will find a bulleted list of the conclusions and recommendations contained in the *East Mamm Creek Project Drilling and Cementing Study*, followed by the Colorado Oil and Gas Conservation Commission's (COGCC's) response and planned actions concerning each conclusion and recommendation.

DEPARTMENT OF NATURAL RESOURCES: Mike King, Executive Director
COGCC COMMISSION: Richard Alward – Thomas L. Compton – DeAnn Craig – Mark Cutright – Michael Dowling – Joshua B. Epel – Mike King – Chris Urbina
COGCC STAFF: David Neslin, Director – Margaret Ash, Field Inspection Manager – Debbie Baldwin, Environmental Manager – Stuart Ellsworth, Engineering Manager

COGCC Conclusions and Recommendations

- COGCC's Cementing NTO has been effective in improving cementing performance.
  - ✓ Require minimum standoff of 50% for all casing strings.
  - ✓ Update document contact information.

  - ✓ COGCC will continue to attach the February 9, 2007 *Notice to Operators Drilling MesaVerde Group or Deeper Wells in the Mamm Creek Field Area in Garfield County, Well Cementing Procedure and Reporting Requirements* ("Cementing NTO") as a Condition of Approval (COA) to all drilling permits in the area subject to the Cementing NTO.
  - ✓ Recent drilling permits in the East Mamm Creek Area (defined in the Cementing NTO) have been approved with the following COA: CENTRALIZER SYSTEMS MUST BE DESIGNED TO ACHIEVE A MINIMUM OF 50% STANDOFF ON ALL CASING STRINGS. REPORT CENTRALIZER PLACEMENT AND CALCULATED STANDOFF ON THE REQUEST TO COMPLETE.
  - ✓ Contact information will be updated in the next revision of the NTO.

- COGCC's Bradenhead NTO has been effective in providing timely recognition and mitigation of potential gas flow scenarios.

  - ✓ COGCC will continue to attach the July 8, 2010 *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* ("Bradenhead NTO") as a COA to all drilling permits in the areas subject to the Bradenhead NTO.

- Remediation requirements should be triggered when Bradenhead pressure reaches a pressure [of] 250 psi at the surface. Overall pressure gradients exceeding 0.6 psi/ft require further evaluation. COGCC's current threshold for reporting and mitigation (venting or remediation, depending on the nature of the flow) is 150 psi. Continue to vent or utilize Bradenhead gas whenever possible.

  - ✓ COGCC will continue to use a Bradenhead surface pressure of 150 psi as a reporting threshold, and the Bradenhead NTO requires that operators maintain Bradenhead pressures below 150 psi. Mitigation (venting and/or remediation) is considered for any wells that have exceeded a Bradenhead pressure of 150 psi. Venting is normally advised as an initial mitigation measure, unless flow rates are consistently high or significant volumes of fluids are produced from the Bradenhead annulus.
  - ✓ Remediation may or may not be required for wells where a bradenhead pressure has been observed above 250 psi. COGCC evaluates the wellbore characteristics to determine casing and cement configuration, the type of fluid in the annulus, pressure build rates, and the nature of fluid discharge when high bradenhead pressures are observed. In some cases, venting may still be advised if remediation is not practical.

- ✓ The recommended 0.6 psi/ft evaluation threshold is generally consistent with COGCC's 150 psi reporting threshold discussed above, although it may be more or less stringent, depending on the total vertical depth of the surface casing. The following example illustrates this concept:

    - Total Vertical Depth (TVD) of well = 7,500 feet
    - Surface Casing Total Vertical Depth = 1,125 feet (15% of well TVD)
    - Bradenhead annulus is fluid-filled (with water) = 0.43 psi/ft fluid gradient
    - Calculated Threshold Evaluation Pressure = 1,125 feet * (0.6 psi/ft – 0.43 psi/ft) = 191 psi

  In this example, 150 psi would be more stringent than a 0.6 psi/ft total surface pressure gradient threshold. However, for wells with surface casing total vertical depths of less than 882 feet (a back-calculated value using the formula shown above), the 0.6 psi/ft total surface pressure gradient threshold would be more stringent than a 150 psi/ft threshold. COGCC will evaluate use of the 0.6 psi/ft threshold during annual review of operator submittals which are required by the Bradenhead NTO.

- In surface casing cement applications where fallback occurs, "top out " procedures are preferred to perforating casing and circulating cement when the annular cement top is less than 250 feet in depth.

  - ✓ In the past, operators have normally proposed the method of surface casing cement top out to COGCC engineering staff, based on operational logistics specific to the well in question.
  - ✓ For future surface casing top out attempts in the Cementing NTO area, COGCC staff will encourage the use of a small diameter pipe (i.e. one inch pipe) in "top out" procedures, as opposed to perforating surface casing, to remediate surface casing cement fallback when annular cement top is less than 250 feet in depth. This depth threshold will not apply in certain of the Piceance Basin outside of the Mamm Creek Field because it is not practical based on geologic conditions in some other areas.

Encana Conclusions and Recommendations

- Encana's SOP has been effective in improving production casing cementing performance.
    - Further improvements may be available in terms of controlling gas migration, especially when cement is returned to surface on production casing jobs.
    - The existing document should be expanded or a similar document should be developed specifically for establishing standards for surface and intermediate casing installation and cementing.

