Safety Evaluation Report
For the Moore Ranch ISR Project
in Campbell County, Wyoming,
Materials License No. SUA-1596

Docket No. 40-9073
Uranium One Americas, Inc.

U.S. Nuclear Regulatory Commission

Office of Federal and State Materials and Environmental Management Programs

September 2010

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INTRODUCTION

By letter dated October 2, 2007, Energy Metals Corporation (EMC), a wholly-owned subsidiary of Uranium One Americas, submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a new source material license for the Moore Ranch Uranium Project (Moore Ranch facility), located in Campbell County, Wyoming. Source material licenses are subject to safety requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material." On August 10, 2007, Energy Metals Corporation was acquired by Uranium One, Inc., therefore, the applicant for the proposed Moore Ranch facility is Uranium One Americas, Inc. (Uranium One).[1] Uranium One is proposing to recover uranium using the *in-situ* leach (ISL) recovery process [also known as *in-situ* recovery (ISR)]. The proposed Moore Ranch facility includes a central processing plant, two wellfields, two to four deep disposal wells for liquid effluents, and the attendant infrastructure (e.g., pipelines).

The Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. The NRC must license facilities, including ISR operations, in accordance with NRC regulatory requirements to protect public health and safety from radiological hazards. In accordance with 10 CFR 40.32, "General Requirements for Issuance of Specific Licenses," the NRC staff is required to make the following safety findings when issuing an ISR license:

- The application is for a purpose authorized by the Atomic Energy Act.
- The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life or property.
- The applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property.
- The issuance of the license will not be inimical to the common defense and security or to the health and safety of the public.

This safety evaluation report (SER) documents the safety portion of the staff's review of the October 2, 2007, application, as amended, and includes an analysis to determine Uranium One's compliance with these and other applicable 10 CFR Part 40 requirements, and applicable requirements set forth in 10 CFR Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or

[1] On July 20, 2010, Uranium One Americas, Inc. submitted a notice of indirect change of control to the NRC with respect to its current materials license, SUA-1341, and three pending materials license applications (Docket Nos. 40-8502, 40-9073, 40-9079; and 40-9095, respectively). By this notice, Uranium One Americas, Inc. informed the NRC that its parent company, Uranium One, Inc. had entered into a Purchase and Subscription Agreement with JSC Atomredmetzoloto (ARMZ) and its wholly owned subsidiaries Effective Energy N.V., and Uranium Mining Company, such that upon closing of the transaction Uranium One Americas parent company, Uranium One, Inc., will become a majorily owned subsidiary of ARMZ. The NRC's consolidated review of the notice is being conducted within Docket No. 40-8502, and will not be substantively addressed herein.

Concentration of Source Material from Ores Processed Primarily for Their Source Material Content." This SER also evaluates Uranium One's compliance with applicable requirements in 10 CFR Part 20, "Standards for Protection against Radiation."

A supplemental environmental impact statement (SEIS) has been prepared in parallel with this SER to address the environmental impacts of the proposed action.

The staff's safety review of the proposed Moore Ranch facility was performed using NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," and is a comprehensive assessment of Uranium One's proposed ISR facility. The regulations at 10 CFR Parts 20 and 40, and those in Appendix A to 10 CFR Part 40 contain the technical requirements for licensing an ISR facility. This SER is organized following the organization of NUREG-1569, except that sections addressing environmental aspects are not included in the SER as they are addressed in the SEIS.

The staff's review of the Uranium One application for the proposed Moore Ranch facility identified a number of facility specific issues that require license conditions to ensure that the operation of the facility will be adequately protective of public health and safety. Table 1 includes the license condition language as well as the section of this SER where the regulatory need for the license condition was identified. Appendix A of this SER contains standard license conditions that are applied to all ISR facilities. The staff concludes that the findings described in succeeding sections of this SER, including the necessary license conditions, supports the issuance of a license authorizing the construction and operation of the facility. The staff issued draft licenses to Uranium One on June 22, 2010 and on September 21, 2010 for comment. By email/letter dated September 29, 2010, Uranium One agreed to these license conditions.

Table 1

License Conditions

SER Section	License Condition
2.2.3.2/2.2.4	The licensee shall install a meteorological station within the license area and collect meteorological data for a period of one year, or until the data collected is determined to be representative of long term conditions, at a data recovery rate of 90 percent. The data collected shall include, at a minimum, temperature, precipitation, wind speed, wind direction, and an annual wind rose. The submittal shall include a summary of the stability classification.
2.4.3.2.2/2.4.4	Well Field Packages. 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.
2.6.3.1/2.6.4	The licensee shall submit a preoperational radiological environmental monitoring program report for NRC approval that will include environmental results for groundwater, air particulate, and livestock (grazing sheep), as described in Regulatory Guide 4.14.
3.1.3.2/3.1.4	The licensee shall observe and document gas breakout events in individual production wells during monitoring, sampling, inspection, or

Table 1 License Conditions	
	routine work over of equipment in well fields and header houses. The licensee shall also document changes in well operation or well field piping, pumps, and gauges caused by free gas phase in well field fluids.
3.1.3.2/3.1.4	The licensee shall maintain an inward hydraulic gradient in each individual well field, starting when lixiviant is first injected into the production zone and continuing until the restoration target values (RTVs) have been reached.
4.1.3.4/4.1.4	The licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall: A. Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring. B. Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302. C. Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2. D. Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.
4.2.3.1.1/4.2.4	All liquid effluents from process buildings and other process waste streams, with the exception of sanitary wastes, shall be returned to the process circuit or disposed of as allowed by NRC regulations. Additionally, the licensee is authorized to dispose of process solutions, injection bleed, and restoration brine using deep well injection, as permitted by WDEQ and described in the approved license application. The licensee shall maintain a record of the volumes of solution disposed in each disposal well and submit this information in the annual monitoring report.
4.2.3.2.1/4.2.4	The licensee shall submit a copy of the solid byproduct material disposal agreement to the NRC. The licensee shall dispose of solid byproduct material from the Moore Ranch operations at a site that is authorized by the NRC or an NRC Agreement State to receive byproduct material. The licensee's approved solid byproduct material disposal agreement must be maintained on site. In the event that the agreement expires or is terminated, the licensee shall notify the NRC within seven working days after the date of expiration or termination. A new agreement shall be submitted for NRC approval within

Table 1 License Conditions	
	90 days after expiration or termination, or the licensee will be prohibited from further lixiviant injection.
5.2.3/5.2.4	Until license termination, the licensee shall maintain documentation on unplanned releases of source or byproduct materials (including process solutions) and process chemicals. Documented information shall include, but not be limited to: date, spill volume, total activity of each radionuclide released, radiological survey results, soil sample results (if taken), corrective actions, results of post remediation surveys (if taken), a map showing the spill location and the impacted area, and an evaluation of NRC reporting criteria. The licensee shall have procedures which will evaluate the consequences of the spill or incident/event against 10 CFR 20, Subpart M, and 10 CFR 40.60 reporting criteria. If the criteria are met, then report to the NRC Operations Center as required. If the licensee is required to report any well field excursions and spills of source, byproduct material, and process chemicals that may have an impact on the environment, or any other incidents/events, to any State or other Federal agency, a report shall be made to the NRC Headquarters Project Manager by telephone or electronic mail (e-mail) within 24 hours. This notification shall be followed, within 30 days of the notification, by submittal of a written report to NRC Headquarters, as per LC 9.3, detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved.
5.3.3/5.3.4	The licensee will identify a qualified designee(s) to perform daily inspections in the absence of the RSO or HPT. The qualified designee(s) will have health physics training, and such training program will be specified by the licensee. Furthermore, the qualified designee(s) may perform daily inspections no more than two days per week, and those reports will be reviewed by health physics staff within 48 hours of completing the report. The licensee will also have a health physics staff member available by telephone while the qualified designee(s) is performing the daily inspections.
5.7.4.3.2/5.7.4.4	The licensee shall conduct airborne sampling for natural U, Th-230, Ra-226, Po-210, and Pb-210 at each in-plant air particulate sampling location at a frequency of once every 6 months for the first two years and annually thereafter to ensure compliance with 10 CFR 20.1204(g). The licensee shall also evaluate changes to plant operations to determine if more frequent isotopic analyses are required for compliance with 10 CFR 20.1204(g).
5.7.5.3.1/5.7.5.4	The licensee shall submit to the NRC the procedures by which it will ensure that unmonitored employees will not exceed 10 percent of the dose limit.
5.7.7.3.1/5.7.7.4	The licensee shall develop a survey program for beta/gamma contamination for personnel contamination from restricted areas, and

Table 1 License Conditions	
	beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F.
5.7.8.3.2.1/5.7.8.4	Consistent with Regulatory Guide 4.14, the licensee shall establish air particulate sampling stations in the three sectors with the highest predicted concentration and colocate radon air samplers and direct radiation and soil sampling with the air particulate sampling stations.
5.7.8.3.2.1/5.7.8.4	Consistent with Regulatory Guide 4.14, the licensee shall establish an air particulate sampling location at the nearest residence or occupiable structure. In conjunction with the air particulate sampling location, the licensee shall colocate passive radon monitors with the air particulate sampling location. The air particulate sampling location and other colocated sampling media must be operational prior to commencement of operations. The licensee must notify the NRC, in writing, upon establishing an operational air particulate sampling location and include the sector and distance from the CPP.
5.7.10.3.2/5.7.10.4	The licensee shall submit an updated organizational chart identifying the QA manager position.
6.1.3.1/6.1.4	Ground Water Restoration. 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 ground water 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 40.42. Hazardous constituents in the ground water shall be restored to the numerical ground water protection standards as required by 10 CFR 40, Appendix A, Criterion 5(B)(5). In submitting any license amendment application requesting review of proposed alternate concentration limits (ACLs) pursuant to Criterion 5(B)(6), the licensee must also show that it has first made reasonable effort to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater). 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.
6.2.3/6.2.4	At least 12 months prior to initiation of any planned final site decommissioning, the licensee shall submit a detailed decommissioning plan for NRC review and approval. The plan shall represent as-built conditions at the Moore Ranch facility.
6.5.3/6.5.4	Financial Assurance. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR 40, Appendix A, Criterion 9, adequate to cover the estimated costs, if accomplished by a third party, for decommissioning and decontamination, which includes

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	offsite disposal of radioactive solid process or evaporation pond residues, and ground-water restoration as warranted. The surety shall also include the costs associated with all soil and water sampling analyses necessary to confirm the accomplishment of decontamination. Proposed annual updates to the financial assurance amount, consistent with Criterion 9 of Appendix A to 10 CFR Part 40, shall be provided to the NRC 90 days prior to the anniversary date (e.g., renewal date of the financial assurance instrument/vehicle). The financial assurance update renewal date for Moore Ranch will be determined following consultation with Uranium One and the State of Wyoming. If the NRC has not approved a proposed revision 30 days prior to the expiration date of the existing financial assurance arrangement, the licensee shall extend the existing arrangement, prior to expiration, for one year. Along with each proposed revision or annual update of the financial assurance estimate, the licensee shall submit supporting documentation, showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation, maintenance of a minimum 15-percent contingency, changes in engineering plans, activities performed, and any other conditions affecting the estimated costs for site closure. Within 90 days of NRC approval of a revised closure (decommissioning) plan and its cost estimate, the licensee shall submit, for NRC review and approval, a proposed revision to the financial assurance arrangement if estimated costs exceed the amount covered in the existing arrangement. The revised financial assurance instrument shall then be in effect within 30 days of written NRC approval of the documents. At least 90 days prior to beginning construction associated with any planned expansion or operational change that was not included in the annual financial assurance update, the licensee shall provide, for NRC approval, an updated estimate to cover the expansion or change. The licensee shall also provide the NRC with copies of financial assurance-related correspondence submitted to the State of Wyoming, a copy of the State's financial assurance review, and the final approved financial assurance arrangement. The licensee also must ensure that the financial assurance instrument, where authorized to be held by the State, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil, and water sample analyses, and ground water restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual updates should follow the outline in Appendix C to NUREG-1569 (NRC, 2003), entitled "Recommended

Table 1 License Conditions	
	Outline for Site-Specific In Situ Leach Facility Reclamation and Stabilization Cost Estimates." The licensee shall continuously maintain an approved surety instrument for the Moore Ranch project, in favor of the State of Wyoming. The initial surety estimate shall be submitted for NRC review and approval within 90 days of license issuance, and the surety instrument shall be submitted for NRC review and approval 90 days prior to commencing operations.

The NRC finds that the application for the Moore Ranch materials license complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations. Based on its review, as documented in this SER, the staff concludes that the application meets the applicable requirements in 10 CFR Parts 20 and 40. More specifically, in accordance with 10 CFR 40.32(b-c), the staff finds that Uranium One is qualified by reason of training and experience to use source material for the purpose it requested; and that Uranium One's proposed equipment and procedures for use at its Moore Ranch facility are adequate to protect public health and minimize danger to life or property. Therefore, in accordance with 10 CFR 40.32(d), the staff finds that issuance of a license to Uranium One will not be inimical to the common defense and security or to the health and safety of the public.

References

10 CFR Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily from their Source Material Content."

10 CFR Part 20, "Standards for Protection Against Radiation."

Atomic Energy Act of 1954, as amended, 42 U.S.C. § 2011 et seq.

Uranium One, 2010. Notice of Indirect Transfer of Control, dated July 20, 2020. ADAMS Accession No. ML102090404.

1. PROPOSED ACTIVITIES

1.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that its summary of the proposed activities at the Moore Ranch facility is in compliance with the applicable requirements in 10 CFR 40.31.

1.2 Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR 40.31 using the acceptance criteria presented in Section 1.3 of NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications,"(NRC, 2003) (standard review plan).

1.3 Staff Review and Analysis

Uranium One's application for the Moore Ranch facility consisted of a technical report and an environmental report (Energy Metals, 2007a, 2007b). During the review process, the applicant revised the technical report on July 11, 2008, October 28, 2008, December 4, 2009, December 10, 2009, and January 18, 2010 to address staff comments (Uranium One, 2008a, 2008b, 2009a, 2009b, 2010). Together, these submittals comprise the technical report and form the basis for the staff's review. This safety evaluation report (SER) documents the staff's safety review of the technical report. A supplemental environmental impact statement (SEIS) has been prepared in parallel with this SER to address the environmental impacts of the proposed action (NUREG-1910, Supplement 1, "Environmental Impact Statement for the Moore Ranch ISR Project in Campbell County, Wyoming – Supplement to the Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities," [NRC, 2010]).

Uranium One is the corporate entity proposing to construct and operate an ISR and central processing plant (CPP) at the Moore Ranch facility. The Moore Ranch facility occupies approximately 2,873 hectares (7,100 acres) in Campbell County, WY. The proposed license area is composed of mainly privately owned lands with some minor quantities of State of Wyoming lands. All of the minerals leased in the Moore Ranch facility are on private lands.

The uranium ore body at the Moore Ranch facility occurs at depths of 61 to 76 meters (m) (200 to 250 feet [ft]) below ground surface (BGS). The average grade of uranium in the ore body is approximately 0.1-percent U_3O_8. Operations are planned to occur in two well fields and a CPP building at the site. Uranium One plans to extract uranium by injecting a lixiviant consisting of native ground water combined with sodium bicarbonate/carbonate and oxygen into the ore body. The amenability of uranium deposits to the ISR process at the Moore Ranch facility has been demonstrated by nearby ISR operations in similar ore bodies in the Powder River Basin (PRB), including the Smith Ranch/Highland and the Irigary/Christensen Ranch projects.

After injection of the lixiviant into the ore body in a well field, the uranium-bearing solution (pregnant lixiviant) will be extracted from the subsurface by production wells. Upon recovery from the subsurface, the lixiviant will be pumped through a series of ion exchange columns (tanks containing ion exchange resin) located within the Moore Ranch facility CPP. The uranium will be stripped from the lixiviant by the resin, eluted (stripped) off the resin, precipitated from the eluate, dried, and packaged in other parts of the plant. Barren lixiviant will be reconstituted, as necessary, and reinjected into the ore body to continue the milling.

A small production bleed of approximately 1 percent will be diverted from the barren lixiviant stream before it is reinjected into the ore body. By withdrawing slightly more lixiviant from the ore body than is injected, an inward gradient can be maintained in each well field. This inward gradient helps prevent "excursions," which are the migration of uranium-bearing solution away from the injection wells. Uranium One proposes to install monitoring wells within the mineralized portion of the extraction zone (i.e., the production zone) and outside the production zone in a "ring" around the production area to monitor for any excursions. Monitor wells will also be installed in the overlying and underlying aquifers.

Operation of the Moore Ranch facility will result in the generation of "byproduct material", as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended, and as codified in 10 CFR 40.4. Both liquid and solid forms of byproduct material will be generated during operations. Liquid byproduct material generated from the production and restoration fluids during operations will be disposed through use of deep disposal wells, as authorized by the State of Wyoming Department of Environmental Quality (WDEQ). Solid byproduct material (e.g., spent ion exchange resin, pumps, pipes, and building materials used during operations that cannot be decontaminated) will be disposed of at a licensed mill tailings facility or other licensed facility not yet identified. The applicant will be required to have an agreement in place for the disposal of solid byproduct material prior to commencement of operations.

As discussed in Section 1.7 of the technical report, the Moore Ranch facility CPP will operate at a flow rate of 11,355 liters per minute (Lpm) (3,000 gallons per minute [gpm]). The CPP is initially designed to produce between 0.907 million and 1.36 million kilograms (kg) (2 million and 3 million pounds) of yellowcake per year, with the capacity expanded to 1.81 million kg (4 million pounds) as satellite operations are added. Following approval of the source material license, construction is proposed to begin in the fourth quarter of 2010, and restoration operations in the individual well fields are expected to continue for 10 years after the start of production in 2012. The applicant anticipates that the CPP will continue to process resin from other satellite operations after the decommissioning and reclamation of the Moore Ranch facility well fields are completed.

Once extraction is completed in a well field, decommissioning will begin, starting with ground water restoration. Restoration will consist of ground water treatment and stability monitoring. Surface reclamation activities will commence following regulatory approval of ground water restoration activities.

The applicant committed to having an approved financial assurance arrangement in-place prior to startup of operations. The financial assurance arrangement will be consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 9 and will include estimated costs for ground water restoration and decommissioning of surface features at the Moore Ranch facility.

1.4 Evaluation Findings

The staff reviewed the proposed activities at the Moore Ranch facility in accordance with review procedures in Section 1.3 of the standard review plan. Information contained in the Uranium One application described the proposed activities at the Moore Ranch facility, including: (1) the corporate entities involved, (2) the location of the facility, (3) land ownership, (4) ore-body locations, (5) the proposed recovery process, (6) operating plans and design throughput, (7) schedules for construction, startup, and duration of operations, (8) waste management and disposal plans, and (9) financial assurance.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 1.3 of the standard review plan and the requirements of 10 CFR 40.31.

1.5 References

Energy Metals Corporation (EMC), U.S., 2007a. "Application for USNRC Source Material License, Moore Ranch Uranium Project, Campbell County, Wyoming, Technical Report." Casper, Wyoming: Uranium One Americas Corporation. ADAMS Accession Nos. ML072851258, ML072851259, ML072851260, ML072851268, ML072851350, ML072900446. October 2, 2007.

EMC 2007b. "Application for USNRC Source Material License, Moore Ranch Uranium Project, Campbell County, Wyoming, Environmental Report." Casper, Wyoming: Uranium One Americas Corporation. ADAMS Accession Nos. ML072851222, ML072851239, ML072851249, ML072851254, ML072851255. October 2, 2007.

NRC, 2003. "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications - Final Report," NUREG-1569. Washington, DC: June 2003.

NRC, 2010. "Environmental Impact Statement for the Moore Ranch ISR Project in Campbell County, Wyoming; Supplement to the Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities," NUREG-1910, Supplement 1. Washington, DC: August 2010.

Uranium One, 2008a. Letter to NRC Regarding Additional Information Requested for the Moore Ranch In Situ Uranium Recovery Project License Application, First Set of Responses, July 11, 2008. ADAMS Accession No. ML082060527.

Uranium One, 2008b. Letter to NRC Regarding Additional Information Requested for the Moore Ranch In Situ Uranium Recovery Project License Application, Second Set of Responses, October 28, 2008. ADAMS Accession No. ML090400079.

Uranium One, 2009a. Letter to NRC Regarding Additional Information Requested for the Moore Ranch In Situ Uranium Recovery Project License Application, Safety Evaluation Report Open Issues, December 4, 2009. ADAMS Accession No. ML093440306.

Uranium One, 2009b. Letter to NRC Regarding Additional Information Requested for the Moore Ranch In Situ Uranium Recovery Project License Application, Safety Evaluation Report Open Issues, December 10, 2009. ADAMS Accession No. ML093570298.

Uranium One, 2010. Letter to NRC Regarding Additional Information Requested for the Moore Ranch In Situ Uranium Recovery Project License Application, Safety Evaluation Report Open Issues, January 18, 2010. ADAMS Accession No. ML100250919.

2. SITE CHARACTERIZATION

2.1 Site Location and Layout

2.1.1 Regulatory Requirements

The staff will determine if the applicant has adequately identified the site location in accordance with the requirements of 10 CFR 40.31(g)(2).

2.1.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 2.1.3 of the standard review plan.

2.1.3 Staff Review and Analysis

The proposed Moore Ranch facility is located in Campbell County, WY, approximately 80.45 kilometers (km) (50 miles [mi]) north-northeast of Casper, WY. The location of the proposed license area is comprised of either the following or portions of the following townships: Township 42 North, Range 75 West, Sections 25, 26, 27, 28, 33, 34, 35, 36; Township 41 North, Range 75 West, Sections 1, 2, 3, 4, 9 and 10, and Township 42 North, Range 74 West, Sections 30 and 31. The proposed licensed area is along and south of State Highway 387. The applicant stated that the coordinates of the general center of the project site are latitude 43°34'12.83" N and longitude 105°50'49.72" W.

Figure 2.1-2 of the technical report is a topographic map showing the proposed licensed area, including the CPP and well fields. Figure 2.1-3 of the technical report is a topographic map of the main processing area showing the location of buildings, fences, and roads. The total area within the proposed site boundary is approximately 2,873 hectares (7,100 acres), whereas the restricted area around the central plant is approximately 0.4 hectare (1 acre). The staff notes that the proposed site boundary is, in many locations, more than 1.61 km (1 mi) away from the CPP and the well fields. The applicant identified that the proposed license boundary is based on the boundaries of mineral leases that it holds. The applicant plans on conducting additional exploration, delineation, and characterization activities to evaluate the potential for developing these mineral leases. The staff notes that well fields other than those identified in the application are not included in this license.

The regional location, counties, site configuration, major drainages, nearby population centers, and transportation links are shown on an appropriately scaled map (Figure 2.1-1 of the technical report). Proposed principal site facilities, structures, restricted areas, well fields, and natural site topography are provided in other maps. Proposed license exclusion area boundaries and property ownership, including surface and mineral ownership, are also provided in Figures 1.4-1 and 1.4-2 of the technical report. Supporting data sources are appropriately referenced by the applicant.

2.1.4 Evaluation Findings

The staff has reviewed the site location and layout of the Moore Ranch facility in accordance with Section 2.1.3 of the standard review plan. The applicant has described the site location and layout with appropriately scaled and labeled maps showing the site layout, principal facilities and structures, boundaries, and topography. Based upon the review conducted by staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 2.1.3 of the standard review plan and the requirements of 10 CFR 40.31(g)(2).

2.2 Meteorology

This section discusses the meteorological conditions of the region surrounding and including the Moore Ranch facility. Meteorological data is used for the selection of environmental monitoring locations, the assessment of the impact of operations on the environment, and the performance of radiological dose assessments.

2.2.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the meteorology program – which is part of the site monitoring programs required by Criterion 7 of Appendix A to 10 CFR Part 40 – is sufficiently complete to allow for estimating doses to workers and members of the public.

2.2.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7 using the acceptance criteria presented in Section 2.5.3 of the standard review plan.

2.2.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the meteorological conditions at the Moore Ranch facility. The aspects reviewed in the following sections include: general site conditions, meteorological data acquisition, wind, and atmospheric dispersion.

2.2.3.1 General Site Conditions

The Moore Ranch facility is situated in an area considered semiarid and characterized by cold, harsh winters and hot, dry summers. Temperature extremes range from -31.7 degrees Celsius (-25 degrees Fahrenheit) in the winter to 37.8 degrees Celsius (100 degrees Fahrenheit) in the summer with an average annual precipitation of 25.4 centimeters (cm) (10 inches [in]).

2.2.3.2 Meteorological Data Acquisition

The applicant did not collect or use onsite meteorological data. In lieu of having a meteorological station onsite, the applicant proposed utilizing nearby meteorological stations. Meteorological stations were identified at 10 sites around the Moore Ranch facility, and they are depicted in Figure 2.5-1 of the technical report. Meteorological data from the Antelope Coal Mine Meteorological Station (ACC) and the Glenrock Coal Company (GCC) site was used for the Moore Ranch facility meteorological analysis. The ACC site is approximately 40.2 km (25 mi) east from the Moore Ranch facility and the GCC site is approximately 56.3 km (35 mi) south.

The applicant stated that the ACC meteorology most nearly represents the meteorology of the Moore Ranch facility and, therefore, proposed using it as the primary source of meteorological data. Arguments that the ACC station is representative of the Moore Ranch facility are as follows:

- ACC station lies closest to the Moore Ranch facility.
- Given the north-to-south trend in wind directions in the PRB, the similar latitudes of the ACC station and the Moore Ranch facility should account for this trend.
- The topography at the ACC station is very similar to the topography at the Moore Ranch facility.

To support its conclusion, the applicant provided additional meteorological data from five coal mine meteorological stations, as well as from ACC. Cumulative wind roses and meteorological data summaries for each coal mine meteorological station were provided as well. Table 2.2-2 shows the meteorological data summary for each coal mine.

Table 2.2-2 Meteorological Data Summary

Coal Mine Site	Monitoring Period	Predominant Wind Direction	Percent of Predominant Wind
Cordero Rojo	1/1/1987–10/19/2009	south-southeast	12.5%
Black Thunder	1/1/1995–10/2/2009	northwest	12.5%
Jacobs Ranch	1/1/1996–12/21/2009	northwest	11.3%
North Rochelle	1/1/2000–10/6/2009	northwest	10.4%
ACC	1/1/1997–12/31/2006	west	15.2%
GCC	1/1/1997–12/31/2006	west-southwest	20.0%

The Cordero Rojo Coal Mine Meteorological Station is the furthest north and each subsequent coal mine meteorological station descends south with the GCC being the furthest south.

Considering the variation of the predominant wind direction and the variation of the percent of predominant wind direction with respect to the other coal mine meteorological stations, the staff does not concur with the conclusion that the ACC meteorological data would be representative of the meteorological data at the Moore Ranch facility and the requirements in 10 CFR Part 40, Appendix A Criterion 7 are not met. As stated earlier in this section, the distance between the ACC meteorological station and the Moore Ranch facility is approximately 40.2 km (25 mi). Data provided by the applicant suggests that the predominant wind direction can differ with distance and latitude. Although the applicant compared physical features of the ACC site to the Moore Ranch facility, it is not clear what quantitative or qualitative criteria the applicant used to conclude that the ACC site can be used to represent the Moore Ranch facility. Without an explanation of the criteria used by the applicant for comparison, the staff cannot determine if the meteorological data from ACC are representative of the Moore Ranch facility. Therefore, the staff has determined that the applicant did not provide sufficient data to conclude that the ACC meteorological station is representative of the Moore Ranch facility. A license condition is necessary to ensure that adequate meteorological data is collected. This license condition can be found in Section 2.2.4 of this SER.

2.2.3.3 Wind

Although the staff determined that the use of ACC and GCC data would not meet the requirements for use at the Moore Ranch facility, the staff reviewed all meteorological data presented in the application in order to assess the adequacy of the methodology used to collect the data. The following documents the staff's review of wind data. Regulatory Guide 3.63 (NRC, 1988), states that for atmospheric dispersion assessments wind speed and wind direction should be monitored at approximately 10 m (32.8 ft) above ground level. The staff notes that the applicant used wind speed and wind direction obtained at a height of 10 m (32.8 ft) above the surface of the terrain. A description of the meteorological instruments is provided in Table 2.2b-1 of the technical report. The staff finds that the orientation and instruments used for meteorological data are consistent with Regulatory Guide 3.63.

Regulatory Guide 3.63 recommends an annual data recovery of at least 90 percent for each individual parameter measured, including wind direction and wind speed. Wind speed and wind direction data were collected from January 1, 1997, to December 31, 2006. The three highest predominate wind speed data by sector for the ACC site were 25.4 kilometers per hour (kph) (15.79 miles per hour [mph]) west-southwest, 23.3 kph (14.49 mph) north-northwest, and 21.3 kph (13.26 mph) north. The annual average wind speed for all sectors was 18 kph (11.2 mph). Table 2.5-9 of the technical report reported wind speed recovery as 93.49 percent and wind direction recovery as 93.5 percent. The staff has determined that the wind speed and wind direction recovery data for the ACC site were equal to or greater than 90 percent as recommended in Regulatory Guide 3.63.

The applicant provided seasonal wind roses from 1997 to 2006. The applicant also provided a wind data summary from 1997 to 2006, including a 10-year annual wind rose for the ACC station. The time period ranged from January 1, 1997, to December 31, 2006. The most predominant annual wind direction was from the west. The staff has determined that the approach used in determining the 10-year annual wind rose for the ACC site is consistent with Regulatory Guide 3.63.

2.2.3.4 Atmospheric Dispersion

Mixing height is the height at which air near the Earth's surface is well mixed due to turbulence caused by the interaction between the surface and the atmosphere. Mixing height, also known as inversion, is a data parameter used in atmospheric dispersion models to calculate the concentration of a contaminant and the radiation dose at a receptor point at a certain distance from the facility. The applicant stated that the WDEQ Air Quality Division (AQD) mixing heights will be used for all dispersion modeling. WDEQ-AQD has provided statewide mixing heights to be used in dispersion modeling with the Industrial Source Complex model. Table 2.2-1 lists the assigned annual average mixing heights according to stability class.

