ORDER FOR SUPPLIES OR SERVICES

IMPORTANT: Mark all packages and papers with contract and/or order numbers. BPA NO.

1. DATE OF ORDER: 9/9/10
2. CONTRACT NO. (If any): NRC-41-09-011
3. ORDER NO.: T020
MODIFICATION NO.:
4. REQUISITION/REFERENCE NO.: NRC 41-09-011
5. ISSUING OFFICE (Address correspondence to):
U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: Valerie Whipple
Mail Stop: TWB-01-B10M
Washington, DC 20555

6. SHIP TO:
a. NAME OF CONSIGNEE: U.S. Nuclear Regulatory Commission
b. STREET ADDRESS: James Webb, Mail Stop TWFN 8F5
c. CITY: Washington
d. STATE: DC
e. ZIP CODE: 20555
f. SHIP VIA:

7. TO:
a. NAME OF CONTRACTOR: SOUTHWEST RESEARCH INSTITUTE
b. COMPANY NAME:
c. STREET ADDRESS: 6220 CULEBRA RD
d. CITY: SAN ANTONIO
e. STATE: TX
f. ZIP CODE: 782385166

8. TYPE OF ORDER
- [ ] a. PURCHASE
  REFERENCE YOUR ______
  Please furnish the following on the terms and conditions specified on both sides of this order and on the attached sheet, if any, including delivery as indicated.
- [X] b. DELIVERY
  Except for billing instructions on the reverse, this delivery order is subject to instructions contained on this side only of this form and is issued subject to the terms and conditions of the above-numbered contract.

9. ACCOUNTING AND APPROPRIATION DATA
B&R: 05515355226 F1115 BOC: 252A APPN: 31X0200
FFS: 5510R128 **$60,000**
DUNS: 007936842

10. REQUISITIONING OFFICE: FSM

11. BUSINESS CLASSIFICATION (Check appropriate box(es))
- [ ] a. SMALL
- [ ] b. OTHER THAN SMALL
- [ ] c. DISADVANTAGED
- [ ] g. SERVICE-DISABLED VETERAN-OWNED
- [ ] d. WOMEN-OWNED
- [ ] e. HUBZone
- [ ] f. EMERGING SMALLBUSINESS

12. F.O.B. POINT: Destination

13. PLACE OF
a. INSPECTION:
b. ACCEPTANCE:

14. GOVERNMENT B/L NO.:
15. DELIVER TO F.O.B. POINT ON OR BEFORE (Date):
16. DISCOUNT TERMS: Net 30

17. SCHEDULE (See reverse for Rejections)

ITEM NO. (a)	SUPPLIES OR SERVICES (b)	QUANTITY ORDERED (c)	UNIT (d)	UNIT PRICE (e)	AMOUNT (f)	QUANTITY ACCEPTED (g)
	The Contractor shall provide services in accordance with the attached Statement of Work Entitled "Technical Safety Review of Crow Butte Resources, Inc. License Amendment Application for the Three Crow Project." Total task order ceiling: $208,295 The total obligated amount: $60,000 The Period of Performance is Date of Award through September 30, 2011 NRC Project Officer: Edna Knox-Davin 301-415-6577 Technical Monitor: James Webb 301-415-6252 List of Attachments: Statement of Work DUNS: 007936842					

18. SHIPPING POINT:
19. GROSS SHIPPING WEIGHT:
20. INVOICE NO.:

17(h) TOTAL (Cont. pages):

SEE BILLING INSTRUCTIONS ON REVERSE

21. MAIL INVOICE TO:
a. NAME: Department of Interior / NBC
NRCPayments@nbc.gov
b. STREET ADDRESS (or P.O. Box): Attn: Fiscal Services Branch - D2770
7301 W. Mansfield Avenue
c. CITY: Denver
d. STATE: CO
e. ZIP CODE: 80235-2230

17(i). GRAND TOTAL: $208,295

22. UNITED STATES OF AMERICA BY (Signature): [signature]

23. NAME (Typed): Valerie Whipple, Contracting Officer
TITLE: CONTRACTING/ORDERING OFFICER

Please indicate your acceptance of this order by having an official who is authorized to bind your organization, execute this document in the space provided below.

ACCEPTED:

Signature: ______________________

Name: **R.B. Kalmbach**

Title: **Executive Director, Contracts**

Date: **9/8/2010**

TASK ORDER TERMS AND CONDITIONS

1. CONSIDERATION AND OBLIGATION--COST PLUS FIXED FEE (JUN 1988) ALTERNATE I (JUN 1991)

The total estimated cost to the Government for full performance of this contract is **$208,295**, of which the sum of [redacted] represents the estimated reimbursable costs, and of which [redacted] represents the fixed fee.

(b) There shall be no adjustment in the amount of the Contractor's fixed fee by reason of differences between any estimate of cost for performance of the work under this contract and the actual cost for performance of that work.

(c) The amount currently obligated by the Government with respect to this contract is **$60,000**, of which the sum of [redacted] represents the estimated reimbursable costs, and of which [redacted] represents the fixed fee.

2. PERIOD OF PERFORMANCE

The period of performance of this order shall be Date of Award through September 30, 2011.

3. 2052.215-70 KEY PERSONNEL (JAN 1993)

(a) The following individuals are considered to be essential to the successful performance of the work hereunder:

Name	Position
[redacted]	Project Manager Principal Investigator

The contractor agrees that personnel may not be removed from the contract work or replaced without compliance with paragraphs (b) and (c) of this section.

(b) If one or more of the key personnel, for whatever reason, becomes, or is expected to become, unavailable for work under this contract for a continuous period exceeding 30 work days, or is expected to devote substantially less effort to the work than indicated in the proposal or initially anticipated, the contractor shall immediately notify the contracting officer and shall, subject to the concurrence of the contracting officer, promptly replace the personnel with personnel of at least substantially equal ability and qualifications.

(c) Each request for approval of substitutions must be in writing and contain a detailed explanation of the circumstances necessitating the proposed substitutions. The request must also contain a complete resume for the proposed substitute and other information requested or needed by the contracting officer to evaluate the proposed substitution. The contracting officer and the project officer shall evaluate the contractor's request and the contracting officer shall promptly notify the contractor of his or her decision in writing.

(d) If the contracting officer determines that suitable and timely replacement of key personnel who have been reassigned, terminated, or have otherwise become unavailable for the contract work is not reasonably forthcoming, or that the resultant reduction of productive effort would be so substantial as to impair the successful completion of the contract or the service order, the contract may be terminated by the contracting officer for default or for the convenience of the Government, as appropriate. If the contracting officer finds the contractor at fault for the condition, the contract price or fixed fee may be equitably adjusted downward to compensate the Government for any resultant delay, loss, or damage.

4. SEAT BELTS

Contractors, subcontractors, and grantees, are encouraged to adopt and enforce on-the-job seat belt policies and programs for their employees when operating company-owned, rented, or personally owned vehicles.

5. WHISTLEBLOWER PROTECTION FOR NRC CONTRACTOR AND SUBCONTRACTOR EMPLOYEES (JULY 2006)

(a) The U.S. Nuclear Regulatory Commission (NRC) contractor and its subcontractor are subject to the Whistleblower Employee Protection public law provisions as codified at 42 U.S.C. 5851. NRC contractor(s) and subcontractor(s) shall comply with the requirements of this Whistleblower Employee Protection law, and the implementing regulations of the NRC and the Department of Labor (DOL). See, for example, DOL Procedures on Handling Complaints at 29 C.F.R. Part 24 concerning the employer obligations, prohibited acts, DOL procedures and the requirement for prominent posting of notice of Employee Rights at Appendix A to Part 24.

(b) Under this Whistleblower Employee Protection law, as implemented by regulations, NRC contractor and subcontractor employees are protected from discharge, reprisal, threats, intimidation, coercion, blacklisting or other employment discrimination practices with respect to compensation, terms, conditions or privileges of their employment because the contractor or subcontractor employee(s) has provided notice to the employer, refused to engage in unlawful practices, assisted in proceedings or testified on activities concerning alleged violations of the Atomic Energy Act of 1954 (as amended) and the Energy Reorganization Act of 1974 (as amended).

(c) The contractor shall insert this or the substance of this clause in any subcontracts involving work performed under this contract.

STATEMENT OF WORK

TASK TITLE:	TECHNICAL SAFETY REVEW OF CROW BUTTE RESOURCES, INC. LICENSE AMENDMENT APPLICATION FOR THE THREE CROW PROJECT
JOB CODE:	F1115
TASK ORDER NUMBER:	020
TASK AREA:	7
B&R NUMBER:	05515-355-226
NRC ISSUING OFFICE:	FSME
NRC PROJECT OFFICER (PO):	EDNA KNOX-DAVIN
NRC TECHNICAL PROJECT MANAGER (TPM):	JAMES WEBB
NRC TECHNICAL MONITOR:	TBD
FEE RECOVERABLE:	YES
TAC NUMBER:	TBD
DOCKET NUMBER:	

1 Background

On January 11, 2010, Crow Butte Resources, Inc. d/b/a Cameco Resources submitted a Revised Notice of Intent to the NRC (ML1002104361) for the request for additional amendments to Source Materials License SUA-1534 for the development of additional uranium in-situ leach mining resources. In July 2010, the applicant plans to submit to the NRC, the application, Technical and Environmental Report for the proposed additional amendment.

The Technical Report will be prepared in accordance with NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," and the Environmental Report will be prepared in accordance with the guidance in NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." NRC staff will conduct an acceptance review of the application to determine whether the application is acceptable for detailed technical and environmental review. If the staff determines that the application is complete and acceptable for initiation of the detailed technical review, the application will be docketed and a copy of the Technical Report will be forwarded to the Center for Nuclear Waste Regulatory Analyses (CNWRA) for initiation of the scope of work in this task order.

2 Objective

The objective of this task order is to obtain assistance from the Center for Nuclear Waste Regulatory Analyses (CNWRA) in the form of a detailed technical review of selected hydrology-related sections of the Three Crow Technical Report. CNWRA staff is expected to determine the technical acceptability of the hydrology-related sections.

3 Work Requirements/Scope of Work

CNWRA staff shall follow the guidance in the review areas as provided in NUREG-1569. CNWRA staff shall prepare a draft Safety Evaluation Report (SER). The SER shall be prepared in a manner that identifies or summarizes the applicant's position for each task within the hydrology-related sections, makes a comparison to an appropriate regulation, guidance(s), and/or to an acceptable industry practice and determines if the position is acceptable or not acceptable. If the applicant's position is not acceptable, the SER shall state why it is not acceptable and identify in bold, **"This is an open issue"**. If the position is acceptable, the SER shall state that the applicant's position is acceptable and why it is acceptable. CNWRA staff shall review the following hydrology-related sections of the technical report:

- Uses of Adjacent Lands and Water Section of the Three Crow Technical Report

  CNWRA staff shall determine the acceptability or adequacy of the following aspects of the Uses of Adjacent Lands and Water Sections. More specifically, CNWRA staff shall a) determine whether the application provides sufficient information on the use of the lands and waters within a 3.3 km distance from the site boundary surrounding the proposed facilities to assess the likely consequences of any impacts of in situ recovery operations on adjacent properties; b) reference data sources and evaluate the information to be evaluated to determine whether it is sufficient to delineate the likely impact(s) of the facility, under both normal operating conditions and accidents, on the groundwater, surface water and human/animal population near the site; c) determine that within 3.3 km from the site boundary, the nature and extent of present and projected water and land use and another trends or changes in population or industrial patterns have been acceptably reported and that any other nuclear fuel cycle facilities located or proposed within an 89 km radius of the site have been identified.

- Geology Section of the Three Crow Technical Report

  CNWRA staff shall determine the acceptability or adequacy of the following aspects of the Geology Section. CNWRA staff shall review the application to determine whether a thorough evaluation of the geologic setting for the proposed in situ recovery activity, and the basic data supporting all conclusions have been presented. CNWRA staff shall a) evaluate the establishment of the continuity of the geologic strata at the site and review for applicability, correctness, inclusivity, and likely ability of the strata to isolate in situ recovery fluids; b) focus attention particularly on fractures or faults, permeable stratigraphic units, and lateral facies changes that might preclude the applicant-identified geologic barriers to fluid migration from performing adequately; c) determine that the application contains accurate geologic maps, isopach maps of the mineralized strata and of the confining layers, geologic cross sections at places critical to a thorough understanding of the selected site, descriptions of representative supporting core samples, geophysical and lithologic logs, and other data required for a thorough understanding of the pertinent geology; d) determine that regional stratigraphic and geologic information is discussed in sufficient detail to give clear perspective and orientation to the site-specific material presented; e) assess the discussion of regional geology and stratigraphy to determine if it is adequately referenced and is illustrated by regional surface and subsurface geologic maps, stratigraphic columns, and cross sections; f) review seismic information to assess its suitability for evaluating the seismic hazard for the proposed facility. A sample SER is shown in Attachment A. This sample SER is not publicly available and is subject to change.

- Hydrology Section of the Three Crow Technical Report

CNWRA staff shall determine the acceptability or adequacy of the following aspects of the Hydrology Section. CNWRA staff shall a) evaluate whether the applicant has developed an acceptable conceptual model of the site hydrology and whether the conceptual model is adequately supported by the data presented in the site characterization; b) review surface water data, including maps that identify nearby lakes, rivers, surface drainage areas, or other surface-water bodies; stream flow data; and the applicant's assessment of the likely consequences of surface-water contamination from in situ recovery operations; c) verify that the applicant has generally characterized perennial surface-water bodies such that an assessment of impacts from operations can be made; d) evaluate the applicant's assessment of the potential for erosion or flooding. e) If surface water or erosion modeling is used by the applicant, verify that acceptable models and input parameters have been used in the flood analyses and that the resulting flood forces have been acceptably accommodated in the design of surface impoundments; f) ensure that the evaluation of flooding and erosion potential is consistent with available geomorphological, and topographic data or analysis of paleodischarge information; g) evaluate the site hydrogeologic conceptual model for groundwater flow in potentially affected aquifers; h) review available data from well logs and hydrologic tests and measurements to obtain confidence that sufficient data have been collected and that the data support the applicant's hydrologic conceptual model for groundwater flow within and around the permit boundary; i) evaluate the applicant's interpretation of groundwater hydraulic gradients, horizontal hydraulic conductivity, and the thickness, areal extent, and vertical hydraulic conductivity of confining formations; j) examine pumping tests, analyses, and/or other measurement techniques used to determine the hydrologic properties of the local aquifer and aquitards that affect or may be affected by the proposed in situ recovery operation; k) examine pumping tests that are used to investigate vertical confinement or hydraulic isolation between the ore production zone and the upper and lower aquifers; l) evaluate the applicant's assessment of water quality of potentially affected groundwater resources. This information will provide the basis for evaluating potential effects of in situ recovery extraction on the quality of local groundwater resources; m) verify that a sufficient number of baseline groundwater samples are collected to provide meaningful statistics, that samples are spaced in time sufficiently to capture temporal variation, and that the chemical constituents and water quality parameters are evaluated sufficiently to establish pre-operational water quality, including classes of use; n) review the applicant's assessment of seasonal variability, and, if data are available, the historical variability for levels of surface-water bodies and water levels or potentiometric heads in aquifers and ensure that sufficient time intervals have elapsed between measurements to allow assessment of seasonal variability; o) verify that the applicant has provided information on past, current, and anticipated future water uses, including descriptions of local groundwater well locations, type of use, amounts used, and screened intervals; p) where possible, use information reviewed by the state and, where possible, not duplicate efforts or questions. If such information is used, document its use in the safety evaluation report. A sample SER is shown in Attachment B. This sample SER is not publicly available and is subject to change.