  - ✓ Encana's Standard Operating Procedures (Encana's SOP's) complies with the COGCC rules and the Cementing NTO, and in many cases Encana's SOP's are more comprehensive than the COGCC's requirements.
  - ✓ COGCC will continue to work with operators in the Mamm Creek Field Area in exploring options to achieve adequate isolation of natural gas and water-bearing zones from total depth to surface on the production casing. However, COGCC staff believes that monitoring pressure and in some cases, venting low pressure and Wasatch gas is effective in preventing natural gas

migration to water-bearing zones. Based on COGCC's observations to date, attempts at circulating cement across Wasatch gas zones have only been marginally effective in isolating Wasatch gas zones, and the possibility exists that cement channeling above Wasatch gas zones may divert the gas and prevent the ability to monitor and mitigate gas pressures in the Bradenhead annulus.

- ✓ COGCC staff will explore the option of amending standards for casing installation, including wellbore conditioning and centralization standards, into the next revision of the Cementing NTO.

- Slimhole environments resulting from intermediate casing installation may result in higher GFP [gas flow potential] tendencies, particularly in deviated cases.
    - Deviation, coupled with a slimhole environment requires adequate centralization, fluid loss control and general cementing best practices to control gas migration tendencies. Adherence to rigorous engineering design is critical in these environments.

    - ✓ COGCC staff will explore the option of amending standards for casing installation, including wellbore conditioning and centralization standards, into the next revision of the Cementing NTO.

- Use of more advanced LCM in cement slurries may provide superior performance and limit cement fallback. Materials include but are not limited to fibers, laminates, and nut hulls. Experiments should be performed in all casing string applications to identify optimum LCM for the EMCPA.

    - ✓ Recent drilling permits in the area have been approved with the following COAs which require reporting of lost circulation and encourage the use of LCM in wellbore conditioning, prior to pumping cement slurries:
        - IF LOST CIRCULATION OF 20 BBL/HR OR MORE IS EXPERIENCED AT ANY TIME DURING THE DRILLING OF THIS WELL, OPERATOR SHALL STOP DRILLING, PUMP LOST CIRCULATION MATERIAL AS NEEDED.
        - IF LOST CIRCULATION OF 100+ BBLS WITHIN 24 HR OR MAJOR GAS (GAS OVER 1800 UNITS WHILE DRILLING) OCCURS AT A TRUE VERTICAL DEPTH LESS THAN 4200', OPERATOR SHALL NOTIFY COGCC'S WESTERN COLORADO ENGINEERING SUPERVISOR WITHIN 24 HOURS, AND PRIOR TO RUNNING CASING, TO DISCUSS THE OPTIONS FOR UTILIZING A DV TOOL ON PRODUCTION OR INTERMEDIATE CASING.
    - ✓ COGCC staff will explore the option of adding more stringent standards for reporting lost circulation and the use of lost circulation material (LCM), similar to the COA's shown above, in the next revision of the Cementing NTO.

- Surface casing deviation in the well plan requires rigorous engineering design on the surface section of the wellbore.

- Develop and implement an expanded Encana SOP or a specific SOP to account for surface casing installation and cementing to minimize the potential for fluid migration along the surface casing cement sheath.

✓ COGCC staff will explore the option of amending standards for casing installation, including wellbore conditioning and centralization standards, into the next revision of the Cementing NTO. Surface casing installation and cementing standards should be designed to isolate water bearing zones from shallow gas zones in deviated surface wellbores.

- In areas with lost circulation in the surface casing section, utilize lightweight lead slurries, and evaluate the potential for Type III or TXI Lightweight tail slurries to reduce density.

✓ COGCC staff will explore the option of amending reporting standards, as discussed above, for reporting lost circulation in the area subject to the Cementing NTO. Surface casing cement should be designed on a well-by-well basis considering lost circulation zones observed during drilling.

✓ Reports of lost circulation in the surface interval will be used as a tool to prioritize the witnessing of surface casing cement jobs by COGCC staff.

✓ Surface casing cement jobs that fail to achieve a full column of cement from the casing's total depth to surface during the primary circulation attempt must be remediated, as required by COGCC Rule 317.h. Surface casing cement remediation should follow the "top out" recommendations discussed above.

- More rigorous casing and cementing design may improve cement remediation results when remediation is necessary.
  - Provide proper casing centralization in sections above the primary TOC.

✓ Recent drilling permits in the area subject to the Cementing NTO have been approved with the following COA to help ensure proper centralization of casing within the wellbore: CENTRALIZER SYSTEMS MUST BE DESIGNED TO ACHIEVE A MINIMUM OF 50% STANDOFF ON ALL CASING STRINGS. REPORT CENTRALIZER PLACEMENT AND CALCULATED STANDOFF ON THE REQUEST TO COMPLETE.

✓ COGCC staff will explore the option of including this standard for casing centralization in the next revision of the Cementing NTO.

✓ Cement remediation, when necessary, will be evaluated on a well-by-well basis.