Table 2.2-1 Assigned Average Mixing Heights

Stability Class	Average Mixing Height
Class A	3,450 m (11,319 ft)
Class B	2,300 m (7,546 ft)
Class C	2,300 m (7,546 ft)
Class D	2,300 m (7,546 ft)
Class E	10,000 m (32,808 ft)
Class F	10,000 m (32,808 ft)

Joint frequency distributions show how frequently each stability class occurs over a given time period. Joint frequency distributions are developed from wind speed and wind direction. Stability class determines the extent to which a released contaminant will disperse in the atmosphere, and it is used to determine the concentration of the contaminant at a receptor point at a certain distance from the site. Stability class can vary from extremely unstable to extremely stable, and can be determined by temperature differences between two heights or the fluctuation of horizontal wind direction at a given height. The applicant has stated that the Pasquill stability classes were determined from the standard deviation of horizontal wind direction (sigma theta method) and used data from the ACC and GCC sites between January 1, 1997, and December 31, 2006. Because stability classes are based on ACC and GCC data, the applicant will need to recalculate these classes using site-specific data once it is collected per the license condition in Section 2.2.4 of this SER.

2.2.4 Evaluation Findings

The staff reviewed the proposed monitoring of meteorological conditions at the Moore Ranch facility in accordance with Section 2.5.3 of the standard review plan. The applicant used data from various NWS meteorological stations to represent conditions at the Moore Ranch facility; however, such representativeness has not been demonstrated. Because the applicant has not provided representative meteorological data in the application, the staff is imposing the following license condition to ensure that representative data are collected prior to commencement of operations:

> The licensee shall install a meteorological station within the license area and collect meteorological data for a period of one year, or until the data collected is determined to be representative of long term conditions, at a data recovery rate of 90 percent. The data collected shall include, at a minimum, temperature, precipitation, wind speed, wind direction, and an annual wind rose. The submittal shall include a summary of the stability classification.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by information to be collected in accordance with the noted license condition, meets the applicable acceptance criteria of Section 2.5.3 of the standard review plan and the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.2.5 Reference

NRC, 1988. "Onsite Meteorological Measurement Program for Uranium Recovery Facilities - Data Acquisition and Reporting," Regulatory Guide 3.63. Washington, DC. March 1988.

2.3 Geology and Seismology

2.3.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the characterization of geology and seismology at the Moore Ranch facility is sufficient to document the applicant's ability to maintain control over production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c).

2.3.2 Regulatory Acceptance Criteria

The application was reviewed using the acceptance criteria presented in Section 2.6.3 of the standard review plan.

2.3.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the geology and seismology of the Moore Ranch facility. The aspects reviewed in the following sections include: regional geology, site geology, soils, and seismology.

2.3.3.1 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 license 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, and 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.

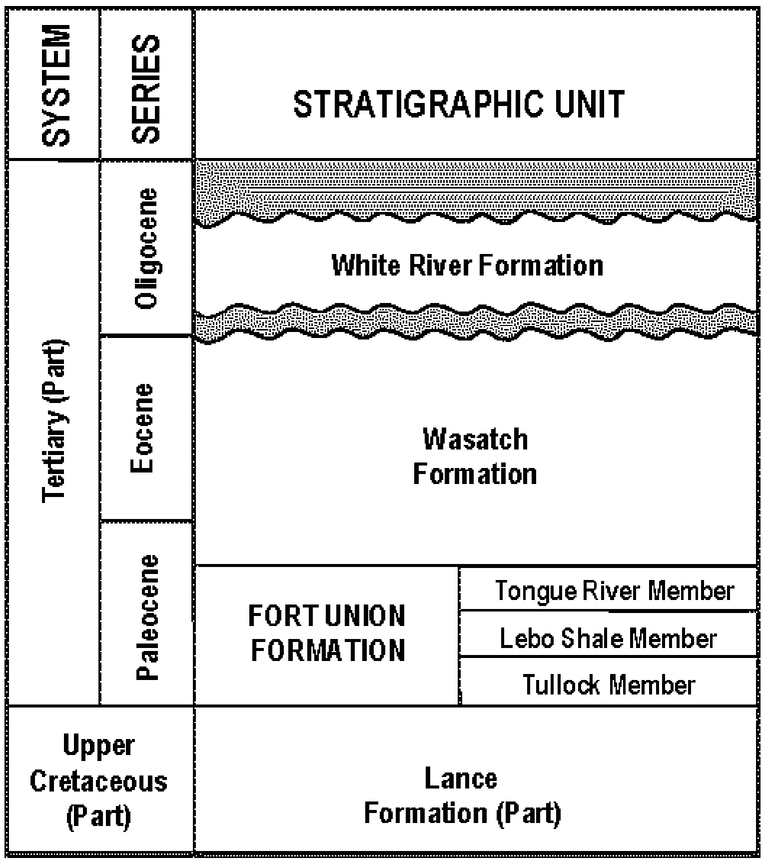

Figure 2.3-1 PRB regional stratigraphy (Source: Department of Energy/National Energy Technology Laboratory (DOE)/(NETL)-2003/1184, "Powder River Basin Coalbed Methane Development and Produced Water Management Study," November 2002)

2.3.3.2 Site Geology

At the Moore Ranch facility, the Wasatch formation is the surficial geological unit. In the proposed license area, the applicant reported that the Wasatch is composed of interbedded sandstones, siltstones, claystones, and coals as shown in Figure 2.3-2. Fine-grained layers range from highly consolidated, medium gray siltstones to dark grey carbonaceous claystone. 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 was described in or near the license area.

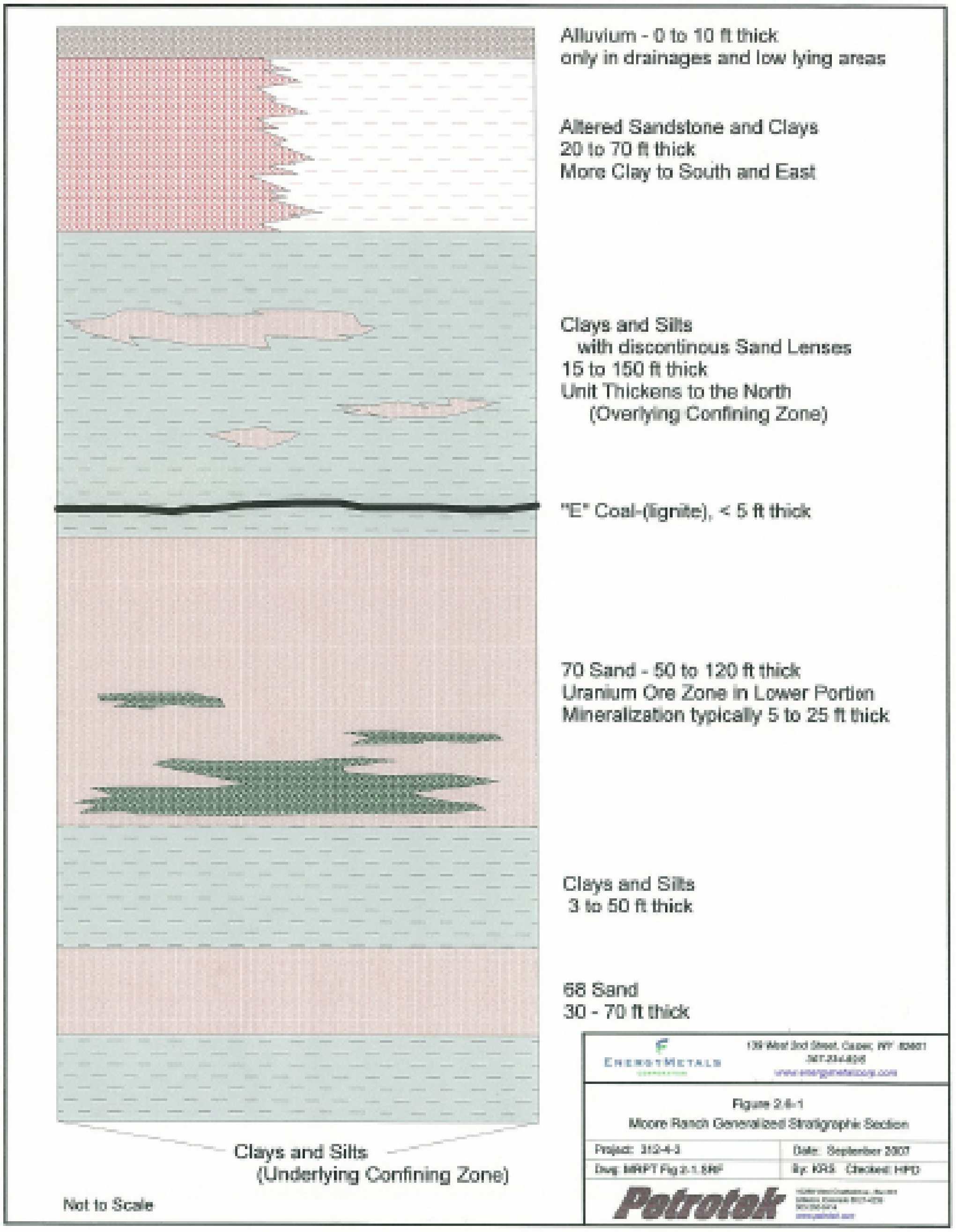

Figure 2.3-2 Moore Ranch license area stratigraphy (adapted from Figure 2-1 of the technical report)

The applicant 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. Mineralogy of the ore-bearing unit is an arkosic sandstone (sandstone containing at least 25 percent feldspar) 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.

The applicant stated that the original subsurface exploration of the proposed license area was conducted by Conoco Inc. (Conoco). This subsurface investigation involved drilling and wireline logging thousands of well borings in and around the proposed license area in the 1970s and 1980s. Hundreds of additional well borings were drilled and logged by the applicant in late 2006 and early 2008. Drill holes completed by Conoco were reportedly abandoned in accordance with Wyoming statutes in effect at the time. The applicant abandoned all recent drill holes in accordance with Wyoming Statute 35-11-401 (State of Wyoming, 1977). Maps of locations and tables of descriptions of all known drill holes in the license area were provided in the application.

The applicant provided geological cross-sections showing the stratigraphy and isopach maps showing the thickness of each layer in the license area. These maps were developed from historical Conoco and recent 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 license 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 license 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 the applicant for the proposed Moore Ranch facility 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 staff across the license area and for each of the proposed well fields using the cross-sections, well boring logs, and isopachs.

The applicant provided four cross-sections, A-A’, D-D’, H-H’, and K-K’, which show the stratigraphy across the entire proposed Moore Ranch facility license area. These cross-sections indicate that the stratigraphy is more or less continuous across the proposed license area. Approximately 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.

The applicant 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	The68 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 Section	**Description**
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 described as a 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)

Table 2.3-2 Geological Characterization of the Moore Ranch Well Field 2	
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), the shale is essentially missing in all of the seven boring numbers from 4018 to 649, a distance of approximately 396.24 m (1,300 ft). The applicant 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 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 the applicant include the deep coal layer, which is the CBM production zone under the proposed Moore Ranch facility 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 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 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 3.1.3.3.5 of this SER.

2.3.3.3 Soils

The applicant 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 facility 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 because of high levels of selenium and poor soil texture. Most soils exhibited a slight water erosion hazard and moderate wind erosion hazard. Based on the discussion provided above, the staff finds that the soils in the proposed license area were adequately described.

2.3.3.4 Seismology

The applicant 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 facility 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 facility area would be in the range of intensity of Levels V–VII. According to Table 2.68, this would cause light to moderate damage in the proposed license area.

2.3.4 Evaluation Findings

The staff has completed its review of the site characterization information addressing geology and seismology at the Moore Ranch facility in accordance with Section 2.6.3 of the standard review plan. The applicant has adequately 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 upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 2.6.3 of the standard review plan and 10 CFR 40.41(c).

2.3.5 References

State of Wyoming, 1977. *Wyoming Environmental Quality Act*, Wyoming Statute 35-11-401, as amended.

United States Department of Energy, 2002. DOE/NETL-2003/1184, “Powder River Basin Coalbed Methane Development and Produced Water Management Study,” November 2002.

2.4 Hydrology

2.4.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the characterization of surface and ground water hydrology at the Moore Ranch facility is sufficient to document the applicant’s ability to maintain control over production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.4.2 Regulatory Acceptance Criteria

The application was reviewed for consistency with the applicable requirements of 10 CFR 40.41(c), using the acceptance criteria presented in Section 2.7.3 of the standard review plan.

2.4.3 Staff Review and Analysis

The following sections present the staff’s review and analysis of various aspects of the surface water and ground water hydrology at the Moore Ranch facility.

2.4.3.1 Surface Water

The applicant described the surface water hydrology for the proposed facility. The entire Moore Ranch facility 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 immediately 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 dry by the end of the summer. Based on the discussion provided above and a site tour conducted in the fall of 2008 the staff finds the surface water drainages to be adequately described.

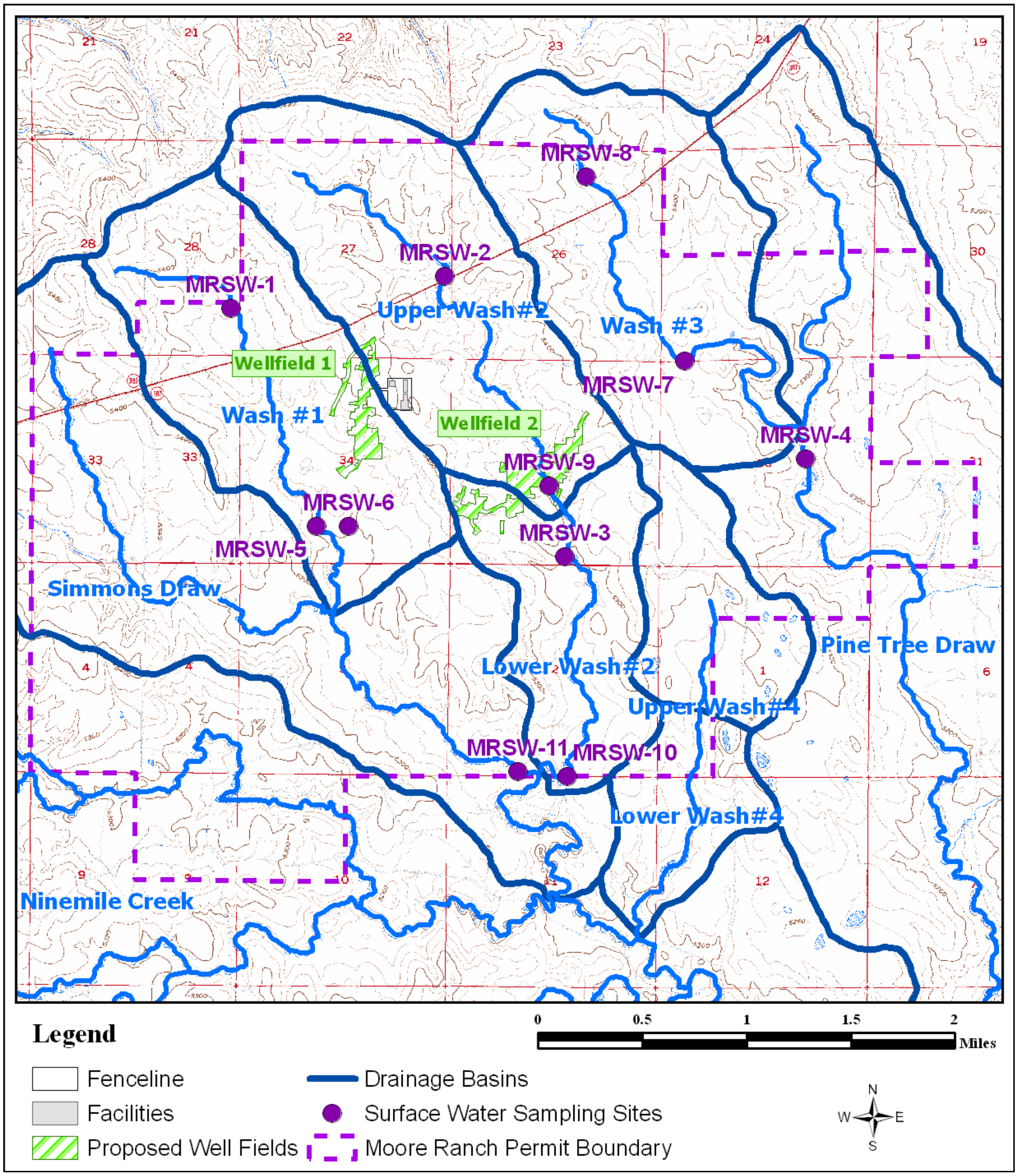

Figure 2.4-1 Moore Ranch license area Nine Mile Creek drainages (adapted from Figure 2.7-1 of the technical report)

The applicant 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. Peak floods were estimated using 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.

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, the applicant 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. The applicant 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 applicant 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, the applicant 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. The applicant 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.

To prevent erosion for all drainages, the applicant 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 applicant 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. The applicant 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. 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 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 facility 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 drainages 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)

The applicant 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 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 facility 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, the applicant showed that CBM-produced water discharge rates are significantly declining in the license area. The applicant 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. The applicant 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 the applicant that they are not likely to renew the permits in 2014.

2.4.3.2 Ground Water

2.4.3.2.1 Regional and Site Hydrogeology

Regionally, ground water flows northward through the Wasatch, Fort Union, and 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.

2.4.3.2.1.1 72 Sand

The applicant stated that within the Moore Ranch facility 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 (NRC, 1982). This aquifer was therefore present before CBM activity in the area began and is not an artifact of CBM water infiltration. The applicant 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.

The applicant 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). The applicant 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. The applicant 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. The applicant estimated the average hydraulic gradient in 72 sand was 0.0039 m/m (or ft/ft) with flow to the north.

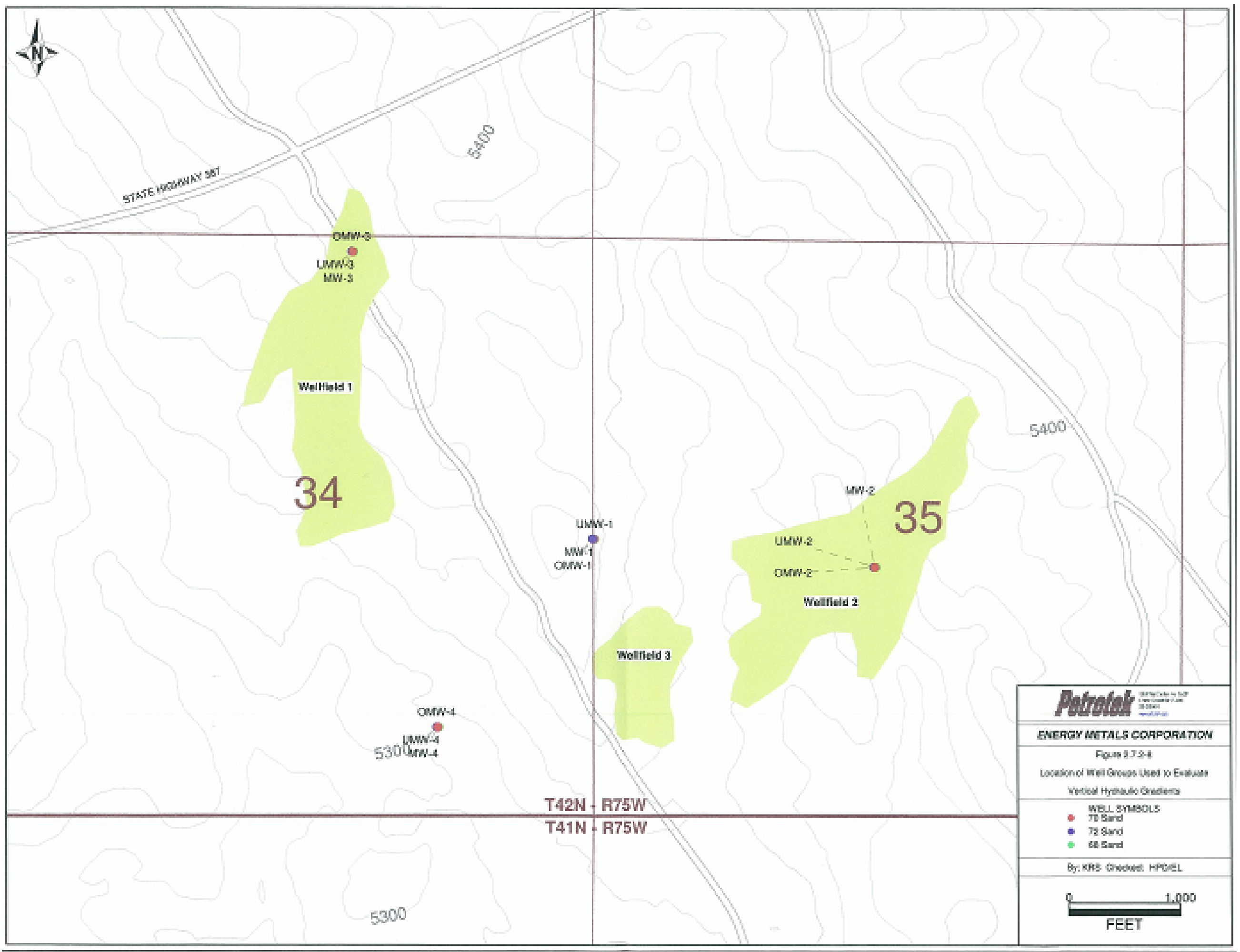

Figure 2.4-3 Location of Moore Ranch Monitoring Well Groups 1, 2, 3, and 4 (Figure 2.7.2-8 of the technical report)

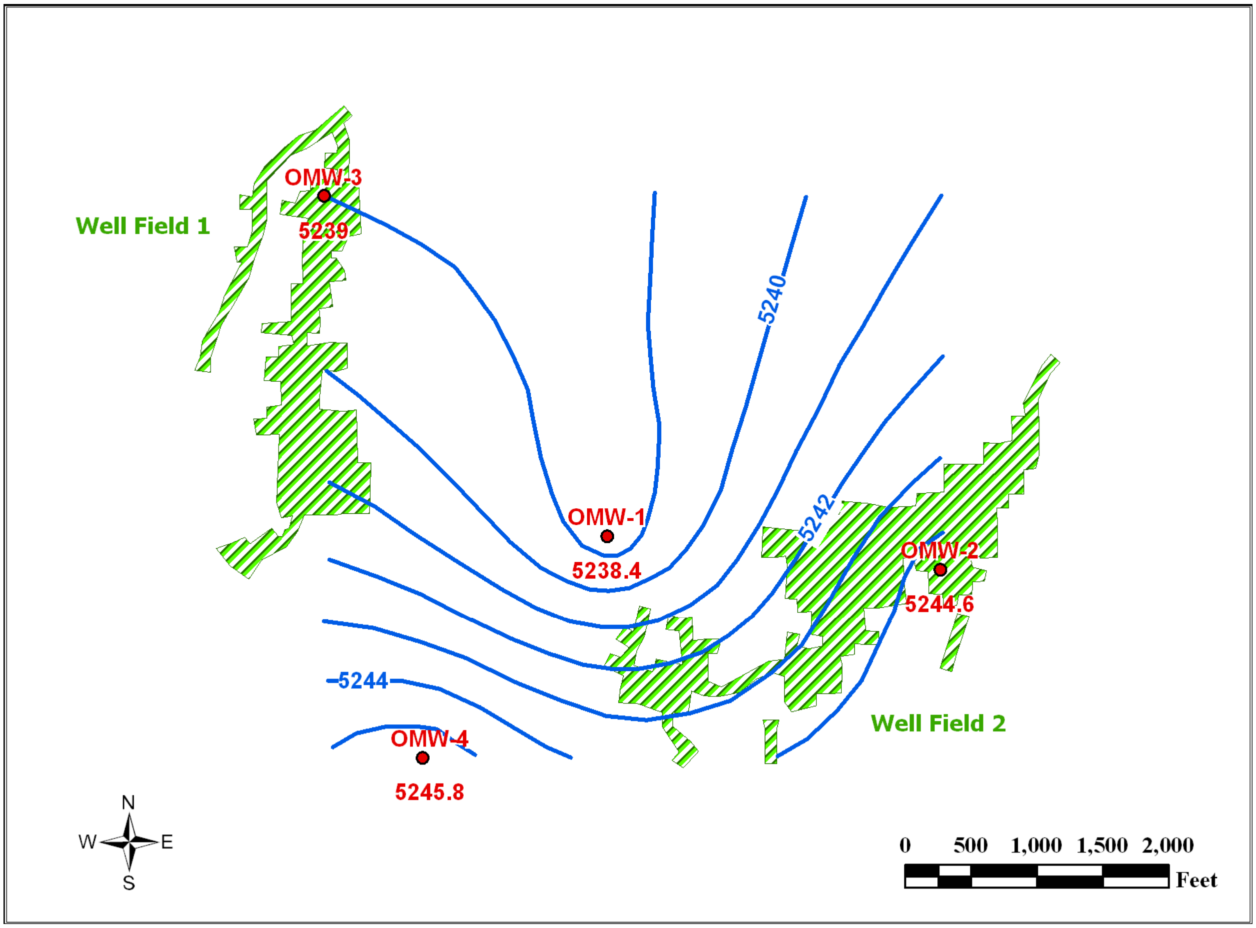

Figure 2.4-4 72 sand potentiometric surface, March 2008 (adapted from Figure 2.7-2-6f of the technical report)

2.4.3.2.1.2 70 Sand

The applicant reported that the next aquifer is the 70 sand, which is the extraction zone in the Moore Ranch facility license area. It is located at 30.48 to 100.58 m (100 to 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. The applicant 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.

The applicant 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. The applicant 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 the applicant 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 and the horizontal hydraulic gradient was estimated by the applicant to be 0.004 m/m (or ft/ft).

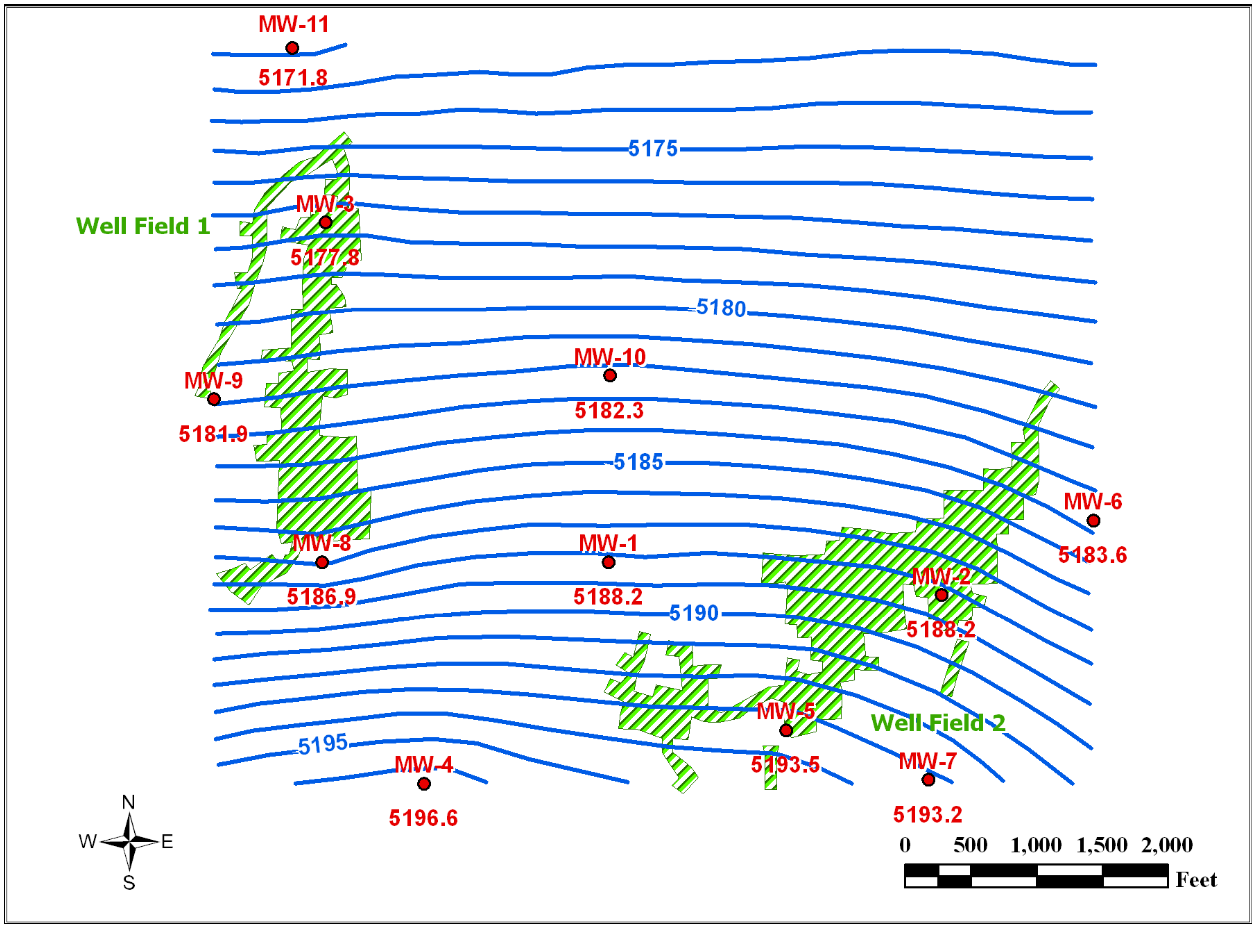

Figure 2.4-5 70 sand potentiometric surface, March 2008 (adapted from Figure 2.7-2-5e of the technical report)

A comparison of water levels in the 70 sand and 72 sand 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, the applicant 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 unconfined (unsaturated) aquifer. In regions where the 70 sand is unsaturated, the applicant concluded that no physical hydrologic connection exists between the 70 sand aquifer and the perched aquifer in the overlying 72 sand.

2.4.3.2.1.3 68 Sand

The underlying aquifer to the 70 sand extraction zone is the 68 sand. The applicant 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. The applicant 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. The applicant conducted a 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.

The applicant 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. No pumping well activity that could have been the cause was discovered. 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 the applicant 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 the applicant to conclude the transmissivity in UMW-3 is low due to well completion damage or natural causes. The applicant stated it will continue to monitor this well closely.

Potentiometric contours for the 68 sand aquifer for February 2007, June 2007, July 2007, February 2008, and March 2008 as presented in Figure 2.7.2-7a through Figure 2.7.2-7e of the technical report. 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.