- Plans and Schedules for Groundwater Quality Restoration Section of the Three Crow Technical Report

CNWRA staff shall determine the acceptability or adequacy of the following aspects of the Plans and Schedules for Groundwater Quality Restoration Section. CNWRA staff shall evaluate a) groundwater modeling or other methods used to estimate restoration time and the extent of uncertainties in processes and data; b) estimates of the concentrations and lateral and vertical dispersion of those chemicals that may persist in leached-out well field production zones after termination of in situ recovery operations and before restoration activities; c) descriptions of proposed methods and techniques to be used to restore groundwater quality, including the applicant's use of in situ chemical or biological reduction and criteria to interpret the success and stability of any proposed method; d) the schedule for sequential restoration of well fields; e) the descriptions of the expected post-reclamation conditions and quality of restored groundwater, compared with the pre-operational water quality characteristics, and any prior experience restoring groundwater at the site; f) the adverse effects of the proposed water quality restoration operations on groundwater outside production zones; g) the procedures to be used for plugging, sealing, capping, and abandoning wells; h) the methods to monitor the progress and stability of restoration; and i) the methods of effluent disposal, such as deep well injection, discharge to surface water, and/or land application. A sample SER is available in Attachment C. This sample SER is not publicly available and is subject to change.

4 Technical Qualifications Required

CNWRA shall provide the services of appropriate staff with primary expertise in hydrology and/or hydrogeology for the conduct of the technical review.

6 Meetings and Travel

Two trips for two CNWRA staff members for one day is required to NRC Headquarters in Washington D.C. for a kickoff meeting and a draft SER review to identify and discuss potential open issues. CNWRA staff shall participate in conference or telephone calls, as needed, to address and resolve issues or questions that may arise during the conduct of the technical review. Conference calls with the applicant are expected after the first draft of the SER and after completion of the final draft SER.

7 NRC Furnished Material

NRC will provide one copy of the Three Crow Technical Report. NRC will provide a sample SER (See Attachments).

8 Schedule/Deliverables

Deliverables	Schedule
Review license application and participate in kickoff meeting/conference call to discuss review. Prepare a written summary of kickoff meeting to NRC with action item(s) if necessary to NRC.	3 Weeks from award of task
Prepare first draft of SER for assigned sections with open issues and request for additional information (RAI) to be submitted to NRC for review and comments.	10 Weeks from award of task
Present open issues and RAIs and discuss with NRC staff at NRC Headquarters. Prepare handouts and slides.	11 Weeks from award of task
Resolve comments and prepare final draft of SER for assigned sections and submit to NRC.	4 Weeks from receipt of NRC comments.

Evaluate applicant's responses to open issues and RAIs and prepare preliminary final SER.	8 Weeks from receipt of applicant's response to open issues and RAIs
Submit preliminary final SER to NRC for review and comment.	9 Weeks from receipt of applicant's response to open issues and RAIs
Discuss preliminary final SER with NRC and prepare final SER.	11 Weeks from receipt of applicant's response to open issues and RAIs
Submit final SER to NRC.	13 Weeks from receipt of applicant's response to open issues and RAIs.

NOTE: Deliverable and Schedule takes into account for the possibility that the applicant may take as much as 6 months to respond to NRC open issues.

9 Technical Direction

The NRC Technical Monitor for this task order will be determined upon award. Edna Knox-Davin is the designated NRC Project Officer. James Webb is the NRC Technical Project Manager. Technical instructions may be provided to the CNWRA staff by the NRC Technical Monitor and/or the NRC Technical Project Officer during the duration of this task order. Technical instructions shall not constitute new assignments of work or changes of such a nature as to justify an adjustment in cost or the period of performance. Directions, if any, for changes in scope of work, cost, or period of performance will be issued by the NRC Contracting Officer.

10 Technical Reports

Technical reports for the task shall be submitted via electronic mail with electronic attachments consistent with the word processor in use at the NRC or portable document format (pdf), as appropriate. The CNWRA shall also provide one copy of each technical report to the NRC Project Officer and Technical Project Manager.

11 Financial and Technical Status Reports

The CNWRA shall submit periodic technical and financial reports in accordance with the contract. The estimated staff effort should be recorded at the subtask level. The work accomplished and the degree of completeness should also be tracked by subtask. The reports are due within 20 calendar days after the end of the report period (i.e., each four week period). The Technical Project Manager shall receive two copies of the periodic status report and the Project Officer shall receive one copy. See the contract for further distribution requirements.

ATTACHMENT A
MOORE RANCH SER

(This is a sample SER. This Section of the SER is not publicly available and is subject to change)

2.3 Geology and Seismology

2.3.1 Regional Geology

Regionally, the proposed license area lies within the PRB, which is an asymmetric syncline (a basin with its deepest point not in the center) filled with marine, nonmarine, and continental sediments. The sediments reach a maximum thickness of about 4,877 to 5,182 m (16,000–17,000 ft) in the permit area. The general regional stratigraphy of the PRB is shown in Figure 2.3-1.

The White River formation is found in the center of the basin and is underlain by the Wasatch formation. The Wasatch is composed of thick lenses of coarse, cross-bedded sands that are a maximum of 487.68 m (1,600 ft) thick. These sandstone horizons can be mapped over large areas and are the host rocks for several uranium deposits in the PRB. The Wasatch overlies the Fort Union formation. The lower member of the Fort Union consists of fine-grained sandstone with minor claystone and coal. The upper member consists of shale, clayey sandstone, fine- to coarse-grained sandstone, and some extensive bituminous lignite beds. Coal in the Fort Union formation is a source of coalbed methane (CBM) in the PRB and the license area. The Lance formation underlies the Fort Union formation.

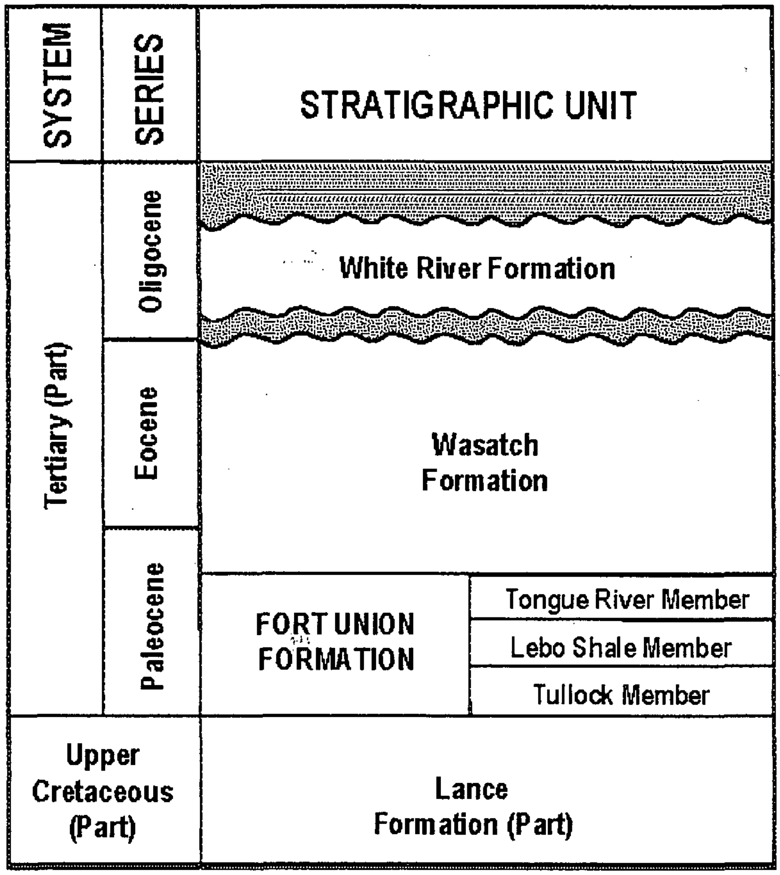

Figure 2.3-1 PRB regional stratigraphy (Source: Department of Energy/National Energy Technology Laboratory (DOE)/(NETL)-2003/1184, "Powder River Basin Coalbed Methane Development and Produced Water Management Study," November 2002)

2.3.2 Site Geology

At the Moore Ranch site, the Wasatch formation is the surficial geological unit. In the proposed license area, Uranium One reported that the Wasatch is composed of interbedded sandstones, siltstones, claystones, and coals as shown in Figure 2.3-2. The fine-grained layers range from highly consolidated, medium gray siltstones to dark grey carbonaceous claystone. The sandstones are semiconsolidated and well sorted with grain sizes ranging from very fine to very coarse. Individual beds vary in thickness from a few centimeters (inches) to many meters (feet). No faulting or fracturing is known to exist in or near the license area.

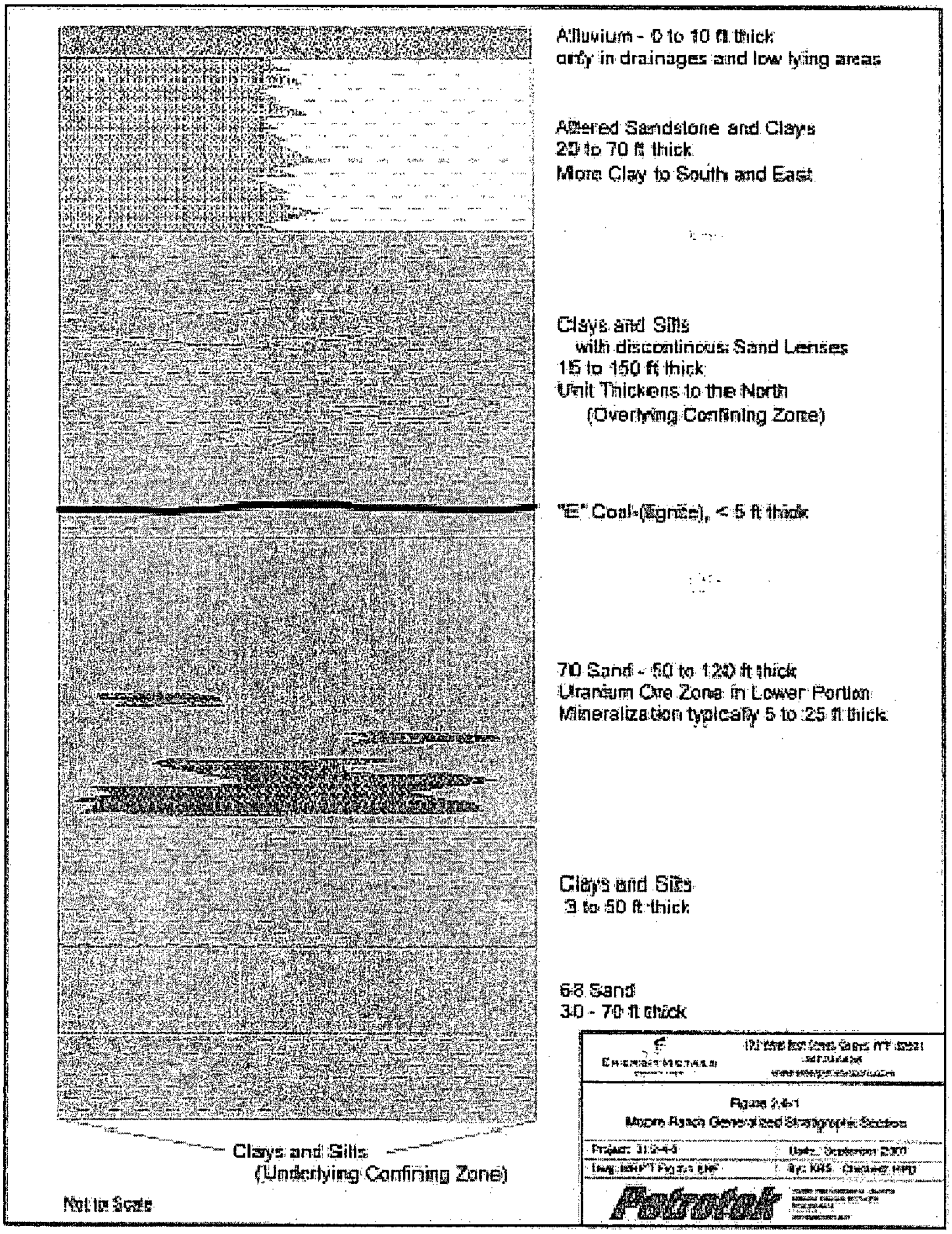

Figure 2.3-2 Moore Ranch license area stratigraphy (adapted from Figure 2-1 of the technical report)

Uranium One stated that the Wasatch sandstones were deposited by fluvial channels. These channels later became the host rocks for the uranium ore deposits in the proposed license area and are generally oriented northward. Uranium One reported the mineralogy of the ore-bearing unit is an arkosic sandstone with calcite and clays as the cementing material. The dominant clay is montmorillonite (50 percent) along with illite (25 percent) and kaolinite (25 percent). The uranium is associated with either the calcite or the clay cement.

Uranium One stated that the original subsurface exploration of the proposed license area was conducted by Conoco. This subsurface investigation involved drilling and wireline logging thousands of well borings in and around the proposed permit area in the 1970s and 1980s. Hundreds of additional well borings were drilled and logged by Uranium One in late 2006 and early 2008. The applicant reported that drill holes completed by Conoco were reported abandoned in accordance with Wyoming statutes in effect at the time. Uranium One abandoned all recent drill holes in accordance with Wyoming Statute 35-11-401. Uranium One provided maps of locations and tables of descriptions of all known drill holes in the license area. The NRC staff finds the plugging and abandonment to be acceptable.

Uranium One provided geological cross-sections that show the stratigraphy and isopach maps that show the thickness of each layer in the license area. These maps were developed from historical Conoco and recent Uranium One exploration well boring logs. Eleven cross-sections were provided along the major and minor axes of the proposed well fields, between well fields, and across the proposed permit area. The original well logs were shown for each boring used to define the cross-sections. Eleven isopachs for major sandstone and siltstone/claystone layers across the proposed permit area were also provided. For the proposed license area, the cross-sections show the sandstones and confining layers from land surface to the deep CBM production zone under the proposed license area. Conoco used a nomenclature that designated sandstones in the Wasatch with decreasing numbers with increasing depth. This nomenclature was retained by Uranium One for the proposed Moore Ranch license area. The order of the sandstones from surface to depth is the "80 sand," "72 sand," "70 sand," "68 sand," "60 sand," "50 sand," "40 sand," "30 sand," "20 sand," and "10 sand." The CBM production zone is in a thick coal layer just below the "10 sand." The "70 sand" is the proposed production extraction zone in the license area. An evaluation of the stratigraphy and specifically the presence and thickness of the overlying and underlying confining layers for the "70 sand" was performed by the NRC staff across the license area and for each of the proposed well fields using the cross-sections, well boring logs, and isopachs.