Joint Conclusions and Recommendations

- Shallow gas zones exist in the surface hole, and they must be properly identified and isolated

- Perform open hole logging of the initial well on each pad to identify shallow gas-bearing zones in the surface hole

✓ Recent drilling permits in the area were approved with the following COA: SUBMIT THE FOLLOWING OPEN-HOLE LOGS ON THE SURFACE HOLE FOR THE FIRST WELL DRILLED ON THIS PAD, VIA EMAIL TO COGCC WESTERN COLORADO ENGINEERING SUPERVISOR, WITHIN 24HOURS OF RUNNING AND WITH FORM 5: SPONTANEOUS POTENTIAL, GAMMA RAY, FORMATION DENSITY, COMPENSATED NEUTRON, AND RESISTIVITY (TRIPLE COMBO).

✓ COGCC staff will consider incorporating the above requirement into the next revision of the Cementing NTO.

✓ Knowledge of shallow gas zones, that can be identified by open hole logs, combined with proper casing centralization and cement slurry design, are key factors in isolating shallow gas zones.

- Drilling fluid losses and whole cement losses and gas flow events are unpredictable.

✓ Operators are required by rule to report significant downhole problems to COGCC. Operator staff work with COGCC staff to develop mitigation and remediation strategies when unanticipated events occur during drilling or cementing.

- The lenticular nature of potentially productive gas-bearing sands is conducive to drilling fluid losses and flows, as the unpredictable pressures of individual lenses are distinct and separate from each other.

✓ Because of the lenticular and unpredictable nature of the gas-bearing and loss circulation zones in the Mamm Creek Field Area, COGCC staff feels it is necessary to continue monitoring and evaluating each well on a case-by-case basis.

✓ In summary, the current Cementing NTO includes the following requirements that involve the monitoring and reporting of, and protection against: loss zones, gas zones, well bore integrity, and pressure monitoring:

- Upon completion of the primary cementing operation, the annular fluid level around the production casing shall be monitored for a minimum of 4 hours prior to the installation of the casing slips.
- The Bradenhead pressure shall be measured at intervals of 6, 12, 24, 48 and 72 hours after the production casing is cemented.
- Following the cementing operation, a combination temperature/cement bond log shall be run within 12 to 48 hours to locate the actual cement top.
- Prior to completion of the well, the Bradenhead pressure record, cement bond log, temperature survey log, and revised formation tops shall be provided to the COGCC Northwest Area Engineer along with a Sundry Notice, Form 4 requesting approval to complete the well.

- Operators drilling within the East Mamm Creek Area are required to perform a Formation Integrity Test (FIT) at least fifty (50) feet below the surface casing shoe. If the well bore does not test to the equivalent of mud weight of 13.0 ppg during the above noted FIT, the operator shall be required to set intermediate casing.

✓ Recent drilling permits in the East Mamm Creek Area have been approved with the following COAs, which are more stringent than the current Cementing NTO:

- IF LOST CIRCULATION OF 20 BBL/HR OR MORE IS EXPERIENCED AT ANY TIME DURING THE DRILLING OF THIS WELL, OPERATOR SHALL STOP DRILLING, PUMP LOST CIRCULATION MATERIAL AS NEEDED.
- IF LOST CIRCULATION OF 100+ BBLS WITHIN 24 HR OR MAJOR GAS (GAS OVER 1800 UNITS WHILE DRILLING) OCCURS AT A TRUE VERTICAL DEPTH LESS THAN 4200', OPERATOR SHALL NOTIFY COGCC'S WESTERN COLORADO ENGINEERING SUPERVISOR WITHIN 24 HOURS, AND PRIOR TO RUNNING CASING, TO DISCUSS THE OPTIONS FOR UTILIZING A DV TOOL ON PRODUCTION OR INTERMEDIATE CASING.
- PRODUCTION CASING CEMENT TOP MUST BE 500' ABOVE THE SHALLOWEST GAS SIGNATURE OBSERVED ON MUD LOGS OR OPEN-HOLE LOGS. THE SHALLOWEST GAS SIGNATURE, AS DEFINED BY 2500 UNITS, DEPTH SHALL BE REPORTED ON THE REQUEST TO COMPLETE.

✓ COGCC staff will consider incorporating the above requirement into the next revision of the Cementing NTO.

- Differences between reservoir fluid pressure gradient and fracture pressure gradient are often minimal.

✓ Because of the minimal differences in reservoir pressure and fracture pressure, it can be difficult for operators to design mud and cement system that controls the reservoir fluids while avoiding inducing fractures and fluid loss zones.

- Current NTO's applicable to the Mamm Creek Field Area require surface casing to be set a minimum of 10% of the total vertical depth of the well to ensure the ability to properly control a gas kick, should it happen during drilling, running casing, or cementing. In the East Mamm Creek Area, the Cementing NTO increases this surface casing requirement to 15% of the total vertical depth of the well. A Formation Integrity Test is also required below the surface casing shoe in the East Mamm Creek Area to ensure well control.
- The current Cementing NTO also requires monitoring of pressures and fluid levels for the first 72 hours, at minimum, after a well has been cemented, to ensure a stable wellbore.

- Recognition and definition of the "top of gas" is critical for TOC designs on intermediate and production casing strings.

- Considering that gas flows in the EMCPA are more prevalent in the Wasatch Formation and productive intervals of the Williams Fork Formation, Crescent recommends that the first show of gas in either of these sections be used as the "top of gas" for design purposes. In other areas outside of the EMCPA, this definition may not be appropriate. Area geology and characteristics of gas-bearing zones must dictate the definition of "top of gas" and the resulting requirement for TOC.