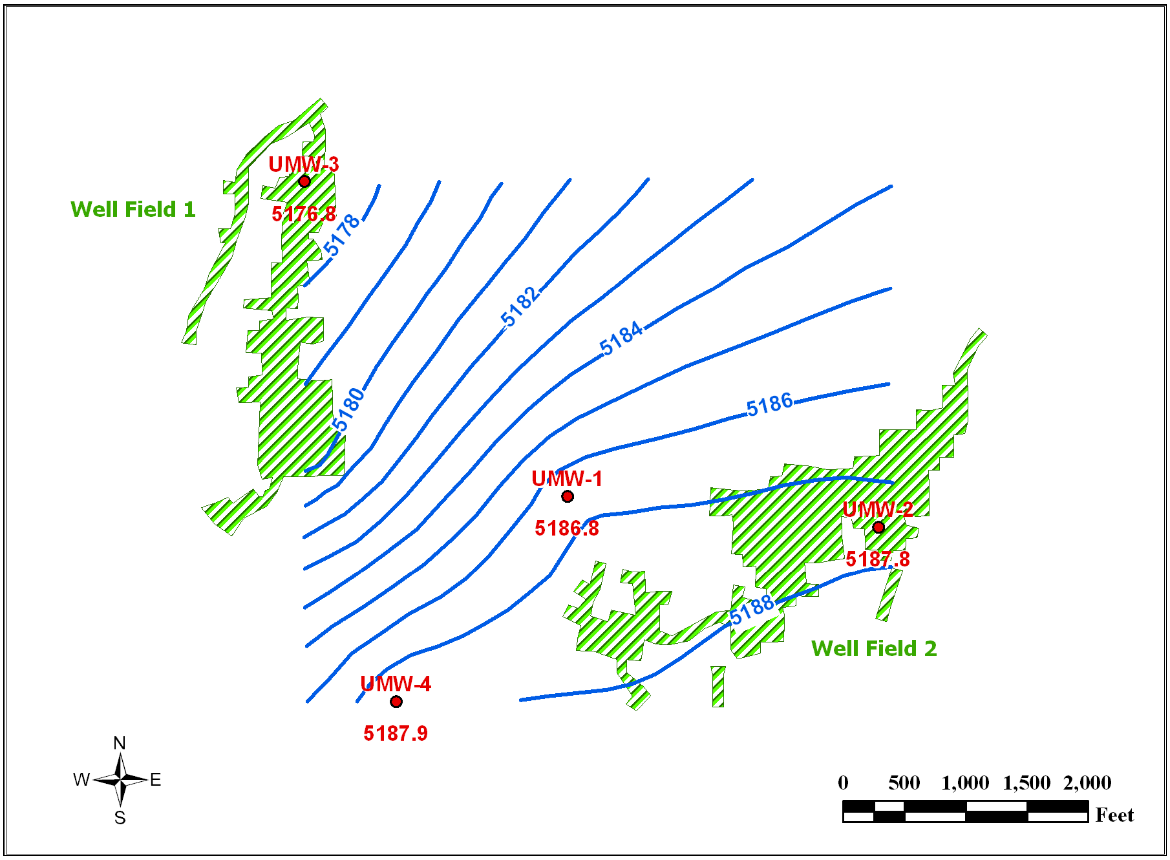

Figure 2.4-6 68 sand potentiometric surface, March 2008 (adapted from Figure 2.7-2-7e of the technical report)

2.4.3.2.1.4 60 Sand

The applicant 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 applicant considers the 60 sand to be the underlying aquifer.

The applicant 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).

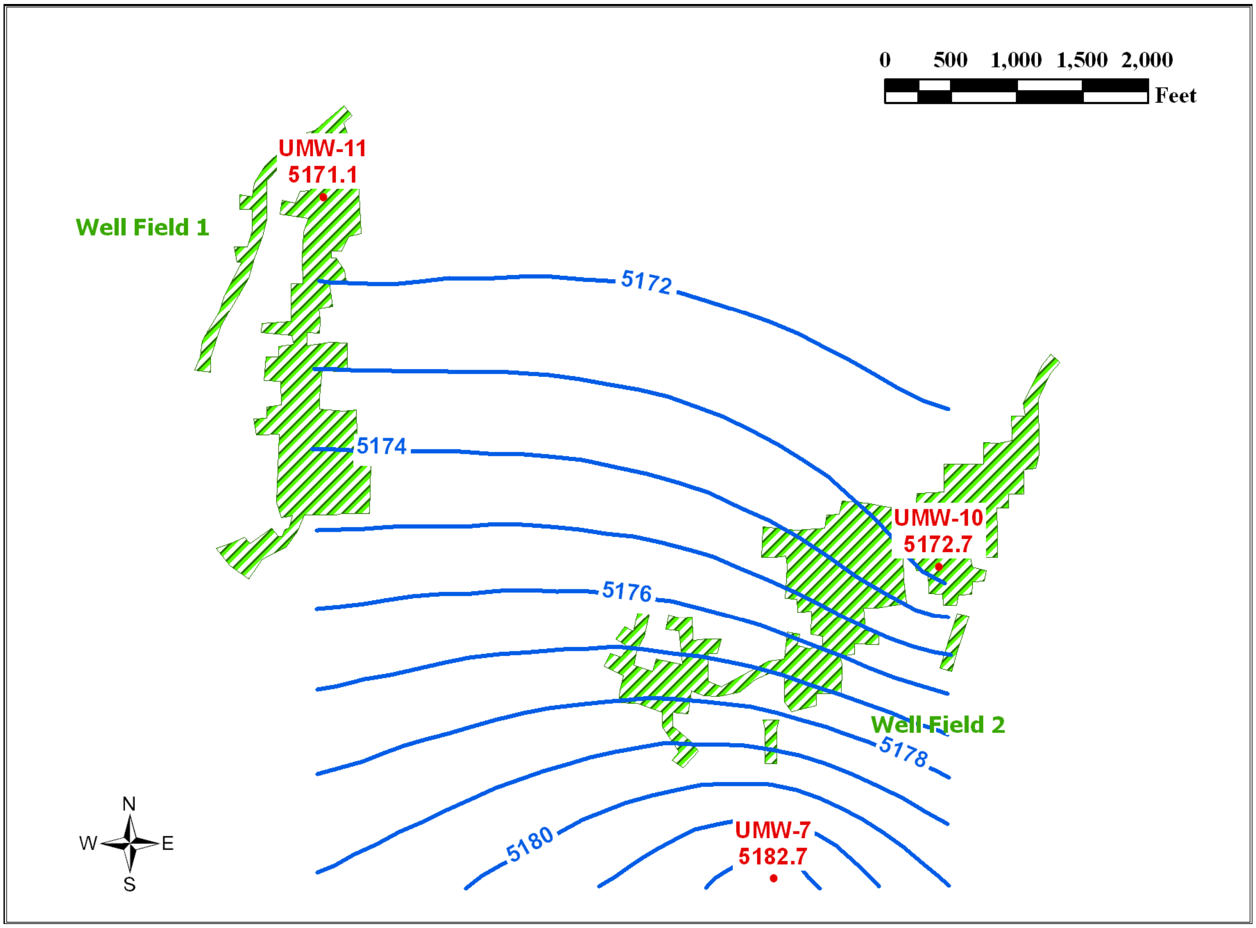

Figure 2.4-7 60 sand potentiometric surface, August 2009 (adapted from Figure 2.7-2-8 of the technical report)

2.4.3.2.1.5 40 and 50 Sands

The applicant 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. 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 staff finds that the 40 and 50 sands are adequately described given their separation from the extraction zone and underlying aquifers.

2.4.3.2.1.6 Vertical Hydraulic Gradients

The applicant 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 staff calculated the average vertical gradient across the confining layers using the values provided by the applicant, which are shown in Table 2.4-2.

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 the applicant has already established, the 72 sand is a perched aquifer, and the 70 sand is an unconfined (unsaturated) aquifer over the majority of the license area. The staff finds that the lack of saturation in the 70 sand alone establishes that minimal hydrologic connection exists between the 72 sand and the 70 sand.

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. The applicant 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. The applicant 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 staff, therefore, did not calculate an average gradient as an assumption of steady-state conditions could not be made. 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
	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

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						0.52
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.

The applicant 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 3.2 km (2 mi) buffer for the proposed Moore Ranch facility 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 may be used for uranium exploration drilling. The well is located approximately 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 3.2 km (2 mi) 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 4.8 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 facility application indicated there is no current use of these wells for domestic purposes.

2.4.3.2.2 Pumping Tests

The applicant presented 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 staff 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, the applicant 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 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.

The applicant 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. 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 unconfined (unsaturated) aquifer in both well fields. The applicant was not able to retrieve the raw data to recalculate the values with the appropriate unconfined (unsaturated) aquifer method; therefore, it excluded these tests from the determination of hydraulic parameters. As these test results could not be reevaluated and the applicant has committed to conduct more testing, the 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	NR	Not applicable	1807 (68 sand)

Table 2.4-3 Conoco Pumping Test Results, 1977–1980 (Summarized from the technical report)							
				[2.5]			
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 the applicant 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. The applicant 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 unconfined (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) [ft]	Extraction zone Well Response	Overlying/ Underlying Well Response
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 unconfined (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 the applicant concluded this response was unrelated to the pumping test. Another pumping test at MW-3 has not been conducted to verify this conclusion. The applicant has stated it will conduct future well field hydrologic testing to resolve these issues. The staff will review the results of this testing in the hydrologic data package that the applicant will submit to the NRC.

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

The applicant 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 unconfined (unsaturated) aquifer and the impact of barometric pressure variation on the water levels during the tests. The applicant 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, the applicant conducted an additional well pumping test in Well Field 2 known as the five-spot hydrologic test. This test was conducted to assess the aquifer characteristics of the 70 sand and to evaluate the hydraulics of the unconfined (unsaturated) aquifer in the 70 sand. The test included a step rate test to determine withdrawal rates that would stress but not dewater the unconfined (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 proposed pattern for the ISR operations. 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 unconfined (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 unconfined (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.

The applicant 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 unconfined (unsaturated) aquifer without dewatering it. A long-term extraction test was then conducted 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). 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 unconfined (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. Based on the information provided by the applicant and the staff’s independent analysis, the staff finds that this pumping test provides a reasonable estimate of the hydraulic parameters in the 70 sand in this location.

The applicant 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 unconfined (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 staff finds that the extraction/injection test showed that an unconfined (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 unconfined (unsaturated) aquifer can sustain recovery and injection rates that are anticipated during production at the Moore Ranch facility.

In 2009, the applicant 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 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 the Moore Ranch facility are not currently available for the 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 2.5.3.2, 3.1.3.3.2, 3.1.3.3.3, 3.1.3.3.4, 3.1.3.3.5, 5.7.9.3.2, 5.7.9.3.5, and 6.1.3.2 of this SER, by license condition the staff will require that the applicant submit these well field packages for review for Well Field 1 and for review and approval for Well Field 2. This condition is presented in Section 2.4.4 of this SER.

The staff notes that the hydrologic test package for Well Field 1 should include, at a minimum, the following information:

- The location, depth, screen interval, targeted aquifer, and completion report for all injection, production, and monitoring wells in Well Field 1.
- Pumping tests in the 70 sand to demonstrate the connection across the 70 sand aquifer and with the monitoring well ring. The package should include all data, analysis, and results for these pumping tests.
- The baseline ground water quality measurements for all wells in the 68, 70, and 72 sand aquifers.
- The UCLs for all monitoring wells in the 68, 70, and 72 sand aquifers in Well Field 1.
- The RTVs for the 70 sand aquifer in Well Field 1.

For Well Field 2, the hydrologic test package will be reviewed and approved by the NRC. The reason for the NRC approval of this well field relates to the more complex geology that exists where the 70 sand aquifer coalesces with the 68 sand. For Well Field 2, the hydrologic test data package should include, at a minimum, the following information:

- The location, depth, screen interval, targeted aquifer, and completion report for all injection, production, and monitoring wells in Well Field 2.
- A long term pumping test (greater than 3 days) in the 70 sand aquifer in the region where it coalesces with the 68 sand. Observation wells must be appropriately located in both the 70 sand, 68 sand, and 60 sand aquifers for this test. The package should include all data, analysis, and results for these pumping tests.
- Pumping tests in the 70 sand to demonstrate the connection across the 70 sand aquifer and with the monitoring well ring. The package should include all data, analysis, and results for these pumping tests.
- The baseline ground water quality measurements for all wells in the 60, 68, 70, and 72 sand aquifers.
- The UCLs for all monitoring wells in the 60, 68, 70, and 72 sand aquifers in Well Field 2.
- The RTVs for the 70 sand aquifer and the 68 sand aquifer in Well Field 2.

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)

2.4.4 Evaluation Findings

The staff reviewed the hydrologic site characterization information for the proposed Moore Ranch facility in accordance with Section 2.7.3 of the standard review plan. The applicant has 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 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.

However, the applicant has not provided sufficient pumping test data for the staff to draw conclusions regarding adequate communication within, and confinement of the 70 sand aquifer from surrounding aquifers. Because the applicant has not provided this information in the application, the staff is imposing the following license condition to ensure that representative data are collected prior to operation of Well Fields 1 and 2:

Well Field Packages. 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. Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information to be collected in accordance with the noted license condition, meet the applicable acceptance criteria of Section 2.7.3 of the standard review plan and the requirements of 10 CFR 40.41(c).

2.4.5 References

Craig, G.S., and J.G. Rankl, 1978. "Analysis of Runoff from Small Drainage Basins in Wyoming," Water Supply Paper 2056. U.S. Geological Survey.

NRC, 1982. "Draft Environmental Statement Related to the Operation of Sand Rock Mill Project (Draft Report for Comment)," NUREG-0889. Washington, DC: March 1982.

Wyoming Department of Environmental Quality, Land Quality Division, "Non Coal Mine Environmental Protection Performance Standards," Chapter 3. April 2006.

2.5 Background Surface Water and Ground Water Quality

2.5.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the characterization of surface and ground water quality at the Moore Ranch facility has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40, Appendix A Criterion 7 using the acceptance criteria presented in Section 2.7.3 of the standard review plan.

2.5.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the surface water and ground water quality the Moore Ranch facility.

2.5.3.1 Surface Water

The applicant provided background surface water quality data within the Moore Ranch facility proposed license area. It reported that surface water samples were collected during late fall 2006, early spring 2007, and early summer 2007 from nine sampling locations, MRSW-1 through MSRW-9, shown in Figure 2.4-1. The applicant reported that two sampling locations, MSRW-10 and MSRW-11, did not contain any water available to sample. All of the sampling points were located at drainages and existing ponds within and near the well fields, and samples were analyzed for all the analytes listed in Table 2.7.3-1 of NUREG-1569.

The applicant provided the surface water quality results for all nine sampling locations in Table 2.7.3-1 through Table 2.7.3-9 of the technical report. Table 2.5-1 shows the seasonal averages calculated by the applicant for all analytes. The numbers in bold in the table indicate where a U.S. Environmental Protection Agency (EPA) drinking water standard or WDEQ Class of Use standard (WDEQ, 2005) was exceeded. Average water quality of all samples exceeded EPA secondary drinking water and Class I (domestic use), Class II (agricultural use), and Class III (livestock use) standards for pH. The EPA secondary drinking water and the Class I standard for total dissolved solids (TDS) were exceeded in the fall and summer samples. The EPA secondary drinking water and the Class I standard for iron were exceeded in the fall sample.

The applicant noted that the surface water quality samples exhibited the characteristics of CBM-produced water discharge in the summer and the fall. In particular, Table 2.5-1 shows that significantly higher values of bicarbonate, carbonate, chloride, conductivity, TDS, sulfate, gross alpha, gross beta, nitrogen, magnesium, iron, and sodium were present in the fall samples when the surface water was mainly composed of CBM discharge because of the lack of precipitation. Table 2.5-1 shows that values for these parameters were lower in the spring and summer samples, which was attributed to dilution from snow melts and heavy precipitation events. The applicant concluded that the seasonal variability of surface water quality during the baseline characterization was largely due to the influence from Devon Energy's CBM-produced water outfalls. It stated that the lack of water at MRSW-10 and MRSW-11 indicates that Bill Barrett Corporation's CBM-produced water infiltrates into the shallow alluvial ground water and does not contribute to surface water quality variation. The staff agrees that the background surface water quality is affected by CBM-produced water discharge. The implications of this impact on operational water quality monitoring are discussed in Section 5.7.9 of this SER.

Table 2.5-1 Average Seasonal Surface Water Quality in the Moore Ranch License Area (Adapted from Table 2.7.3-10 of the technical report)			
Parameter	**Season**		
	Fall 2006	**Spring 2007**	**Summer 2007**
Bicarbonates as HCO_3 (mg/L)	787	459	374
Carbonates as CO_3 (mg/L)	277	23	32
Chloride (mg/L)	12.7	3.6	2.8
Conductivity (umhos/cm)	1827	845	819
Fluoride (mg/L)	0.9	0.5	0.4
pH (s.u.)	8.92	9.04	9.23
TDS (mg/L)	1169	478	538
Sulfate (mg/L)	108	57	90
Gross Alpha (pCi/L)	7.0	2.6	*NR
Gross Beta(pCi/L)	18.3	8.7	*NR
Lead-210 (pCi/L)	2.5	2.0	1.0
Polonium-210(pCi/L)	<1.0	<1.0	<1.0
Radium-226 (pCi/L)	<0.2	0.4	0.6
Radium-228 (pCi/L)	<1.0	<1.0	1.9
Thorium-230 (pCi/L)	<0.2	<0.2	<0.2
Nitrogen, Ammonia as N (mg/L)	0.31	0.10	0.10
Nitrogen, Nitrate + Nitrite as N (mg/L)	0.3	<0.1	<0.1
Aluminum (mg/L)		0.1	0.4
Arsenic (mg/L)	0.007	0.003	0.004
Barium (mg/L)	0.5	0.3	0.2
Boron (mg/L)	0.1	<0.1	<0.1
Cadmium (mg/L)	<0.005	<0.005	<0.005
Calcium (mg/L)	24	27	20
Chromium (mg/L)	<0.05	<0.05	<0.05
Copper (mg/L)	<0.01	0.015	<0.01
Iron (mg/L)	0.39	0.08	0.28
Lead (mg/L)	<0.05	0.002	0.001
Magnesium (mg/L)	41	20	18
Manganese (mg/L)	0.02	0.01	0.01
Mercury (mg/L)	<0.001	<0.001	<0.001
Molybdenum (mg/L)	<0.01	<0.01	<0.01

Table 2.5-1 Average Seasonal Surface Water Quality in the Moore Ranch License Area			
Nickel (mg/L)	<0.05	<0.05	<0.05
Potassium (mg/L)	14	9	7
Selenium (mg/L)	0.001	0.001	0.002
Silica (mg/L)	5.6	6.9	4.9
Sodium (mg/L)	409	104	135
Uranium (mg/L)	0.004429	0.002775	0.0016111
Vanadium (mg/L)	<0.1	<0.1	<0.1
Zinc (mg/L)	<0.01	0.01	0.01

* NR – not reported

2.5.3.2 Ground Water

The applicant provided the ground water quality of regional aquifers around the proposed Moore Ranch facility license area using data from a published study by M. E. Lowry, et al., (1986), of ground water from wells and springs in the PRB. Aquifers sampled in this study from the deepest to shallowest included the Madison limestone, Tensleep sandstone, Lance formation, Fox Hills formation, Fort Union formation, Wasatch formation, and alluvium. The applicant stated that the study reported that 84 percent of the samples exceeded the EPA secondary drinking water standard of 500 milligrams per liter (mg/L) TDS and approximately 55 percent of samples exceeded 1,000 mg/L. Only 8 percent of the samples exceeded a TDS value greater than 3,000 mg/L. Lowry, et al., (1986), also stated that magnesium levels exceeded the EPA secondary drinking water standards in 43 percent of 257 samples. Iron concentrations exceeded the EPA secondary drinking water standards in 15 percent of 366 samples. Selenium levels exceeded the EPA maximum contaminant levels in 2.5 percent of the wells. Lead exceeded the maximum contaminant levels in 3.6 percent of the samples.

The applicant reported that radionuclide data from regional aquifers for the PRB were sparse. It provided some studies that showed uranium ranged from 0.5 to 10,000 micrograms per liter in 96 wells in the Wasatch formation. Radium samples from the same sample set showed values ranging from 0.2 to 173 picocuries per liter (pCi/L). Uranium in the Fort Union formation was reported as ranging from 5 to 3550 micrograms per liter in 31 mine well samples, and radium-226 was 3.7 to 954 pCi/L. Samples from wells in the Fort Union formation were low in uranium and in radium-226. Samples from the Lance formation were low in uranium and radium-226.

The applicant characterized the preoperational ground water quality in the proposed Moore Ranch facility license area from data collected by Conoco and its own recent sampling. It reported that Conoco installed wells in the late 1970s in the proposed license area in the 70 sand, 68 sand, the 40–50 sands, and the Roland coal. The applicant provided the completion data for these wells in Table 2.7.3-13 of the technical report. It stated that most of the Conoco wells were sampled once within the period from 1978 to 1980, but a few were sampled several times.

In 2007, the applicant installed a monitoring well network to evaluate preoperational baseline ground water quality in the proposed license area. The baseline well network was composed of four groups of three wells that were completed in the 70 sand extraction zone, the 72 sand overlying aquifer, and the 68 sand in and near the proposed well fields and eight additional wells in the 70 sand. Three nonbaseline wells of the original Conoco 70 sand wells were included, and two of them (Wells 1808 and 8-3) were completed in both the 68 and 70 sands. Four private stock wells were also sampled. The locations of these wells are shown in Figure 2.5-1. The completion information for most of the wells was presented in Table 2.7.3-15 of the technical report. Data from three to four rounds of water sampling in 2007 were included in the application.

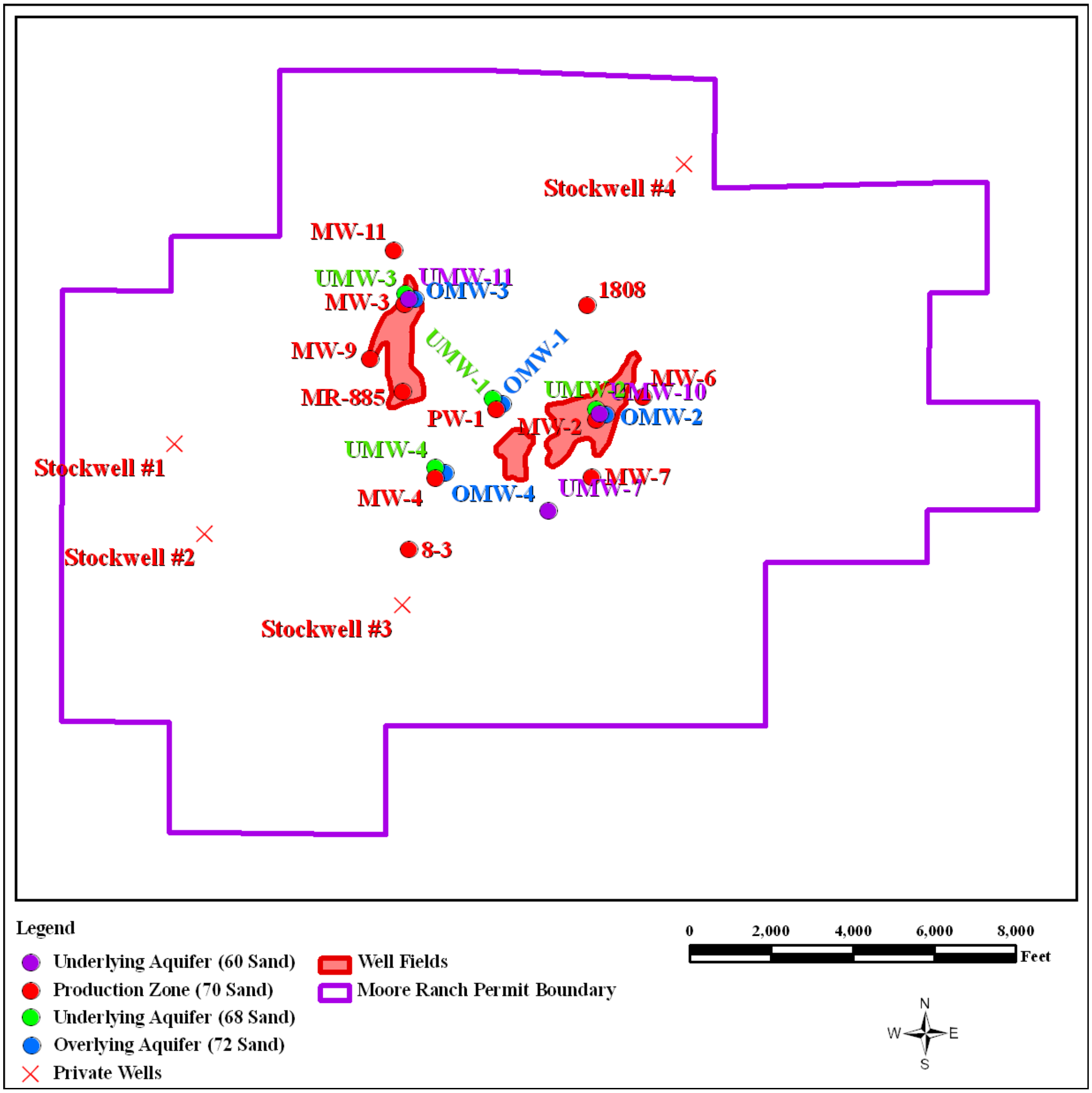

Figure 2.5-1 Locations of monitoring wells for Moore Ranch preoperational baseline ground water sampling

In 2009, the applicant determined that the 60 sand would act as the underlying aquifer in portions of Well Field 2 where the 70 sand and 68 sand coalesce. It therefore added three monitoring wells in the 60 sand to characterize its preoperational water quality. Locations of these wells are also shown in Figure 2.5-1. These three wells were sampled two to three times in the spring and summer of 2009. Three wells were also installed in the 80 sand, which overlies the 72 sand. Only one of these wells had sufficient water for sampling.

The applicant provided the results of the historical Conoco monitoring well sampling in Table 2.7.3-17 and Table 2.7.3-18 of the technical report. Results of the applicant's 2007 baseline wells sampling for individual wells in the 68, 70, and 72 sands were presented in Table 2.7.3-19a of the technical report. Results for nonbaseline wells were presented in Table 2.7.3-19b and included wells in the 58, 50, and 40 sands, the 80 sand, the three wells installed by Conoco, and four private stock wells that were resampled by the applicant in 2007. The water-quality sampling results for the 60 sand were provided in Table 2.7.2-1a. The parameters measured were listed in Table 2.7.3-16 of the technical report and included all suggested analytes in Table 2.7.3-1 in NUREG-1569.

The applicant provided a comparison of historical water quality in the three historical Conoco wells with their current water quality in Table 2.7.3-20a of the technical report. The staff found that the data showed that the water quality in these three wells had been consistent over the past 25 years with the exception of Well 8-3, which showed a significant increase in ammonium sulfate, iron, manganese, TDS, and conductivity. Well 8-3 is completed in both the 68 and 70 sands. The applicant indicated that this water quality variation was a function of contamination of the wells from small animals based on field observations.

The applicant also compared the recent water quality in the three private stock wells with historical water quality in the same wells in Table 2.7.3-20b. The staff found that the data showed that the water quality in the stock wells had been consistent over the past 25 years with the exception of Stock Well No. 3, which showed a significant increase in iron and manganese. Sulfate, conductivity, and TDS were also much higher in Stock Well No. 3 than in the surrounding stock wells in the recent 2007 sampling. The applicant indicated that no completion report was available for Stock Well No. 3, but, with a pump depth at 120 ft, it appears to be completed in the 70 sand. No explanation for the change in Stock Well No. 3 was provided.

The applicant presented a comparison of the sampled 2007 baseline preoperational water quality in the 68, 70, and 72 sands aquifers with EPA drinking water and WDEQ Class I standards in Table 2.7.3-21. The applicant reported that the results showed that over half of the samples exceeded the WDEQ Class I and EPA drinking water standard for TDS with most of these in the 70 sand extraction zone. The TDS standard was exceeded in one 80 sand well and one 60 sand well. Half of the extraction zone samples also exceeded the WDEQ Class I and EPA standards for sulfate. One 60 sand well exceeded the standards for sulfate. Ammonia, iron, manganese, and selenium exceeded the WDEQ Class I and EPA drinking water standard in some of the wells. Ammonia exceeded the WDEQ Class I standard in two 72 sand wells. The WDEQ Class I and EPA drinking water standard for iron was exceeded in one 68 sand well, one 72 sand well, and two 70 sand wells. The manganese standards for both were exceeded in one 70 sand and one 72 sand well, and the selenium standards for both were exceeded in two 68 sand wells and two 70 sand wells. The WDEQ Class I and EPA drinking water standard for selenium was exceeded in all 60 sand monitoring wells.

For radionuclides, the applicant reported the majority of wells in the 70 sand and underlying 68 sand exceeded the EPA primary drinking water standards for uranium and radium-226. None of the samples in the overlying 72 sand aquifer exceeded the EPA uranium standard, and only one well, OMW3, exceeded the radium standard. The average uranium concentration for the ore 70 sand was 0.16 mg/L, which is over five times the EPA drinking water standard. The combined radium-226 and radium-228 concentration in the 70 sand averaged 96.2 pCi/L, which is over the EPA standard. The EPA uranium standard was exceeded in all three 60 sand wells.

The staff calculated the average preoperational baseline water quality for all analytes for the 72, 70, 68, and 60 sands from 2007 and 2009, which is shown in Table 2.5-2. The numbers in bold indicate where the average value exceeded an EPA drinking water standard or WDEQ Class of Use standard. On an average basis, the EPA drinking water and Class I standards were exceeded in the 72 sand for TDS, sulfate, and manganese. The EPA drinking water and Class I standards were also exceeded in the 70 sand for TDS, sulfate, gross alpha, radium-226, and uranium. In the 68 sand, these standards were exceeded for pH, gross alpha, radium-226, selenium, and uranium. In the 60 sand, the standards were exceeded for pH, gross alpha, selenium, and uranium. The staff finds these average values to be generally representative of those shown in the individual wells.