Uranium One provided four cross-sections, A-A', D-D', H-H', and K-K', which show the stratigraphy across the entire proposed Moore Ranch license area. The cross-sections indicate that the stratigraphy is more or less continuous across the proposed license area. About 1.6 km (1 mi) to the south and east of the well fields, the "70 sand" extraction zone nears and outcrops to the surface. To the north and west of the well fields, the "70 sand" dips at about 1 to 2 degrees. The remaining cross-sections showed the stratigraphy across the specific well fields. Uranium One defined two well fields, designated as Well Field 1 and Well Field 2. Well Field 1 is best described by cross-section F-F' (Figure 2.6-8 of the technical report), which traverses the longer north-south axis, and by cross-section B-B' (Figure 2.6-4 of the technical report), which covers the shorter east-west axis of this elliptically shaped well field. Well Field 2 is best described by cross-section G-G' (Figure 2.6-9 of the technical report), which traverses the longer northeast-southwest axis and by cross-section C-C' (Figure 2.6-5 of the technical report), which covers the shorter east-west axis of this elliptically shaped well field. Cross-sections I-I' (Figure 2.6-11 of the technical report) and J-J' (Figure 2.6-12 of the technical report) cover a small region in the far western tip of the well field. The geology of each well field is described in Tables 2.3-1 and 2.3-2, respectively.

Table 2.3-1 Geological Characterization of the Moore Ranch Well Field 1

Geological Section	Description
72 sand	The "72 sand," is shown on the isopach as being 12.19–24.38 m (40 to 80 ft) thick in the northern two-thirds of Well Field 1. It abruptly pinches out in the southern one-third of the well field. (Figure 2.6-14 of technical report)
70 overlying shale	The "70 overlying shale" is described as a siltstone/ mudstone /claystone layer which is continuous across the well field. This layer is 1.52 to 10.67 m (5 to 35 ft) thick over the northern two-thirds of the well field. In the southern one-third, it abruptly increases in thickness from 12.19 to 42.67 m (40 to 140 ft) as the overlying sand pinches out. At the base is a ubiquitous coal seam known as the E-coal. (Figure 2.6-15 of technical report)
70 sand	The "70 sand" is the extraction zone. It is 15.24 to 27.43 m (50 to 90 ft) thick and 45.72 to 91.44 m (150 to 300 ft) BGS. (Figure 2.6-15 of technical report)
70 underlying shale	The "70 underlying shale" is continuous across Well Field 1 and is 3.05 to 12.19 m (10 to 40 ft) thick. (Figure 2.6-17 of technical report)
68 sand	The "68 sand" is 15.24 to 21.34 m (50 to 70 ft) thick across Well Field 1 (Figure 2.6-19 of the technical report).
68 underlying shale	The"68 underlying shale" is approximately 6.1 m (20 ft) thick across the southeastern half of the well field. This shale thins sharply along the north-south central axis from 6.1 m (20 ft) to less than 1.52 m (5 ft) and completely disappears in the west-central section of the well field. The absence of this shale means that the underlying "60 sand" coalesces with the "68 sand" in the western half of Well Field 1. (Figure 2.6-20 of technical report)
60 sand	The "60 sand" is 24.38 to 30.48 m (80 to 100 ft) thick in Well Field 1.
58 sand, 50 sand, and 40 sand	The remaining sands are the "58 sand," "50 sand," and "40 sand," which are continuous and separated by shales. These sandstones range in thickness from 3.05 to 15.24 m (10 to 50 ft), 18.29 to 27.43 m (60 to 90 ft), and 18.29 to 24.38 m (60 to 80 ft), respectively.

Table 2.3-2 Geological Characterization of the Moore Ranch Well Field 2

Geological	Description

Table 2.3-2 Geological Characterization of the Moore Ranch Well Field 2	
Section	
72 sand	The "72 sand" is shown on the isopach as being 3.05 to 18.29 m (10 to 60 ft) thick. It is absent in a small area in the center of the well field. (Figure 2.6-14 of the technical report)
70 overlying shale	The "70 overlying shale," is a described as siltstone/claystone/mudstone layer which is continuous across the well field This layer is 3.05 to 15.24 m (10 to 50 ft) thick over the majority of the well field. It thickens to 36.58 m (120 ft) thick in the central portion of the well field where the "72 sand" disappears. The E-coal is at the base of the "70 overlying shale." (Figure 2.6-15 of the technical report)
70 sand	The "70 sand" extraction zone is 15.24 to 39.62 m (50 to 130 ft) thick and 60.96 to 91.44 m (200 to 300 ft) BGS. (Figure 2.6-16 of the technical report)
70 underlying shale	The "70 underlying shale" is 1.52 to 6.1 m (5 to 20 ft) thick across Well Field 2 and is not continuous. In the northeastern half of the well field the shale thins to less than 1.52 m (5 ft) and is completely missing in some portions. (Figure 2.6-17 of the technical report)
68 sand	The "68 sand" is continuous and 12.19 to 21.34 m (40 to 70 ft) thick across Well Field 2. (Figure 2.6-19 of the technical report)
68 underlying shale	The "68 underlying shale" is continuous and is 1.52 to 6.1 m (5 to 20 ft) thick across Well Field 2. It completely disappears in the west-central section of the well field. (Figure 2.6-20 of the technical report)
60 sand	The "60 sand" is continuous over the entire area of Well Field 2.
58 sand, 50 sand, and 40 sand	The remaining strata underlying this sand are the "58 sand," "50 sand," and "40 sand," which are continuous and separated by shales. These sandstones range in thickness from 6.1 to 18.29 m (20 to 60 ft), 21.34 to 27.43 m (70 to 90 ft), and 24.38 to 27.43 m (80 to 90 ft), respectively.

As described in Table 2.3-2, the "70 underlying shale" is 1.52 to 6.1 m (5 to 20 ft) thick across Well Field 2 and not continuous. In the northeastern half of the well field the shale thins to less than 1.52 m (5 ft) and is completely missing in some portions. As shown in cross-section G-G' (Figure 2.6-9 of the technical report), it is essentially missing in all of the seven boring numbers from 4018 to 649, a distance of approximately 396.24 m (1,300 ft). Uranium One provided an inset isopach detail of this area to further assess the shale thickness in this region (Figure 2.6-18 of the technical report). Using an areal analysis of the isopach detail map, the NRC staff calculated the total area in Well Field 2 where the underlying shale is less than 1.52 m (5 ft) to be approximately 8 hectare (19.75 acres) with the shale completely missing for approximately 1.52 hectare (3.75 acres). In these regions, the "68 sand" and "60 sand" coalesce.

Seven of the cross-sections provided by Uranium One include the deep coal layer, which is the CBM production zone under the proposed Moore Ranch license area. This zone is consistently located at depths approximately 1,341 m (4,400 ft) mean sea level and below, whereas the "70 sand" extraction zone lies above 1,584.96 m (5,200 ft) mean sea level. Therefore, the CBM zone is separated from the ore sand by 243.84 m (800 ft) or more across the entire proposed license area. Between the ore sand and the coal are the nine sandstones from the "70 sand" to the "10 sand" and nine shale layers.

Based on the isopach and cross-sections provided by the applicant, the NRC staff has concluded that the overlying and underlying confining layers appear to be sufficiently thick and continuous to isolate the production zone "70 sand" in Well Field 1. In Well Field 2, the overlying confining layers appear to be sufficiently thick and continuous to isolate the production zone "70 sand." However, the NRC staff has found that the underlying confining shale in Well Field 2 is very thin or absent over the northeastern half of the well field as described above. In these areas, the "70 sand" coalesces with the underlying "68 sand." The consequences of the lack of the underlying confining shale for the "70 sand" extraction zone are discussed in Section 3.1.3.5 of this SER.

2.3.3 Soils

Uranium One described the soils in the proposed license area based on a soil survey conducted in 2007. A map of soils was provided for the area. Soils in the proposed Moore Ranch license area were described as typical for semiarid grasslands and shrublands in the Western United States. Most soils were taxonomically classified as Ustic Paleargids, Ustic Haplargids, Ustic Torriorthents, and Ustic Haplocambids. Suitable topsoil was present in most soils. No prime farmland was identified. Limiting factors were reported to be selenium and texture. Most soils exhibited a slight water erosion hazard and moderate wind erosion hazard. The NRC staff finds that the soils in the proposed license area were adequately described.

2.3.4 Seismology

Uranium One described the historical seismology for the area using data for Campbell, Natrona, Converse, and Johnson Counties and included the magnitude, date, and location of all known seismic events. The largest earthquake occurred in Natrona County in 1897 and was classified as a Level VI-VII earthquake, which damaged some buildings. No active faults with surface expression are known in Campbell County where Moore Ranch is located, so no fault-specific analysis was possible. Floating or random earthquakes were analyzed, and published data indicated the largest floating earthquake for the province where Campbell County is located would have an average magnitude of 6.25. If this earthquake was placed within 15 km (9.32 mi) of any structure in Campbell County, it would be estimated to create an acceleration of 0.15 g, which is a Level VI earthquake, and would be expected to create light to moderate damage. Recent U.S. Geological Survey probabilistic acceleration maps for Wyoming were published in 2000. These maps, which display the 500-year, 1,000-year, and 2,500-year probabilistic accelerations for Wyoming, were included in the application and show that the damage expected from earthquakes using these probabilities in the Moore Ranch area would be in the range of intensity of Levels V–VII. According to Table 2.68, this would incur light to moderate damage in the proposed license area. The NRC staff finds the assessment of the seismology to be acceptable.

2.3.5 Evaluation Findings

The NRC staff has completed its review of the site characterization information addressing geology and seismology at the Moore Ranch facility. This review included an evaluation using the review procedures in Section 2.6.2 of the standard review plan and the acceptance criteria outlined in Section 2.6.3 of the standard review plan.

The licensee has acceptably described the geology and seismology by providing (1) a description of the local and regional stratigraphy, (2) geologic, topographic, and isopach maps at acceptable scales showing surface and subsurface features and locations of all wells and site explorations used in defining stratigraphy, (3) a geologic and geochemical description of the mineralized zone and the geologic units adjacent to the mineralized zone, (4) a description of the local and regional geologic structure, (5) a discussion of the seismicity and seismic history of the region, (6) a generalized stratigraphic column that includes the thickness of rock units, a representation of lithologies, and a definition of mineralized horizon, and (7) a description and map of the soils. Based on the information provided in the application and on the detailed review conducted of the characterization of the geology and seismology at the Moore Ranch facility, the staff concludes that the information is acceptable.

ATTACHMENT B
MOORE RANCH SER
(This is a sample SER. This Section of the SER is not publicly available and is subject to change)

2.4 Hydrology

2.4.1 Surface Water

Uranium One described the surface water hydrology for the proposed facility. The entire Moore Ranch license area lies within the Ninemile Creek drainage basin, which has a drainage area of 163.2 km^2 (63 mi^2). Ninemile Creek is a tributary to Antelope Creek, which is a tributary of the South Cheyenne River.

Several Ninemile Creek tributaries lie within the license area as shown in Figure 2.4-1. The main tributaries are Simmons Draw and Pine Tree Draw. Simmons Draw flows southeasterly through the west side of the license area. Pine Tree Draw flows in a southerly direction on the east side of the license area. Wash No. 1 is an ephemeral tributary to Simmons Draw, and it flows just to the west of Well Field 1. Upper Wash No. 2 is another ephemeral tributary to Simmons Draw and flows directly through the central portion of Well Field 2. It empties into Lower Wash No. 2. Both Wash No. 1 and Upper Wash No. 2 have small gradients (Table 2.7.1-1 of the technical report).

Other tributaries are present in the license area but do not drain the basins that encompass the planned well fields. Several small dams and ponds are within and downstream of the license area. These provide some storage and control of surface water runoff. These ponds are typically full during spring runoff or large precipitation events and then typically dry by the end of the summer. The NRC staff conducted a site tour in the fall of 2008 and finds the surface water drainages to be adequately described.

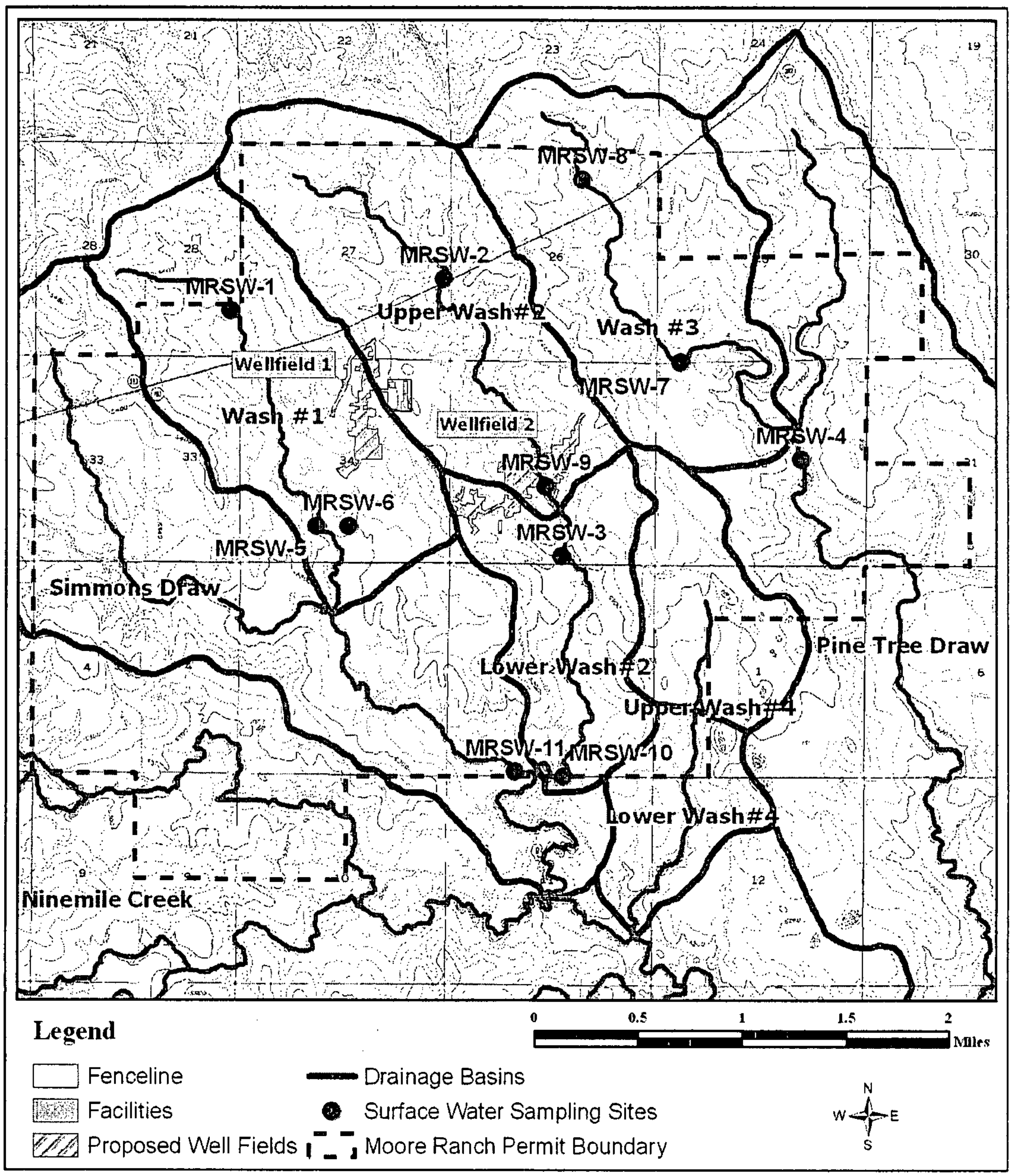

Figure 2.4-1 Moore Ranch license area Nine Mile Creek drainages (adapted from Figure 2.7-1 of the technical report)

Uranium One provided peak flood calculations for recurrence intervals of 5, 10, 25, 50, and 100 years for all drainages in the license area as shown in Table 2.4-1. The applicant used a U.S. Soil Conservation Service (SCS) method and a basin characteristics equation developed specifically by Craig and Rankl (1978) for small Wyoming drainages of 25.9 km^2 (10 mi^2) or less. The NRC finds these methods and the peak flood estimates for the recurrence intervals to be acceptable.