✓ Recent drilling permits in the East Mamm Creek Area have been approved with the following COA, which provides definition of a gas signature that will be used for identifying TOC requirements: PRODUCTION CASING CEMENT TOP MUST BE 500' ABOVE THE SHALLOWEST GAS SIGNATURE OBSERVED ON MUD LOGS OR OPEN-HOLE LOGS. THE SHALLOWEST GAS SIGNATURE, AS DEFINED BY 2500 UNITS, DEPTH SHALL BE REPORTED ON THE REQUEST TO COMPLETE.

✓ COGCC staff will consider incorporating this requirement into the next revision of the Cementing NTO.

- To protect gas resources, stimulate wells prior to remediation processes whenever possible.
  - Squeeze holes limit mechanical integrity and reduce pressure ratings thereby reducing the rate available to stimulate each perforated interval.
  - Reduced diameter when using 3-1/2 inch liners also inhibits rate, impacting stimulation efficiency. The reduced diameter also limits the tools available to isolate fracturing stages.

✓ COGCC's current policies for the Mamm Creek Field Area and other parts of the Piceance Basin allow for stimulation of a well, or a portion of the well, prior to cement remediation when it is safe to do so, based on evaluation of cement coverage above the proposed stimulation stage and existing Bradenhead pressure prior to stimulation, if any. COGCC staff evaluates this option on a well-by-well basis, and if applicable, COGCC staff clearly states what portion of the well bore is authorized to be stimulated prior to remediation as a Condition of Approval on the approved Request to Complete Sundry Notice. Ultimately, remediation is required above all known producing horizons, per rule 317.i., prior to producing the well.

✓ In most cases, COGCC does not mandate installation of liners to remediate wells. Liner installation is sometimes proposed by operators to cover lengthy casing intervals that cannot be remediated through squeeze cementing. COGCC evaluates operator proposals for liner installations on a case-by-case basis to ensure that all producing zones are adequately isolated.

- There is no evidence that "hydraulic fracture" stimulation operations have had an effect on cement sheath integrity, and they have not contributed to Bradenhead pressures on the annulus in any wellbore evaluated during this study.

- ✓ Although no evidence was found by Crescent Consulting, LLC et al, that stimulation operations impacted cement sheath integrity in the study area, COGCC staff reviews Cement Bond Logs for all wells subject to the Cementing NTO prior to authorizing stimulation operations. This review is a precautionary measure required by the Cementing NTO to ensure that the cement sheath has sufficient integrity to withstand the hydraulic fracturing operations.
- ✓ Rule 341 states the following requirement for all well stimulation operations in Colorado, which allows for rapid identification of any casing or cement failures during hydraulic fracture stimulation that would result in a significant increase of Bradenhead pressure: During stimulation operations, Bradenhead annulus pressure shall be continuously monitored and recorded on all wells being stimulated.

- Bradenhead pressure alone is not reflective of poor cementing practice or performance.

  - ✓ Production casing cement jobs in the Mamm Creek Field Area are currently designed to isolate all producing gas zones in the Williams Fork Formation. Low-volume, low-pressure, non-economic gas bearing zones are also found in the shallower Wasatch formation. COGCC staff believes that the current practices of monitoring for Wasatch gas zones, and venting if they occur, is an effective method for mitigating potential impacts associated with these zones. As discussed above, attempts at circulating cement across Wasatch gas zones have only been marginally effective in isolating Wasatch gas zones, and the possibility exists that cement channeling above Wasatch gas zones may divert the gas and prevent the ability to monitor and mitigate gas pressures in the Bradenhead annulus.
  - ✓ COGCC staff will continue to explore options to isolate these zones on a well-by-well basis, when significant Wasatch gas shows are observed during drilling or logging. Targeted cement remediation is sometimes advised above specific gas-bearing intervals or cement tops with inadequate seals, based on Bradenhead pressure build rates and the nature of fluid discharge when high Bradenhead pressures are observed.

- Monitoring Bradenhead pressure changes over time is an effective method to evaluate the necessity of cement remediation, which may or may not be advised when Bradenhead pressure is observed.

  - ✓ Bradenhead pressure that occurs from Wasatch formation gas is often mitigated through venting. When possible, this mitigation method is preferred by COGCC staff because it avoids compromising the casing integrity by perforating for cement remediation. As discussed above, monitoring Bradenhead pressure changes over time is used as one of several criteria to evaluate the necessity of cement remediation.

- Squeeze cementing efforts can be an effective remediation. Post-remediation monitoring is recommended as the squeeze cement can deteriorate over time with pressure and temperature cycling

- Remediation efforts reduced or eliminated Bradenhead pressures in every case. These may or may not be permanent solutions to gas movement, as cement squeezes are susceptible to degradation through pressure and temperature cycling.

- Remediation success and efficiency is subject to technology advances in problem identification, and plan execution. Each situation is unique and should be treated as such.