Table 2.5-2 Average Preoperational Baseline Ground Water Quality for the "72 Sand" Overlying Aquifer, the "70 Sand" Extraction zone Aquifer, the "68 Sand" and the "60 Sand" Underlying Aquifer (Adapted from Table 2.7.3-21 of the technical report)

Water Quality Parameter	Average			
	72 Sand	**70 Sand**	**68 Sand**	**60 Sand**
Bicarbonates as HCO_3 (mg/L)	208.2	277.2	148.6	225.8
Carbonates asCO_3 (mg/L)	1.6	1.0	10.4	4.4
Chloride (mg/L)	4.1	2.3	2.0	2.6
Conductivity (umhos/cm)	1051.6	1034.2	753.3	621.0
Fluoride (mg/L)	0.2	0.2	0.2	0.2
pH (s.u.)	8.07	7.58	8.99	8.77
TDS (mg/L)	770.6	712.5	416.5	414.4
Sulfate (mg/L)	401.0	330.3	162.0	128.4
Gross Alpha (pCi/L)	5.7	259.1	78.24	74.7
Gross Beta (pCi/L)	14.4	80.6	40.09	16.4
Lead-210 (pCi/L)	2.0	9.2	6.81	1.37
Polonium-210 (pCi/L)	1.2	5.6	3.55	1.17
Radium-226 (pCi/L)	1.1	95.6	21.1	0.71
Radium-228 (pCi/L)	1.9	1.7	1.2	1.32
Thorium-230 (pCi/L)	0.3	0.3	0.2	0.05
Nitrogen, Ammonia as N (mg/L)	0.214	0.1	0.5	Non-detect

Table 2.5-2 Average Preoperational Baseline Ground Water Quality for the "72 Sand" Overlying Aquifer, the "70 Sand" Extraction zone Aquifer, the "68 Sand" and the "60 Sand" Underlying Aquifer				
Nitrogen, Nitrate + Nitrite as N (mg/L)	0.4	0.2	0.3	Non-detect
Aluminum (mg/L)	0.1	0.1	0.1	Non-detect
Arsenic (mg/L)	0.001	0.002	0.002	0.001
Barium (mg/L)	0.1	0.1	0.1	Non-detect
Boron (mg/L)	0.1	0.1	0.1	Non-detect
Cadmium (mg/L)	0.005	0.005	0.005	Non-detect
Calcium (mg/L)	137.4	135.2	54.4	58.8
Chromium (mg/L)	0.05	0.05	0.05	Non-detect
Copper (mg/L)	0.01	0.01	0.011	Non-detect
Iron (mg/L)	0.082	0.151	0.052	Non-detect
Lead (mg/L)	0.001	0.002	0.005	Non-detect
Magnesium (mg/L)	37.3	31.8	7.4	6.1
Manganese (mg/L)	0.064	0.033	0.016	0.014
Mercury (mg/L)	0.001	0.001	0.001	Non-detect
Molybdenum (mg/L)	0.1	0.1	0.1	Non-detect
Nickel (mg/L)	0.05	0.05	0.05	Non-detect
Potassium (mg/L)	16.6	10.2	14.7	8.3
Selenium (mg/L)	0.001	0.025	0.135	0.083
Silica (mg/L)	10.9	13.0	11.2	Non-detect
Sodium (mg/L)	32.3	33.3	63.4	70.2
Uranium (mg/L)	0.001	0.161	0.050	0.0532
Vanadium (mg/L)	0.1	0.1	0.1	Non-detect
Zinc (mg/L)	0.01	0.01	0.01	Non-detect

To characterize the types of water present in the proposed license area aquifers, the applicant presented Piper diagrams of average water quality in baseline monitoring wells in the 68, 70, and 72 sands in Figure 2.7.3-3a of the technical report. A Piper diagram of the average water quality in the nonbaseline monitoring wells was provided in Figure 2.7.3-3b. The applicant also provided Piper diagrams of the average water quality in the 40, 50, 58, 60, 68, 70, 72, and 80 sands and in the Roland coal in Figure 2.7.3-4 of the technical report. A Stiff diagram of the water quality for all the different aquifers was shown in Figure 2.7.3-5. The Piper and Stiff diagrams indicate that ground water within the 70 sand extraction zone is of the calcium sulfate type. Ground water in the 72 sand overlying aquifer is also of the calcium sulfate type. Ground water within the underlying 68 sand and 40–50 sands varies between calcium to sodium sulfate and calcium to sodium bicarbonate. The Roland coal is a strongly sodium-bicarbonate-type water.

Because CBM-produced water was, and continues to be, discharged at the surface in impoundments and drainage channels in the proposed license area, there exists the possibility that ground water quality in the surficial overlying aquifer 72 sand has been, and may continue to be, impacted by this water. To assess if impact has already occurred, the applicant examined the water quality of the four 72 sand wells it had installed for the 2007 baseline monitoring in and around the well fields. It found that the 72 sand water quality was a calcium sulfate type. The applicant then examined the historical water quality monitoring of three wells in Sections 4, 15, and 22 of T42N, R75W, just north of the Moore Ranch facility license area. These wells were installed by CBM producers before operations began. The data showed that shallow ground water in the 72 sand, before CBM production began, was also of the calcium sulfate type. In addition, the applicant reviewed ground water quality in shallow piezometers installed by Conoco in the Well Field 2 area in the 72 sand in the 1980s prior to any CBM development. These piezometers also displayed calcium sulfate water.

The applicant stated that CBM-produced water from the Roland Coal in the Moore Ranch facility area is of the sodium bicarbonate type. The applicant stated that any shallow aquifer system that has received CBM-produced water infiltration would typically display an evolution from the pre-CBM calcium sulfate type to the sodium bicarbonate type of the CBM-produced water. Finally, the applicant reported that WDEQ had examples in the PRB where CBM-produced water infiltration had impacted the surficial aquifers. In these examples, ground water quality changed due to increases in selenium, TDS, or sulfate. The applicant noted that the current water quality in the 72 sand at the Moore Ranch facility does not show this change and thus concluded that its water quality has not been affected by CBM water.

The staff recognizes the apparent lack of evidence of impact to the 72 sand aquifer from CBM-produced water based on a comparison of the type of water from this small data set of four wells. However, the staff notes that the applicant has described CBM-produced water impacts to surface water and ground water in the proposed license area. It stated that there was a clear difference in the fall and summer surface water quality attributable to CBM water discharges. It also reported that surface water samples were not obtained in some locations (MRSW-10 and MRSW-11) because there is infiltration of CBM-produced water in the drainage channel. The applicant also performed an analysis of the linear transit time for CBM-produced water released on the surface to reach the 72 sand and presented the results in Table 2.7.3-23 of the technical report. Using a conservative thickness of 60.96 m (200 ft) for the overlying siltstone and varying hydraulic conductivity (10^{-4}, 10^{-5}, and 10^{-6} centimeters per second), the applicant found that it was possible for the 72 sand to receive infiltration from CBM-produced water within 0.7, 6.8, and 67.7 years of its release, respectively.

Given these observations, the staff reviewed the individual water quality given in Table 2.7.3-19 of the technical report for the four 72 sand wells recently sampled in the Moore Ranch facility license area and evaluated their proximity to surface water drainages receiving CBM-produced water discharge. The staff found that OMW-2, which is located very near Upper Wash No. 2 and downstream from two CBM-produced water discharge points that discharge to this drainage, showed significantly higher values for sodium, calcium, magnesium, sulfate, TDS, conductivity, magnesium, total iron, total manganese, and radium-226 than did the OMW-1 and OMW-3, which are not close to discharge points or stream channels that receive CBM water. OMW-4, which is located near Wash No. 1 and two CBM water discharge points to Wash No. 1, also showed water quality that was elevated similar to OMW-3 with the exception of sodium. The staff finds that this initial sampling may indicate that CBM-produced water has infiltrated and impacted the 72 sand water quality at the Moore Ranch facility near these surface drainages.

As the 72 sand is the overlying and surficial aquifer at the Moore Ranch facility, the applicant will be required to fully characterize the baseline water quality in the 72 sand before operations begin. This baseline evaluation will allow the applicant to better assess the impact of CBM-produced water on the 72 sand. The applicant will be required through a license condition specified in Section 2.4.3.2.2 of this SER to provide this baseline water quality in its well field hydrologic test data packages to the NRC. This will enable the staff to evaluate any impact to the 72 sand from historical CBM operations. As discussed in Section 2.4.3.2.2 of this SER, this baseline evaluation is important to enable the applicant and the NRC to distinguish between historical and future CBM water impacts, as opposed to those from the proposed ISR operations.

2.5.4 Evaluation Findings

The staff reviewed the preoperational surface water quality of the proposed Moore Ranch facility in accordance with Section 2.7.3 of the standard review plan. The applicant described the preoperational surface water quality by providing appropriate chemical and radiochemical analyses of water samples from drainages in and near the mineralized zones. Additionally, the applicant described the preoperational ground water quality for the 72 sand, the 70 sand extraction zone, and the 68 sand and 60 sand underlying aquifers. It has initially addressed the issue of impacts of CBM-produced water to the surface water and the 72 sand water quality; however, the staff notes that impacts to 72 sand should be resolved with baseline water quality testing before operations begin as required by a standard license condition. Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by the information to be collected in accordance with the standard license condition, meet the applicable acceptance criteria of Section 2.7.3 of the standard review plan and the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.5 References

Lowry, M.E., et al., “Hydrology of Area 50, Northern Great Plains and Rocky Mountain Coal Provinces, Wyoming and Montana,” Water Resources Investigations Open File Report 830-545, U.S. Geological Survey, Cheyenne, WY, 1986.

WDEQ, 2005. Water Quality Division, “Water Quality Rules and Regulations, Chapter 8, Standards for Wyoming Groundwaters’’.

2.6 Background Radiological Characteristics

This section discusses the background radiological characteristics of the surrounding environment. Background radiological characteristics are used to evaluate the potential radiological impact of operations on human health and the environment. Such impacts could result from spills, routine discharges from operations, and other potential releases to the environment. In addition, the data collected are used to identify a radiological baseline for decommissioning, restoration, and reclamation.

2.6.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the background radiological characteristics or the preoperational environmental monitoring program is in compliance with Criterion 7 of Appendix A to 10 CFR Part 40.

2.6.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7 using the acceptance criteria presented in Section 2.9.3 of the standard review plan. Also, as discussed in Regulatory Guide 4.14 (NRC, 1980), the preoperational monitoring program needs to include at least 12 consecutive months of data, in accordance with Criterion 7 of Appendix A to 10 CFR Part 40, including the submittal of complete soil sampling, direct radiation, and radon flux data prior to any major site construction.

2.6.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the background radiological characteristics of the Moore Ranch facility. Review areas addressed in this section include: air particulate and radon sampling, radon flux monitoring, vegetation, food, and fish sampling, direct radiation measurements, soil sampling, sediment sampling, ground water sampling, and surface water sampling.

2.6.3.1 Air (Particulate and Radon) Sampling

Regulatory Guide 4.14 recommends preoperational air particulate and radon sampling at three locations at or near the site boundaries, one location at or close to the nearest residence, and one control location remote from the site. The recommended sampling frequency for air particulates is a weekly filter change or more frequently, as required by dust loading, and the analysis frequency for air particulates is quarterly composites of weekly samples. Sampling and analysis frequency for air radon is continuous or for at least 1 week per month for analysis of radon-222. Sampling locations for air radon should be the same as those for the continuous air particulate samples. The applicant identified a total of four air particulate air sampling stations and 10 radon monitoring stations in Figure 2.9-25 of the technical report. These stations were used to collect preoperational data. Background sampling stations are identified in Figure 2.9-25 of the technical report as MR-1 and MRA-4 for radon and air particulates, respectively.

The applicant collected particulate air samples weekly and composited the samples for quarterly analysis from February 6, 2007, to January 9, 2008. Radon monitoring data were collected continuously for each quarter from December 4, 2006, to January 3, 2008. Air particulate samples were analyzed for the radionuclides natural uranium, radium-226, lead-210, and thorium-230. Radon samples were analyzed for radon-222. Results of the particulate and radon air sampling are shown in Table 2.9-13(s) and Table 2.9-12(s), respectively, of the technical report. The results show that the radon concentrations measured at the 10 radon sampling locations ranged from less than 0.06 pCi/l to 1.7 pCi/l.

Table 2.6-1 lists the air particulate sampling results for each radionuclide.

Table 2.6-1 Air Particulate Sampling Results		
Radionuclide	**Minimum Concentration**	**Maximum Concentration**
Natural uranium	Less than 1.0×10^{-16} µCi/mL	5.0×10^{-15} µCi/mL
Radium-226	1.0×10^{-16} µCi/mL	8.64×10^{-16} µCi/mL
Lead-210	Less than 2.0×10^{-15} µCi/mL	3.59×10^{-14} µCi/mL
Thorium-230	Less than 1.0×10^{-16} µCi/mL	2.14×10^{-15} µCi/mL

The staff finds the radon and air particulate sampling and analytical protocol to be consistent with Regulatory Guide 4.14. The staff notes that the air particulate results did not represent a minimum of 12 consecutive months of data as recommended by Regulatory Guide 4.14. The applicant has indicated that additional air particulate data would be collected between December 2009 through February 1, 2010. This data has not been submitted to the NRC. Submittal of this data will be required by a license condition, which can be found in Section 2.6.4 of this SER.

2.6.3.2 Radon Flux Monitoring

Radon flux data were collected for the Conoco mill (see the environmental report for the Sand Rock Mill Project, Campbell County, WY, Docket No. 40-8743, issued July 1980), which was proposed but never built at the Moore Ranch facility. Radon emanation results collected in 1979 are shown in Table 2.9-14 of the technical report and ranged from 0.7 to 2.9 picocuries per square meter per second using the charcoal canister method and from 0.4 to 2.7 picocuries per square meter per second using the drum method. The applicant did not collect any radon flux data and made no comparison to the Conoco data collected in 1979. The applicant does not currently plan to have impoundments or evaporation ponds and thus proposes to have no radon flux monitoring during operation. As no impoundments or evaporation ponds are currently proposed, the staff agrees that radon flux monitoring is not necessary for preoperational or operational monitoring.

2.6.3.3 Vegetation, Food, and Fish Sampling

Regulatory Guide 4.14 recommends vegetation samples from three locations near the site in different sectors, including three food locations that consist of crops and livestock within 3 km (1.86 mi) of the site and fish in each body of water. The applicant collected vegetation samples from three locations in April 2007, which are depicted in Figure 2.9-38 of the technical report. Locations at the Moore Ranch facility for vegetation sampling were selected downwind (northeast, east, and southeast) of the proposed plant area. The applicant indicated that consideration was also given to areas with sufficient vegetation density and that the volume of vegetation collected could be large enough to help meet specified analytical detection limits. Vegetation sampling results are reported in Table 2.9-18(s) of the technical report and samples were analyzed for lead-210, polonium-210, radium-226, thorium-230, and natural uranium. Table 2.6-2 summarizes of the range of the results.

Table 2.6-2. Vegetation Sampling Summary		
Radionuclide	**Maximum (µCi/kg)**	**Minimum (µCi/kg)**
Lead-210	3.2×10^{-4}	4.6×10^{-5}
Polonium-210	4.8×10^{-5}	9.2×10^{-7}
Radium-226	5.1×10^{-5}	6.1×10^{-6}
Thorium-230	2.6×10^{-5}	Non-detect
Natural uranium	6.0×10^{-5}	Non-detect

The vegetation sampling and analysis program is consistent with the guidance in Regulatory Guide 4.14 for the preoperational period, and therefore, the staff finds it acceptable.

The applicant provided land use definitions in Table 2.2-1 of the technical report. Land use includes pastureland, which is land used primarily for the long-term production of adapted, domesticated forage plants. These plants are grazed by livestock or occasionally cut and cured for livestock feed. Land use also includes rangeland, which consists of grasses, grasslike plants, forbs, or shrubs used for the grazing of livestock. The applicant stated in Section 2.8.2 of the technical report that the regional setting for the license area is on all private lands, with sheep grazing being the major land use in the region. Discussions by the applicant with landowners indicated that the population and residence for grazing animals is approximately 700 sheep year round and an additional 150 sheep during the period from April through November of each year. Of these 850 heads of sheep, approximately 650 feeder lambs are harvested each year for human consumption. The applicant stated that it will collect baseline samples from three lambs to establish background radiological characteristics. Samples will be collected and analyzed in accordance with Regulatory Guide 4.14, and the results from these samples will be included in the Section 2.9.11 of the technical report. The license condition described in Section 2.6.4 of this SER will require the applicant to collect these samples prior to operation.

The applicant indicated that no fish species are found on the site as all water bodies are ephemeral in nature and do not contain sufficient water to support aquatic fish species. Furthermore, the applicant indicated through landowner contacts that crops have not been raised on pastures within the project area since the late 1980's. Therefore, taking these facts into consideration, the staff concludes that the justification for not collecting fish and crop samples is adequate.

2.6.3.4 Direct Radiation

Regulatory Guide 4.14 recommends a total of 80 direct radiation measurements at 150 m (492 ft) intervals up to a distance of 1,500 m (4,921 ft) in eight directions from the center or 5 or more direct radiation measurements at the same locations used for the collection of particulate samples once prior to site construction. The applicant did not follow this guidance. In lieu of this guidance, the applicant collected 40 direct radiation measurements using thermoluminescence dosimeters (TLDs) at locations identified in Figure 2.9-25 of the technical report with a quarterly change out of the TLDs over a 1-year period. TLDs were colocated with the passive radon air sampling devices discussed above. The applicant also collected additional direct radiation measurements (gamma-ray surveys) using all terrain vehicles as discussed in further detail below. TLD results (estimated quarterly field dose expressed in millirem) are shown in Table 2.9-11(s) of the technical report. Results ranged from 16.4 to 54.2 millirem per quarter and 117.5 to 157.1 millirem per year (mrem/yr). The quarterly range corresponds to an estimated field dose rate of 6 microroentgens per hour (μR/h) to 24 μR/h.

The applicant conducted extensive gamma-ray surveys for baseline measurements at the site. Gamma-ray measurements were collected with a sodium iodide (NaI) detector mounted to all terrain vehicles. NaI detectors are fairly durable detectors for gamma-ray measurements in the field and the NaI detector is energy dependent. This means that the NaI detector responds slightly different to radionuclides with different gamma-ray energies other than its calibration radionuclide. To understand this difference, the NaI detectors were cross-calibrated to high-pressure ionization chambers in the field for the purpose of cross-references. High-pressure ionization chambers are energy-independent detectors that provide a more accurate gamma-ray exposure rate and are not influenced by other gamma-ray energies. The applicant correlated the dependent measurements of the NaI detectors with the independent high-pressure ionization chambers for future references and work with the NaI detectors.

Gamma-ray survey results showed a relatively small degree of variability in gamma-ray exposure rates for most of the site. At one localized area on site, gamma-ray exposure rates approached 40 μR/h. This was much higher than the other exposure rate readings. The applicant noted that weathered sedimentary rocks were lying on the ground surface at this location. It is possible that the weathered sedimentary rocks contributed to the higher exposure rate. Results of the gamma-ray survey are shown in Figure 2.9-5 of the technical report. A summary of the baseline gamma-ray survey is depicted in Figure 2.9-14 of the technical report. A total of 343,187 measurements were collected for the baseline gamma-ray survey. This method minimizes the chances for large hot spots being undetected. The average gamma-ray exposure rate was 14.3 μR/h. The results from this gamma-ray survey are consistent with the estimated quarterly field dose for TLDs in Table 2.9-11 of the technical report. Although the applicant did not collect direct radiation measurements in accordance with Regulatory Guide 4.14, the applicant did take a sufficient number of gamma-ray survey measurements to support an adequate direct radiation measurement program. The staff has determined that the applicant developed a reasonable alternative to Regulatory Guide 4.14 for direct radiation preoperational environmental and gamma-ray survey measurements. Therefore, the staff finds results of the direct radiation and gamma-ray survey measurements to be acceptable.

2.6.3.5 Soil Sampling

Regulatory Guide 4.14 recommends that up to 40 surface soil samples be collected at 300-meter (984 foot) intervals to a distance of 1,500 m (4,921 ft) in eight meteorological sectors as well as 5 or more surface soil samples collected at air particulate stations. In addition, at least five subsurface soil samples in four meteorological sectors should be collected. The applicant identified a total of 45 locations for surface and subsurface soil samples, which are shown in Figure 2.9-18 of the technical report. In accordance with Regulatory Guide 4.14 and Criterion 6(6) of 10 CFR Part 40, Appendix A, the applicant collected a combination of surface and subsurface soil samples at a depth of 5 cm (1.97 in) and 15 cm (5.91 in), respectively, in eight compass directions in April 2007 at these locations. Subsurface soil samples were collected at

12 of the 45 locations. Soil sampling locations were also collected at air sampling locations. All samples were analyzed for radium-226 and approximately 10 percent of the total samples were analyzed for natural uranium, lead-210, and thorium-230. Radium-226 concentrations in the surface and subsurface soils ranged from 0.6 to 4.8 picocuries per gram (pCi/g) and 0.6 to 9.2 pCi/g, respectively. Radium-226 results are depicted in Figure 2.9-17 of the technical report, and the other radionuclide results are reported in Table 2.9-3 of the technical report. The staff has determined that this soil sampling effort is consistent with Regulatory Guide 4.14 and is adequate.

2.6.3.6 Sediment Sampling

Regulatory Guide 4.14 recommends sediment sampling at two locations in each stream and one in each water impoundment. The applicant conducted baseline sediment sampling in April 2007 and August 2007, which included ephemeral stream drainage channels and surface water impoundments. Stream sediment sampling locations were determined from topographical maps to represent the primary drainages found at the site. Sediment sampling locations for surface water impoundments were determined from topographic maps and the applicant's general knowledge of the local terrain. Sediment samples were collected from 13 surface water impoundments and 7 streams and were analyzed for natural uranium, thorium-230, radium-226, and lead-210. Results of the sediment collection for surface water impoundments and streams are shown in Table 2.9-7(s/a) and Table 2.9-7(s/b) of the technical report. Sediment sample results from the 1980 Conoco report is also shown in Table 2.9-8(s). Table 2.6-3 summarizes the range of results.

Table 2.6-3 Sediment Sampling Summary

Radionuclide	April 2007 (pCi/g)	August 2007 (pCi/g)	Conoco 1979 (pCi/g)
Radium-226	0.7–1.6	1.1–3.1	0.8–1.8
Lead-210	1.0–3.2	2.3–11.0	Not available
Thorium-230	0.4–0.7	0.8–3.2	0.9–2.0
Natural uranium	0.5–1.0	1.1–9.6	0.6–3.3

The staff concludes that the sediment sampling and analysis program was consistent with Regulatory Guide 4.14 and, therefore, the staff finds the preoperational sediment sampling and analysis acceptable.

2.6.3.7 Ground Water Sampling

Regulatory Guide 4.14, recommends six or more ground water samples at wells located around future disposal areas. The "disposal area" concept discussed in this portion of the Regulatory Guide applies to tailings impoundments used at conventional uranium mills. Because the applicant's ISR operations will not generate any tailings, this portion of Regulatory Guide 4.14 does not apply.

The applicant conducted baseline ground water radiological sampling at 11 wells distributed across the site. Samples were obtained on a quarterly basis, but only three quarters of samples were collected. The staff notes that the applicant did not sample for at least 12 consecutive months of data as recommended by Regulatory Guide 4.14. The applicant stated that they will collect ground water samples in the first quarter of 2010. This data has not yet been submitted to the NRC. Submittal of this data will be required by the license condition presented in Section 2.6.4 of this SER.

The sampled wells are shown in Figure 2.9-34 of the technical report. The applicant stated that these wells were located within the mineralized areas, as well as upgradient and downgradient, and in the aquifers above and below the mineralized aquifer. Additionally, several nearby stock wells, used for watering cattle, were sampled. The staff observes that the ground water flow is predominately to the north. Consequently, the wells on the south side are considered upgradient and those wells on the north side are considered downgradient.

Results from ground water sampling are provided in Table 2.9-15 and Table 2.9-15(s) of the technical report. Ground water samples were analyzed for dissolved natural uranium, thorium-230, radium-226, radium-228, polonium-210, lead-210, gross alpha, and gross beta. Regulatory Guide 4.14 recommends sampling ground water for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. The applicant conducted additional analysis for gross alpha, gross beta, and radium-228. The staff recognizes that gross alpha and gross beta results are qualitative tools, and the results cannot be used for any radiological dose assessment.

The 70 sand (mineralized aquifer) sample results showed the largest range of concentrations for natural uranium, polonium-210, lead-210, and radium-226 when compared to the stock wells, the underlying 68 sand, and the overlying 72 sand. No significant difference was observed in thorium-230 concentrations between any of the sands or the stock wells. Table 2.6-4 summarizes the range of results for each area.

Table 2.6-4 Ground Water Sampling Summary

Radionuclides	68 Sand (pCi/L)	70 Sand (pCi/L)	72 Sand (pCi/L)	Stock Wells (pCi/L)
Lead-210	<1.0–13	<1.0–69	<1.0–8.2	<1.0–14
Polonium-210	<1.0–2.3	<1.0–51	<1.0–2.6	<1.0–2.4
Radium-226	<0.2–1.4	1.0–335	0.6–3.0	<0.2–3.6
Thorium-230	<0.2	<0.2–0.9	<0.2–1	<0.2–0.9
Natural uranium	<0.2–75	<0.2–576	0.5–6.7	0.7–32.8

Additionally, as discussed in Section 5.7.9 of the SER, the applicant will conduct more detailed ground water sampling prior to beginning operation in a well field.

The staff concludes that the ground water radiological sampling and analysis program was consistent with Regulatory Guide 4.14. Therefore, based on the information provided in the application as supplemented by information collected in accordance with the license condition presented in Section 2.6.4 of this SER, the staff finds the preoperational ground water sampling and analysis acceptable.

2.6.3.8 Surface Water Sampling

Regulatory Guide 4.14 recommends surface water sampling for several types of areas. The locations can include large permanent onsite water impoundments such as ponds or lakes, offsite impoundments that may be subject to direct surface drainage from potentially contaminated areas, surface waters or drainage systems crossing the site boundary, and surface waters that may be subject to drainage from potentially contaminated areas. These surface water samples are to be collected as a grab sample on a monthly and quarterly basis for water impoundments and drainage systems, respectively.

The applicant provided dissolved and suspended surface water results for 12 locations as shown in Table 2.7.3-1 through Table 2.7.3-11 from 2006 to 2009. Constituents analyzed included dissolved and suspended analysis for polonium-210, lead-210, radium-226, thorium-230, and natural uranium. The staff has determined that the isotopic analysis is consistent with Regulatory Guide 4.14, and finds this acceptable. Although the applicant provided dissolved and suspended surface water results for 12 locations from 2006 to 2009, there were several results that were missing. The staff recognizes that the surface water bodies and streams may be ephemeral, and notes that the sum of the sample results for this time period presented by the applicant did represent a total of 12 months. The sum of the number of sample results for each surface water sample was consistent with Regulatory Guide 4.14, for the minimum collection period of data. The staff concludes that the surface water sampling and analysis program was consistent with Regulatory Guide 4.14, and the staff finds the preoperational surface water sampling and analysis acceptable.

2.6.4 Evaluation Findings

The staff reviewed the background radiological characteristics of the Moore Ranch facility in accordance with Section 2.9.3 of the standard review plan. The applicant has provided adequate justification for not conducting radon flux monitoring and food, crop, and fish sampling during preoperational monitoring. The applicant established background radiological characteristics by providing monitoring programs that include sampling frequency and methods, sampling locations, and types of analyses. However, the staff determined that air particulates and ground water data were not collected for 12 consecutive months as required by 10 CFR Part 40, Appendix A, Criterion 7. Additionally, the applicant has not collected samples from livestock (grazing sheep). Because the applicant has not provided the required information, the staff is imposing the following license condition to ensure that representative data are collected prior to operations:

> The licensee shall submit a preoperational radiological environmental monitoring program report for NRC approval that will include environmental results for groundwater, air particulate, and livestock (grazing sheep), as described in Regulatory Guide 4.14.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented information collected in accordance with the noted license condition, meet the applicable acceptance criteria of Section 2.9.3 of the standard review plan and the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.6.5 Reference

NRC, 1980. "Radiological Effluent and Environmental Monitoring at Uranium Mills," Regulatory Guide 4.14, Revision 1. Washington, DC: April 1980.

3.0 OPERATIONS

3.1 In Situ Recovery Process and Equipment

3.1.1 Regulatory Requirements

The staff will determine if the applicant demonstrated that the equipment and processes used in the well fields during operation at the Moore Ranch facility meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.1.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.1.3 of the standard review plan.

3.1.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the ISR processes and equipment proposed for the Moore Ranch facility. Review areas addressed in this section include: well field infrastructure, operations in the 70 sand aquifer, and the proposed schedule for operations.

3.1.3.1 Introduction

The applicant has described the ISR process and equipment to be used at the Moore Ranch facility. The license area will contain two separate well fields, Well Fields 1 and 2. The total well field area will be approximately 60.71 hectares (150 acres), and uranium will be extracted from an ore body within 70 sand at depths of 54.86 to 76.2 m (180 to 250 ft) BGS. The width of the ore bodies range from 30.48 to 304.8 m (100 to 1,000 ft) with thicknesses of 15.24 to 27.43 m (50 to 90 ft). The average grade of uranium is about 0.1-percent U_3O_8.

The applicant stated that the 70 sand ore body aquifer is partially unsaturated with the water level lower than the bottom of the overlying shale over the majority of the license area at the Moore Ranch facility except for the northern tip of Well Field 1. It is therefore an unconfined (unsaturated) aquifer in the proposed well fields. The staff notes that an unconfined (unsaturated) aquifer responds differently to ISR operations than a confined aquifer does. It therefore offers a unique set of safety concerns.

First, flow to a production well in an unconfined (unsaturated) aquifer arises from gravity drainage of the sediments in addition to the mechanisms of compression of sediments, which move water to a well in a confined aquifer. This drainage creates dewatered cones of depression around production wells and ground water mounds around injection wells. Dewatering and mounding may affect the operation of the well fields by limiting rates of withdrawal, which could potentially affect the control and capture of excursions.

Second, effects of pumping an unconfined (unsaturated) aquifer are expressed over a smaller area than those in a confined aquifer. Because these cones of depression are not expressed over a large distance, this may make it difficult to prevent and control excursions. Third, the unconfined aquifer has smaller potentiometric head due to its reduced water levels (partially unsaturated condition). These heads are further reduced at the production wells from the dewatering of the unconfined (unsaturated) aquifer. When lixiviant with high concentrations of dissolved oxygen is injected into an aquifer with low hydrostatic head, the dissolved oxygen will evolve out of solution to create a gas phase along with the existing water phase in the aquifer.