Table 2.4-1 Peak Flood Discharge Estimates for Specific Recurrence Intervals for Moore Ranch Drainages (adapted from Table 2.7.1-2 of the technical report)											
Drainage	Drainage Area (km^2)	Craig and Rankl's Method (cms)					SCS Method (cms)				
		5 year	10 year	25 year	50 year	100 year	5 year	10 year	25 year	50 year	100 year
Ninemile Creek	163.2	133.1	195.4	277.5	396.4	509.7					
Pine Tree Draw	8.2	31.1	45.3	62.3	87.8	110.4					
Simmons Draw	8.1	39.6	56.6	73.6	101.9	127.4					
Wash No. 1	1.7	11.6	16.4	21.8	31.1	37.1	4.2	7.1	9.9	12.7	15.6
Upper Wash No. 2	1.9	13.6	19.0	25.2	34.0	42.5	4.5	7.4	10.5	13.6	16.4
Lower Wash No. 2	0.95	14.2	18.1	21.8	28.0	34.0	2.8	4.2	6.8	8.8	10.2
Wash No. 3	1.8	11.3	15.9	21.5	28.3	36.8	4.5	7.4	10.2	13.3	10.5
Upper Wash No. 4	0.7	7.4	10.2	13.0	17.3	21.0	2.4	4.0	5.4	7.1	8.5
Lower Wash No. 4	0.53	7.6	9.9	12.5	16.1	19.0	2.0	3.1	4.2	5.9	7.1

Based on an analysis of the topography and drainages, Uranium One determined that Well Field 1 and the CPP shown in Figure 2.4-1 were located above any elevation that would be flooded and would only be subjected to sheet flow events. Uranium One stated that the CPP and facilities will be graded and sloped to direct precipitation runoff away from building foundations to a storm water conveyance system designed to pass a 50-year flood event. The NRC staff concludes that a 50-year flood is a reasonable design basis for runoff control for the CPP and facilities area.

Uranium One stated that the magnitude of the peak flows predicted for Upper Wash No. 2, which passes through Well Field 2, may present an erosion and flooding risk to well field infrastructure. It determined that a 100-year flood event would create a water depth of 0.88 m (2.9 ft) with a velocity of 2.26 m per second (7.4 ft per second) in Upper Wash No. 2 based on its cross-section geometry about 198.12 m (650 ft) north of the boundary of Well Field 2. Therefore, Uranium One proposed to minimize damage to infrastructure from peak flow events in Well Field 2 by avoiding well installation in the main channels of ephemeral drainages. Uranium One stated that if it is necessary to install wells in the high water marks of a channel in this well field, it would provide adequate wellhead protection to protect the wells during flood conditions. The NRC determined that these protection efforts are adequate.

To prevent erosion for all drainages, Uranium One stated that properly sized culverts will be installed for crossings to meet a 25-year flood event. Embankments and culverts and drainage crossings will be protected using best management practices such as rip rap and rock in accordance with Chapter 3 of the WDEQ Land Quality Division (LQD) Rules and Regulations. The NRC staff finds these approaches acceptable.

Uranium One reported that CBM production has occurred and continues to occur in the license area from the Roland coal formation approximately 396.24 m (1,300 ft) BGS. It stated that CBM-produced water from these operations has been, and continues to be, discharged to surface water drainages and impoundments in the license area under three separate Wyoming Pollutant Discharge Elimination System (WYPDES) permits, one held by Devon Energy and two held by Bill Barrett Corporation. Uranium One provided a map displaying the location of all 22 permitted CBM discharge points and impoundments in the license area in Figure 2.7.1.2 of the technical report. The specific locations of each discharge point for each permit were also provided in Table 2.7.1-8 of the technical report, including seven that are located upstream of the license area.

The NRC staff verified the location of many of these discharge points and impoundments during a site visit in the fall of 2008. The staff also confirmed that all of the CBM permitted discharge points in the Moore Ranch license area are located near drainages, particularly Wash No. 1 and Upper and Lower Wash No. 2. An example of a CBM discharge point in the license area is shown in Figure 2.4-2.. These discharge points are constructed to release the CBM-produced water directly to drainage or small impoundments that are specifically designed to facilitate infiltration to the subsurface.

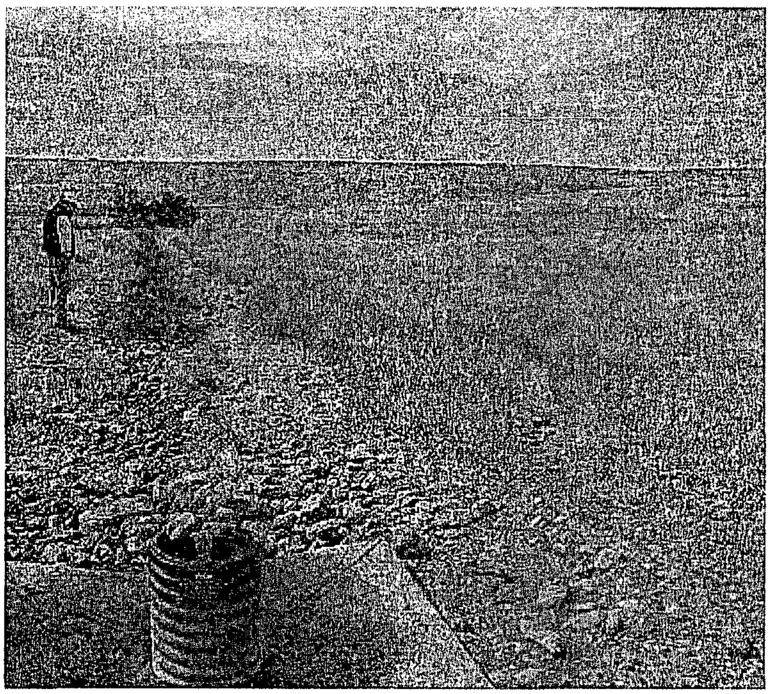

Figure 2.4-2 CBM Discharge Point 020EPTD discharging to the Upper Wash No. 2 down a drainage ditch on the northern edge of Well Field 2 (photograph taken September 2008)

Uranium One provided the WYPDES permitted CBM water quality discharge limits for all three of the permits in Table 2.7.1.6 of the technical report along with the maximum daily flow allowance. It also provided the historical average CBM-produced water quality and discharge rates in Tables 2.7.1.10, 2.7.1.11, and 2.7.1.12 of the technical report. The historical and projected discharge rates for the Devon permit were provided in Table 2.7.1-9 of the technical report. An analysis by the NRC staff of this table showed that, from 2000 to 2008, approximately 352 million liters (93 million gallons) of CBM-produced water was discharged to the surface drainages and impoundments in the Moore Ranch license area. It is expected that most of this CBM water seeped into the surficial aquifer under and around the ephemeral channels where it was directly discharged or locally discharged under the small CBM impoundments.

In Table 2.7.1-9 of the technical report, Uranium One showed that CBM-produced water discharge rates are significantly declining in the permit area. Uranium One predicted the rate of decline at 5 percent per year for these discharge points, which would result in a discharge of less than 10.6 million liters per year (2.8 million gallons per year) from 2009 to 2013. Uranium One also stated that all of the permits will be up for renewal in early 2009 with an expiration date of 2014. The permit holders have informed Uranium One that they are not likely to renew the permits in 2014. The NRC staff finds the description of the historical and present CBM-produced water discharges in the license area to be acceptable.

2.4.2 Ground Water

2.4.2.1 Regional and Site Hydrogeology

Regionally, ground water flows northward through Wasatch, Fort Union, and the deeper aquifers in the PRB. The regional gradient is 0.004 to 0.006 meters per meter (m/m or ft/ft) to the north. Recharge to the regional system occurs within formation outcrops along the western and southern edges of the PRB, and some infiltration occurs through surficial sediments.

2.4.2.1.1 "72 Sand"

Uranium One stated that within the Moore Ranch license area, the first aquifer encountered is the "72 sand," which occurs at depths of 9.14 to 60.96 m (30 to 200 ft) BGS across the license area. The "72 sand" is unsaturated in the southern portion of the license area and saturated in the northern portion. It is described as a perched aquifer, which, when saturated, is considered the surficial aquifer and overlying aquifer to the "70 sand" extraction zone. This perched water aquifer was described in a prior exploration of this site by Conoco in the late 1970s and early 1980s (Ref. 2). This aquifer was therefore present before CBM activity in the area began and is not an artifact of CBM water infiltration. Uranium One provided data on historical saturation of the "72 sand" in Well Field 2 and at surrounding stock wells, which further supported its presence before CBM operations began.

Uranium One measured water levels in the "72 sand" using four wells, OMW-1, OMW-2, OMW-3, and OMW-4, in the central portion of the license area. These wells are part of four well groups in the license area that were used to define water levels in the extraction zone and overlying and underlying aquifers as shown in Figure 2.4-3. Note that this figure shows the original well field configuration based on three well fields (Well Fields 1, 2, and 3). Uranium One has since combined the original Well Field 3 into Well Field 2; the rest of this SER only refers to Well Field 1 and Well Field 2.

A hydrograph of water levels from December 2006 to February 2008 in the "72 sand" wells was presented in Figure 2.7.2-6a of the technical report. It showed little variation over the time period except for a decrease in water level on OMW-2 in May 2007. The saturated thickness of the "72 sand" was reported to range from 3.04 m (10 ft) at OMW-2 to 15.24 m (50 ft) at OMW-1. Uranium One provided the water level contours for the "72 sand" aquifer for February 2007, June 2007, February 2008, and March 2008 based on the water level data in Figure 2.7.2-6b through Figure 2.7.2-6f of the technical report. The March 2008 contours are shown in Figure 2.4-4. Uranium One estimated the average hydraulic gradient in "72 sand" was 0.0039 m/m (or ft/ft) with flow to the north.

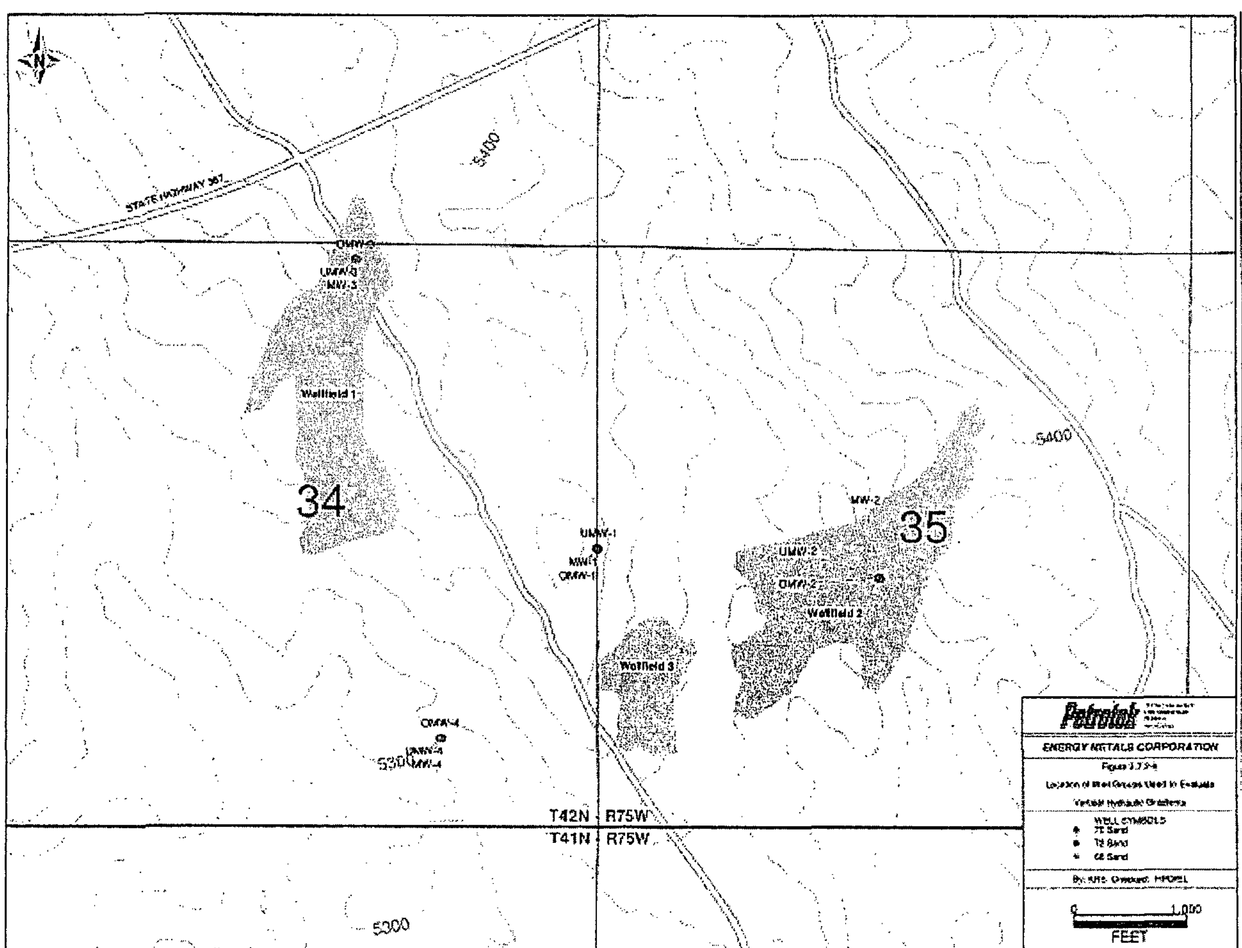

Figure 2.4-3 Location of Moore Ranch Monitoring Well Groups 1, 2, 3, and 4 (Figure 2.7.2-8 of the technical report)