    - ✓ Operators are required to maintain the mechanical integrity of their wells, per Rule 326.d. Operators monitor tubing, casing, and Bradenhead pressures, as well as production rates. Pressure anomalies are a possible indicator of a casing leak. Casing repairs require prior approval by COGCC, per Rule 317.d. Certain cement squeezes in non-productive zones may have to be re-squeezed, particularly for shut-in or temporarily abandoned wells, if the casing lacks mechanical integrity during routine testing.
    - ✓ Remedial squeeze cementing is required by COGCC staff in cases where Bradenhead pressure or flow cannot be mitigated effectively by venting.
    - ✓ Cement remediation plans are reviewed by COGCC staff on a well-by-well basis.
    - ✓ COGCC requires monitoring and reporting of all Bradenhead pressures in the Bradenhead NTO area. This is an effective method of monitoring remediation success and casing integrity issues, including potential deterioration of squeeze cement.

- Statistical overview of well data to isolate root causes of known problems was ineffective in the EMCPA. Crescent concludes that each well must be engineered as an individual entity (there are no "one size fits all" solutions).

    - ✓ While best practices and standard operating procedures for the Mamm Creek Field Area are continually being adapted with more information and better technology, COGCC staff agrees that each well must be engineered as an individual entity. Therefore, COGCC staff reviews every well permit, remediation procedure, request to complete, and completion report on a well-by-well basis.

- Water well construction practices could be improved. Historic and current construction practices are not optimized for zonal isolation of shallow gas-bearing zones that may be encountered while drilling water wells.

    - ✓ Water well construction and regulation is outside of COGCC authority. COGCC will share the information that has been gained in the *East Mamm Creek Project Drilling and Cementing Study*

with the Colorado Division of Water Resources, so they may consider improvements to water well construction regulations as they see fit.

Please see the attached Document “COAs Applied to A10E Pad Permits” for a full list of COA’s that have been applied to recent drilling permits in the East Mamm Creek Area. COGCC staff will review and consider the incorporation of all COAs on this list into the next revision of the Cementing NTO. Also attached is the Mamm Creek Field Casing and Cementing Guidance Matrix.

A10E Pad COAs:

1) COMPLIANCE WITH THE MOST CURRENT REVISION OF THE NORTHWEST COLORADO NOTIFICATION POLICY IS REQUIRED.

2) GARFIELD COUNTY RULISON FIELD NOTICE TO OPERATORS. **NOTE:** ALL NOTICES SHALL BE GIVEN VIA E-MAIL. SEE ATTACHED NOTICE

3) NEW MAMM CREEK FIELD NOTICE TO OPERATORS APPLIES TO THIS WELL. **NOTE:** ALL NOTICES SHALL BE GIVEN VIA E-MAIL. SEE ATTACHED NOTICE

4) THE PROPOSED SURFACE CASING IS MORE THAN 50' BELOW THE DEPTH OF THE DEEPEST WATER WELL WITHIN 1MILE OF THE SURFACE LOCATION WHEN CORRECTED FOR ELEVATION DIFFERENCES. THE DEEPEST WATER WELL WITHIN 1 MILE IS 450 FEET DEEP.

5) SUBMIT PASON OR EQUIVALENT MUD LOG DATA FROM SURFACE TO TOTAL WELL DEPTH WITH THE REQUEST TO COMPLETE.

6) SUBMIT ALL ELECTRONIC DRILLING RECORDER DATA IN ADDITION TO A MUD/DRILLING LOG FROM SURFACE TO TOTAL DEPTH DRILLED FOR THE FIRST WELL DRILLED ON THIS PAD WITH THE FOLLOWING CURVATURE DATA: RATE OF PENETRATION (ROP), GAS, MUD VOLUME, TORQUE, DIFFERENTIAL PRESSURE AND WEIGHT ON BIT (WOB).

7) SUBMIT THE FOLLOWING OPEN-HOLE LOGS ON THE SURFACE HOLE FOR THE FIRST WELL DRILLED ON THIS PAD, VIA EMIAL TO COGCC WESTERN COLORADO ENGINEERING SUPERVISOR, WITHIN 24HS OF RUNNING AND WITH FORM 5: SPONTANEOUS POTENTIAL, GAMMA RAY, FORMATION DENSITY, COMPENSATED NEUTRON, AND RESISTIVITY (TRIPLE COMBO).

8) SUBMIT THE FOLLOWING OPEN-HOLE LOGS ON THE PRODUCTION HOLE, FOR AT LEAST ONE WELL PER PAD (ON THE F12E, PREFERABLY ONE OF THE WELLS BEING DRILLED TO THE NORTHWEST OF THE PAD), FROM TOTAL WELL DEPTH TO SURFACE CASING SHOE WITH FORM 5: SPONTANEOUS POTENTIAL, GAMMA RAY, FORMATION DENSITY, COMPENSATED NEUTRON, AND RESISTIVITY (TRIPLE COMBO).

9) 80% EXCESS CEMENT, OVER THE CALCULATED VOLUME REQUIRED TO FILL THE ENTIRE ANNULUS, IS REQUIRED TO BE PUMPED ON THE SURFACE CASING CEMENT JOB. SUBMIT CEMENT TICKETS AS AN ATTACHMENT TO THE REQUEST TO COMPLETE, FOR VERIFICATION OF CEMENT VOLUMES.

10) IF LOST CIRCULATION OF 20 BBL/HR OR MORE IS EXPERIENCED AT ANY TIME DURING THE DRILLING OF THIS WELL, OPERATOR SHALL STOP DRILLING, PUMP LOST CIRCULATION MATERIAL AS NEEDED.