This two-phase flow system can create reduced injectivity/productivity near the injection and extraction wells and throughout the aquifer. This reduced conductivity can change the flow system in an unpredictable manner, which may also impact the control of excursions. In addition, reduced conductivity may also cause portions of the production zone to be bypassed during restoration. Finally, the evolution of gas in the aquifer can impact well field piping, pumps, and instrumentation because ISR equipment is designed to handle single-phase water flow. If a gas phase is introduced it can cause two-phase flow in piping and create cavitation in pumps, which can lead to damage. ISR flow and pressure instruments are also designed for a single-phase liquid, and the presence of a gas phase could cause this instrumentation to fail to work properly. Thus, the presence of a free gas phase is a safety and operational problem for piping, pumps, and flow/pressure gauges.

To evaluate the proposed ISR operation at the Moore Ranch facility, the staff first focused its review on an assessment of the ISR process well field infrastructure. Then the staff review focused on the unique aspects of unconfined (unsaturated) aquifer behavior that must be addressed to ensure that the applicant will be able to conduct its ISR operations at the Moore Ranch facility in a safe manner.

3.1.3.2 Well Field Infrastructure

The applicant described the well field design and infrastructure to be used at the Moore Ranch facility. It first presented well installation and cementing procedures to protect overlying and underling aquifers and prevent cross-contamination. It stated that all wells would be completed with Standard Dimension Ratio 17 polyvinyl chloride (PVC) casing with a nominal 12.7 cm (5 in) outside diameter. Each joint will be connected with pipe threads or a watertight ring seal. Typical well completion schematics were shown for injection wells that can also act as production wells and monitoring wells. Well development procedures were described, along with well integrity testing procedures, schedules, and reporting procedures. The applicant stated that well casing integrity will be tested at a pressure of 1241 kilopascals (kPa) (180 pounds per square inch (psi)), which is the maximum operating pressure of 1034 kPa (150 psi) plus a 20-percent safety factor. The well installation, development, integrity testing, and operating information reflect accepted NRC practice for ISR operations.

The applicant stated the well field injection and recovery pattern will be a conventional square five-spot pattern, which may be modified to meet the characteristics of the specific ore body location within a well field. Modifications to the spot pattern will be allowed without NRC review and approval. Injection wells are anticipated to be located between 22.86 m (75 ft) and 45.72 m (150 ft) apart. Injection pressures will be maintained below formation fracture pressures based on a typical field fracture gradient of 22.62 kPa/m (1 psi per foot (psi/ft)). The applicant reported that the downhole operating pressures will be in a range of 689.48– 1034.22 kPa (100–150 psi), which translates to a fracture gradient of 12.44 to 18.78 kPa/m (0.55 to 0.83 psi/ft) for the shallowest operating depth of 54.86 (180 ft).

The applicant provided a description of the design and instrumentation of the well field infrastructure. Header houses will be used to distribute injection fluid to injection wells and collect production solution. A schematic of the typical header house design and instrumentation was provided in Figure 3.1-3A of the technical report. Eight header houses are planned for Well Field 1 and 11 header houses for Well Field 2. Each header house will service approximately 40 to 60 wells.

Well field piping will be constructed of high-density polyethylene (HDPE), PVC, or steel and will have an operating pressure of 1034 to 2068 kPa (150 to 300 psi). Individual well lines and trunk lines will be buried to prevent freezing. The flow rate and pressure of each injection and production well will be monitored at the header house by individual flow meters and pressure gauges tied to the header house control panel, which will be in communication with the central control room. High-pressure, low-pressure and flow alarms will be installed to alert well field and plant operators if specified ranges are exceeded, and automatic shutoff valves will activate if significant changes in pressure or flow occur. To detect leaks, header houses will have "wet building" alarms to notify operators of the presence of any liquids in the sump. The applicant will implement a program of continuous well field monitoring by roving well field operators and will require daily inspection of well fields to detect leaks. The staff concludes that the design, materials, instrumentation, and monitoring of the header houses and well fields reflect current industry practice, and has been found to prevent and detect spills and leaks in a timely fashion.

The applicant acknowledged that dissolved oxygen added to the lixiviant can come out of solution in the low head conditions of the unconfined (unsaturated) aquifer. The presence of a gas phase creates two phase flow which can damage piping and pumps and interfere with flow/pressure measurements. To prevent and correct this problem, the applicant stated it would monitor gas concentrations in the injection fluids and check for gas production in fluids at the header houses. It stated that observation of gassy water will trigger corrective actions. The applicant specifically committed to conduct observation and internal reporting of any gas breakout in individual production well water samples at the time of sampling, careful monitoring of dissolved oxygen concentrations added to injection fluids, observation and internal reporting of any gas breakout in waters produced during the routine work over of injection wells, and change of well function as dictated by reports of gassy waters.

The applicant plans to bring the well fields into production in succession and also perform restoration sequentially. It proposes a phased operating scenario in which production will begin in part of Well Field 2, move to the remaining portion of Well Field 2 and part of Well Field 1, and then finish with Well Field 1. As Well Field 1 is being produced alone, Well Field 2 will begin restoration followed by the restoration of Well Field 1. The applicant stated that during the production phase, the ISR will be operated at a maximum rate of 11,355 Lpm (3,000 gpm) with a well field bleed of approximately 113.55 Lpm (30 gpm). This is a 1.0 percent bleed. The applicant reported an additional 37.85 Lpm (10 gpm) will be added from the CPP, so that the anticipated total disposal volume will be 151.4 Lpm (40 gpm) during operations. The water disposal volume during the restoration phase may be as high as 529.9 Lpm (140 gpm). The staff finds this operating scenario and waste disposal volume to be acceptably described. Based on the staff's independent review, the staff finds the proposed well field bleed of 1 percent acceptable because more fluids will be extracted than injected, which will help maintain an inward gradient. The staff will require maintenance of a well field bleed with the license condition presented in Section 3.1.4 of this SER.

The applicant stated that all liquid byproduct material waste will be injected into deep disposal wells onsite during production and restoration operations. No storage or evaporation ponds will be constructed for disposal. See Section 4.2 of this SER for the discussion of liquid effluents at the Moore Ranch facility.

3.1.3.3 In Situ Recovery Operations in the 70 Sand Unconfined (Unsaturated) Aquifer

The staff evaluated several issues that are of concern for ISR operation in the 70 sand unconfined (unsaturated) aquifer at the Moore Ranch facility. These issues are as follows:

- how to maintain an adequate cone of depression to prevent excursions;
- where to place monitoring ring wells to detect and correct excursions;
- how to prevent the dewatering of the unsaturated aquifer during excursion capture;
- what pumping test strategy is needed in the unconfined (unsaturated) aquifer to demonstrate communication with the monitoring well ring;
- the behavior of the unconfined (unsaturated) aquifer in the area of Well Field 2 where the 68 and 70 sands coalesce; and
- how to detect and correct for “gas lock”.

3.1.3.3.1 Cone of Depression in Unconfined (Unsaturated) Aquifer

The first issue is the creation and maintenance of an adequate cone of depression in the unconfined (unsaturated) aquifer at the Moore Ranch facility to prevent excursions. To address this issue, the applicant conducted additional field testing and ground water flow modeling of the unconfined (unsaturated) 70 sand aquifer to understand its drawdown and dewatering/mounding behavior. This is discussed in Appendix B2 to the technical report. These field tests included a five-spot pumping field test and extraction/injection test in Well Field 2 as described in Section 2.4.3.2 of this SER. Field results from the five-spot pumping test demonstrated that the unconfined (unsaturated) aquifer is responsive to pumping, creating a steep dewatered cone of depression around the well. Based on this test, the applicant determined that the 70 sand aquifer can maintain rates around 75.7 Lpm (20 gpm) at a single extraction well without causing excessive dewatering.

The applicant then conducted a five-spot extraction/injection test to assess the ground water dewatering and mounding in the 70 sand at anticipated production and injection rates in the same five-spot well pattern (see Appendix B2 to the technical report). The five-spot test was performed in three phases: (1) extraction from the central well and distribution of this flow to the four surrounding injection wells; (2) extraction from the central well and distribution of this flow to only two injection wells; and (3) extraction from the central well with all the flow diverted to one injection well. The drawdown and mounding for each phase are shown in Figures 5ST(19)–(21) in Appendix B2 to the technical report. The field data clearly demonstrated that the dewatering and mounding behavior occurs close to the extraction and production wells in a five-spot pattern in the 70 sand unconfined (unsaturated) aquifer for anticipated production/rates.

The applicant used this five-spot pumping test results to calibrate a single layer local ground water flow model (which is discussed in Appendix B4 to the technical report) around the five-spot test location to simulate the unconfined (unsaturated) flow behavior. The ground water model chosen was MODFLOW SURFACT, which was run using the Groundwater Vistas (Version 5.0) ® platform, a graphical user interface that simplifies data entry, model creation, model execution, calibration, and the interpretation of results. The staff concluded that the ground water flow model was acceptably calibrated using the five-spot field pumping test results and subjected to appropriate sensitivity tests.

The calibrated five-spot ground water flow model was then used to simulate the dewatering and mounding from the extraction/injection field test (see Appendix B4 to the technical report) to verify the ground water model. The model reproduced field dewatering results well but underpredicted the mounding observed at the injection wells. This is likely a consequence of the assumptions used to simulate unconfined (unsaturated) flow in MODLFOW SURFACT.

The applicant calculated a transmissivity of 91.43 cubic meters per day per meter (300 cubic feet per day per foot) and a specific yield of 0.028 for the 70 sand based on the calibration of the ground water flow model, transmissivity is the amount of flow over the width of the aquifer under a unit gradient. Specific yield is the volume of fluid released from a unit volume for a 0.3 meter (1 foot) drop in head in an aquifer. Using these values in accepted analytical transient drawdown equations, the applicant determined that the drawdown in the unconfined (unsaturated) aquifer, at a distance of 152.4 m (500 ft) from a single pumping well, would be 0.15 m (0.5 ft) after 10 days of extraction at 83.27 Lpm (22 gpm). The applicant stated that these results show that a cone of depression could rapidly extend out to monitoring wells located 152.4 m (500 ft) from the mined extraction zone. This result, however, although acceptable for a single extraction well, did not take into account the fact that the extraction well will be surrounded by injection wells, which will experience ground water mounding as shown in the isolated five-spot extraction/injection test. This test, while illustrative, could not be used to predict the cone of depression in the 70 sand unconfined (unsaturated) aquifer across the well fields under expected operating conditions.

To address this issue, the applicant created a sitewide ground water flow model to model the cone of depression for all the well fields during operations. It used MODFLOW SURFACT to simulate the unconfined (unsaturated) flow system. The model encompassed the entire license area in a 16.1 km square (10 mile square) grid (see Figure 1 of Appendix B5 to the technical report). Grid cell dimensions in the well fields were chosen to be 7.62 by 7.62 m (25 by 25 ft) to allow for sufficient resolution of the water levels in the well patterns and increased to 60.96 by 60.96 m (200 by 200 ft) outside the well fields. The model used a single layer to simulate the 70 sand, which was defined using geological selections from field-well logs. Field-measured and -calibrated values from the five-spot field test and flow model were used to define hydraulic conductivity, specific yield, and storativity. Boundary conditions were defined as general head boundaries on the northern, western, and eastern sides of the model and assigned field estimated values. A recharge boundary was placed on the southern side of the model where the 70 sand outcrops at the surface. The recharge value was used to calibrate the steady-state model to observed water levels. The staff notes that a major limitation of the model was that the parameters used in the simulation were developed from calibration to the five-spot field test conducted in Well Field 2. These parameters may not be representative of the 70 sand across the entire model grid. The applicant stated that it would update the model as fieldwide parameter measurements became available. For the current objectives, the sitewide numerical ground water flow model development and calibration was evaluated and found to represent known conditions at the Moore Ranch facility. Therefore, the sitewide ground water flow model is acceptable by the staff.

As discussed in Section 2.4.3.2 of this SER, the applicant created a ground water flow model to address certain aspects of the proposed operations in an unconfined (unsaturated) aquifer. This was accomplished by simulating proposed phases of production and restoration using well patterns as shown in Figures 5 and 6 of Appendix B5 to the technical report for Well Fields 1 and 2, respectively. These phases were as follows:

- production in Well Field 2 at 7 of the 11 header houses (148 production wells) at a rate of 11,203.6 Lpm (2,960 gpm) with a bleed of 89.63 Lpm (23.68 gpm) (0.8 percent) for 18 months;
- production in Well Field 2 at the remaining four header houses (81 production wells) and three header houses in Well Field 1 (61 production wells) at a combined rate of 10,749.4 Lpm (2,840 gpm) for 18 months (The bleed in Well Field 2 is 139.74 Lpm (36.92 gpm) (1.3 percent) and Well Field 1 is 118.24 Lpm (31.24 gpm) (1.1 percent));
- production in Well Field 1 at the remaining five header houses (99 production wells) at a rate of 7494.3 Lpm (1,980 gpm) with a net bleed of 74.94 Lpm (19.8 gpm) (1.0 percent) for 18 months and a simultaneous ground water sweep in Well Field 2 at a rate of 75.7 Lpm (20 gpm) to prevent movement toward Well Field 1; and
- restoration of Well Field 1 for 4.3 years and Well Field 2 for 6.0 years using an extraction rate of 946.25 Lpm (250 gpm) and return of 757 Lpm (200 gpm) to simulate during a reverse osmosis (RO) treatment, with 20 percent of the flow sent to the deep disposal well.

Model results indicate that at the end of Phase 1, a cone of depression extends outside of Well Field 1 that ensures flow into the well field. Model results for Phase 2 also show that an inward cone of depression is maintained for this production scheme in both well fields. Finally, the results for Phase 3 demonstrate that the operational scheme creates the cone of depression necessary to prevent excursions. The staff concludes that these simulations demonstrate that the well fields can be operated at the bleed levels proposed in an unconfined (unsaturated) aquifer setting to create the cone of depression necessary to prevent excursions.

In Phase 4, restoration was simulated. Results of Phase 4 indicate that restoration will be accomplished primarily through a restoration treatment phase using RO on the extracted ground water and reinjection of the permeate from the treatment into the aquifer. Traditional ground water sweep cannot be utilized because this could result in aquifer dewatering according to the model. RO is a high-pressure filtering process that removes contaminants from the ore body water. The RO unit will have a capacity of 1892.5 Lpm (500 gpm) or 946.25 Lpm (250 gpm) for each well field. During RO treatment about 20 percent of the extracted water is brine reject containing the removed contaminants and is not returned. The amount of reject is equivalent to 189.25 Lpm (50 gpm) for each well field.

To simulate the RO treatment restoration phase, the applicant used the ground water flow model with one extraction well at 189.25 Lpm (50 gpm) in each well field instead of distributing injection and extraction across well field patterns. Figures 19 and 20 of Appendix B5 to the technical report show the drawdown for this restoration phase for 4.3 and 6.0 years for Well Fields 1 and 2, respectively. Once again, an inward cone of depression is maintained around the well fields and a ground water divide is created between well fields to prevent flow between them. The staff concludes that these simulations demonstrate that the well fields can be restored at the bleed levels proposed in an unconfined (unsaturated) aquifer to create the cone of depression necessary to prevent excursions.

3.1.3.3.2 Placement of Monitoring Wells on the Perimeter Ring To Detect Excursions

The second issue is the placement of monitoring ring wells in the unsaturated 70 sand aquifer to ensure that excursions from the production zone will be detected. The applicant has indicated that the excursion monitoring wells will be located 152.4 m (500 ft) from the edge of the production zone at a spacing of 152.4 m (500 ft) apart. To demonstrate that this spacing was sufficient to detect excursions, the applicant conducted simulations using the unconfined (unsaturated) ground water flow model developed for the site and discussed in Section 2.4.3.2 of this SER.

The discussion and results of the simulation are presented in Appendix B to the technical report. Excursions were simulated in Well Field 2 where unconfined (unsaturated) aquifer conditions are prevalent. Two five-spot patterns of the well field were allowed to go out of balance by shutting down production wells, so that only injection was occurring in two patterns on the north (WP1) and north-central (WP2) portion of the well field. Using the MODPATH particle tracking program in MODFLOW, the paths of particles from the injection well to the perimeter monitoring well were simulated. The results indicate that all particles would be detected by the monitoring well ring downgradient from the well patterns.

Based on these simulations, the staff concludes that the 152.4 meter (500 foot) spacing proposed for the monitoring well ring will detect excursions in the 70 sand unconfined (unsaturated) aquifer. The staff notes that the applicant will be able to confirm the behavior of the unconfined (unsaturated) aquifer during well field testing before operations begin. By license condition, the results of this testing will be provided to the NRC in a well field hydrologic test data package, which the staff can evaluate to ensure that the field data support the results of the simulation. This license condition is discussed in Section 2.4.3.2.2 of this SER.

3.1.3.3.3 Dewatering of the Unconfined (Unsaturated) 70 Sand Aquifer

The ground water flow model simulations provide evidence that the applicant can maintain a cone of depression for expected production and restoration operations in the unconfined (unsaturated) 70 sand aquifer. However, as noted above, substantial dewatering can occur at extraction wells if rates exceed more than 75.7 Lpm (20 gpm). As the applicant has already described, dewatering of wells in the unconfined (unsaturated) aquifer may limit the flexibility in the extraction rates, which can be used at the Moore Ranch facility. These limits may pose a problem if an excursion of lixiviant from a well field occurs. Correcting an excursion typically involves a strategy of ceasing injection and increasing pumping rates near the excursion.

In the technical report, the applicant stated that an excursion could be reversed within a relatively short period of time, assuming that the required extraction rates can be maintained. To support the claim, the applicant conducted additional ground water flow simulations using the ground water flow model developed and discussed earlier. In these simulations presented in Appendix B to the technical report, the applicant created two excursions at two separate patterns in the north (WP1) and north-central (WP2) portion of Well Field 2 as described in

Section 3.1.3.3.2 of this SER. It then simulated the capture of the excursions using only the extraction well pumping at 151.4 m (40 gpm) at the WP1 pattern. To further stress the system, it simulated capture at the WP2 excursion using the extraction well pumping at 113.55 Lpm (30 gpm) along with the three nearest extraction wells also pumping at 113.55 Lpm (30 gpm) in the adjacent patterns for a total of four wells at this rate.

The flow vectors for these simulations for WP1 (one well at 151.4 Lpm (40 gpm)) and WP2 (four wells at 113.55 Lpm (30 gpm)) are presented in Figures 6a and 6b in Appendix B to the technical report. The vectors show that the flow can be reversed back toward the wells within 10 days to capture the excursions. The drawdown contours for these simulations after 30 days are shown in Figure 7 and hydrographs in Figures 8 and 9, respectively. These figures indicate that although the localized drawdown is substantial, it does not dewater the 70 sand aquifer. The applicant did concede that continued pumping past this time frame may lead to dewatering. It offered other possible extraction well combinations, locations, and rate scenarios that may be used to capture the excursion and avoid dewatering. The staff finds that the applicant has demonstrated an understanding of the dewatering issue, which will allow them to adjust and optimize operations to capture excursions.

Based on these modeling simulations, the staff concludes that excursions may be captured at the Moore Ranch facility without dewatering the 70 sand unconfined (unsaturated) aquifer. The staff notes that the applicant will be able to confirm the behavior of the unconfined (unsaturated) aquifer with field data from well field testing before operations begin. By license condition, the results of this testing will be provided to the NRC in a well field hydrologic test data package, which the staff can evaluate to ensure that the field data support the results of the simulation. This license condition is discussed in Section 2.4.3.2.2 of this SER.

3.1.3.3.4 Pumping Test Strategy in the Unconfined (Unsaturated) Aquifer To Demonstrate Communication with the Monitoring Well Ring

The applicant stated that monitoring wells will be installed in the production zone as shown in Figure 3.1-3 of the technical report. The excursion monitoring wells for each well field will be located on a ring that is set 152.4 m (500 ft) from the nearest production well pattern with 152.4 m (500 ft) between monitoring wells. The ground water model simulations indicated that the cones of depression will reach the monitoring well ring under anticipated operating scenarios as described above. However, to verify that the wells installed in the well field are in communication with the monitoring well ring, the applicant must conduct field pumping tests.

The applicant acknowledged that the steep drawdown of limited areal extent created by pumping in the unconfined (unsaturated) 70 sand aquifer will require a unique pumping test strategy to ensure that the well field is in communication with the monitoring well ring. Using the sitewide ground water flow model, the applicant ran simulations to develop a strategy to conduct the pumping tests. For Well Field 1, it was determined that at least six pumping wells operating in succession at 151.4 Lpm (40 gpm) were required to demonstrate a drawdown of 0.15 m (0.5 ft) in the monitoring well ring. The applicant, therefore, concluded it will take six or more individual pumping tests to demonstrate hydraulic communication between the monitor ring and production zone in each of the well fields. These tests will be conducted when the well fields are installed as part of the hydrologic data collection for each well field.

The staff finds that the applicant has provided an initial pumping test strategy that would be sufficient to demonstrate communication across the 70 sand unconfined (unsaturated) aquifer with the monitoring well ring. By license condition, the results of this testing will be provided to the NRC for review and approval in a well field hydrologic test data package, which the NRC can evaluate to ensure the field data support the results of the simulation. This license condition is discussed in Section 2.4.3.2.2 of this SER.

3.1.3.3.5 Response of the 70 Sand Unconfined (Unsaturated) Aquifer in Well Field 2 Where the 68 and 70 Sand Coalesce

In the northeastern and central portion of Well Field 2, the applicant has shown that the 70 sand coalesces with the 68 sand. In these regions, the applicant has stated that the production zone will be considered to include the 68 sand. Therefore, the 70 sand aquifer behavior in this area may be different. Specifically, the drawdown may be less because the production aquifer now has a combined thickness of the 68 and 70 sands. This reduced drawdown could impact communication with the monitoring well ring and excursion capture. Finally, the injected lixiviant may enter the 68 sand and require that this sand be restored.

To understand the interaction between the two sands in this region, the applicant developed a MODLFOW SURFACT ground water flow model with two layers to simulate the behavior of the 68 and 70 sands during operations in Well Field 2. The model was described, and the results were presented in Appendix B6 to the technical report. The 70 sand had a thickness of 30.48 m (100 ft), and the 68 sand had a thickness of 18.29 m (60 ft). The hydraulic conductivity of the 70 sand was set at 1.22 m/d (4 ft/d) and the 68 sand was set at 0.003 m/d (0.01 ft/d) based on field pumping tests. Nine five-spots were simulated with a total injection rate of 674.49 Lpm (178.2 gpm) and recovery rate of 681.3 Lpm (180 gpm). The model was run for 18 months to simulate a complete production cycle, and the model was run to evaluate the impacts of restoration.

Model results indicated that during this phase most of the drawdown occurs in the 70 sand. The change in head in the 68 sand at the end of production was shown to be less than 0.3 m (1 foot). Results also showed that the changes in head in the 68 sand were less than 0.3 m (1 foot) at the end of the restoration phase with a maximum drawdown of 0.09 m (0.3 foot).

The staff notes that these results reflect the three orders of magnitude difference between the conductivity of the two sands. This difference leads to preferential flow in the more conductive 70 sand in response to the operations. The staff concludes that if these simulations are confirmed by field testing, it is likely that the effect of the 68 sand on the 70 sand hydraulic behavior will be minimal in the areas where the two sands coalesce. The fluid movement into and out of the 68 sand would also be expected to be minimal.

The staff notes that the applicant will be able to confirm the behavior of the 70 sand and 68 sand where they coalesce with field data from well field testing in Well Field 2 before operations begin. By license condition, the results of this testing will be provided to the NRC for review and approval in a well field hydrologic test data package, which the NRC can evaluate to ensure that the field data support the results of the simulation. This license condition is initially discussed in Section 2.4.3.2.2 of this SER.

3.1.3.3.6 Detection and Correction of "Gas Lock" in the 70 Sand Unconfined (Unsaturated) Aquifer

The applicant stated that the lixiviant will be composed of varying concentrations and combinations of sodium carbonate, sodium bicarbonate, oxygen, and carbon dioxide added to native ground water. Possible lixiviant concentrations of different species are shown in Table 3.1-1 of the technical report. The staff notes that this type of lixiviant has been used in ISR operations in confined aquifers and is known to be amenable to ground water restoration. However, its successful application in unconfined (unsaturated) aquifers has not been established.

The staff notes that when lixiviant with high concentrations of dissolved oxygen is injected at typical operating pressures into the lower hydrostatic head of an unconfined (unsaturated) aquifer production zone, the dissolved oxygen could evolve out of solution. This creates a free gas phase along with the existing water phase in the aquifer. It is well established that the presence of a free gas phase in the aquifer creates a two-phase flow system with a nonlinear reduction in conductivity to the water phase (Bear, 1972). This reduction is known in field terms as "gas lock."

If "gas lock" occurs at the Moore Ranch facility, it may create regions of lower conductivity in the 70 sand that can create several safety issues in the operation of the ISR extraction process. First, if injectivity is reduced at the injection well, it will cause pressures to rise in the tubing that can potentially lead to well shut in or, in a worst case scenario, well casing failures. Second, as the evolution of the gas will be dependent on the hydrostatic head in the aquifer, the reduction in conductivity may change the flow system in an unpredictable manner. Instead of the expected pattern of dewatering and mounding for the well field and associated cone of depression provided by the applicant in the ground water simulations, preferential flow may develop, which cannot be predicted. Finally, reduced conductivity may cause portions of the production zone to be bypassed during restoration, potentially making restoration more difficult.

To examine the potential for "gas lock" to occur at the Moore Ranch facility, staff first estimated the maximum concentration of oxygen that could be dissolved in solution in a typical injection well. The applicant reported that the maximum well operating pressure will be 1241.06 kPa (180 psi), which is equivalent to 126.49 m (415 ft) of water. Using a rule of thumb of 3.28 part per million (ppm) oxygen per meter (1 ppm oxygen per foot) of head, the maximum dissolved oxygen that can be maintained in the lixiviant at the maximum well pressures is therefore approximately 415 ppm. The staff then evaluated the maximum amount of dissolved oxygen that can be maintained in solution in the aquifer at an injection well. The staff assumed injection will be done at 70 sand MW-2, which has a static head of 23.77 m (78 ft). Ground water flow modeling simulations in the 70 sand done by the applicant show that the head at the injection wells for expected operation rates will be around 3.05 m (10 ft) higher than the original head. If lixiviant is injected into the bottom of the 70 sand at this location, it means the head will be approximately 26.82 m (88 ft). Using a rule of thumb of 3.28 ppm oxygen per meter (1 ppm dissolved oxygen per foot), the maximum dissolved oxygen that can be maintained in solution in the aquifer is 88 ppm.

Based on this scenario, if lixiviant with a higher oxygen concentration than 88 ppm is injected, it will immediately experience a reduction in head on the aquifer. As a result, any additional dissolved oxygen above 88 ppm may be released as a free gas phase near the injection well. In addition, as the lixiviant moves through the aquifer to the production wells, further reductions in head could release more oxygen if it is not consumed in the chemical reactions. This could be a significant problem toward the end of the operating life of the facility. Therefore, the staff concludes that operations at the Moore Ranch facility could lead to a free gas phase in the aquifer, which can create "gas lock."

The applicant acknowledged that injection of dissolved oxygen at higher concentrations than can be maintained in the extraction zone 70 sand aquifer may result in the creation of a free gas phase, which could potentially create "gas lock" conditions where conductivity is reduced. The applicant stated that during operation, prevention of "gas lock" will be an operational goal since it creates efficiency problems. During recovery operations, the applicant stated that "gas lock" would be quickly detected at injection wells, which will display a marked or total loss of injectivity in hours or within days. Operational personnel will observe this change in injectivity in reduced flow or increased wellhead pressure measurements. The applicant stated that normal remedial action will result in removal of the well from service, installation of a submersible pump, and backflowing of the well to stimulate the movement of the gas block back up the well. The fluids will be routed back into the lixiviant system or to waste disposal. During restoration, the applicant stated that dissolved oxygen injection is deliberately reduced to cease oxidation within the extraction zone. Waters that are injected for restoration are undersaturated with respect to oxygen and would scavenge any oxygen from the production zone to remove areas of "gas lock" within the formation. Since several PVs are used during restoration, the applicant posited that any residual gas blockage, which could reduce conductivity and create preferential flow in the extraction zone, will be removed. Based on information contained in the application and the staff's review, the staff concludes that the applicant has demonstrated it will have adequate methods to detect and correct "gas lock" conditions at the Moore Ranch facility.

3.1.3.3.7 Schedule

The applicant presented a very general production, restoration, and decommissioning schedule for the ISR operation in Figure 3.1-6 of the technical report. This schedule indicates that production in Well Field 2 will begin in 2012 and continue until 2015. Restoration will begin immediately and continue through 2021. Production in Well Field 1 will begin in mid-2013 and continue through mid-2016. Restoration will begin immediately and continue until 2020. Decommissioning will commence in either well field at the end of restoration. The applicant noted these are proposed timelines that will be updated as necessary. The staff finds the proposed schedule contains the major aspects of site operation and, therefore, is an acceptable estimate at this time.

3.1.4 Evaluation Findings

The staff reviewed the ISR process and equipment proposed for use at the Moore Ranch facility in accordance with Section 3.1.3 of the standard review plan. The applicant described the well field infrastructure, equipment, and ISR operations and used the results from field testing and ground water modeling to support the safe application of ISR in the 70 sand unconfined (unsaturated) aquifer at the Moore Ranch facility. The applicant addressed the mineralized zone(s) and demonstrated protection against the vertical migration of water, proposed acceptable well designs and tests for well integrity, and demonstrated that the ISR process will meet the following criteria:

- Downhole injection pressures are less than formation fracture pressures.
- Overall production rates are higher than injection rates to create and maintain a cone of depression.
- Plant material balances and flow rates are appropriate.
- Reasonable estimates of gaseous, liquid, and byproduct material and effluents are provided (used in evaluation of effluent monitoring and control measures in Section 4.0 of the standard review plan).
- Disposal operations and capacity are sufficient.

The ability to operate with overall production rates higher than injection rates to create and maintain a cone of depression is an important aspect of operations. Therefore, the staff will impose the following license condition to ensure that the cone of depression is maintained during operations:

> The licensee shall maintain an inward hydraulic gradient in each individual well field, starting when lixiviant is first injected into the production zone and continuing until the restoration target values (RTVs) have been reached.