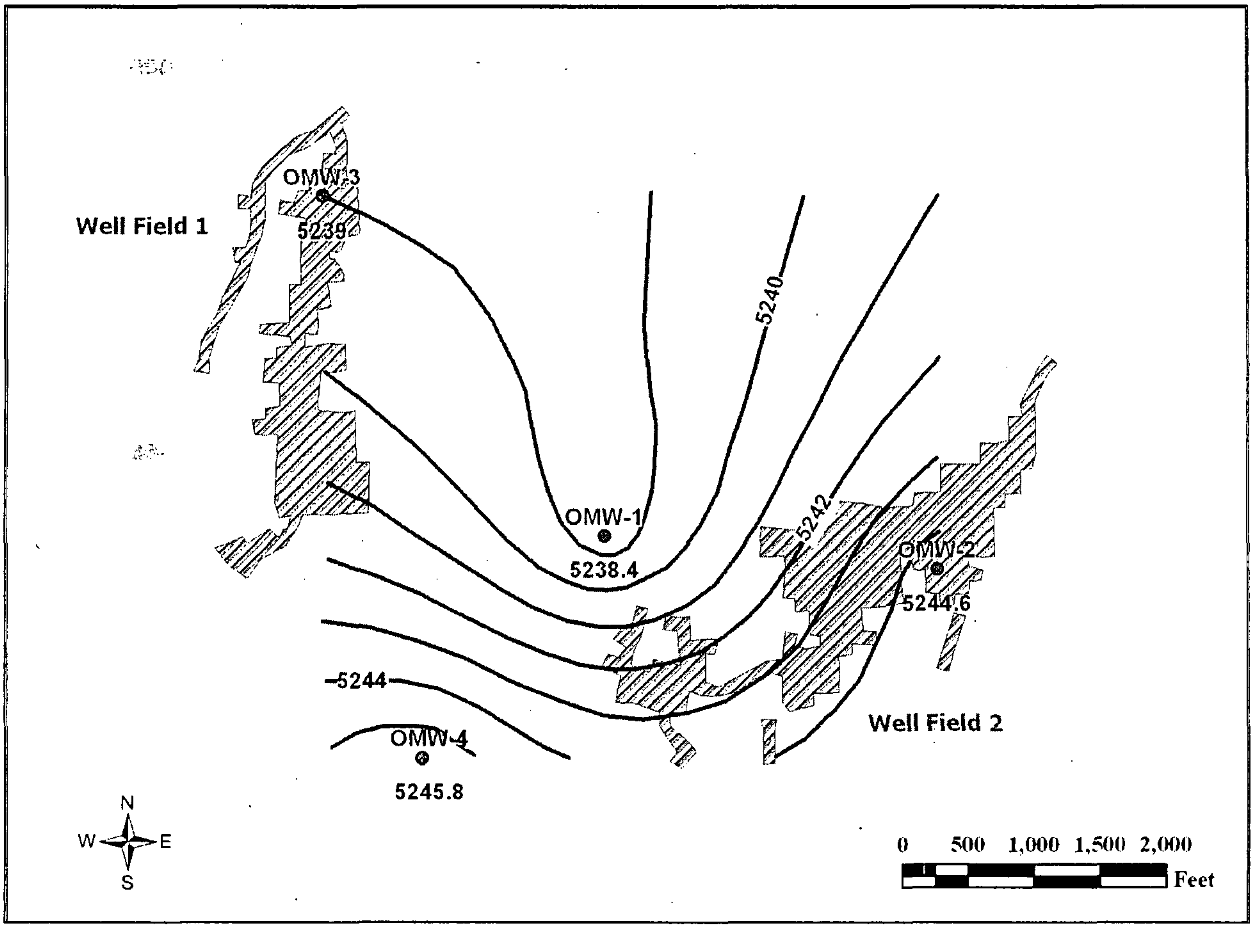

Figure 2.4-4 "72 sand" potentiometric surface, March 2008 (adapted from Figure 2.7-2-6f of the technical report)

2.4.2.1.2 "70 Sand"

Uranium One reported that the next aquifer is the "70 sand," which is the extraction zone in the Moore Ranch license area. It is located at 30.48 to 100.58 m (100–330 ft) BGS and it outcrops approximately 1.6 km (1 mile) southeast of the license area where recharge enters the sand and flows north-northwest across the license area. Uranium One stated that in the southern portion of the license area, where the overlying "72 sand" is not saturated, the "70 sand" is the surficial aquifer.

Uranium One measured water levels in the "70 sand" using 11 wells across the central portion of the license area as shown in Figure 2.4-5. It provided hydrographs for these wells from

December 2006 to February 2008 in Figures 2.7.2-5f and 2.2.2-5g of the technical report. The hydrographs show that water levels have remained essentially constant over this time period for all wells with one exception. MW-8, at the southern tip of Well Field 1, showed a decline of 6.1 m (20 ft) in July 2007 and a recovery to its original water level by February 2008. Uranium One stated that the well had been purged for sampling at this time, and it suspected that the well experienced a very slow recovery from this event.

The water level contours for the "70 sand" were provided by Uranium One in Figures 2.7.2-5a through 2.7.2-5e of the technical report for February 2007, June 2007, July 2007, February 2008, and March 2008. These contours were defined using water level data from the 11 wells. A water level contour map for the March 2008 water levels in the "70 sand" is shown in Figure 2.4 5. The flow in the aquifer is to the north. The horizontal hydraulic gradient was estimated by the applicant to be 0.004 m/m (or ft/ft).

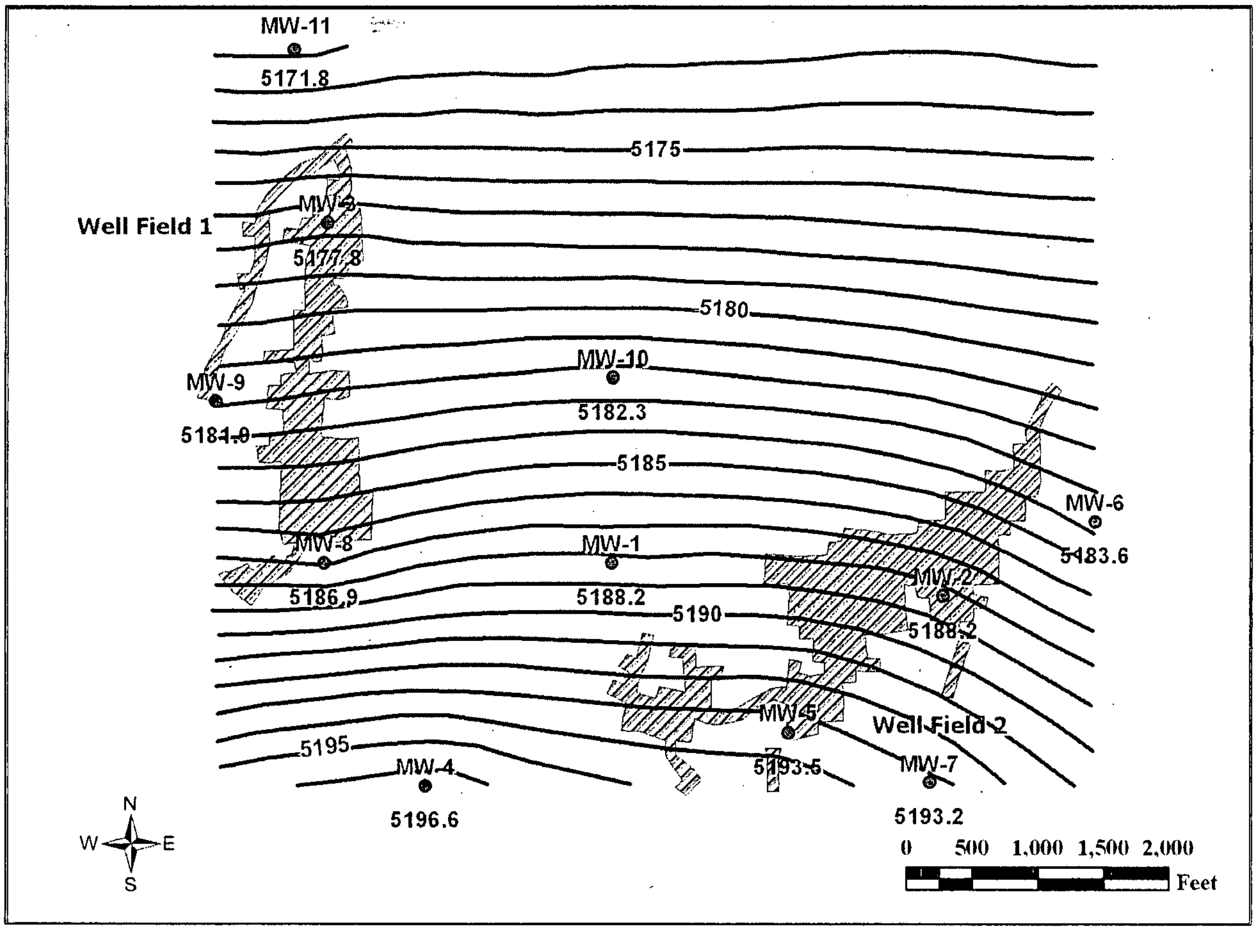

Figure 2.4-5 "70 sand" potentiometric surface, March 2008 (adapted from Figure 2.7-2-5e of the technical report)

A comparison of water levels indicates shows the "70 sand" water level ranges 50 to 60 ft lower than the overlying perched "72 sand" aquifer in grouped wells in Well Fields 1 and 2. In addition, Uranium One indicated the "70 sand" water level lies below the bottom of the "70 overlying shale" throughout most of the license area so that the "70 sand" is not saturated across its entire thickness. It is therefore an unsaturated aquifer. In regions where the "70 sand" is unsaturated, Uranium One concluded that no physical hydrologic connection exists between the "70 sand" aquifer and the perched aquifer in the overlying "72 sand."

2.4.2.1.3 "68 Sand"

The underlying aquifer to the "70 sand" extraction zone is the "68 sand." Uranium One measured water levels in the "68 sand" using four wells, UMW-1, UMW-2, UMW-3, and UMW-4, across the license area as shown in Figure 2.4-6. Uranium One provided a hydrograph of the water levels from December 2006 through February 2008 in the "68 sand" for the four wells in Figure 2.7.2-7f of the technical report. This hydrograph shows that UMW-1, UMW-2, and UMW-4 displayed relatively constant water levels in the "68 sand" over this time period. However, UMW-3, located in the northern tip of Well Field 1 showed a slow 7.62 m (25 ft) decline in water level from February 20, 2007, to July 2007, which recovered partially by October 2007. Uranium One conducted an almost 4-day pumping test in Well Field 1 in February 2007 on MW-3 in the "70 sand" directly above UMW-3 at the same time this drawdown began.

Uranium One conducted an investigation of other possible causes for the water level decline in UMW-3 during this time period. It examined the area near UMW-3 for the presence of nearby pumping wells in the "68 sand" or "70 sand" or in the deeper CBM wells that could have impacted the well. Uranium One stated that no pumping well activity that could have been the cause was uncovered. In addition to this event, UMW-3 also experienced another separate water level decline of about 21.33 m (70 ft) on October 3, 2007, which Uranium One attributed to a sampling event. The well recovered by 15.24 m (50 ft) in 1 month and returned to its original water levels by February 2008. Recently, in August 2009, the water level in the well was anomalously high. The behavior at UMW-3 has led Uranium One to conclude that there is low transmissivity in UMW-3 due to well completion damage or natural causes. Uranium One stated it will continue to monitor this well closely.

Uranium One presented the potentiometric contours for the "68 sand" aquifer for February 2007, June 2007, July 2007, February 2008, and March 2008 in Figure 2.7.2-7a through Figure 2.7.2-7e of the technical report. The potentiometric contours for the "68 sand" for March 2008 are shown in Figure 2.4-6. The hydraulic gradient was estimated by the applicant to be 0.0005 m/m (or ft/ft) with flow to the northwest.

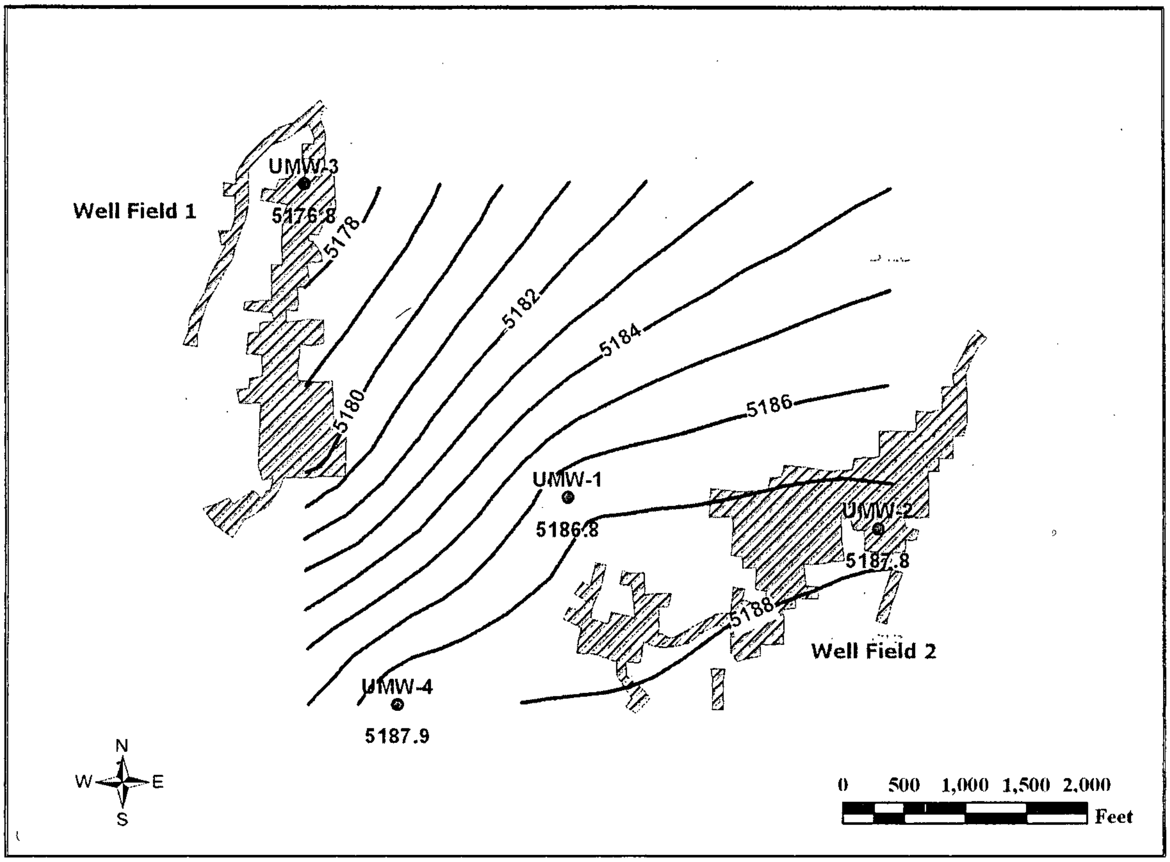

Figure 2.4-6 "68 sand" potentiometric surface, March 2008 (adapted from Figure 2.7-2-7e of the technical report)

2.4.2.1.4 "60 Sand"

Uranium One reported that the next aquifer in the license area is known as the "60 sand." The "60 sand" aquifer is approximately 30.48 m (100 ft) thick and continuous across the license area. As previously discussed, the "68" and "70" sands coalesce through portions of well field 2. In these areas, the "60" sand is considered to be the underlying aquifer. In these areas, Uranium One stated that it considers the "60 sand" as the underlying aquifer to the extraction zone.