11) IF LOST CIRCULATION OF 100+ BBLS WITHIN 24 HR OR MAJOR GAS (GAS OVER 1800 UNITS WHILE DRILLING) OCCURS AT A TRUE VERTICAL DEPTH LESS THAN 4200', OPERATOR SHALL NOTIFY COGCC'S WESTERN COLORADO ENGINEERING SUPERVISOR WITHIN 24 HOURS, AND PRIOR TO RUNNING CASING, TO DISCUSS THE OPTIONS FOR UTILIZING A DV TOOL ON PRODUCTION OR INTERMEDIATE CASING.

12) PRODUCTION CASING CEMENT TOP MUST BE 500' ABOVE THE SHALLOWEST GAS SIGNATURE OBSERVED ON MUD LOGS OR OPEN-HOLE LOGS. THE SHALLOWEST GAS SIGNATURE, AS DEFINED BY 2500 UNITS, DEPTH SHALL BE REPORTED ON THE REQUEST TO COMPLETE.

13) SURFACE CASING SHALL BE SET A MINIMUM OF 50' BELOW THE MOLINA MEMBER OF THE WASATCH FORMATION. THE MOLINA AND ATWELL GULCH MEMBERS OF THE WASATCH FORMATION TOPS SHALL BE REPORTED ON THE REQUEST TO COMPLETE.

14) SUBMIT 48 HOUR NOTICES, VIA EMIAL, FOR RUNNING AND CEMENTING ALL CASING STRINGS AND PERFORMING A WELL CONTROL DRILL TO COGCC'S GARFIELD COUNTY FIELD INSPECTOR, COGCC'S NORTHWEST AREA FIELD INSPECTION SUPERVISOR, AND COGCC'S WESTERN COLORADO ENGINEERING SUPERVISOR. CONTACT INFORMATION FOR NOTICES CAN BE FOUND ON COGCC'S CURRENT NOTIFICATION POLICY.

15) FRESH WATER DRILLING MUD MUST BE UTILIZED DURING THE DRILLING OF THE SURFACE CASING INTERVAL, AS OPPOSED TO WATER ONLY. MUD THAT HAS BEEN USED TO DRILL A PRODUCTION INTERVAL MAY NOT BE REUSED TO DRILL ANOTHER SURFACE INTERVAL.

16) CENTRALIZER SYSTEMS MUST BE DESIGNED TO ACHIEVE A MINIMUM OF 50% STANDOFF ON ALL CASING STRINGS. REPORT CENTRALIZER PLACEMENT AND CALCULATED STANDOFF ON THE REQUEST TO COMPLETE.

17) RUN A CEMENT EVALUATION TOOL ON ALL CASING STRINGS, BEFORE DRILL OUT OF EACH SHOE, FROM FLOAT COLLAR TO SURFACE. TIMING OF THE LOGS SHALL BE BASED ON COMPRESSIVE STRENGTH TESTS OF SLURRIES PROVIDED BY CEMENT SERVICE PROVIDER. ALL LOGS SHALL BE PROVIDED WITH THE REQUEST TO COMPLETE

18) UTILIZE INTERMEDIATE CASING IF THE FORMATION INTEGRITY TEST FAILS OR IF THE SURFACE CASING REQUIRES PERFORATION AND CEMENT SQUEEZING.

19) SUBMIT DAILY DRILLING REPORTS TO COGCC WITH THE REQUEST TO COMPLETE.

20) SUBMIT DAILY WELL STIMULATION REPORTS TO COGCC WITH THE FORM 5 DRILLING COMPLETION REPORT.

21) COLLECT SAMPLES FOR LABORATORY ANALYSIS FROM THE DOMESTIC WATER WELLS LOCATED WITHIN ½ MILE OF THE A10E WELL PAD PRE- AND POST-DRILLING OF THE SHEROWSKI 3-16 AND SHEROWSKI 2-13C GAS WELLS. WATER SAMPLE ANALYSIS MUST INCLUDE DISSOLVED METHANE, BTEX, MAJOR ANIONS AND CATIONS. IF THE CONCENTRATION OF DISSOLVED METHANE IS >1.1 MG/L, COLLECT A SAMPLE FOR ANALYSIS OF GAS COMPOSITION AND OF THE STABLE ISOTOPES OF METHANE.

22) CONDUCT DOCUMENTED **VISUAL MONITORING** OF **WEST DIVIDE CREEK (WDC)** IN SECTION 12, R7S T92W AND **ALL OTHER SURFACE STREAMS AND PONDS** IN SE 1/4 SECTION 3 7S 92W, SW 1/4 SECTION 2 7S 92W, NW SECTION 11 7S 92W AND NE SECTION 10 7S 92W FOR PRESENCE NATURAL GAS, AIR, OR OTHER GAS BUBBLES **WHILE DRILLING AND FRACING** GAS WELLS SHEROWSKI 3-16 AND SHEROWSKI 2-13C GAS WELLS.