The applicant also provided a description of monitoring to prevent, detect, and correct for two-phase water and gas flow, and detect and correct spills. The staff will impose the following license condition to ensure that two-phase water and gas flow are monitored during operations:

> The licensee shall observe and document gas breakout events in individual production wells during monitoring, sampling, inspection, or routine work over of equipment in well fields and header houses. The licensee shall also document changes in well operation or well field piping, pumps, and gauges caused by free gas phase in well field fluids.

Safety issues were addressed regarding the operation of an ISR in an unconfined (unsaturated) aquifer, including the maintenance of the cone of depression, excursion monitoring and capture without dewatering, the interaction of the 68 sand and 70 sand in Well Field 2 and implications for the cone of depression and excursions, and the provision of an appropriate pumping test strategy. The applicant has provided operating plans, schedules, and timetables for well field operation, surface reclamation, and ground water restoration.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by the noted license conditions during operations meet the applicable acceptance criteria of Section 3.1.3 of the standard review plan and the requirements of 10 CFR 40.32(c), and 10 CFR 40.41(c).

3.1.5 Reference

Bear, J., 1972. “Flow of Immiscible Fluids,” *Dynamics of Fluids in Porous Media*, Chapter 9, pp. 439–578.

3.2 Central Processing Plant and Other Facilities—Equipment Used and Materials Processed

3.2.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the equipment and processes used during operation in the CPP and other facilities at the Moore Ranch facility meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.2.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.2.3 of the standard review plan.

3.2.3 Staff Review and Analysis

The Moore Ranch CPP facilities will be housed in a building approximately 106.68 m long by 30.48 m wide (350 ft long by 100 ft wide). The CPP will include the following systems: ion exchange, resin transfer, chemical addition, filtration, elution, precipitation, product drying and packaging, and liquid waste removal. All production facilities, including the CPP, deep disposal wells, and chemical storage area, will all be located within a 4.45 hectare (11-acre) fenced area at the site.

The applicant indicates that the only expected emission at the facility will be radon-222 gas. Small amounts of radon-222 may be released in the plant building during solution spills, filter changes, ion exchange resin transfer operations, and maintenance activities. The applicant states that the potential sources of fumes or gases are minimal in the ion exchange process area, since the solutions used in that process are maintained under a positive pressure. In addition, the vents from the individual vessels will be connected to a manifold that will be exhausted outside the plant building through the plant stack. Building ventilation in the process equipment area will be accomplished by the use of an exhaust system that draws in fresh air and sweeps the plant air out to the atmosphere.

Final processing of uranium to produce yellowcake will be performed in a vacuum dryer. Vacuum dryers are designed to minimize discharge any uranium when operating. Air particulate controls of the vacuum drying system include a bag house, condenser, vacuum pump, and packaging hood. The bag house is an air and vapor filtration unit mounted directly above the drying chamber. Any particulates that pass through the bag filters are wetted and entrained in the moisture within the condensing unit. The vacuum pump is a rotary water-sealed unit that provides a negative pressure on the entire system during the drying cycle. Particulate capture for the packaging system is provided by a sealed hood that fits on the top of the drum, which is vented through a sock filter to the condenser and the vacuum pump system when the dried yellowcake is being transferred.

Potential sources of nonradiological fumes or gases could result from the use of process-related chemicals, primarily in the precipitation area. Bulk hazardous chemicals, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored. Process safety controls also will be in place at the central plant where sulfuric or hydrochloric acid is added to the precipitation circuit. All tanks would be enclosed, limiting the amount of vapors that could escape.

3.2.4 Evaluation Findings

The staff reviewed the proposed equipment to be used and materials to be processed in the recovery plant and chemical storage facilities at the Moore Ranch facility in accordance with Section 3.2.3 of the standard review plan. The applicant described the equipment, facilities, and procedures that will be used to protect health and minimize danger to life or property. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the acceptance criteria of Section 3.2.3 of the standard review plan as well as the requirements of 10 CFR 40.32(c) and 10 CFR 40.41(c).

3.3 Instrumentation and Control

3.3.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the instrumentation and control proposed for the Moore Ranch facility meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.3.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.3.3 of the standard review plan.

3.3.3 Staff Review and Analysis

The applicant has indicated that the well field and ion exchange circuits would have an automatic emergency shutdown system with pressure and flow rate switches when normal operating parameters are exceeded. Instrumentation will be provided to measure total production and injection and pressure on the main trunk lines and into and out of the individual header houses. In the event of an automatic shutdown as a result of a problem in these systems, the circuit can be manually restarted only after the problem is identified and corrective action taken. In addition, the deep well disposal system would have automatic shutoff switches for any flow or pressure malfunctions.

In the process areas, instrumentation will provide continuous monitoring for rates and pressures of process fluids and chemicals. In addition, tank levels will be monitored in chemical storage tanks and process tanks. Alarms and the automatic shutdown of systems will be provided for deviations outside of established operating parameters.

The yellowcake drying system will include instruments to self shut down for malfunctions such as heating or vacuum system failures and will alarm if there is an indication that the emission control system is not performing within operational specifications. Checks of the yellowcake drying instrumentation would be made and logged at least hourly during operations. To the extent that Criterion 8 of Appendix A to 10 CFR Part 40 is applicable to ISR operations, its requirements for yellowcake operations will be followed. Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions in the CPP (see Section 5.7 of this SER).

The instrumentation and control systems have been acceptably described for components, including the well fields, well field houses, trunk lines, production circuit, and deep injection disposal wells. Such instrumentation allows for continuous monitoring and control of systems, including total inflow to the plant, total waste flow exiting the plant, tank levels, and the yellowcake dryer. Appropriate alarms and interlocks are part of the instrumentation systems. Each control system is equipped with a backup system that automatically activates in the event of a failure of the operating system or a common-cause failure such as a power failure.

3.3.4 Evaluation Findings

The staff reviewed the proposed instrumentation and control for the Moore Ranch facility in accordance with Section 3.3.3 of the standard review plan. The applicant adequately described the instrumentation and controls that will be used at the Moore Ranch facility. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 3.3.3 of the standard review plan and the requirements of 10 CFR 40.32(c) and 40.41(c).

4. EFFLUENT CONTROL SYSTEMS

4.1 Gaseous and Airborne Particulates

This section discusses the basic design and operation of the gaseous and airborne particulates effluent control systems for ISR facilities. The purpose of the effluent control systems is to prevent and minimize the spread of gaseous and airborne particulate contamination to the atmosphere by the use of emission controls and to ensure compliance for radiation doses limits to the public.

4.1.1 Regulatory Requirements

For gaseous and airborne particulates generated at the Moore Ranch facility, the staff will determine if the applicant has demonstrated compliance with Criterion 8 of Appendix A to 10 CFR Part 40 requires milling operations to be conducted so that all airborne effluent releases are reduced to levels as low as reasonably achievable (ALARA). Criterion 8 is applicable to the Moore Ranch facility only insofar as it requires controlling the hazards of emissions from yellowcake drying and packaging operations there. The applicant must also demonstrate that gaseous and airborne particulates are in compliance with other relevant sections of 10 CFR Part 20 and 10 CFR Part 40.

4.1.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 4.1.3 of the standard review plan.

4.1.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the gaseous and airborne particulates that will be generated at the Moore Ranch facility. Review areas addressed in this section include: identification of major discharge release points, airborne uranium, radon, and effluent monitoring reporting requirements.

4.1.3.1 Major Discharge Release Points

The applicant stated that the main contaminants of concern for air effluents are radon gas (radon-222) and its daughter products and uranium particulates. The applicant has identified four potential pathways for gaseous effluent to be released to unrestricted areas. One set of release points are the doors and windows. Small amounts of contaminants may be released in the plant building during solution spills, filter exchanges, resin exchange, and maintenance activities. The plant building will be equipped with exhaust fans to remove any contaminants that may be released in the building. Fans will be used to circulate air through the facility and discharge the air through these doors and windows to unrestricted areas. A major source of potential discharge of air is from the vacuum dryer system. Production of yellowcake in the final processing of the uranium will be performed in a vacuum dryer in an enclosed system, and the applicant stated that a small amount of particulate emissions will be released into the plant from this system. Air used by the vacuum dryer is discharged into an enclosed area (i.e., yellowcake dryer and packaging area), and not discharged directly to the unrestricted area.

The applicant states that vacuum dryer technology provides an emission control approach to ALARA at the source that exceeds the 95- to 99-percent efficiency of multihearth dryers and is designed to capture virtually all escaping particles. The staff cannot determine from this information if the applicant is monitoring the particulate emissions that may be less than the 1 to 5 percent that is not being capture by the vacuum dryer technology. A plant layout in Figure 3.2-1 and Figure 3.2-2 of the technical report shows the yellowcake dryer and packaging area separated by a wall and doorway from the other sections of the plant. However, the applicant has not demonstrated to the staff whether the air between these two areas communicates with each section of the plant and whether the air effluent from each of these areas is being monitored to unrestricted areas.

A third set of release points are the plant vents. Vents from the individual ion exchange units will be connected to a manifold that will be exhausted outside the plant building through the plant stack(s) or vent(s) to the unrestricted area. A fourth potential pathway for gaseous effluents to be released to unrestricted areas are from non-point sources, such as well fields, which include mud pits during drilling, sample collection in the header houses, and wellhead venting activities.

4.1.3.2 Airborne Uranium

The applicant indicated that the major source of uranium particulates will be from yellowcake processing and drying operations during normal operations. According to the applicant, yellowcake drying will occur in vacuum dryer(s) and that, by design, vacuum dryers do not discharge any uranium when operating. Air particulates will be controlled by a bag house, condenser, vacuum pump, and packaging hood. According to the applicant, the bag house is an air and vapor filtration unit mounted directly above the drying chamber so that dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The bag house will be heated to prevent condensation and will be kept under negative pressure and a water cooled condenser will be located downstream of the bag house.

Uranium particulates that pass through the bag filters will be wetted and entrained in the condensing moisture within this unit. The applicant has referenced NUREG/CR-6733, “A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees,” (Mackin, et al., 2001), and states that the vacuum dryer technology provides an emission control approach to ALARA at the source that exceeds the 95- to 99-percent efficiency of multihearth dryers and is designed to capture virtually all escaping particles. Based on this information, the staff has determined that some particulates may escape from the vacuum dryer.

The applicant stated that the packaging system will be operated on a batch basis. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a bottom port into drums. A level gauge, a weight scale, or other suitable device will be used to determine when a drum is full. Particulate capture will be provided by a sealed hood that fits on the top of the drum, which is vented through a sock filter to the condenser and the vacuum pump system when the yellowcake powder is being transferred.

The vacuum dryer system will include instruments to operate the system automatically and shut it down for malfunctions such as heating or vacuum system failures. Alarms will activate if the emission control system is not performing within operational specifications. To ensure that the emission control system is performing within specified operating conditions, instruments will be installed that will signal an audible alarm if the air pressure (i.e., vacuum level) falls below specified levels. The applicant stated that during dryer operations, the operator will perform and document checks of the differential pressure or vacuum every hour in accordance with Criterion 8 of Appendix A to 10 CFR Part 40.

The applicant has not provided any information regarding the airflow path and the location of the point of discharge of the gaseous effluents from the vacuum dryer and packaging system after the condenser. However, uranium particulates that pass through the bag filters will be wetted and entrained in the condensing unit. Further, air from the packaging unit will be vented through a sock filter to the condenser and the vacuum pump system. This approach with the vacuum dryer meets the requirements of 10 CFR 20.1702, "Use of Other Controls," which requires the use of process or other engineering measures to control the concentrations of radioactive material in the air.

4.1.3.3 Radon

Radon-222 is found in both the pregnant lixiviant conveyed from the well fields into the facility for separation of uranium and in the barren lixiviant sent back to the well fields because the ion exchange columns are pressurized downflow. A separate ventilation system will be installed for all indoor nonsealed process tanks and vessels where radon-222 or process fumes would be expected. Pressurized downflow ion exchange columns will be used to minimize radon releases to the atmosphere by keeping the radon in solution. This system will consist of air ducts or piping systems connected to the top of each of the process tanks and vents from the individual vessels will be connected to a manifold that will be exhausted outside the plant building through the plant stack. The applicant plans to use redundant exhaust fans and will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation systems, controlling any releases that occur inside the vessel. The staff has determined that the applicant has developed sufficient controls for plant equipment to channel potential air radon to the outside atmosphere, and that this will adequately minimize radon exposure to workers in the plant.

To the extent that it applies, Criterion 8 of Appendix A to 10 CFR Part 40 requires milling operations to be conducted so that all airborne effluent releases are reduced to levels ALARA, and the primary means of accomplishing this must be by means of emission controls. The applicant plans to discharge gaseous effluents outside the plant building through the plant stack but has not demonstrated how the gaseous effluents will be monitored and reduced to levels ALARA. The staff has thus determined that the applicant has not demonstrated that dose limits to individual members of the public will meet the 10 CFR 20.1301 and 10 CFR 20.1302 requirements. Therefore, a condition will be included in the license, as discussed in Section 4.1.4 of this SER.

Small amounts of radon-222 may be released in the plant building during solution spills, filter changes, ion exchange resin transfer operations, and maintenance activities. The applicant stated that the design of the fans will be capable of limiting employee exposures with the failure of any single fan. Also, separate ventilation systems may be used as needed for the functional areas within the plant. The work ventilation system will be designed to force air to circulate within the plant process areas. The ventilation system will exhaust outside the building, drawing fresh air in, using four fans with a capacity of 1,132 cubic meters per minute (40,000 cubic feet per minute) each, with two fans located in the ion exchange area, one fan in the resin transfer area, and one fan in the precipitation area. The air exchange rate will be approximately 1.25 air exchanges per hour.

4.1.3.4 Effluent Monitoring Reporting Requirements

To estimate potential annual radiation doses to the public resulting from effluent releases, 10 CFR 40.65 requires a report – every six months -- specifying the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous six months of operations. Potential effluent pathways have been identified in Section 4.1.3.1 of this SER. The applicant has stated that no discrete monitoring locations are available to make representative measurements of radon-222 concentration or flow rates used to estimate semiannual airborne emissions of radon-222. Furthermore, because of these factors, the methods described in Section 7.3 of the technical report will be used to estimate the actual semiannual emissions of radon-222 from the facility as required in 10 CFR 40.65. The applicant states that the parameters from Table 7.3-1 of the technical report coupled with updated parameters in Table 4.1-1 below to account for actual operational information will be used to calculate the semiannual emission estimates. These updated parameters will be applied to Equations 1 thru 6 of Section 7.3.3 to calculate the semiannual releases as required in 10 CFR 40.65.

Table 4.1-1 Operational Parameters Used to Estimate Semiannual Radon-222 Emissions

Parameter	Projected Value	Unit
Mined Area	Determine based on actual minded area for the reporting period	$m^2\ y^{-1}$
Average Lixiviant Flow	Determine based on actual lixiviant flow for the reporting period	$L\ m^{-1}$
Average Restoration Flow	Determine based on actual restoration flow for the reporting period	$L\ m^{-1}$
Operating days per year	Determine based on actual operating days for the reporting period	days
Number of mud pits generated per year	Determine based on actual number of mud pits generated for the reporting period	Sum of mud pits
Storage time in mud pits	Determine based on actual storage time for the reporting period	days

Table 4.1-1 Operational Parameters Used to Estimate Semiannual Radon-222 Emissions		
Number of Resin Transfers per day	Determine based on actual number of resin transfers for the reporting period	Sum of resin transfers

Table 4.1-2 identifies the parameters for which site specific values have not been measured. The applicant further stated that in these cases, default or typical parameters as described in Regulatory Guide 3.59 (NRC, 1987) will be used.

Table 4.1-2 Default Based Parameters Used to Estimate Radon-222 Emissions			
Parameter	**Value**	**Unit**	**Source**
Ore radium-226 Concentration	282	pCi/g	RG 3.59
Radon-222 emanating power	0.2	Unitless	RG 3.59

Regulatory Guide 3.59 provides guidance to applicants and licensees in preparing environmental reports and environmental impact statements and to the staff in reviewing those reports. Regulatory Guide 3.59 further states in the Section B, that when environmental monitoring data are not yet available (as in the case of the licensing of new facilities or authorizing of significant modifications to existing ones), predictive models are used to evaluate the potential impacts of the prospective new operations. The staff notes that the methods described in Regulatory Guide 3.59 are a predictive model for estimating airborne emissions when actual data is not available. The staff has determined that the applicant is proposing a hybrid method for estimating radioactive airborne source terms to determine the quantity of radioactive material released in gaseous effluents to unrestricted areas. The hybrid model proposed by the applicant includes actual operating data as described in Table 4.1-1 and default values as described in Table 4.1-2.

The release or emission rate from a facility is the quantity of material released per unit time. In general, the release rate is a function of the radioactive material concentration and the flow rate. Other parameters can be used to better define the release rate. The applicant proposes to use actual measurements of the flow rate during operations but only estimating the radioactive material concentration based on a radium-226 ore concentration. The staff cannot validate the uncertainty that may be associated with the average radium-226 ore concentration during actual operations and, therefore, does not agree with this approach. The staff has determined that measurements from monitoring would provide a more accurate value for estimating the quantity of radioactive material released from effluent to unrestricted areas.

In summary, the staff cannot determine if the applicant will monitor the air effluent to unrestricted areas to ensure compliance with 10 CFR 20.1101(d) and 10 CFR 20.1302(a). Therefore, the staff will include a condition addressing this issue in the license. This license condition is presented in Section 4.1.4 of this SER.

4.1.4 Evaluation Findings

The staff reviewed the proposed effluent control systems for gaseous and airborne particulates for the Moore Ranch facility in accordance with Section 4.1.3 of the standard review plan. The applicant described the release points, sources of both uranium and radon at the Moore Ranch facility, and the effluent monitoring reporting criteria. However, the applicant has not proposed an acceptable method for monitoring air effluent to unrestricted areas. Therefore, the staff is imposing the following license condition to ensure that an acceptable method is developed to ensure that proper effluent monitoring is in place prior to the commencement of operations:

> The licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall:
>
> A. Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.
>
> B. Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302.
>
> C. Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.
>
> D. Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.

Based upon the review conducted by the staff as indicated in above, the information provided in the application as supplemented by the information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of Section 4.1.3 of the standard review plan and the requirements of 10 CFR Part 20 and 40.

4.1.5 References

Mackin, P.C., D. Daruwalla, J. Winterle, M. Smith, and D.A. Pickett, 2001. NUREG/CR–6733, “A Baseline Risk-Informed Performance-Based Approach for *In-Situ* Leach Uranium Extraction Licensees.” Washington, DC: NRC, September 2001.

NRC, 1987. “Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations,” Regulatory Guide 3.59. Washington, DC: March 1987.

4.2 <u>Liquid and Solid Effluents</u>

4.2.1 Regulatory Requirements

For liquid effluents generated at the Moore Ranch facility, the staff will determine if the applicant has demonstrated compliance with 10 CFR 20.1301, 20.2002, and 20.2007. For solid effluents generated at the Moore Ranch facility, the staff will determine if the applicant demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 2.

4.2.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 4.2.3 of the standard review plan.

4.2.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the liquid and solid effluents that will be generated at the Moore Ranch facility. Review areas addressed in this section include: liquid byproduct material, other liquid waste, solid byproduct material, other solid waste, and hazardous waste.

4.2.3.1 Liquids

Other than sanitary sewage, liquid waste generated by the Moore Ranch facility will be byproduct material, in the form of liquid waste from production bleed, liquid waste from restoration activities (RO brine), and miscellaneous plant wastewater.

4.2.3.1.1 Liquid Byproduct Material

Liquid wastes generated during the uranium recovery process are byproduct material. This includes liquids from maintaining a production bleed, RO brine, plant wastewater (including liquids generated during decontamination of equipment), and accidental releases during operations. The applicant plans on disposing its liquid byproduct material in deep disposal wells onsite. Use of this disposal method requires an underground injection control (UIC) permit for a Class I well from the WDEQ Water Quality Division. The applicant submitted a request for a UIC permit from WDEQ on August 17, 2009.

Use of deep disposal wells also requires a staff finding that the requirements of 10 CFR 20.1301 and 20.2002 are met. An application seeking approval for a waste disposal method under 10 CFR 20.2002 should include:

- A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner and conditions of waste disposal.

- An analysis and evaluation of pertinent information on the nature of the environment.
- The nature and location of other potentially affected licensed and unlicensed facilities.
- Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits of 10 CFR 20.1301.

The applicant indicates that the normal operational waste stream would be nonhazardous under the Resource Conservation and Recovery Act (see Table 4.2-1 below) and would range in volume between 190.76 Lpm (50.4 gpm) during normal operations and as much as 340.65 Lpm (90 gpm) during restoration.

Table 4.2-1 Summary of Anticipated Liquid 11e.(2) Water Quality Parameters

Chemical Species	Minimum (mg/L)	Maximum (mg/L)
pH	6	9
Ammonia as nitrogen	50	500
Sodium	150	3,000
Calcium	200	1,000
Potassium	10	1,000
Bicarbonate as HCO_3	1,500	4,000
Carbonate as CO_3	0	500
Sulfate	80	2,000
Chloride	200	4,000
Uranium as U_3O_8	1	15
Radium-226 (pCi/L)	300	3,000
TDS	400	15,000

The application for a Class I UIC permit included two options as summarized in Table 4.2-2.

Table 4.2-2 Summary of Deep Injection Well Options

Formation	Target Injection Depth (m) [ft]	Anticipated Injection Capacity per Well Lpm [gpm]	Total Number of Wells Required
Lance Formation	1,128 to 2,286 [3,700 to 7,500]	473.13 [125]	2
Teckla/Teapot/Parkman	2,413 to 2,929 [7,916 to 9,610]	113.55 [30]	4

In each case, there would be sufficient capacity to meet the anticipated maximum disposal rate of 340.65 Lpm (90 gpm) in the event that a well becomes inoperable. The applicant would sample the waste stream quarterly or whenever a process change occurs that could significantly alter the composition of the waste stream. Sampling data would be submitted to WDEQ quarterly. The applicant considers deep well disposal preferable to other forms of handling liquid byproduct material (evaporation ponds and land application) because it better isolates the material from human contact, and it reduces the required disposal volume of solid byproduct material.

Class I wells are used to inject wastes into deep, isolated aquifers. The applicant provided a discussion of the construction techniques used for Class I deep injection wells in Wyoming. Deep disposal wells are constructed with several layers of materials that provide redundant layers of protection to minimize the possibility of liquids contaminating protected aquifers. Additionally, operators are required to demonstrate that no significant leaks exist prior to operation through a mechanical integrity test (MIT) and every five years after for the life of operation of the well. Operators are required to monitor several parameters, such as injection pressure, that would indicate potential failure of a deep injection well. This data is summarized in reports that are available for NRC review during inspections of the facility.

Section 2.3 of this SER discusses the geology of the Moore Ranch facility; Figure 2.3-1 shows the regional stratigraphy of the PRB from the ground surface to the Lance Formation. The proposed license area primarily consists of rangeland and pastureland. Major deposits of CBM are located within and around the proposed license area. The nearest licensed facility is approximately 20 km (12.32 miles) west of the Moore Ranch facility.

The staff performed a dose analyses for the direct radiation pathway for the Moore Ranch deep well disposal method using Microshield version 5.05. Although the applicant estimated that approximately eight Curies of radium-226 would reside in the deep well after 12.5 years of operation, staff calculated the dose rate based on a conservative value of 100 Curies of radium-226 and 100 Curies of bismuth-214 (ingrowth from radium-226) injected to a subsurface level of 1,127 m (3700 ft) with a soil density of 1.76 grams per cubic centimeter (g/cm^3) (110 pounds per cubic foot [lb/ft^3]) (Lindeburg, 2003). The dose analyses resulted in a calculated dose rate at a receptor point three feet directly above the deep well injection point to be 1.897E-24 mR/Hr. This calculated dose rate is extremely small and cannot be measured by conventional radiation measuring devices used today. Furthermore, this calculated dose rate could not be differentiated from background exposure levels. Integrating this dose rate over a one year period would result in an annual dose that would be below the dose limits in 10 CFR 20. The staff has determined that the uranium inventory was not included in this dose analyses because natural uranium by itself is not a significant gamma dose contributor and the uranium inventory value would not significantly alter the final calculated dose rate for the direct radiation pathway.

Note that in order for a UIC permit to be issued by WDEQ, there can be no exposure pathway through drinking water. The UIC review process verifies that the injected fluids are isolated from the accessible environment, including potential sources of drinking water.

For its deep well disposal plans, the applicant has shown that it would be in compliance with the NRC regulations found in 10 CFR 20.2002, “Method for Obtaining Approval of Proposed Disposal Procedures,” for the alternate disposal of byproduct material as well as the dose limits in 10 CFR 20.1301. The applicant has described the environment and the waste composition and has analyzed potential radiologic doses through feasible exposure pathways and demonstrated that liquid waste disposal operations would result in doses that are ALARA.

The applicant’s disposal plans for liquid byproduct material are contingent upon the approval of the State of Wyoming. Approval by the State of Wyoming demonstrates compliance with 10 CFR 20.2007 which requires that disposal by injection in deep wells must also meet any other applicable Federal, State, and local government regulations pertaining to deep well injection. As part of the standard conditions, the applicant will be required to submit a copy of the approved permit to the NRC before injection of lixiviant can commence. Additionally, a license condition identifying the approved liquid effluent disposal methods will be included in the license issued to the applicant. This license condition is presented in Section 4.2.4 of this SER.

Liquid byproduct material may be generated as a result of accidental releases such as spills from well fields, the CPP, or deep disposal well operations. The only instance in which the well field features could contribute to contamination would be in the event of a release of injection or recovery solutions due to pipe or well failure. However, the piping would be checked for leaks through a visual inspection during construction or a pressure test prior to operation. Additionally, the flows would be at a relatively low pressure and could be stopped quickly, well field header houses would be equipped with wet alarms for early detection of leaks, and piping from the well fields would generally be buried to minimize the possibility of an accident. Additional measures the applicant has committed to implementing to identify well field leaks are described in Section 3.1.3.2 of this SER.

Regarding the CPP, spills could result from a release of process chemicals from bulk storage tanks, piping failure, or a process storage tank failure. The design of the CPP will include a concrete curb built around the entire process building. It would be designed to contain the entire contents of the largest tank within the building in the event of a rupture and also to contain the operating volumes of the two largest tanks in the unlikely event that their simultaneous failure were to occur. Any spill of plant fluids would be contained by this curb, drained to the sump system, and pumped to the liquid byproduct material disposal system. Standard operating procedures and employee training will be in place for emergency situations, including spills in the processing plant.

The design of the deep well pump houses and wellheads would be such that any release of liquids would be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building would be contained and managed as appropriate. The wells would be equipped with a high-level shutoff switch on the injection tubing to prevent operation of the pumps at pressures greater than the limiting surface injection pressure. In addition, the wells would be equipped with a low-pressure shutdown switch on the surface injection line that would deactivate the injection pump in the event of a surface leak. Lines leading to the deep well would be instrumented for leak detection and automatic shutoff.

4.2.3.1.2 Other Liquid Waste

Domestic liquid wastes from restrooms and lunch facilities will also be generated at the Moore Ranch facility. These wastes are not byproduct material and will be disposed of via a septic system that meets the requirements of the State of Wyoming.

4.2.3.2 Solids

The disposal of solid wastes generated by operation of the Moore Ranch facility is discussed below. Section 6.3 of this SER discusses the processes the applicant plans to use when removing structures and equipment from the Moore Ranch facility.

4.2.3.2.1 Solid Byproduct Material

Examples of solid byproduct material include items such as spent ion exchange resin, resin fines, contaminated pumps and pipes, contaminated building materials, filters, protective clothing, worn parts, and soil contaminated by spills of process solutions. Solid byproduct material would be collected; stored within the CPP in appropriate containers and, when full, moved to 15.28 cubic meter (20 cubic yard) rolloff containers for eventual shipment to a licensed disposal facility. During storage, the containers would be located within a restricted area. Access to the solid byproduct storage facility would be controlled through the use of security fencing, locked gates, and proper posting as a restricted area.

The applicant has committed to disposing its solid byproduct material (expected to average about 75 cubic meters [100 cubic yards per year]) at a licensed disposal site and has indicated that a disposal agreement will be in place prior to the start of operations. This approach is consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 2. A condition addressing disposal of solid byproduct material will be included in the license issued to the applicant. This condition can be found in Section 4.2.4 of this SER.

Surface and subsurface soil at the site occasionally may become contaminated by leaks and spills of process solutions. Although the specific concentration of radionuclides in these process solutions is expected to be low, contaminant concentrations in the soil may exceed regulatory limits if the solution is confined to a small area or if multiple spills occur in the same location. The affected soil would be surveyed for contamination, and the area of the spill documented as required by the NRC. Contamination in concentrations exceeding regulatory requirements may be removed immediately, or may be left in place and documented for future clean up (if necessary) during the decommissioning phase, consistent with 10 CFR 40.60. Soil cleanup and survey methods would be designed to meet current NRC requirements and would be described in the decommissioning plan required by the a license condition (see Section 6.2 of this SER).

4.2.3.2.2 Other Solid Waste

The applicant estimates that approximately 1,530 cubic meters (2,000 cubic yards) of solid waste that is not byproduct material will be generated at the Moore Ranch facility each year. Such waste includes used equipment, debris, and sanitary waste. These materials will be collected on-site and disposed of at the nearest available sanitary landfill, as authorized by State and/or local authorities.

4.2.3.2.3 Hazardous Waste

The applicant identified waste oil and universal hazardous wastes, such as used batteries, as the main hazardous wastes that would be generated at the Moore Ranch facility. Hazardous waste is expected to be generated at a rate of less than 100 kg (220 pounds) per month. It is likely that the Moore Ranch facility can be considered a Conditionally Exempt Small Quantity Generator under the Resource Conservation and Recovery Act (RCRA). In the event that the applicant generates hazardous wastes at a faster rate, it may need to apply for additional permits from WDEQ – which has delegated authority under RCRA to regulate hazardous waste. The NRC does not regulate hazardous waste.