Uranium One measured water levels in the "60 sand" using three wells, UMW-7, UMW-10, and UMW-11, across the license area and prepared the potentiometric contours for the "60 sand," which are shown in Figure 2.4-7. The contours show the ground water flow is to the north at a gradient of about 0.002 m/m (or ft/ft).

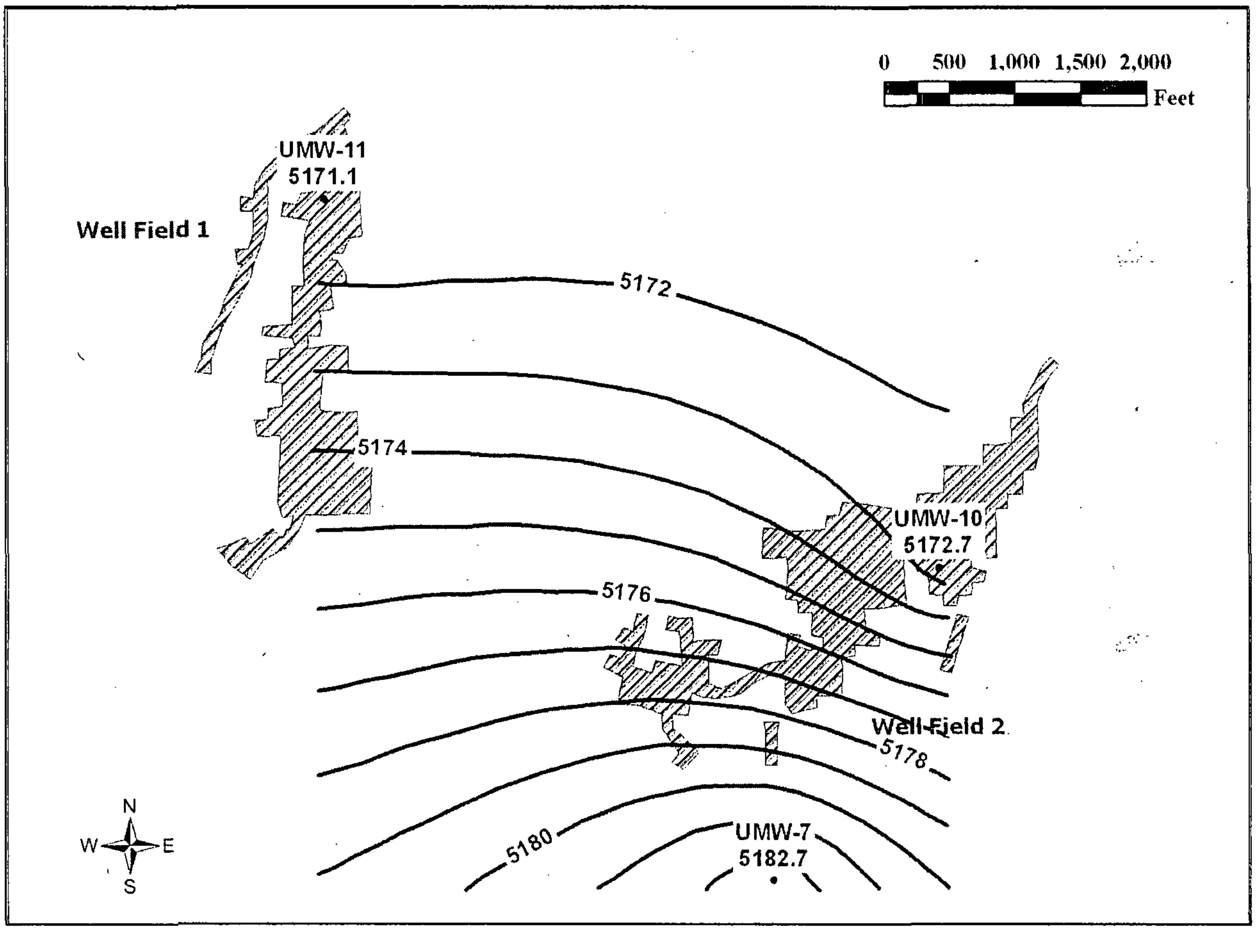

Figure 2.4-7 "60 sand" potentiometric surface, August 2009 (adapted from Figure 2.7-2-8 of the technical report)

2.4.2.1.5 "40 and 50 Sands"

Uranium One stated that the next aquifers are the "40 and 50 sands," which are separated from the "60 sand" and each other by confining shale layers. No description was provided for the water levels or hydrogeology of the "40 and 50 sands." The cross-sections provided by the applicant show that the shales are sufficiently thick to separate the "60 sand" and the "40 and 50 sands." The NRC staff finds that the "40 and 50 sands" are adequately described given their separation from the extraction zone and underlying aquifers.

2.4.2.1.6 Vertical Hydraulic Gradients

Uranium One estimated vertical hydraulic gradients across the confining layers between the aquifers using water levels from Well Groups 1, 2, 3, and 4 shown in Figure 2.4-2. Vertical gradients are used to establish the confining nature of the shales between aquifers. The NRC staff calculated the average vertical gradient across the confining layers using the values provided by Uranium One, which are shown in Table 2.4-2.

The vertical gradients between the “72 and 70 sands” across the “70 overlying shale” averaged 0.87, 0.60, 0.91, and 0.80 m/m (or ft/ft) for Well Groups 1, 2, 3, and 4, respectively. These values indicate that the “70 overlying shale” is confining in these locations. As Uranium One has already established that the “72 sand” is a perched aquifer and that the “70 sand” is an unsaturated aquifer over the majority of the license area, the NRC staff finds that the lack of saturation between these aquifers alone establishes that there is minimal hydrologic connection between them.

The vertical gradients between the “70 and 68 sands” across the “70 underlying confining” shale in Well Groups 1, 2, and 4 averaged 0.02, 0.00, and 0.09 m/m (or ft/ft) for Well Groups 1, 2, and 4, respectively. These gradients indicate that hydrologic communication exists between the aquifers across the confining layer. Uranium One has already established that the “70 underlying shale” is thin or absent in portions of Well Field 2. The lack of vertical gradient supports its absence. In Well Groups 1 and 4, the “underlying 70 shale” appears to be present but may not exhibit enough integrity to be truly confining. Uranium One stated that vertical gradient of the “70 and 68 sands” between the aquifers in Well Group 3 located in Well Field 1 was variable as it was strongly influenced by the large steady decline and recovery in water level in UMW-3 in the “68 sand” over the time period. The NRC staff, therefore, did not calculate an average gradient as an assumption of steady-state conditions could not be made. The NRC staff, however, noted that the water level decline in UMW-3 in the “68 sand” over this time was not reflected in MW-3 in the “70 sand” as shown in the hydrograph in Figure 2.7.2-7i of the technical report. This observation supports the confining nature of the “70 underlying shale” in this location.

Table 2.4-2 Vertical Gradients between the Overlying Sand and Extraction zone (“72 and 70 Sands”), the Extraction zone and Underlying Sands (“70 and 68 Sands”), and the Extraction zone “68 Sand” and “60 Sand”

Well Groups	Completion Zones	Vertical Gradient (m/m) (ft/ft)	Vertical Gradient (m/m) (ft/ft)	Vertical Gradient (m/m) (ft/ft)	Vertical Gradient (m/m) (ft/ft)	Vertical Gradient (m/m) (ft/ft)	Vertical Gradient (m/m) (ft/ft)
Date		**2/9/2007**	**6/12/2007**	**7/17/2007**	**2/21/2008**	**3/5/2008**	**8/11/2009**
1	“72 and 70 sands”	0.88	0.86	0.86	0.85	0.86	
	“70 and 68 sands”	0.02	0.02	0.02	0.02	0.02	
2	“72 and 70 sands”	0.61	0.64	0.56	0.60	0.60	0.61
	“70 and 68 sands”	0.01	-0.06	0.01	0.01	0.01	0.01

Table 2.4-2 Vertical Gradients between the Overlying Sand and Extraction zone ("72 and 70 Sands"), the Extraction zone and Underlying Sands ("70 and 68 Sands"), and the Extraction zone "68 Sand" and "60 Sand"							
	"68 and 60 sands"						0.14
3	"72 and 70 sands"	0.91	0.90	0.91	0.90	0.90	0.88
	"70 and 68 sands"	-0.13	0.14	0.24	0.01	0.01	-0.60
	"68 and 60 sands"						0.52
4	"72 and 70 sands"	0.81	0.80	0.80	0.80	0.80	
	"70 and 68 sands"	0.06	0.10	0.10	0.09	0.09	

Positive values indicate a downward gradient, whereas negative values indicate an upward gradient.

Uranium One also assessed the vertical gradient across the confining layer between the "68 sand" and the "60 sand" in Well Field 2 at the locations where the "70 and 68 sands" coalesce and where the "60 sand" is the underlying aquifer. As measured in August 2009, the gradient in this location in Well Field 2 was 0.14, which indicates that the shale under the "68 sand" has sufficient integrity to protect the "60 sand" from excursions in this region.

Three domestic water wells are located within the two mile buffer for the proposed Moore Ranch license area. One well, UM 1575 2 33 42 75, is located within the license area. This well was installed by Rio Algom Mining Corporation in 1972. The Wyoming State Engineer's Office (WSEO) permit for this well, P12299.0W, states that it is for domestic and industrial use with a note that it is may be used for uranium exploration drilling. The well is located about 1,219.2 m (4,000 ft) to the southwest of the monitoring well ring of Well Field 1. It is therefore hydrologically upgradient of the well field. The well is screened from 106.07 to 134.11 m (348 to 440 ft) below ground surface. According to cross sections in this area, this screen depth would place it in the 60 sand aquifer. The 60 sand aquifer is below a confining shale under the 68 sand aquifer which acts as the underlying aquifer for Well Field 1. The two other domestic wells, 9 Mile #1 and 9 Mile #2, are located at the two mile buffer limit to the southeast of the proposed license area. According to the 9 Mile #1 permit, P9309.0W, the well was installed in 1971 and is screened 57.91 to 76.2 m (190 to 250 ft). According to P12240.0W, the 9 Mile #2 well was installed in 1965, it has a depth of 54.86 m (180 ft) with no screen interval information. Both wells are located at least 4.83 km (3 mi) and hydrologically upgradient from Well Field 2. No completion records or cross sections were available to assess which aquifer the wells were completed in. The current Moore Ranch application indicated there is no current use of these wells for domestic purposes.

2.4.2.2 Pumping Tests

Uranium One presented the results of pumping tests conducted by Conoco from 1977 to 1980 and by the applicant in 2007, 2008, and 2009 in several locations near and in the proposed well fields. These tests were performed to evaluate communication between the "70 sand" extraction zone, the overlying "72 sand" and underlying "68 sand," and the "68 sand" and "60 sand" in Well Field 2. They were also used to determine the hydrologic properties of the aquifers in the license area. As discussed further below, the applicant has not yet collected information from local scale pumping tests on which the NRC could draw conclusions regarding adequate communication within, and confinement of, the "70 sand" aquifer from surrounding aquifers. A license condition will thus be required to address this issue.

A summary of the Conoco pumping tests are shown in Table 2.4-3. The locations of the wells used in the Conoco pumping tests are shown in Figure 2.2.2-9 of the technical report. In all of the tests, communication was demonstrated between the "70 sand" pumping well and other observation wells in the "70 sand." In Well Field 1, Well 887, completed in the underlying "68 sand," showed a response during Test 1 that indicated communication between the "68 and 70 sands" in this part of Well Field 1. This test result was dismissed at the time as a problem with well completion. In 2008, Uranium One repeated the pumping test at Well 885 and used a higher rate and longer duration to evaluate if the communication existed. The new test used rates of 37.85 Lpm (10 gpm), 47.31 Lpm (12.5 gpm), and 60.94 Lpm (16.1 gpm) for 1 hour, 1 hour, and 18 hours, respectively. The results provided in Figure CR 2-7c(5) of Appendix B-3 to the technical report showed no decline in Well 887 in the "68 sand" for the entire test period. This test supported the conclusion that there was no communication between the "68 and 70 sands" in this location. In Well Field 2, Test 3 showed that "68 sand" Well 1807 responded with a drawdown of 0.11 m (0.37 ft). This result indicated there was communication between the "70 sand" and the "68 sand" in Well Field 2 due to the thinness or absence of the "underlying 70 shale." In Well Field 2, Tests 5 and 6 showed no communication between the "70 and 68 sands." The NRC staff concludes that the Conoco tests show that there was communication between the pumping well and observation wells in the "70 sand." The tests also show the there was communication between the "70 sand" and the "68 sand" in Well Field 2.

Uranium One reported that Conoco calculated the hydraulic properties of the "70 sand" from these pumping tests using a pumping test analysis method for a confined aquifer. The results were presented in Table 2.7.2-4 of the technical report and show a hydraulic conductivity of 0.58 m per day (m/d) (1.9 ft per day [ft/d]), 0.43 m/d (1.4 ft/d), and 4.21 m/d (13.8 ft/d) for the "70 sand" in Well Fields 1, and 2, respectively. A confined aquifer storativity is reported for Well Fields 1 and 2. Note that the "70 sand" is described as an unsaturated aquifer in both well fields. Uranium One was not able to retrieve the raw data to recalculate the values with the appropriate unsaturated aquifer method; therefore, it excluded these tests from the determination of hydraulic parameters. As these test results could not be reevaluated and Uranium One has committed to conduct more testing, the NRC staff concurs on their exclusion.

Table 2.4-3 Conoco Pumping Test Results, 1977–1980 (Summarized from the technical report)							
Well Test No.	**Pumping Well ("70 Sand")**	**Well Field**	**Time**	**Flow (Lpm) [gpm]**	**Pumping Well Drawdown (m) [ft]**	**"70 sand" Well Response**	**Overlying/ Underlying Well Response**
1	885	1	1 day	12.87 [3.4]	NR	886, 888	887 ("68 sand")
2	1	2	140 min	13.24 [3.5]	NR	1805, 1806	Not applicable
3	1	2	170 min	9.46 [2.5]	NR	Not applicable	1807 ("68 sand")
4	1814	2	1,140 min	71.92 [19]	NR	1816	Not applicable
5	1823 ("68 sand")	2	70 min	6.43 [1.7]	1.83 [6]	1816	No response
6	1814	2	3,100 min	63.59 [16.8]	9.75 [32]	1816, 1815, 1817	No response

Three pumping tests were performed by Uranium One in 2007 to demonstrate communication within the "70 sand" in the well fields, determine hydraulic characteristics of the "70 sand," locate hydrologic boundaries, and assess if sufficient confinement of the extraction zone exists. Uranium One installed 20 new wells for the tests, including 11 wells in the "70 sand" extraction zone, 4 overlying "72 sand" wells, and 4 underlying "68 sand" wells. The well locations are shown in Figure 2.7.2-10 of the technical report. Eight of the 11 monitoring wells in the "70 sand" license area were stated to be in unsaturated aquifer conditions in Table 3-1 of Appendix B to the technical report. Of the three that were noted to be in confined aquifer conditions, MW-11 is far north of Well Field 1, MW-3 is in the northern tip of Well Field 1, and MW-4 is far south and west of the proposed Well Fields 1 and 2, respectively. A hydrologic report of the pumping test execution, data, analysis, and results was provided in Appendix B1 to the application. The results of the 2007 pumping tests are presented in Table 2.4-4.