23) COLLECT **ANALYTICAL SAMPLES** FOR ANALYTICAL SUITE IDENTIFIED IN COA 1 FROM ALL **SURFACE WATER BODIES AND ALL WELLS**

IDENTIFIED IN COA 1 AND COA 2, IF VISUAL MONITORING INDICATES THE PRESENCE NATURAL GAS OR FORCED AIR BUBBLES IN SURFACE WATER WHILE DRILLING AND FRACING

24) IF VISUAL MONITORING OR ANY OTHER OBSERVATION INDICATES THAT THERE IS AN INCREASE IN THE PRESENCE NATURAL GAS, AIR, OTHER GAS OR FLUID DISCHARGING INTO SURFACE WATER OR GROUND WATER WHILE DRILLING AND FRACING, NOTIFY COGCC STAFF AND LANDOWNER AS SOON AS PRACTICAL, BUT NO LATER THAN 24 HOURS AFTER OBSERVATION

25) IF VISUAL MONITORING OR ANY OTHER OBSERVATION INDICATES THAT THERE IS AN INCREASE IN THE PRESENCE OF NATURAL GAS, AIR, OTHER GAS, OR FLUID DISCHARGING INTO SURFACE WATER OR GROUND WATER DURING DRILLING AND FRACING, SUBMIT THE CHEMICAL INVENTORY (REFER TO RULE 205.C) TO THE COGCC AS SOON AS PRACTICAL, BUT NO LATER THAN 24 HOURS AFTER OBSERVATION.

26) IF VISUAL MONITORING OR ANY OTHER OBSERVATION INDICATES THAT THERE IS AN INCREASE IN THE PRESENCE OF NATURAL GAS, AIR, OTHER GAS, OR FLUID DISCHARGING INTO SURFACE WATER OR GROUND WATER DURING DRILLING AND FRACING, COLLECT **SAMPLES** FOR LABORATORY ANALYSIS FROM **SURFACE WATER BODIES AND ALL WELLS** IDENTIFIED IN ENV COA-1 AND ENV COA-2. THE SAMPLES SHALL BE ANALYZED FOR THE PARAMETER LIST IDENTIFIED IN ENV COA-1 AND OTHER PARAMETERS AGREED TO BASED ON THE CHEMICAL INVENTORY OR OTHER PROCESS KNOWLEDGE.

27) PROVIDE A SCHEDULE AND LOCATIONS FOR VISUAL MONITORING OF WDC AND SURFACE WATER BODIES. THE SCHEDULE WILL BE APPROVED BY COGCC STAFF PRIOR TO INITIATION OF DRILLING ACTIVITIES.

	COGCC CASING AND CEMENTING EVALUATION: MAMM CREEK FIELD CASING AND CEMENT DESIGN OPTIONS					
	OPTION A		OPTION B	OPTION C	OPTION D	OPTION E
GOALS	**CURRENT PRACTICE** **Continue using current Mamm Creek NTO casing and cement design requirements:** **1) GARCO requirement - SC minimum 10% of TVD. NTO requirement - PC TOC 500' above TOG.** **2) EMCA requirements - SC minimum 15% of TVD and 500' below water wells within 1 mile, IC required if FIT fails. NTO requirement - PC TOC 500' above TOG.**	**CURRENT PRACTICE** **Maintain current casing and cement requirements, and continue current practice of evaluating mitigation strategies (venting) and/or remedial strategies (squeeze cementing) on a case-by-case basis.**	**Maintain current casing and cement requirements, but require circulation of production casing cement to surface in a single stage.**	**Maintain current casing and cement requirements, but require use of a DV tool at a depth of approximately 50' below the top of the Mesaverde Formation, and require production casing cement from the DV tool to at least 50' above the surface casing shoe or limit coverage to shallow Wasatch gas zones (TOC may be below SC shoe).**	**Establish a requirement to run deeper surface casing.**	**Establish new requirements for less surface casing and require installation of intermediate casing. Surface casing would be set at least 200' below the deepest water well within 1 mile, but it would not be subject to a % of TVD requirement. For protection from downhole kicks, require intermediate casing on all wells to a depth of approximately 50' below the top of the Mesaverde Formation.**
Ability to Effectively Mitigate Lost Circulation Problems Below Successive Casing Strings	Intermediate strings are currently run infrequently. Hole size is chosen to accommodate intermediate casing, if necessary. Lost circulation is manageable by using LCM while drilling.	Venting or remediation does not have an effect on lost circulation	Heavy cement column may induce losses into lost circulation zones. May result in additional losses into zones that were not a problem using lighter-weight mud during drilling.	No likely problems other than those discussed for current practices (Option A).	No likely problems other than those discussed for current practices (Option A).	Potential for less lost circulation during drilling because shallow Wasatch lost circulation zones would be covered by surface casing. Potentially, less lost circulation would occur during production casing cementing because additional Wasatch lost circulation zones would be covered by intermediate casing.
Mitigation of Potential Wellbore or Cement Damage Resulting from Kicks	No current requirement to provide cement coverage across the surface casing shoe following a kick.	Venting would prevent pressure buildup at the surface casing shoe, if the cement or formation was damaged during a kick.	A full cement column would cover the surface casing shoe with cement.	Stage cement could be designed to cover the surface casing shoe with cement.	This option does not contemplate cement between the surface casing shoe and the production casing TOC.	The intermediate casing would cover the surface casing shoe and offer better protection for kicks that occur during drilling of the production hole.
General Cement Sheath Quality	Production casing cement effectively isolates Williams Fork gas, but Wasatch gas is not covered between the surface casing shoe and the production casing TOC.	When cement remediation is performed, squeeze holes create a weakness in the production casing. Even if the squeeze holes pass a pressure test after the remedial job, they may develop leaks at a later date.	Potential problems with mud removal prior to cementing and cement transition time. Hydrostatic pressure is lost with a full column of cement (no mud above the cement), which may induce gas flows during transition. Williams Fork and Wasatch gas flows could promote cement channeling and gas migration through the cement sheath and into shallow formations. Would lose ability to remediate a poor cement job.	Production casing cement effectively isolates Williams Fork gas. A DV tool allows selective isolation of Wasatch gas. This option could provide better cement sheath quality across the Wasatch gas zones compared to a single-stage full cement column (Option B). If cement channelling occurs in the stage cement, gas could migrate through the cement sheath and into shallow formations. Complicates future remediation between the production casing TOC and the DV tool. DV may not function properly, and it creates a weak point (potential for future leaks) in the production casing.	Production casing cement effectively isolates Williams Fork gas, but Wasatch gas is not covered between the surface casing shoe and the production casing TOC. Potential to decrease surface casing cement sheath quality compared to current practices (Option A), because of more exposure to shallow gas zones during cementing.	Production casing cement effectively isolates Williams Fork gas. Potential increase in surface casing cement quality compared to current practices (Option A), because of less exposure to shallow gas zones during cementing. This option could provide better cement sheath quality across the Wasatch gas zones compared to a single-stage full cement column (Option B). If cement channelling occurs in the intermediate casing cement, gas could migrate through the cement sheath and into shallow formations.
Shallow (Wasatch) Gas Isolation	No isolation, but impacts are mitigated.	No isolation, but impacts are mitigated.	May result in increased gas migration (Wasatch and Williams Fork) through cement channeling with no potential to monitor.	May result in increased gas migration (Wasatch) through cement channeling with no potential to monitor.	Potential to isolate additional Wasatch gas zones, provided that cement channelling does not occur.	Potential to isolate additional Wasatch gas zones, but may result in increased gas migration (Wasatch) through cement channeling in the intermediate casing cement sheath, with no potential to monitor.
Deep (Williams Fork) Gas Isolation	Effective	Effective	May result in increased gas migration (Wasatch and Williams Fork) through cement channeling with no potential to monitor.	Effective	Effective	Effective