4.2.4 Evaluation Findings

The staff reviewed the aspects of solid and liquid effluents of the proposed Moore Ranch facility in accordance with Section 4.2.3 of the standard review plan. The applicant described the solid and liquid effluents that would be generated at the facility. An acceptable disposal method (i.e., deep disposal wells) is identified for liquid byproduct material, pending approval through a WDEQ permit, and the disposal method would be of sufficient capacity to handle liquids from production and restoration efforts. As the safe disposal of liquid byproduct material is an important component of operations at the facility, the staff is imposing the following license condition to ensure proper disposal during operations:

> All liquid effluents from process buildings and other process waste streams, with the exception of sanitary wastes, shall be returned to the process circuit or disposed of as allowed by NRC regulations. Additionally, the licensee is authorized to dispose of process solutions, injection bleed, and restoration brine using deep well injection, as permitted by WDEQ and described in the approved license application.
>
> The licensee shall maintain a record of the volumes of solution disposed in each disposal well and submit this information in the annual monitoring report.

By providing information on the health and safety impacts of system failures and identifying preventive measures and mitigation for such occurrences, the applicant has shown that effluent control systems, procedures, and required training will limit radiation exposures under both normal and accident conditions. The applicant has committed to maintaining occupational radiation doses and doses to the general public at ALARA levels and within applicable 10 CFR Part 20 exposure limits.

Although it has committed to securing and providing to the NRC its disposal agreement for solid byproduct material, the applicant does not yet have a plan in place for the disposal of these materials that will be generated by its facility. Therefore, the staff is imposing the following license so that an agreement is in place prior to operations:

> The licensee shall submit a copy of the solid byproduct material disposal agreement to the NRC.
>
> The licensee shall dispose of solid byproduct material from the Moore Ranch operations at a site that is authorized by the NRC or an NRC Agreement State to receive byproduct material. The licensee's approved solid byproduct material disposal agreement must be maintained on site. In the event that the agreement expires or is terminated, the licensee shall notify the NRC within seven working days after the date of expiration or termination. A new agreement shall be submitted for NRC approval within 90 days after expiration or termination, or the licensee will be prohibited from further lixiviant injection.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of Section 4.2.3 of the standard review plan and the requirements of 10 CFR Part 20 and 40.

4.2.5 Reference

Lindeburg, M.R. 2003. Civil Engineering Reference Manual for the PE Exam, Ninth Edition, pg. 35-8

5. OPERATIONS

5.1 Corporate Organization and Administrative Procedures

5.1.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed corporate organization for the Moore Ranch facility are consistent with the requirements of 10 CFR 40.32(b) which requires that the applicant is qualified through training and experience to use source materials.

5.1.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 5.1.3 of the standard review plan.

5.1.3 Staff Review and Analysis

The applicant's organizational structure flows vertically downward from its board of directors. The management portion of the applicant's corporate organization includes its board of directors, Chief Operating Officer, Executive Vice President (EVP), Senior Vice President for ISR Operations (Sr. VP), Director of Environmental and Regulatory Affairs, Manager of Wyoming Operations (MWO), and Manager of Wyoming Environmental and Regulatory Affairs.

The board of directors is ultimately responsible for radiation and environmental compliance and provides operational direction to the EVP through the Chief Operating Officer. The EVP is responsible for interpreting and acting upon the policy and procedural decisions of board of directors. The EVP is directly responsible for ensuring that the applicant's personnel comply with industrial safety, radiation safety, and environmental protection programs. The EVP also has the responsibility for maintaining compliance with all regulatory license conditions, regulations, and reporting requirements.

The Sr. VP reports directly to the EVP and is responsible for managing all company ISR operations, including the radiation safety and environmental compliance programs at ISR facilities. Both the EVP and the Sr. VP have the responsibility and the authority to immediately terminate any activity that is determined to be a threat to employees, public health, or the environment or that is potentially in violation of State or Federal regulations. The Director of Environmental and Regulatory Affairs also reports directly to the EVP. This position is responsible for the development and review of radiological, health and safety, and environmental protection programs and for ensuring that company operations comply with all applicable regulatory requirements.

The MWO and the Manager of Wyoming Environmental and Regulatory Affairs both report directly to the Sr. VP. The MWO is responsible for all ISR uranium production activity at the Wyoming project sites, and all site operations, maintenance, construction, environmental health and safety, and support groups report directly to the MWO. The Manager of Wyoming Environmental and Regulatory Affairs is responsible for all radiation protection, health and safety, and environmental programs at ISR operations in the State of Wyoming and for ensuring that the applicant complies with all applicable regulatory requirements. The Manager of Wyoming Environmental and Regulatory Affairs also advises the radiation safety officer (RSO) to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements.

The mine manager is responsible for all uranium production activity at the Moore Ranch facility. All site operations, maintenance, construction, environmental health and safety, and support groups report directly to the mine manager. The operations superintendent, construction superintendent, and chief geologist are the site department supervisors who report directly to the mine manager.

The RSO is responsible for the development, administration, and enforcement of all radiation safety programs and is also designated the Quality Assurance (QA) manager. The RSO works with supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect radiological safety and to ensure that established programs are maintained. The RSO has no production-related responsibilities, and although the RSO reports directly to the mine manager, the mine manager cannot unilaterally override a decision of the RSO to suspend, postpone, or modify an activity. This is consistent with the responsibilities and authority presented in Regulatory Position 1.2 of Regulatory Guide 8.31 (NRC, 2002).

5.1.4 Evaluation Findings

The staff reviewed the corporate organization of the proposed Moore Ranch facility in accordance with Section 5.1.3 of the standard review plan. The applicant defined management responsibilities and authority at each level. Proposed integration among groups that support operation and maintenance of the facility is portrayed in the organizational management structure diagram and is adequate. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the acceptance criteria of Section 5.1.3 of the standard review plan and the requirements of 10 CFR 40.32(b).

5.1.5 Reference

NRC, 2002. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

5.2 Management Control Program

5.2.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed management control program for the Moore Ranch facility is consistent with the requirements of 10 CFR Part 20, Subpart L, Subpart M and with 10 CFR 40.61. The staff will also determine if the applicant has demonstrated that the health and safety requirements of 10 CFR 40.32(c) will be met.

5.2.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.2.3 of the standard review plan.

5.2.3 Staff Review and Analysis

The applicant will develop written operating procedures for all process activities involving radioactive materials at the Moore Ranch facility and for nonprocess activities, including environmental monitoring, radiological protection, emergency actions, and industrial safety. All procedures involving radiation safety will be reviewed by the RSO, who will also perform an annual documented review of the operating procedures. Radiation work permits will be issued for activities of a nonroutine nature with the potential for significant exposure to radioactive materials and for which no operating procedure exists.

The applicant will develop instructions for maintenance, control, and retention of records that will be consistent with Subpart L, "Records," of 10 CFR Part 20 and with 10 CFR 40.61, "Records." The RSO will be responsible for ensuring that the required records are maintained and controlled. Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, transportation accidents, and information pertinent to decommissioning and reclamation (e.g., spills, excursions, contamination events, site and aquifer characterization, and background levels) will be maintained on site and available for NRC inspection until license termination. Spills, excursions, and other contamination events at ISR facilities may not be captured by the Part 20 and Part 40 reporting requirements, but such events nonetheless need to be tracked to adequately ensure that the health and safety requirements of 10 CFR 40.32(c) will be met. Therefore, NRC notification and documentation of such events will be required through the license condition presented in Section 5.2.4 of this SER.

The applicant has requested an exemption from the requirements of 10 CFR 20.1902(e). This regulation requires that each area or room in which licensed material in excess of 10 times the quantity specified in Appendix C to Part 20 is used or stored be posted. The applicant has proposed an alternative approach in which all entrances to the facility are posted with the words, "Caution: Any Area Within This Facility May Contain Radioactive Material." This approach is consistent with the standard review plan and is therefore acceptable to the staff.

The applicant has requested a performance-based license and has provided for the establishment of a Safety and Environmental Review Panel (SERP). The SERP would consist of a minimum of three individuals. One member of the SERP would have expertise in management and would be responsible for managerial and financial approval for changes, one member would have expertise in operations and/or construction and would have expertise in implementation of any changes, and one member would be the RSO, or equivalent. Others may be added to the SERP, as appropriate, to address specific technical aspects of the change, experiment, or test. The SERP would be responsible for monitoring any proposed change in the facility or process, making changes in procedures, and conducting tests or experiments not contained in the current NRC license. As such, the SERP would be responsible for ensuring that any such changes result in no degradation in the essential safety or environmental commitments of the applicant. On an annual basis, the applicant would submit a report to the NRC that describes all changes, tests, or experiments made pursuant to the performance-based license, including a summary of the SERP evaluation of each change.

5.2.4 Evaluation Findings

The staff reviewed the management control program of the proposed Moore Ranch facility in accordance with Section 5.2.3 of the standard review plan. The applicant will develop operating procedures for all activities involving radioactive materials. Processes associated with the SERP have been identified. The applicant has also described maintenance, control, and retention of records at the facility. The staff notes that spills, excursions, and other contamination events at ISR facilities may not be captured by the Part 20 and Part 40 reporting requirements, but such events nonetheless need to be tracked to adequately ensure that the health and safety requirements of 10 CFR 40.32 will be met. Therefore, the staff is imposing the following license condition to ensure that these activities are reported and documented during operation of the facility:

> Until license termination, the licensee shall maintain documentation on unplanned releases of source or byproduct materials (including process solutions) and process chemicals. Documented information shall include, but not be limited to: date, spill volume, total activity of each radionuclide released, radiological survey results, soil sample results (if taken), corrective actions, results of post remediation surveys (if taken), a map showing the spill location and the impacted area, and an evaluation of NRC reporting criteria.
>
> The licensee shall have procedures which will evaluate the consequences of the spill or incident/event against 10 CFR 20, Subpart M, and 10 CFR 40.60 reporting criteria. If the criteria are met, then report to the NRC Operations Center as required.
>
> If the licensee is required to report any well field excursions and spills of source, byproduct material, and process chemicals that may have an impact on the environment, or any other incidents/events, to any State or other Federal agency, a report shall be made to the NRC Headquarters Project Manager by telephone or electronic mail (e-mail) within 24 hours. This notification shall be followed, within 30 days of the notification, by submittal of a written report to NRC Headquarters, as per LC 9.3, detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved.

The applicant has proposed an alternative method of meeting the posting requirements of 10 CFR 20.1902(e) that is consistent with the standard review plan. A condition related to this exemption will be included in the license issued to the applicant.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by additional notification and documentation in accordance with the noted license condition meet the applicable acceptance criteria of Section 5.2.3 of the standard review plan and the requirements of 10 CFR Part 20, Subpart L, Subpart M, 10 CFR 40.32(c) and 10 CFR 40.61.

5.3 Management Audit and Inspection Program

5.3.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed management audit and inspection program for the Moore Ranch facility meet the requirements of 10 CFR 40 .32 (b) and (c).

5.3.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 5.3.3 of the standard review plan.

5.3.3 Staff Review and Analysis

Regulatory Guide 8.31 suggests that a daily inspection be conducted by the RSO or designated health physics technician (HPT) and that a weekly inspection be conducted by the RSO and the facility foreman. In accordance with this guidance, the applicant stated that the RSO, the radiation safety technician, or a qualified designee will conduct a daily walkthrough inspection of the plant. A weekly inspection will be conducted by the RSO and the MWO, or their designees, of all facility areas to observe general radiation control practices and review required changes in procedures and equipment. The RSO will prepare a monthly written summary of radiological activities at the Moore Ranch facility with recommendations for corrective actions and improvements.

10 CFR 40.32(b) requires in relevant part that an applicant show that its personnel have had sufficient training to ensure that any source material will be used in a safe manner. The applicant has indicated that qualified designees will receive specific training for conducting daily inspections. The training for the qualified designee will address specific procedural requirements contained in the standard operating procedures and related documents. The applicant stated that the training will be documented in the individual's training records. The staff does not concur that this training will be sufficient to meet 10 CFR 40.32(b). The staff has determined that a license condition is warranted to identify the training required for the qualified designee. The license condition is presented in Section 5.3.4 of this SER.

10 CFR 40.32(c) requires in relevant part that an applicant show that its procedures will ensure adequate protection. In this regard, the applicant will conduct annual audits of the radiation safety and ALARA programs to provide assurance that all radiation health protection procedures and license condition requirements are being properly implemented. The audit will be conducted in accordance with recommendations in Regulatory Guide 8.31. The ALARA audit report will be submitted to, and reviewed by, the Sr. VP and the MWO. In addition, an audit of the QA/quality control (QC) program will conducted annually and documented with the ALARA audit.

5.3.4 Evaluation Findings

The staff reviewed the management audit and inspection program of the proposed Moore Ranch facility in accordance with Section 5.3.3 of the standard review plan. The applicant described the various aspects of daily and weekly inspections that will be performed by the applicant's staff. The applicant described the personnel that will perform these inspections; however, the applicant has not adequately identified personnel that will perform daily inspections in the absence of the radiation safety staff. Because the applicant has not provided this information, the staff is imposing the following license condition to ensure that a properly qualified person performs daily inspections in the absence of the radiation safety staff:

> The licensee will identify a qualified designee(s) to perform daily inspections in the absence of the RSO or HPT. The qualified designee(s) will have health physics training, and such training program will be specified by the licensee. Furthermore, the qualified designee(s) may perform daily inspections no more than two days per week, and those reports will be reviewed by health physics staff within 48 hours of completing the report. The licensee will also have a health physics staff member available by telephone while the qualified designee(s) is performing the daily inspections.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented with the noted license condition meet the applicable acceptance criteria of Section 5.3.3 of the standard review plan and the requirements of 10 CFR 40.32(d).

5.4 Qualifications for Personnel Conducting the Radiation Safety Program

5.4.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the personnel conducting the radiation safety program meet the requirements of 10 CFR Part 20.1101 and 10 CFR 40.32(b).

5.4.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.4.3 of the standard review plan. Regulatory Guide 8.31 provides recommendations for technical qualifications of radiation safety staff.

5.4.3 Staff Review and Analysis

5.4.3.1 Radiation Safety Officer

The applicant identified the minimum qualifications for the RSO to include a bachelor's degree or an associate's degree in a physical science, industrial hygiene, or engineering from an accredited college or university, or an equivalent combination of training and relevant experience in uranium milling/solution extraction radiation protection. Regulatory Position 2.4.1

of Regulatory Guide 8.31 states that 2 years of relevant experience are generally considered equivalent to 1 year of academic study. The applicant stated that an RSO candidate with an associate's degree will also be required to have an additional 4 years of relevant experience to meet the educational requirement.

Other minimum qualifications for the RSO identified by the applicant include a minimum of 1 year of work experience relevant to uranium milling/solution milling operations in applied health physics, radiation protection, industrial hygiene, or similar work and at least 4 weeks of specialized training in health physics applicable to uranium milling/solution extraction operations. An RSO must also possess a thorough knowledge of the proper application and use of all health physics equipment used in the operations, the procedures used in radiological sampling and monitoring, methods used to calculate personnel exposures to uranium and its daughters, and a thorough understanding of the solution milling process and equipment used and how hazards are generated and controlled during the process. The staff has determined that the qualifications are consistent with Regulatory Guide 8.31 and, therefore, finds them acceptable.

5.4.3.2 Health Physics Technician

The applicant identified the minimum qualifications for the HPT as one of the following combinations of education, training, and experience. One set of qualifications would include an associate's degree or 2 or more years of study in the physical sciences, engineering, or a health-related field; at least a total of 4 weeks of generalized training in radiation protection applicable to uranium milling/solution extraction operations; and 1 year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium milling/solution extraction operation.

The applicant states that a high school diploma, a total of 3 months of specialized training in radiation protection relevant to uranium milling/solution extraction of which up to 1 month may be on-the-job training, and 2 years of relevant work experience in applied radiation protection would be an alternative set of qualifications for an HPT. The staff has determined that the qualifications are consistent with Regulatory Guide 8.31 and, therefore, finds them acceptable.

5.4.4 Evaluation Findings

The staff reviewed the qualification requirements of the personnel conducting the radiation safety program at the proposed Moore Ranch facility in accordance with Section 5.4.3 of the standard review plan. The applicant described qualifications that are consistent with Regulatory Guide 8.31. Therefore, based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.4.3 of the standard review plan and the requirements of 10 CFR 20.1101 and 10 CFR 40.32(b).

5.5 Radiation Safety Training

5.5.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed radiation safety training program for the Moore Ranch facility meets the requirements of 10 CFR 20.1101 and 40.32(b).

5.5.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.5.3 of the standard review plan.

5.5.3 Staff Review and Analysis

The applicant stated that it will administer the training program in accordance with Regulatory Guide 8.13 (NRC, 1999); Regulatory Guide 8.29 (NRC, 1996); and Regulatory Guide 8.31. The applicant stated that all new workers, including supervisors, will be given instruction on the health and safety aspects of the specific jobs that they will perform. Training topics will include fundamentals of health protection, facility-provided protection, health protection measurements, radiation protection regulations, and emergency procedures. Each worker will be given a written test, including annual refresher training, and training records will be kept until license termination. The HPTs will also receive on-the-job training.

The applicant stated that visitors not receiving training will be escorted by site personnel properly trained and knowledgeable about the hazards of the facility. Contractors having work assignments at the facility will be given appropriate radiation safety training. Contractors performing work on heavily contaminated equipment will receive the same training normally required of site workers. The applicant has proposed a training program that is consistent with the applicable Regulatory Guides; therefore, the staff finds the radiation safety training program acceptable.

5.5.4 Evaluation Findings

The staff reviewed the radiation safety training aspects of the proposed Moore Ranch facility in accordance with Section 5.5.3 of the standard review plan. The applicant proposed a radiation safety training program for the Moore Ranch facility that is consistent with the guidance contained in Regulatory Guide 8.31, Regulatory Guide 8.13, and Regulatory Guide 8.29. Specifically, the content of the training material, the testing, the on-the-job training, and the extent and frequency of retraining are acceptable. Radiation safety instructions for employees are acceptable. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.5.3 of the standard review plan and the requirements of 10 CFR 20.1101 and 40.32(b).

5.5.5 References

NRC, 1996. "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1. Washington, DC: February 1996.

NRC, 1999. "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Revision 3. Washington, DC: June 1999.

5.6 Security

5.6.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed security measures for the Moore Ranch facility meet the requirements of 10 CFR 20, Subpart I.

5.6.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.6.3 of the standard review plan.

5.6.3 Staff Review and Analysis

According to the applicant, the Moore Ranch facility active extraction areas would be controlled with fences and appropriate signs. All areas where source or byproduct material is to be handled would be fenced. The main access road would have a locking gate, and staff would be on duty at the facility at all times. Plant operators would perform an inspection at the beginning of each shift to ensure proper storage and security of licensed material. In its transportation of hazardous materials, the applicant will meet all U.S. Department of Transportation (DOT) requirements for packaging, shipping, and security.

5.6.4 Evaluation Findings

The staff reviewed the security aspects of the proposed Moore Ranch facility in accordance with Section 5.6.3 of the standard review plan. The applicant described security measures for stored material and control measures for material not in storage. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.6.3 of the standard review plan and the requirements of 10 CFR Part 20, Subpart I.

5.7 Radiation Safety Controls and Monitoring

5.7.1 Standards

This section describes the techniques the applicant proposes to use to monitor and minimize radiation exposures. As part of its assessment, the staff will present certain standards with which the applicant must comply. These standards are listed below and referenced throughout the remaining portion of Section 5.7. These standards are identified in the following:

Guidance

- Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment,” Revision 2, issued July 2007
- Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data,” Revision 2, issued November 2005
- Regulatory Guide 8.15, “Acceptable Programs for Respiratory Protection,” Revision 1, issued October 1999
- Regulatory Guide 8.22, “Bioassay at Uranium Mills,” Revision 1, issued August 1988
- Regulatory Guide 8.25, “Air Sampling in the Workplace,” Revision 1, issued June 1992
- Regulatory Guide 8.30, “Health Physics Surveys in Uranium Recovery Facilities,” Revision 1, issued May 2002
- Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” May 2002
- Regulatory Guide 8.34, “Monitoring Criteria and Methods To Calculate Occupational Radiation Doses,” Revision 0, issued July 1992
- Regulatory Guide 8.36, “Radiation Dose to the Embryo/Fetus,” Revision 0, issued July 1992

Regulations

- 10 CFR 20, Subpart C – Occupational Dose Limits: §§ 20.1201 – 20.1208
- 10 CFR 20, Subpart F – Surveys and Monitoring: §§ 20.1501 and 20.1502
- 10 CFR 20, Subpart L – Records: §§ 20.2101 – 20.2110
- 10 CFR 20, Subpart M – Reports: §§ 20.2201 – 20.2207

Numerical Standards

- 10 CFR 20, Appendix B, Table 1 - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage DAC, Natural Uranium Class W: - 3.0E-10 microcuries per milliliter (µCi/mL) DAC Natural Uranium Class D: - 5E -10 µCi/mL
- 10 CFR 20.1201 – Total Effective Dose Equivalent (TEDE): 5 rem, or the sum of the DDE and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem
- 10 CFR 20.1201 - Annual Limit to the Eye Lens: 15 rem
- 10 CFR 20.1201 - Annual Limits to the Skin of the Whole Body and Extremity 50 rem
- 10 CFR 20.1201(e) – 10 mg per week limit on intake of soluble uranium

5.7.2 Effluent Control Techniques

During the course of the review, the staff determined that areas of review and acceptance criteria presented in Section 5.7.1 of the standard review plan, which addresses effluent control techniques, were covered in other sections of this SER. The staff’s review of the applicant’s proposed effluent control techniques can be found in Section 4.1 and Section 5.7.8 of this SER and are therefore not discussed here.

5.7.3 External Radiation Exposure Monitoring Program

5.7.3.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed external radiation exposure monitoring program for the Moore Ranch facility meets the requirements of 10 CFR Part 20, Subpart C, 10 CFR 20.1501(c), 10 CFR 20.1502, 10 CFR Part 20, Subpart L, 10 CFR Part 20, Subpart M, and 10 CFR 40.61.

5.7.3.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.7.2.3 of the standard review plan. Regulatory Guides 8.30 (NRC, 2002) and 8.31 provide guidance on how compliance with the regulations can be demonstrated.

5.7.3.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the external radiation exposure monitoring program for the Moore Ranch facility. Review areas addressed in this section include: radiation surveys, personnel monitoring, records, and reporting.

5.7.3.3.1 Surveys

The applicant has identified radiological survey locations depicted in the plant layout in Figure 5.7-1 of the technical report. These locations include the ion exchange columns, filter housings that remove solid materials from the production and injection streams, and tank bottoms where solid material may collect. Surveys will be performed monthly in designated radiation areas and semiannually in all other areas of the plant.

Types of survey instruments required depend on the exposures and doses expected. The applicant stated that the typical well field dose rates are not expected to exceed background; however, areas immediately adjacent to wellheads and header houses where scale buildup on the inside of the surface of piping can occur may contain increased gamma exposure rates from radium-226. Process plant workers will be exposed to elevated gamma exposure rates during operations and maintenance activities in radiation areas. The applicant also stated that, in some cases, the gamma dose rates may exceed 5 millirem per hour and may require posting of signs indicating radiation areas.

Figure 1 of Regulatory Guide 8.30 shows that the surface beta dose rate changes as a function of time after separation from the ore. The applicant stated that it will perform beta surveys at least once for each operation and whenever there is a change in procedures or equipment that may affect the beta dose. The applicant stated that beta exposure rate surveys and beta contamination surveys will be performed at the specific operations that involve direct handling of large quantities of aged yellowcake. This would include in-plant areas associated with precipitation, dewatering (filter press), and drying/packaging. Based upon the foregoing, the staff has determined that the monitoring program is adequate to protect workers from the hazards of beta radiation.

In addition to gamma surveys, Regulatory Guide 8.30 recommends beta surveys for specific operations that involve the direct handling of large quantities of aged yellowcake to ensure that extremity and skin exposures will not exceed regulatory limits. Beta surveys should be used to determine the need for protective clothing for these operations.

Considering the expected doses, the applicant proposes the following survey instruments:

- Model 3 survey meter with the Ludlum Model 44-37 probe or equivalent for external gamma surveys.
- Ludlum Model 2224 with the Ludlum 43-1-1 alpha and beta scintillator probe for beta surveys.
- Ludlum Model 44-6 and Ludlum Model 44-38 sidewall Geiger-Mueller (G-M) detector or equivalent for beta dose rate surveys.
- Ludlum Model 3 survey meter beta and gamma surveys.
- Ludlum Model 43-1-1 alpha and beta phoswich scintillation probe or equivalent for beta contamination surveys.

These instruments will be calibrated at least annually by the manufacturer. The staff has determined that use of these survey instruments will adequately ensure compliance with the 10 CFR Part 20, Subpart F requirements.

5.7.3.3.2 Personnel Monitoring

The applicant stated that Section 5.7.4.3 of the technical report shows that occupational exposure to external gamma and beta radiation will be measured using personnel dosimeters such as TLDs or optically stimulated dosimeters. Dosimeters will have a range from 1 milliroentgen (mR) to 1,000 roentgens (R). The staff has determined that the proposed use of personnel dosimeters will meet the requirements of 10 CFR 20.1501(c). The staff has further determined that the processing of personnel dosimeters quarterly will provide results to ensure that occupational doses are in compliance with 10 CFR Part 20, Subpart C.

The applicant anticipates that employees working at the Moore Ranch facility will not exceed 10 percent of the regulatory limit of 5 rem per year (i.e., 5,000 mrem/yr). Although 10 CFR 20.1502 does not require external dose monitoring for individuals not expected to receive external doses in excess of 10 percent of the regulatory limit, the applicant stated in Section 5.7.4 of the technical report that it will conduct external monitoring of all process plant employees. Results from personnel dosimetry will provide the individual deep dose equivalent (DDE) for use in determining total effective dose equivalent (TEDE). The staff concludes that the applicant will use appropriate instrumentation and detection devices for the external radiation monitoring program, and that devices are capable of measuring beta and gamma radiation. These measurements will be used to adequately protect workers from the hazards of beta and gamma radiation.

The applicant stated that it is committed to maintaining personnel exposures ALARA and that this commitment will be incorporated into the radiation safety controls and monitoring programs at the facility. Regulatory Guide 8.31 recommends that the applicant provide a strong commitment to, and continuing support for, the development and implementation of the radiation protection and ALARA programs. The applicant's statement is consistent with Regulatory Guide 8.31.

5.7.3.3.3 Records and Reporting

As noted in Section 5.2 of this SER, the applicant has discussed records and reporting requirements associated with the external radiation exposure monitoring program. The applicant will develop instructions for maintenance, control, and retention of records that will be consistent with 10 CFR Part 20, Subpart L and Subpart M, and 10 CFR 40.61.

5.7.3.4 Evaluation Findings

The staff reviewed the radiation safety controls and monitoring aspects of the proposed Moore Ranch facility in accordance with Section 5.7.2.3 of the standard review plan. The applicant has provided a drawing that depicts the facility layout and the location of external radiation monitors. The applicant has identified radiation instrumentation to be used for conducting both beta and gamma radiation surveys and the frequency of these surveys. The applicant will provide dosimetry to all process plant employees and measure the DDE and shallow-dose equivalent, if applicable.

The applicant has also provided acceptable information on the range of the gamma radiation survey meter and the ability of this survey meter to meet the posting requirements for a radiation area or higher. The applicant has identified beta survey meters to be used to measure beta radiation in the plant. The applicant has adequately demonstrated that beta radiation surveys will be conducted in compliance with 10 CFR Part 20, Subpart F.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.7.2.3 of the standard review plan and the applicable requirements of 10 CFR 20 and 10 CFR 40.61.

5.7.3.5 Reference

NRC, 2002. "Health Physics Surveys in Uranium Recovery Facilities," Regulatory Guide 8.30, Revision 1. Washington, DC: May 2002.

5.7.4 In-Plant Airborne Radiation Monitoring Program

5.7.4.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed in-plant radiation monitoring program for the Moore Ranch facility meets the requirements of 10 CFR Part 20, Subparts B and C, 10 CFR 20.1501, and 10 CFR 20.1702.

5.7.4.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.3.3 of the standard review plan. Regulatory Guide 8.30 provides guidance on how compliance with the regulations can be demonstrated.

5.7.4.3 Staff Review and Analysis

The following sections describe the in-plant airborne radiation monitoring program, which consists of airborne uranium particulate monitoring, radon daughter concentration monitoring, and the respiratory protection program. In-plant airborne radiation monitoring measures airborne concentrations at various locations in the CPP to determine necessary posting requirements, respiratory protection methods, and dose assessments.

5.7.4.3.1 General Program Description

Although the operation at the Moore Ranch facility will be a wet operation and the lixiviant will be contained within its primary component boundaries (i.e., tanks, piping, vessels, etc.), consideration must be given to spills, leaks, and maintenance activities that can result in the lixiviant/slurry and its contaminants escaping the primary component boundaries. During the production process, yellowcake is eventually extracted from solution and dried for packaging in the dryer and packaging area. During the drying and packaging process, uranium particulates are enclosed in a drying and packaging system that includes a bag house dust collection system and a condenser system. The in-plant airborne radiation monitoring program is designed to detect these contaminants if they escape the primary boundary and become airborne.

Regulatory Guide 8.25 (NRC, 1992) recommends that air sampling be used to:

- determine whether the confinement of radioactive materials is effective;
- measure airborne radioactive material concentrations in the workplace;
- estimate worker intakes;
- determine posting requirements;
- determine what protective equipment and measures are appropriate; and
- warn of significantly elevated levels of airborne radioactive materials.

The applicant's proposed locations of airborne particulate and radon daughter sampling are depicted in Figure 5.7-1 of the technical report. The staff reviewed Figure 5.7-1 and has determined that the applicant has selected reasonable locations to monitor in-plant air particulate and radon daughter sampling, and the sample locations are consistent with Regulatory Guide 8.25.

According to the applicant, air samples will be obtained using area samplers and air samples collected from lapel air samplers on a monthly basis. These air samples will be collected from low-volume air pumps and counted on an alpha scaler. However, samples will be collected from the yellowcake packaging area using area samplers on a weekly basis if workers occupy the area. This increased frequency is warranted because the yellowcake packaging area is an "airborne radioactivity area" as defined in 10 CFR 20.1003. The applicant states that this area will be closed and posted as an airborne radioactivity area during packaging. The staff has determined that the frequency of in-plant air sampling is consistent with Regulatory Guide 8.30 and 10 CFR 20.1501.