Table 2.4-4 Uranium One 2007 "70 Sand" Pumping Test Results (Summarized from the technical report)								
Test No.	**Pumping Well ("70 Sand")**	**Time (d)**	**Flow (Lpm) [gpm]**	**Transmissivity (m^2/d) [ft^2/d]**	**Hydraulic Conductivity (m/d) [ft/d]**	**Pumping Well Drawdown (m)**	**Extraction zone Well Response**	**Overlying/ Underlying Well Response**

Table 2.4-4 Uranium One 2007 "70 Sand" Pumping Test Results (Summarized from the technical report)

						[ft]		
1	PW-1	9.9	59.05 [15.6]	61 [656.5]	2.7 [8.87]	6.28 [20.6]	MW-1 at 33.22 m [109 ft]	No response
2	MW-2	1.0	98.41 [26.0]	97.84 [321]	1.36 [4.46]	5.91 [19.4]	1805 at 105.46 m [346 ft]	UMW-2 at 3.04 m [10 ft] ("68 sand") and 1807 at 76.91 m [252 ft] ("68 sand")
3	MW-3	3.8	54.5 [14.4]	66.05 [711]	2.23 [7.33]	4.39 [14.4]	No response	UMW-3 ("68 sand")

Test 1 was conducted at PW-1, which was a "70 sand" well located in the center of the license area just north of Well Field 2. Only one well, MW-1, also located in the "70 sand," showed any response. Test 2 was conducted at MW-2, located in center of Well Field 2 in the "70 sand." A response was noted in a "70 sand" well and in two underlying "68 sand" wells. This test again demonstrated communication between the "70 sand" and the "68 sand" in Well Field 2 where the underlying shale is thin or missing. Test 3 was conducted by pumping "70 sand" MW-3 in the most northern tip of Well Field 1. There was no response in the overlying wells confirming a lack of communication with the perched aquifer in the "72 sand." There was also no response at the nearest monitoring well, MW-9, in the "70 sand," over 304 meters (1,000 ft) away, as the unsaturated aquifer response was not expressed over this distance. The underlying "68 sand" well, UMW-3, displayed a slow decline of 7.62 m (25 ft), which began at the time of this pumping test, but Uranium One concluded this response was unrelated to the pumping test. Another pumping test at MW-3 has not been conducted to verify this conclusion. Uranium One has stated it will conduct future well field hydrologic testing to resolve these issues. NRC will review the results of this testing in the hydrologic data package that Uranium One will submit to NRC for review and approval as discussed in Section 2.4.2.2 of this SER.

Uranium One calculated the hydraulic parameters of transmissivity, hydraulic conductivity, and storativity for the 2007 pumping tests as shown in Table 2.4-4. Uranium One analyzed the data for the MW-2 pumping test at observation Well 1805 using the Neuman method for unsaturated aquifers. This analysis demonstrated that the "70 sand" exhibited the delayed drainage response of an unsaturated aquifer and that a conductivity of 0.58 m/d (1.9 ft/d) was determined.

Uranium One stated that the 2007 pumping tests were insufficient to provide a detailed analysis of aquifer properties because of the small radius of influence developed in an unsaturated aquifer and the impact of barometric pressure variation on the water levels during the tests. Uranium One revised some of the original conclusions in Appendix B1 by stating that the 2007 pumping tests and analysis were only suitable for scoping purposes.

In 2008, Uranium One conducted an additional well pumping test in Well Field 2 known as the five spot hydrologic test. This test was done to assess the aquifer characteristics of the "70 sand" and to evaluate the hydraulics of the unsaturated aquifer in the "70 sand." The test included a step rate test to determine withdrawal rates that would stress but not dewater the unsaturated aquifer, a long-term extraction test at the pumping well to assess hydraulic conductivity and specific yield, and a five spot injection/extraction test to assess how the aquifer would respond to realistic well field operating conditions.

The "70 sand" pumping well was a new well, PMW-1, located in the west-central region of Well Field 2. It was surrounded by four injection wells in a five spot pattern, which is the pattern to be used in ISR operations. The spacing between the extraction well and the injection wells was 21.79 m (71.5 ft) on the diagonal. Four additional observation monitoring wells were placed at distances of 3.05, 9.14, 12.19, and 21.34 m (10, 30, 40, and 70 ft) from the pumping well. A monitoring well, UMW-5, was screened in the underlying "68 sand." All of the wells in the "70 sand" were unsaturated over the top 6.1 m (20 ft) of the "70 sand" (Figure 5ST(8) of the technical report), thus verifying that the aquifer was unsaturated. The remaining saturation of the "70 sand" was 20.42 to 22.86 m (67 to 75 ft thick). The "underlying 70 shale" was approximately 6.1 m (20 ft) thick over the entire area of influence of the five spot pumping test.

Uranium One first conducted the step rate test. Based on this test, it estimated that a rate of about 75.7 Lpm (20 gpm) could be maintained in the unsaturated aquifer without dewatering it. Uranium One then conducted a long-term extraction test for a period of 3 days, 10 hours, and 52 minutes to determine the hydraulic conductivity and specific yield of the "70 sand." The average rate during this test was 84.48 Lpm (22.32 gpm). The drawdown in the pumping well at the end of the test was 6.49 m (21.3 ft). Drawdown in the four "injection" observation wells ranged from 1.13 to 1.25 m (3.7 to 4.1 ft). No response was seen in the underlying "68 sand," monitor well UMW-5, after correcting for barometric pressure. The aquifer recovered to near pretest water levels within 1 hour. An analysis of the drawdown data from the pumping well and observation wells, using the Neuman method for unsaturated aquifers, resulted in a range of transmissivity of 25.27 to 36.7 m^2/d (272 to 395 ft^2/d), a hydraulic conductivity range of 1.37 to 1.74 m/d (4.5 to 5.7 ft/d), and a specific yield range of 0.011 to 0.039. The NRC staff finds that this pumping test provides an acceptable estimate of the hydraulic parameters in the "70 sand" in this location.

Uranium One then conducted the final extraction/injection test that had three separate phases. In the first phase, the central extraction well was pumped at 75.7 Lpm (20 gpm), and the flow was distributed to each of the four injection wells at a rate of 18.93 Lpm (5 gpm) for 24 hours. In the second phase, the two injection wells were shut in, and 37.85 Lpm (10 gpm) were injected into two remaining injection wells. In the third phase, three injection wells were shut in, and all the flow was sent to one injection well. Each injection well created a mounding of the water table, which is expected in an unsaturated aquifer. The water level increased about 3.05 to 4.57 m (10 to 15 ft) at each injection well. In the second and third phases, as the injection water was diverted to fewer injection wells, the water levels increased as expected. The NRC staff finds that the extraction/injection test showed that an unsaturated aquifer exhibits dewatering at the recovery well and mounding at the injection wells as expected. It also demonstrated that if the injection wells are properly developed, the unsaturated aquifer can sustain recovery and injection rates that are anticipated during production at Moore Ranch.

In 2009, Uranium One conducted a series of short-term pumping tests in the "72 sand," "68 sand," and "60 sand." These tests were conducted to evaluate the hydrologic communication between the aquifers and characterize their hydraulic parameters. One set of tests was conducted in the well cluster in Well Field 1, which includes MW-3 ("70 sand"), OMW-3 ("72 sand"), UMW-3 ("68 sand"), and UMW-11 ("60 sand"). Another set of tests was conducted in a well field cluster in Well Field 2, which includes MW-2 ("70 sand"), OMW-2 ("72 sand"), UMW-2 ("68 sand"), and UMW-10 ("60 sand").

The results of the 2009 pumping tests are shown in Table 2.4-5. They indicate that there is no communication between the "72 sand" and the "70 sand" as anticipated. The results also indicate that with a short-term test, the relatively large drawdown in the "68 sand" in Well Field 2 does not cause a measurable response in the "70 sand," even though the shale between them is thin or missing. The "68 sand" also has a transmissivity that is four orders of magnitude lower than that of the "70 sand." Finally the short-term pumping tests in the "60 sand" indicate it also has a very low transmissivity and is not hydrologically connected to the overlying "68 sand." The NRC staff recognizes the value of these short-term tests to give an initial estimate of the transmissivity of these sands and associated hydrologic response; however, longer-term pumping tests will be required to verify these results. These tests are expected to be conducted when the well fields are installed. The applicant has demonstrated through regional scale pump tests and the five spot pattern pump test that it is possible for ISR operations to be conducted safely. However, the detailed, local scale field data demonstrating efficacy of operations of ISR operations for the complex geology and associated ground water flow system at Moore Ranch are not currently available for the NRC staff to review. This data can be used to demonstrate proper containment of recovery fluids as well as the ability to detect excursions, which are both key safety issues. The detailed, local scale data can only be provided by the intensive data collection and analysis provided by testing on the completed well fields. For this and other reasons specified in Sections 2.5.2, 3.1.3.2, 3.1.3.3, 3.1.3.4, 3.1.3.5, 5.7.9.3, 5.7.9.5, and 6.1.2 of this SER, by license condition NRC staff will require that the applicant submit these well field packages for review and approval prior to the operation of any well field. This condition will read as follows:

> For Well Field 1, the licensee shall submit a hydrologic test data package to the NRC. For Well Field 2, the licensee shall submit a hydrologic test data package to the NRC for review and approval. For both Well Field 1 and Well Field 2, the

hydrologic test packages shall be submitted at least 60 days prior to the planned start date of lixiviant injection.

A.

Table 2.4-5 Uranium One 2009 Short-Term Pumping Tests Results (Summarized from the technical report)

Test No.	Pumping Well	Aquifer	Time	Flow (Lpm) [gpm]	Transmissivity (m^2/d) [ft^2/d]	Pumping Well Drawdown (m) [ft]	Extraction zone "70 sand" Well Response	Overlying/ Underlying Well Response
1	OMW-2	"72 sand"	33 min	3.18 [0.84]	not determined	2.16 [7.1]	No response in MW-2	Not applicable
2	OMW-3	"72 sand"	15–31 min	3.44-3.56 [0.91-0.94]	26.01-27.87 [280-300]	0.18 [0.6]	No response in MW-3	Not applicable
3	UMW-2	"68 sand"	112 min	4.16 [1.1]	0.05-0.07 [0.5-0.7]	19.35 [63.5]	No response in MW-2	No response in UMW-10 ("60 sand")
4	UMW-3	"68 sand"	20 min	3.03 [0.8]	not determined	6.49 [21.3]	No response in MW-3	No response in UMW-11 ("60 sand")
5	UMW-10	"60 sand"	26 min	20.44 [5.4]	0.22 [2.4]	25.91 [85]	Not applicable	No response in UMW-2 ("68 sand")
6	UMW-11	"60 sand"	141	7.95 [2.1]	0.13 [1.4]	6.97 [75]	Not applicable	No response in UMW-3 ("68 sand")

2.4.3 Evaluation Findings

The NRC staff has completed its review of the hydrologic site characterization information for the proposed Moore Ranch facility. The review included an evaluation using the review procedures in Section 2.7.2 of the standard review plan and the acceptance criteria outlined in Section 2.7.3 of the standard review plan.

The applicant has acceptably described the surface water hydrology by providing the following:

- the location of the drainages in and around the license area
- peak flood estimates for appropriate recurrence intervals for all drainages
- a flood potential analysis for the facilities
- a description of historical and current CBM-produced water discharges in and around the license area
- acceptable erosion protection against the effects of flooding from nearby streams.

The applicant has acceptably described the ground water hydrology by providing the following:

- a description of the regional hydrogeology
- a description of the overlying aquifer, extraction zone, and underlying aquifer hydrogeology using potentiometric surfaces maps with acceptable contour intervals based on an appropriate number of monitoring wells
- vertical gradients and pumping test data to evaluate the integrity of the confining layers and initially assess hydraulic parameters.

Based on a detailed review conducted of the characterization of the surface and ground water hydrology at the Moore Ranch facility, the staff concludes that the information provided by the applicant is acceptable, except for the following. The applicant has not provided enough pumping test data for the NRC to draw conclusions regarding adequate communication within, and confinement of, the "70 sand" aquifer from surrounding aquifers. This issue is addressed by the license condition stated in Section 2.4.2.2 of this SER.

ATTACHMENT C
MOORE RANCH SER
(This is a sample SER. This Section of the SER is not publicly available and is subject to change)

6.1 Plans and Schedules for Ground Water Quality Restoration

6.1.1 Introduction

This section discusses the plans for proposed restoration activities at Moore Ranch. This includes proposed restoration standards, methods, effectiveness, estimates of the number of PVs needed to complete restoration, monitoring, wastewater disposal, well plugging and abandonment, and the preliminary restoration schedule.

6.1.2 Restoration Standards

NRC regulations require that the ground water quality be returned to the standards identified in Criterion 5B(5) of Appendix A to 10 CFR Part 40. Those standards are background, the values in the table in Criterion 5C of Appendix A to 10 CFR Part 40, or an alternate concentration limit (ACL) established by the NRC in accordance with Criterion 5B(6) of Appendix A to 10 CFR Part 40. In section 6.1.1 of the technical report, the applicant stated that the goal of the ground water restoration will be to return the concentration of hazardous constituents in the production zone to these standards. The NRC finds these restoration standards to be acceptable and will include this requirement as a license condition. This license condition will be worded as follows:

> The licensee shall conduct ground water restoration activities in accordance with the approved license application. Permanent cessation of lixiviant injection in a well field would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of groundwater restoration. Prior to initiation of ground water restoration activities, the licensee shall determine the restoration schedule. If the licensee determines that these activities are expected to exceed 24 months, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR Part 40.42.
>
> Ground water shall be restored to the ground water protection standards presented in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis. If the restoration activities are unable to achieve the background or maximum contaminant levels (whichever is greater) in Criterion 5(B)(5), the licensee shall submit a license amendment application request for NRC approval of alternate concentration limits (ACLs).

Changes to ground water restoration or post-restoration monitoring plans shall be submitted to the NRC for review and approval at least 60 days prior to ground water restoration in a well field.

In order for a licensee to receive approval to use ACLs, it must first be demonstrated that the licensee has attempted to restore hazardous constituents in groundwater to background or the maximum contaminant level (MCL) – whichever level is higher. A request to establish ACLs is a license amendment application submitted by the licensee. The factors that must be considered in reviewing ACL applications are set forth in 10 CFR Part 40, Appendix A, Criterion 5B(6).