	COGCC CASING AND CEMENTING EVALUATION: MAMM CREEK FIELD CASING AND CEMENT DESIGN OPTIONS					
	OPTION A		OPTION B	OPTION C	OPTION D	OPTION E
GOALS	**CURRENT PRACTICE** **Continue using current Mamm Creek NTO casing and cement design requirements:** **1) GARCO requirement - SC minimum 10% of TVD. NTO requirement - PC TOC 500' above TOG.** **2) EMCA requirements - SC minimum 15% of TVD and 500' below water wells within 1 mile, IC required if FIT fails. NTO requirement - PC TOC 500' above TOG.**	**CURRENT PRACTICE** **Maintain current casing and cement requirements, and continue current practice of evaluating mitigation strategies (venting) and/or remedial strategies (squeeze cementing) on a case-by-case basis.**	**Maintain current casing and cement requirements, but require circulation of production casing cement to surface in a single stage.**	**Maintain current casing and cement requirements, but require use of a DV tool at a depth of approximately 50' below the top of the Mesaverde Formation, and require production casing cement from the DV tool to at least 50' above the surface casing shoe or limit coverage to shallow Wasatch gas zones (TOC may be below SC shoe).**	**Establish a requirement to run deeper surface casing.**	**Establish new requirements for less surface casing and require installation of intermediate casing. Surface casing would be set at least 200' below the deepest water well within 1 mile, but it would not be subject to a % of TVD requirement. For protection from downhole kicks, require intermediate casing on all wells to a depth of approximately 50' below the top of the Mesaverde Formation.**
Occurrence of High Bradenhead Pressure	Much of the Wasatch Formation is not covered by cement, and therefore nuisance Wastach gas in the bradenhead is common.	Current practices effectively mitigate bradenhead pressure buildup. Remediation should only be considered if venting is not effective. Remediation must be performed if the Williams Fork Formation is not adequately isolated during the production casing cement job.	Would potentially "mask" built-up pressure.	Stage cement would potentially "mask" built-up pressure.	May reduce the occurrence of some high bradenhead pressure if the surface casing cement job effectively isolates deeper Wasatch gas zones that would not normally be covered using current practices (Option A).	Intermediate casing cement would potentially "mask" built-up pressure.
Ability to Monitor Bradenhead Pressure	Effective	Effective	Removes ability to monitor bradenhead pressure.	May or may not be effective. Depends on placement of stage cement (cement top above or below the surface casing shoe).	Effective	May or may not be effective. Depends on placement of intermediate casing cement (cement top above or below the surface casing shoe).
Relative Capital Cost for Drilling, Casing, and Cementing (Low, Moderate, or High)	Basis for Comparison	Basis for Comparison	Low if operations go as planned. Moderate if remediation is required to achieve a full column of cement.	Moderate	Low	High