For ISR facilities located in Wyoming, the State's "class of use" standard is one factor that may be considered in evaluating ACL requests, in accordance with Criterion 5B(6)(a)(v-vi) and (b)(vi-vii).

In considering ACL requests, particular importance is placed on protecting underground sources of drinking water (USDWs). The use of modeling and additional groundwater monitoring may be necessary to show that ACLs in ISR well fields would not adversely impact USDWs.

Before an ISR licensee is allowed to extract uranium, the EPA under 40 CFR Part 146.4 and in accordance with the Safe Drinking Water Act (SDWA) must issue an aquifer exemption covering the portion of the aquifer in which the uranium-bearing rock is located. The EPA must find that the portion of the aquifer being exempted "does not currently serve as a source of drinking water" and "cannot now and will not in the future serve as a source of drinking water". Thus, in evaluating the expected impacts of ISR operations, the NRC focuses on impacts outside the area of the exempted aquifer. In most cases, the water in aquifers adjacent to the uranium ore zones does not meet drinking water standards. The NRC will not approve an ACL if it will impact any adjacent USDWs.

Further guidance for the review of ACLs for ISR facilities is being developed in a revision of NUREG-1569 Standard Review Plan for the In Situ Leach [Recovery] Uranium Extraction License Applications. Existing guidance for the review of ACLs is in NUREG-1620 Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978, section 4.3 (NRC, 2003b).

The applicant proposed to set restoration target values (RTVs) for the Moore Ranch well fields based on the average baseline water quality in the "70 sand" production zone, with separate RTVs being determined for the "68 sand" in the areas of Well Field 2 where the production zone will include both the "70 sand" and the "68 sand." RTV's are the primary restoration standard, or baseline, at ISR facilities. A list of constituents to be included as RTVs was provided in Table 6.1-1 of the technical report. Baseline water quality will be determined from samples collected in wells completed in each well field in the planned production zone before ISR operations begin. As described in Section 2.5 of the SER, the applicant has allowed for the possibility of subzones of baseline water quality if values differ substantially across the well fields. By license condition, the applicant will submit the well field hydrologic data package, which includes the RTVs for review and approval by the NRC. This license condition is initially discussed above in Section 2.4.2.2 of this SER.

6.1.3 Restoration Methods

The applicant stated that ground water restoration will occur in two phases: (1) the restoration phase and (2) the stability monitoring phase (discussed in Section 6.1.8 of this SER). The restoration methods proposed by the applicant will consist of (1) ground water transfer, and (2) ground water treatment.

In ground water transfer, ground water from a well field in production will be injected into the well field in restoration. This step blends the well field waters and reduces water consumption and wastewater disposal. Water recovered from the restoration well field may be passed through ion exchange or filtration to remove solids. If a new well field is not available, this step will be skipped.

Ground water treatment will either follow or occur in conjunction with ground water transfer. In this step, water will be pumped from the extraction zone, treated at the surface using ion exchange, filtered by RO or electrodialysis reversal, and then reinjected. RO is a high-pressure filtration process that reduces contaminants in the affected ground water, producing a clean permeate and reject brine. The clean water will be reinjected, and the reject from treatment will be sent to deep disposal wells.

The applicant indicated that at any time during ground water treatment, a chemical reductant might be added to create reducing zones in the extraction zone. The goal of the reductant is to decrease the concentration of redox-sensitive elements such as arsenic, molybdenum, selenium, uranium, and vanadium. The reduction leaves the constituents in the extraction zone in an immobile state (i.e., not able to be transported outside the extraction zone) as opposed to being permanently removed from the extraction zone.

The NRC staff concludes that the methods proposed for restoration at Moore Ranch reflect accepted practice.

6.1.4 Effectiveness of Ground Water Restoration Methods

The applicant reported that the restoration methods proposed for Moore Ranch have been successfully applied to existing ISRs at Irigaray and Christensen Ranch in the PRB. Considering the similar geological setting and type of lixiviant, it stated that the same restoration practices should be successful at Moore Ranch.

To further support the suitability of its proposed restoration methods at Moore Ranch, the applicant provided an analog analysis in Addendum 6.1-A of the technical report. The applicant demonstrated, through a comparison table, that the Irigaray Ranch, Christensen Ranch, and Moore Ranch production zones are in the same geological trend of fluvial Wasatch sediments and have similar hydrogeological characteristics. It also showed that the post-operations water quality from the restoration and Moore Ranch core leach test water quality were similar. It reported that the only major difference between these prior operations and Moore Ranch was that the "70 sand" is an unsaturated aquifer with higher conductivity. The NRC staff finds the COGEMA Irigaray Ranch and Christensen Ranch ISRs to be acceptable analogs for restoration for Moore Ranch.

The NRC staff notes, however, that the restoration methods proposed have only been applied to confined aquifers. Behavior of an unsaturated aquifer, like portions of the "70 sand" at Moore Ranch, presents specific issues that can impact restoration. These issues are discussed in more detail in Section 3.1 of this SER. The NRC staff concludes that the applicant has considered the issues related to restoration of an unsaturated aquifer and has proposed reasonable solutions.

6.1.5 Pore Volume Estimates

6.1.5.1 Flare Factor

The applicant presented the method used to determine its initial estimate of the pore volume (PV) that will be required during ground water restoration and in Section 6.6 of the technical report. The PV was calculated as the product of the affected extraction zone area, the average completed thickness, the flare factor, and the porosity. Flare factor is an estimate of the additional volume outside the extraction zone that is affected by slight variations in flow. The applicant determined a flare factor of 1.2 using MODPATH particle tracking simulations from the sitewide ground water flow model for both well fields, as presented in Appendix B5 to the technical report. The vertical flare factor was assumed to be the same. So the overall flare factor was 1.44. However, the applicant used a flare factor of 1.5 in the calculation to be conservative in the PV assessment. Assuming horizontal flow dominates in the "70 sand," the "average completed thickness" of 9.05 m (29.7 ft) was used in the calculation of the PV. Using these numbers and a porosity of 0.26, the PVs were reported as 360,970,529 and 502,890,240 liters (95,368,700 and 132,864,000 gallons) for Well Fields 1 and 2, respectively.

The applicant defines the "average completed thickness" as the average length of the well screens in the aquifer, and this can be less than the thickness of the aquifer that will be affected during production. This is the case at Moore Ranch, where the saturated thickness of the unsaturated aquifer is approximately 23.77 m (78 ft). The applicant has proposed an effective average thickness of 9.05 m x 1.44 = 13.04 m (29.7 ft x 1.44 = 42.76 ft). In addition, the dewatering of an unsaturated aquifer can create vertical flow near the wells, which is not accounted for in this calculation. Both of these issues can lead to an underestimation of the PV. The applicant stated that based on the ground water flow modeling, the vertical flow effects are very near the wells so that the volume affected above and below the screens is very small and is accounted for in the flare factor. Based on this analysis, the NRC staff concludes that the PVs proposed are an acceptable initial estimate.

6.1.5.2 Single Pore Volume Estimate

In Well Field 2, the "70 sand" and "68 sand" coalesce in several sections in the center of the well field; the production zone will include both of these sands in these areas. However, as discussed in Section 3.1, the applicant predicted by ground water flow modeling that there is negligible flow (approximately 0.003 cubic meters per day [0.1 cubic foot per day]) moving from the "70 sand" to the "68 sand" during production. Therefore, the applicant did not include the PV of the "68 sand" in this region in the estimate. The NRC staff accepts this initial exclusion of the "68 sand" and notes that the applicant will place monitoring wells in the "68 sand" in this region so that any fluid exchange will be detected. If such fluid exchange is detected, any resultant contamination in the "68 sand" would require restoration.

6.1.5.3 Restoration Pore Volumes

The applicant estimated the number of PVs required for restoration in Section 6.6 of the technical report. The applicant predicted that restoration would be achieved for each well field after one PV of ground water sweep and five PVs of RO and chemical reduction treatment. The NRC staff noted that this number of PVs was low compared to the established record of PV requirements from ISRs whose restorations have been approved by the NRC for the PRB. For the nine production units at the Uranium One Irigaray ISR in a similar geological setting, the restorations required PVs ranging from 9.5 to 18.4 with an average of 14.6. Mine Unit A at Smith Ranch/Highland required 15 PVs.

To support its PVs estimate, the applicant used a comprehensive analysis of the restoration of historical well fields at the COGEMA Irigaray and Christensen Ranch ISRs as presented in Addendum 6.1-A of the technical report. The applicant provided evidence to the NRC staff that these ISRs were acceptable analogs for Moore Ranch given the similar geological setting, extraction, and restoration processes. The analysis found that at both of these ISR operations, poor management and execution of the restoration process resulted in increased PVs to achieve restoration goals. Uranium One based this conclusion on three findings: (1) production and restoration were not conducted sequentially and were plagued with extended shut-in and standby periods with delays of several years in some cases, (2) ground water sweep was often largely ineffective and, in some cases, may have exacerbated the problem, and (3) RO was continued in some well fields after it was apparent that little improvement in water quality was occurring. Uranium One substantiated these findings with detailed discussion and with tables and figures in its response.

Based on this analog analysis, the applicant presented several strategies it intends to utilize at Moore Ranch to improve the efficiency of restoration. These strategies are immediate restoration following production, close monitoring, termination of RO once restoration is achieved or water quality has stabilized, and use of ground water transfer. The applicant expects that these strategies will lower the consumptive water use and expedite restoration.

The applicant also stated that although it could not quantify how effective these strategies will be at this time, it will track performance using restoration field data.

The applicant concluded that its preferred approach to estimating the number of PVs needed for restoration is to use the lessons learned from the analogs. It also stated that it will revise the PVs based on field data from operations at Moore Ranch. The NRC staff finds the initial estimate of six PVs and the commitment to revise it based on operations acceptable, as demonstrated in the evaluation of the analogs and the proposed strategy.

6.1.6 Ground Water Restoration Monitoring

The applicant stated that because lixiviant injection will be discontinued during restoration, the possibility of an excursion will be less than that during production. The applicant therefore proposed a reduced monitoring schedule in which the wells in the monitoring ring and overlying/underlying aquifers will be sampled once every 60 days for the excursion parameters of chloride, total alkalinity, and conductivity. Water levels will also be measured. This approach is acceptable to the NRC staff.

The applicant reported that the extraction zone "70 sand" will be monitored during restoration to determine restoration progress, optimize efficiency of restoration methods, and identify any areas of the well field that need attention. Samples will be monitored for all of the parameters shown in Table 6.1-1 of the technical report at the start of restoration. The applicant provided a detailed description of the monitoring to be conducted during restoration in Table 6.1-4. This table included the sample origin, parameters, and frequency to substantiate that it will be able to closely monitor and optimize its restoration strategy to achieve or adjust the initial estimate of six PVs for restoration as proposed. Additionally, the applicant has indicated that the "68 sand" extraction zone will be monitored for restoration success where the "70 sand" and "68 sand" coalesce in Well Field 2. The NRC staff finds this restoration monitoring to be acceptable.

6.1.7 Restoration Wastewater Disposal

As the primary method to dispose of liquid byproduct material generated by restoration activities, the applicant plans to install deep disposal wells at Moore Ranch. An estimate of the concentrations of waste constituents in the waste injection stream was provided in Table 6.1-3 of the technical report. The number, location, and capacity of these wells was described and found acceptable for restoration by NRC staff as evaluated in Section 4.2 of this SER. The use of deep disposal wells is contingent on the applicant obtaining UIC permits from WDEQ. If these permits are not approved, the applicant would have to propose an alternate method to dispose of liquid byproduct material and receive NRC approval prior to operation. Appropriate instrumentation for leak detection in the deep disposal wells and lines was described in Section 4.2.3.3 of the technical report and is also acceptable.

6.1.8 Restoration Stability Monitoring

The applicant stated that after restoration is completed, a minimum 12-month stability monitoring period will begin to ensure that the ground water quality is stable and that standards will not be exceeded. During stability monitoring, the monitoring ring wells will be sampled once every 2 months and analyzed for the excursion parameters of chloride, total alkalinity, and conductivity. Production zone wells will be sampled at the beginning, middle, and end of the stability period and analyzed for all of the constituents listed as RTVs in Table 6.1-1 of the technical report. The criteria to establish restoration stability will be based on well field averages for water quality. The determination of aquifer stability will be based on the trends in the parameter data. If increasing trends are confirmed, an evaluation of the cause will be conducted and corrective actions will be taken.

Uranium One also proposed a strategy to identify and address residual elevated concentrations of constituents of concern known as "hot spots" in the "70 sand" and "68 sand," which may persist after restoration. A "hot spot" will be indicated by a mean well field concentration of +/-2 standard deviations. If a "hot spot" is identified, additional evaluations will be conducted to determine if it could have an impact on water quality outside of the exempted aquifer. This analysis may include trend analysis, transport modeling, collection of additional water quality samples, or measurement of other water quality parameters. Uranium One stated that based on the results of this analysis, additional restoration would be conducted as necessary to protect ground water quality outside the exempted aquifer. This approach to identifying and addressing "hot spots" is acceptable to the NRC staff.

6.1.9 Well Field Plugging and Abandonment

Uranium One stated that well field plugging and abandonment will be initiated once the regulatory agencies concur that the ground water in a well field has been adequately restored and is stable. All wells will be plugged and abandoned according to State of Wyoming requirements. The proposed plugging and abandonment approach is acceptable to the NRC staff.

6.1.10 Restoration Schedule

A preliminary well field restoration schedule was provided in Figure 6.1-1 of the technical report. The applicant reported that based on the results of the numerical ground water flow modeling (Appendix B5 to the technical report), restoration will require approximately 3.75 years to restore Well Field 1 and 5.5 years to restore Well Field 2. These initial estimates and schedule are acceptable to the NRC staff. The NRC staff notes that under the proposed schedule it is anticipated to take more than 24 months to complete decommissioning activities. This timeframe is not consistent with the requirements of 10 CFR 40.42, which requires that decommissioning activities be completed within 24 months of initiation of decommissioning. Permanent cessation of lixiviant injection in a well field would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of groundwater restoration. Per 10 CFR Part 40.42, NRC may approve an alternate schedule, if warranted. Therefore, the applicant will determine the need for an alternate schedule prior to any ground water restoration activities. This requirement is included in the license condition contained in section 6.1.2 of this SER.

6.1.11 Evaluation Findings

The NRC staff has completed its review of the plans and schedules for ground water quality restoration proposed for use at the Moore Ranch facility. This review included an evaluation of the methods that will be used to develop the ground water restoration program and schedules using the review procedures in Section 6.1.2 of the standard review plan and the acceptance criteria outlined in Section 6.1.3 of the standard review plan.

By license condition, the applicant will be required to meet the restoration standards identified in Criterion 5B(5) of Appendix A to 10 CFR Part 40 for hazardous constituents. Regarding the methodology for ground water restoration, the applicant provided an acceptable approach that includes a mix of ground water transfer and ground water treatment.

Based on the information provided in the application and on the detailed review conducted of the plans and schedules for ground water quality restoration for the Moore Ranch facility, the staff concludes that the proposed plans and schedules for ground water quality restoration will adequately protect public health and minimize danger to life or property, in accordance with 10 CFR 40.32(c).