5.7.4.3.2 Airborne Particulate Uranium Monitoring

The applicant indicated that measurement of airborne uranium will be performed by gross alpha counting of the air filters for uranium air particulates. The staff notes that radium-226 and thorium-230 may also be present in the air, and, thus, a mixture of radionuclides may be present on the air filters. Gross alpha counting of the air filters will not be able to differentiate specific radionuclides. Consequently, the applicant may not be able to accurately determine if the action level for uranium or other radionuclides, such as radium-226 and thorium-230, has been reached by relying on gross alpha counting of the air filters.

To confirm that natural uranium is the primary radionuclide of concern in airborne particulate samples, the applicant will conduct isotropic airborne sampling from each of the air particulate monitoring locations noted in Figure 5.7-1 of the technical report. Analytical results will be compared to mixture requirements in 10 CFR 20.1204(g) to ensure that the appropriate DAC (see Section 5.7.1 of this SER) is used. If a "mixture" exists that does not meet the exclusion rule of 10 CFR 20.1204(g), a sum of fractions method will be used to determine the appropriate DAC. The staff finds this procedure acceptable and will include this requirement as a license condition. The license condition can be found in Section 5.7.4.4 of this SER.

The applicant plans to use a DAC value for inhalation Class W natural uranium (see Section 5.7.1 of this SER) for occupational airborne concentrations, and the lower limit of detection (LLD) for natural uranium, Class W, will be less than 3.0E-11 µCi/mL. The staff notes that 3.0E-11 µCi/mL represents 10 percent of the DAC for natural uranium, Class W, for inhalation, which is consistent with Regulatory Guide 8.30. The staff has determined that the applicant has established the LLD for uranium in air within the CPP consistent with Regulatory Guide 8.30.

5.7.4.3.3 Radon Daughter Concentration Monitoring

The applicant has stated that the predominant radionuclide expected to be present in the CPP in air would be radon-222, and that radon samples will be analyzed monthly on an alpha scaler using the modified Kusnetz method. Furthermore, the LLD for radon-222 with daughters will be less than 0.03 working level (WL). The staff notes that 0.03 WL represents 10 percent of the DAC for radon-222 with daughters for inhalation. Regulatory Guide 8.30 recommends that the quantity of the air sampled and the method of analysis should be 10 percent of the Appendix B to 10 CFR Part 20 limit for radon; therefore, the staff determined that the LLD for radon in air is consistent with Regulatory Guide 8.30 and is acceptable.

The purpose of the Kusnetz method is to reduce the magnitude of the counting error by use of a time factor to back-calculate the true concentration during sampling if nonequilibrium conditions exist. Considering the nature of the operational process and activities that may occur in the plant and that radon will be the predominant radionuclide in the plant, a potential exists for nonequilibrium conditions to occur during operations. Results of radon daughter sampling will be expressed in WLs, where 1 WL is defined as any combination of short-lived radon-222 daughters in 1 liter of air, without regard to equilibrium, that emits 1.3E+05 million electron volts of alpha energy. The staff has reviewed the proposed modified Kusnetz method for the radon daughter monitoring program and determined that the method is consistent with Regulatory Guide 8.30.

5.7.4.3.4 Action Limits

Regulatory Position 3.3, “Ventilation Systems,” of Regulatory Guide 8.31 states that the facility should establish a facility-specific operational ALARA goal for concentrations of natural uranium and its daughters at less than 25 percent of the DAC values. The applicant set an action level of 25 percent of the DAC for soluble natural uranium in the plant, and the DAC for soluble (inhalation Class W) natural uranium is 3E-10 µCi/mL. Due to the lack of actual operational data, the applicant will assume the natural solubility is Class W for purposes of establishing the initial DAC upon plant startup. If after operations commence the applicant would like to change the inhalation class, it will be required to submit samples demonstrating that such a change is warranted.

The DAC limit for radon-222 with its daughters present is 0.33 WL. The applicant proposed an action level of 25 percent of the DAC or 0.08 WL. The applicant indicated that air sample results that exceed the action level would result in an investigation of the cause of the elevated concentrations. The staff has determined that the proposed action of 25 percent of the DAC for radon-222 with daughters is consistent with Regulatory Guide 8.31 and that the action levels for natural uranium and radon will adequately protect the CPP workers.

5.7.4.3.5 Respiratory Protection

The applicant stated that respiratory protection will be used where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials. This respiratory protection program will be implemented in accordance with Regulatory Guide 8.15 (NRC, 1999). This approach also meets the requirements of 10 CFR 20.1702, “Use of Other Controls,” which requires the use of process or other engineering measures to control the concentrations of radioactive material in the air. Therefore, the staff finds this acceptable.

5.7.4.4 Evaluation Findings

The staff reviewed the in-plant airborne radiation monitoring program of the proposed Moore Ranch facility in accordance with Section 5.7.3.3 of the standard review plan. The applicant plans to conduct in-plant airborne monitoring consistent with Subpart B, “Radiation Protection Programs,” of 10 CFR Part 20, which defines the radiation protection program. This program includes monitoring for the two primary contaminants and the instruments that it will use to collect and analyze the results of the air samples. The applicant has demonstrated that adequate methods are being used to fully evaluate the airborne particulate monitoring. The applicant has identified methods that will meet the occupational dose limit requirements of Subpart C of 10 CFR Part 20. If the applicant identifies that a “mixture” exists which does not meet the exclusion rule of 10 CFR 20.1204(g), a sum of fractions method will be used to determine the appropriate DAC. The staff is imposing the following license condition to ensure compliance with 10 CFR 20.1204(g):

> The licensee shall conduct airborne sampling for natural U, Th-230, Ra-226, Po-210, and Pb-210 at each in-plant air particulate sampling location at a frequency of once every 6 months for the first two years and annually thereafter to ensure compliance with 10 CFR 20.1204(g). The licensee shall also evaluate changes to plant operations to determine if more frequent isotopic analyses are required for compliance with 10 CFR 20.1204(g).

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of Section 5.7.3.3 of the standard review plan and the requirements of 10 CFR Part 20, Subparts B and C, 10 CFR 20.1501, and 10 CFR 20.1702.

5.7.4.5 References

NRC, 1992. "Air Sampling in the Workplace," Regulatory Guide 8.25, Revision 1. Washington, DC: June 1992.

NRC, 1999. "Acceptable Programs for Respiratory Protection," Revision 1, Regulatory Guide 8.15. Washington, DC: October 1999.

5.7.5 Exposure Calculations

5.7.5.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed exposure calculation for the Moore Ranch facility meets the requirements of Subparts C, F, L, and M of 10 CFR Part 20. Specific regulations that must be followed include: 10 CFR 20.1201(e), 10 CFR 20.1204(f), 10 CFR 20.1204(g), and 10 CFR 20.1502.

5.7.5.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.4.3 of the standard review plan. Regulatory Guides 8.13 and 8.36 (NRC, 1992a) provide guidance on how compliance with the regulations can be demonstrated.

5.7.5.3 Staff Review and Analysis

The following sections discuss the exposure calculations, which include internal and external occupational radiation dose as well as radiation doses to the embryo/fetus. Occupational workers may be exposed externally and internally to radioactive material in a number of ways. This may include radioactive material in the air, loose surface contamination, or radioactive material that may be stored or processed inside equipment or components. In addition to exposure calculations applicable to the occupational workers, this section also addresses exposure calculations for female workers who declare pregnancy and the calculation of radiation dose to the embryo/fetus.

5.7.5.3.1 External Dose Calculation

Occupational dose limits are set forth in 10 CFR Part 20 Subpart C and are listed in Section 5.7.1 of this SER. The applicant states that when the external exposure is determined by measurement with an external personal monitoring device, the deep dose equivalent (DDE) will be used in place of the effective dose equivalent, unless the effective dose equivalent is determined by a dosimetry method approved by the NRC. The assigned DDE must be for the part of the body receiving the highest exposure. The assigned shallow-dose equivalent must be the dose averaged over the contiguous 10 square centimeters (cm^2; 1.55 square inches [in^2]) of skin receiving the highest exposure. The DDE, lens-dose equivalent, and the shallow-dose equivalent may be assessed from surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits.

The applicant stated that occupational exposure to external gamma and beta radiation will be measured using personnel dosimeters such as TLDs or optically stimulated luminescence dosimeters. Routine employee external exposures will be determined and recorded for those employees likely to receive more than 10 percent of the allowable occupational dose limit (i.e. 0.5 rem). Furthermore, all workers will be monitored initially for external and internal dose upon startup of the facility. As data are gathered, the applicant will review worker doses and may discontinue monitoring for worker classifications that are not expected to receive more than 10 percent of the allowable annual occupational dose limit.

Occupational exposure to external radiation (further discussed in Section 5.7.3 of this SER) will be used to determine the total effective dose equivalent (TEDE) for employees whose work locations or functions may exceed 10 percent of the occupational exposure limits. Staff concurs with the approach for determining external exposures by measurement with an external personal monitoring device and that the DDE will be used to define the TEDE due to external exposures. The applicant has committed to recording the results in accordance with 10 CFR Part 20 Subpart L in Section 5.7.4 of the technical report, therefore, this approach is acceptable to the staff.

The applicant stated that the RSO will use historical and current monitoring and survey data to ensure that external radiation exposures are less than 10 percent of the occupational dose limit for all unmonitored workers. The results of the external radiation monitoring program will be recorded and reviewed annually by the RSO to ensure that unmonitored employees have not exceeded 10 percent of the dose limits. The staff has determined that the annual review of these results is not adequate, as it is possible that unmonitored employees may receive in excess of 10 percent of the dose limits prior to the annual review. The applicant has not adequately described how they will ensure that unmonitored employees, who do not have dosimetry, have not exceeded 10 percent of the dose limit. Therefore, the staff will include a condition in the license issued to the applicant; this condition can be found in Section 5.7.5.4 of this SER.

5.7.5.3.2 Internal Dose Calculation

In accordance with 10 CFR Part 20, Subpart C, DAC and ALI values may be used to determine the individual's internal dose and to demonstrate compliance with the occupational dose limits. For purposes of assessing dose and, consequently, compliance with occupational dose equivalent limits, the applicant will, in accordance with 10 CFR 20.1502, collect suitable and timely measurements of (1) concentrations of radioactive materials in the air in work areas, (2) quantities of radionuclides in the body, (3) quantities of radionuclides excreted from the body, or (4) a combination of these measurements. In addition to the annual dose limits, the applicant will limit the soluble uranium intake by an individual to 10 mg in a week in consideration of the chemical toxicity.

The applicant has provided equations and input parameters for computing the intake for natural uranium and the intake for radon daughter products. The equations and input parameters are provided below:

For Natural Uranium Internal Exposure

$$I_U = b\sum_{i=1}^{n}\frac{X_i \times t_i}{PF}$$

Where:	I_u	= uranium intake, ug or uCi
	t_i	= time that the worker is exposed to concentrations, X_i, in hours
	X_i	= average concentration of uranium in breathing zone, ug/cm^3 or uCi/m^3
	b	= breathing rate, 1.2 m^3 per hour
	PF	= the respirator protection factor , if applicable (unitless)

For Radon Daughter Internal Exposure

$$I_r = \frac{1}{170}\sum_{i=1}^{n}\frac{W_i \times t_i}{PF}$$

Where	I_r	= radon daughter intake, working-level month
	t_i	= time that the worker is exposed to concentration, W_i, in hours
	W_i	= average number of working levels in the air near the worker's breathing zone during the time, t_i.
	170	= number of hours in a working month
	PF	= the respirator protection factor, if applicable (unitless)

The staff has reviewed the equations and input parameters provided by the applicant, has determined that they are consistent with Regulatory Guide 8.30 and 8.34 (NRC, 1992b). Therefore, the staff finds the equations and input parameters to be acceptable.

The applicant will either use the results of periodic time studies for each classification of worker, or will generally use 100-percent occupancy time for routine worker exposures. Using this method, each classification of worker is assumed to have spent their entire work shift in the survey area(s). The staff has determined that the applicant has provided a reasonable method for determining internal occupational doses and ensuring compliance with the dose limits as defined in 10 CFR 20, Subpart C and finds these methods acceptable.

The initial DAC used at the startup of the operations will be based on inhalation Class W value for moderately soluble (W classification) natural uranium which is 3.0E-10 µCi/mL. Should the applicant choose to alter the inhalation class, simulated lung fluids studies would be required, and such information would be submitted to the NRC, as part of a license amendment request. However, the applicant is under no obligation to do so, and may use the Class W during operations.

In accordance with 10 CFR 20.1204(f), if the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture must be the most restrictive DAC of any radionuclide in the mixture. The applicant stated that in order to confirm that natural uranium is the primary radionuclide of concern in airborne particulate samples, isotropic airborne samples samples will be analyzed from each of the air particulate monitoring locations noted in Figure 5.7-1 of the technical report. Results of these samples will be compared with the mixture requirements in 10 CFR 20.1204(g) to ensure that the appropriate DAC value is used. If a “mixture” exists that does not meet the exclusion rule of 10 CFR 20.1204(g), a sum of fractions method will be used to determine the appropriate DAC. The staff has determined that the applicant will need to conduct periodic isotropic airborne sampling and compare the results to 10 CFR 20.1204(g) to ensure that the appropriate DAC from Table 1 of Appendix B to 10 CFR Part 20 is used. The language for this license condition is presented in Section 5.7.4.4 of this SER.

Pursuant to 10 CFR 20.1201(e), the applicant committed to limiting the intake of soluble uranium to 10 mg per week. The average concentration at the soluble weekly intake limit is approximately equal to 50 percent of the DAC, as calculated using inhalation Class W, as discussed above. Compliance with this requirement will be demonstrated by recording worker airborne exposure in DAC hours whenever long-lived particulate concentrations in air are determined to be greater than or equal to 10 percent of the DAC. Assignments of positive airborne exposures will be reviewed weekly and any exposures to soluble uranium greater than 5 percent of the 10 mg per week limit will be recorded (in DAC hours) and controlling exposures to be 25 percent of the DAC. The applicant stated that this procedure will ensure both that the weekly intake limit is not exceeded and will be ALARA. The staff has determined that the applicant has demonstrated an acceptable method for complying with 10 CFR 20.1201(e).

5.7.5.3.3 Prenatal/Fetal Dose

The applicant states that the dose equivalent to the embryo/fetus will be determined by monitoring its declared pregnant female employees at the Moore Ranch facility. The DDE will be used for this purpose during the gestation period and the applicant will apply this DDE to the embryo/fetus for external dose. For internal dose, exposure calculations will be performed in accordance with Regulatory Guide 8.36. Doses to the embryo/fetus will be determined if the intake is likely to exceed 1 percent of the ALI during the entire period of gestation. The staff finds this acceptable, as it is consistent with the guidance in Regulatory Guide 8.36. The applicant stated that female workers who require training under 10 CFR 19.12, “Instruction to Workers,” will be provided with training that meets the guidance contained in Regulatory Guide 8.13. In addition, such females will receive a copy of Regulatory Guide 8.13, and supervisors who supervise female workers will also receive training on Regulatory Guide 8.13. The staff has determined that this is acceptable, as it is consistent with Regulatory Guide 8.13.

5.7.5.3.4 Records

The applicant stated that intakes will be totaled and entered onto each employee's occupational exposure record. Reporting and recordkeeping will be consistent with Regulatory Guide 8.7 (NRC, 2005). Individual internal exposures, as reported on the exposure record, will be based on actual hours worked during the monitoring period for each worker, as obtained by the RSO. The RSO will assume that 100 percent of the time was spent in the restricted area.

Alternatively, the RSO may perform a time study to determine the average time of exposure for each classification of workers. Exposures during nonroutine work (i.e., work requiring a radiation work permit) will be based upon actual time.

The applicant stated that any employee may request a written report of his or her exposure history at any time. These reports will be provided within 30 days of the request and will provide the information as presented in 10 CFR 19.13, "Notifications and Reports to Individuals." The applicant also committed to providing the necessary exposure reports per 10 CFR 20 Subpart M. The staff finds the above discussion of records consistent with 10 CFR Part 20 Subparts F, L, and M; therefore the staff finds these procedures acceptable.

5.7.5.4 Evaluation Findings

The staff reviewed the exposure calculations for the proposed Moore Ranch facility in accordance with Section 5.7.4.3 of the standard review plan. The applicant has identified techniques for exposure calculations at the Moore Ranch facility to determine intake of radioactive materials by personnel in work areas. Exposure calculations for natural uranium and airborne radon daughter exposure are provided. These calculations include prenatal and fetal radiation, as well as for routine operations, nonroutine operations, maintenance, and cleanup activities. The applicant has classified the solubility for the DAC to determine the correct internal dose. The applicant will also identify each radionuclide in a mixture when the concentration of one or more is not known so that the DAC for the mixture is the most restrictive DAC of any radionuclide in the mixture. However, the applicant has not adequately described how they will ensure that unmonitored employees, who do not have dosimetry, have not exceeded 10 percent of the dose limit. Therefore, the staff is imposing a license condition to ensure the dose limits are met for unmonitored employees. This condition must be met prior to commencement of operations:

> The licensee shall submit to the NRC the procedures by which it will ensure that unmonitored employees will not exceed 10 percent of the dose limit.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of Section 5.7.4.3 of the standard review plan and the requirements of 10 CFR 20 Subpart C, Subpart F, Subpart L, and Subpart M.

5.7.5.5 References

NRC, 1992a. “Radiation Dose to the Embryo/Fetus,” Regulatory Guide 8.36. Washington, DC: July 1992.

NRC, 1992b. “Monitoring Criteria and Methods To Calculate Occupational Radiation Doses,” Regulatory Guide 8.34. Washington, DC: July 1992.

NRC, 2005. “Instructions for Recording and Reporting Occupational Radiation Exposure Data,” Regulatory Guide 8.7, Revision 2. Washington, DC: November 2005.

5.7.6 Bioassay Program

5.7.6.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed bioassay program for the Moore Ranch facility meets the requirements of Subparts C, L, and M of 10 CFR Part 20.

5.7.6.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.5.3 of the standard review plan. Regulatory Guide 8.9 (NRC, 1993), Regulatory Guide 8.22 (NRC, 1988), 8.30, and 8.34 provide guidance on meeting the applicable regulations.

5.7.6.3 Staff Review and Analysis

The following sections discuss the applicant’s proposed bioassay program, which is designed to monitor and document potential internal uptakes and radiation exposures and to confirm the results of the airborne uranium particulate monitoring program.

5.7.6.3.1 Frequency

The applicant stated that it will use urinalysis as the method of bioassay due to the relatively high solubility of the chemical form of yellowcake present at the ISR facility. Bioassay samples will be collected at the following frequencies:

- baseline urinalysis sample for new employees prior to working at the facility
- quarterly during operations
- monthly for employees who have the potential to be exposed to dried yellowcake or more frequently as determined by the RSO
- upon termination for all employees

The applicant stated that action levels for employees that submit bioassay samples on a monthly basis will be established based on Table 1 of Regulatory Guide 8.22, and action levels for urinalysis collected on a quarterly basis will be based on Table 2 of Regulatory Guide 8.22. Furthermore, employees will deposit and submit the monthly urine samples following 1–2 days off from work to allow for clearance and elimination of uranium that does not become systemic and absorbed by the kidneys. According to the applicant, standard practice for routine urinalysis programs is to assume that the exposure/intake occurred on the day or days immediately following the previous sample collection. The staff has determined that the collection frequency and analysis of urine samples is consistent with Regulatory Guide 8.22.

Regulatory Guide 8.22 recommends that for exposures to Class W or Class Y materials alone, in vivo lung counts or alternate sampling times and action levels should be considered. The applicant stated that it would perform in vivo analyses, as follow up to confirmed urinalysis results in excess of action levels as specified in Table 1 of Regulatory Guide 8.22. The staff finds this procedure acceptable as it is consistent with Regulatory Guide 8.22.

5.7.6.3.2 Dose Determination

Dose may be determined through air monitoring program or bioassays. For example, applicant stated that routine determination of internal exposure will be performed using the results of air monitoring to estimate uranium intake. Exposures to airborne uranium will be compared to the DAC for Class D natural uranium (see Section 5.7.1 of this SER), which represents the clearance rate of the contaminant from the lungs [D = Days, W = Weeks, and Y = Years]. Because the applicant has not demonstrated the technical basis for selecting the “D” inhalation class for airborne uranium, it will assume a Class W for purposes of establishing the initial DAC upon plant startup. The applicant may continue using the Class W designation for the duration of operations; however, simulated lung fluid studies may be performed to change the classification, if so desired. The staff has determined that the initial DAC of Class W is appropriate for determining compliance with Subpart C of 10 CFR Part 20.

If a positive bioassay (urinalysis) result is confirmed, the applicant stated that the RSO will conduct an investigation into the circumstances and determine whether internal exposure for an individual should be determined based on bioassay results. Bioassay results may be used in circumstances in which the confirmed intakes that are used for the estimates result in an annual committed effective dose equivalent greater than 500 millirem and/or when such confirmed results suggest exposures greater than that estimated from air sampling results and time studies. Basic dosimetry model and guidance in NUREG-0874, “Internal Dosimetry Model for Applications to Bioassay at Uranium Mills,” (NRC, 1986), will be used for this purpose as modified by more recent elimination/retention functions and the guidance in Regulatory Guide 8.9 and Regulatory Guide 8.34. The staff has determined that the applicant has defined an acceptable method for evaluating events where positive bioassay (urinalysis) results are confirmed and a decision has been made to convert the confirmed results to a dose.

5.7.6.3.3 Intake Limit

In addition to the dose limit, the applicant has stated that it will comply with the limit on soluble uranium intake by an individual of 10 mg in a week in consideration of chemical toxicity (see Section 5.7.1 of this SER). This limit will be based on the DAC for Class W natural uranium.

Compliance with this requirement will be demonstrated by recording worker airborne exposure in DAC hours whenever long-lived particulate concentrations in the air are determined to be greater than or equal to 10 percent of the DAC and an action level of 25 percent of the DAC. The assignments of positive airborne exposures will be reviewed weekly and any exposures to soluble uranium greater than 5 percent of the 10 mg per week limit will be recorded (in DAC hours) and controlling exposures to 25 percent of the DAC. The applicant stated that this will ensure both that the 10 mg per week limit is not exceeded and is ALARA. The staff has determined that the applicant has demonstrated an acceptable method for complying with 10 CFR 20.1201(e).

5.7.6.3.4 Records and Reporting

For employees who are monitored for internal and/or external exposure, the recording and reporting of monitoring results are required in accordance with Subpart L and Subpart M of 10 CFR Part 20. The applicant stated that records of exposure monitoring results will be maintained for each monitored individual on an NRC Form 5 or equivalent. The applicant will obtain prior dose histories for all employees and obtain an NRC Form 4 signed by the individual monitored or a written statement that includes the names of all facilities that monitored the individual for occupational exposure to radiation during the current year and an estimate of the dose received. The applicant stated that it will also attempt to obtain records of an individual's lifetime cumulative occupational radiation dose for all employees at the facility. This lifetime dose may be based on a written estimate or an up-to-date NRC Form 4 signed by the individual. Monitored employees will be advised in writing on an annual basis of their calculated TEDE. Also, upon request by an individual, the applicant will provide a written report of his or her exposure history at any time. The staff has determined that the recordkeeping is consistent is Regulatory Guide 8.30 and meets the requirements for Subpart L of 10 CFR Part 20. Therefore, the staff finds this acceptable.

5.7.6.4 Evaluation Findings

The staff reviewed the bioassay program for the proposed Moore Ranch facility in accordance with Section 5.7.5.3 of the standard review plan. The applicant has provided a description of the program for baseline bioassay urinalysis prior to, during, and upon exiting employment. Individuals routinely exposed to yellowcake dust are a part of the bioassay program. Action levels identified in Table 1 of Regulatory Guide 8.22 will be used at this site.

The applicant has assumed that the inhalation class for the uranium at the Moore Ranch facility is Class W, and acknowledges that tests would be required to change that class. Furthermore, the applicant discussed the manner in which confirmed bioassay (urinalysis) results will be converted and assigned as an internal dose to the individual. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.7.5.3 of the standard review plan and the requirements of 10 CFR Part 20 Subpart C, Subpart L, and Subpart M.

5.7.6.5 References

NRC, 1986. "Internal Dosimetry Model for Applications to Bioassay at Uranium Mills," NUREG-0874. Washington, DC: July 1986.

NRC, 1988. "Bioassay at Uranium Mills," Regulatory Guide 8.22, Revision 1. Washington, DC: August 1988.

NRC, 1993. "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," Regulatory Guide 8.9, Revision 1. Washington, DC: July 1993.

5.7.7 Contamination Control Program

5.7.7.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed contamination control program for the Moore Ranch facility meets the requirements of Subparts B, C, and F of 10 CFR Part 20.

5.7.7.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.6.3 of the standard review plan. Regulatory Guide 8.30 provides guidance on how compliance with the applicable regulations can be demonstrated.

5.7.7.3 Staff Review and Analysis

The following sections discuss the applicant's proposed contamination control program. The contamination control program is designed to detect radiological contaminants that have escaped the boundary of the uranium recovery process equipment. Contamination can take the form of loose surface contamination and may reside on structures, equipment, materials, or personnel. The purpose of this program is to ensure that contamination will be confined and monitored in known areas and will not be spread to other areas outside of the confined area (e.g., lunch room, bathrooms, and office areas) or to unrestricted areas.

As determined by the staff from discussions with industry during a public meeting held on November 17–18, 2009, Regulatory Guide 8.30 will be the standard by which the staff evaluates alpha contamination control for personnel monitoring and releasing material for unrestricted use (NRC, 2009). The staff is currently revising Regulatory Guide 8.30. When Regulatory Guide 8.30 is revised, a draft revision will be issued for public review and comment. If changes to the alpha contamination control limits are incorporated into the revision of Regulatory Guide 8.30, applicants and licensees will be expected to adopt the revised limits or provide an adequate technical justification for alternate limits.

5.7.7.3.1 Contamination Surveys

The applicant stated that it will perform surface contamination surveys of operating and clean areas of the facility. Surveys for total alpha contamination in clean areas will be conducted weekly. The applicant stated that the action level for surface contamination in these areas will be 250 disintegrations per minute (dpm)/100 cm^2. This represents 25 percent of the removable contamination level as defined in Table 2 of Regulatory Guide 8.30 for natural uranium and daughter products on equipment to be released for unrestricted use, on clothing, and in nonoperating areas. The staff has determined that the surface contamination surveys for operating and clean areas of the facilities are consistent with Regulatory Guide 8.30 for alpha contamination.

The staff concludes that the applicant did not address surveys for beta/gamma contamination for free release of equipment and personnel from restricted areas that may result from the in-growth of uranium daughter and radon daughter products from operations consistent with 10 CFR 20 Subpart F, which requires that surveys be performed to demonstrate compliance with Part 20. Therefore, the staff will include a condition in the license issued to the applicant for the Moore Ranch facility. The condition can be found in Section 5.7.7.4 of this SER.

Personnel leaving the restricted area will be required to perform gross alpha contamination monitoring. Any gross alpha contamination on the skin or clothing will be considered removable and is subject to a limit of 1,000 dpm/100 cm^2. The staff has determined that this is consistent with Table 2 of Regulatory Guide 8.30 for removable natural uranium contamination. The applicant stated that its ALARA objective will be no detectable contamination above background.

The applicant stated that hand-carried items used in the well fields and controlled areas will also be monitored for surface contamination. These contamination surveys will be performed at the contamination control point(s) located for the restricted area boundary using the equipment specified in Section 5.7.6 of the technical report and will be properly documented. Release limits for alpha contamination are listed in Table 5.7-1.

Table 5.7-1 Release Limits for Alpha Contamination

Type of Contamination	Release Limit
Removable	1,000 dpm/100 cm^2
Average total (over 10,000 cm^2)	5,000 dpm/100 cm^2
Maximum total (over 100 cm^2)	15,000 dpm/100 cm^2

The staff finds this practice of contamination control consistent with the radiation protection program set forth in 10 CFR Part 20, Subpart B and with surveys and monitoring as required by 10 CFR Part 20, Subpart F.

Regulatory Guide 8.30 recommends beta surveys of specific operations that involve the direct handling of large quantities of aged yellowcake. Beta surveys should be used to determine the need for protective clothing for these operations as well as to determine if procedures could be changed to reduce beta dose. The applicant stated that beta exposure rate and contamination surveys will be performed at the specific operations that involve the direct handling of large quantities of aged yellowcake. This would include in-plant areas associated with precipitation, dewatering (filter press), and drying/packaging. The applicant stated that beta exposure rate and contamination surveys will be conducted with a Ludlum Model 44-6 sidewall G-M detector or equivalent and the Ludlum Model 43-1-1 alpha and beta phoswich scintillation probe or equivalent, respectively. The applicant states that beta surveys will be performed at the initiation of operations and whenever procedural and/or equipment changes could affect the beta levels to which employees may be exposed. If the applicant determines that beta exposure rates to which workers could be exposed could result in shallow-dose equivalents to the skin equal to or greater than 10 percent of the limits in 10 CFR 20.1201(a)(2), provisions for personnel beta monitoring (e.g., ring and/or wrist badges) will be provided.

The applicant stated that all personnel conducting contamination surveys for release of equipment and materials to unrestricted areas, including resin trucks during off normal hours, will have been trained as radiation workers in accordance with Regulatory Position 2.5, "Radiation Safety Training," of Regulatory Guide 8.31, and as described in Section 5.5.1.3 of the technical report. Radiation worker training will include instruction on the use of portable survey instrumentation for the assessment of contamination on personnel and equipment.

The staff has determined that the applicant's proposal is not consistent with the guidance provided in Regulatory Guide 8.31, which indicates that the RSO or radiation safety office staff are responsible for performing all routine and special radiation surveys required by license conditions and 10 CFR 20. The staff will consider alternate proposals, provided that the applicant provides details related to training, frequency of the proposed activity, oversight by the RSO, and corrective actions. Staff review and approval of deviations from Regulatory Guide 8.31 will be considered as a standard license condition.

5.7.7.3.2 Survey Equipment

The applicant is proposing to use the following survey equipment:

- Total surface alpha activity - Ludlum Model 2241 scaler or the Ludlum Model 177 Ratemeter with a Model 42-65 or Model 43-5 alpha scintillation probe or equivalent
- Ludlum Model 3 survey meter with the Ludlum Model 44-38 G-M probe or equivalent for beta/gamma surface activity
- Swipes will be used for removable contamination

All equipment will be calibrated at least annually and instrumentation will be checked daily when in use. Materials, such as equipment, instruments, and other materials, will be surveyed for alpha contamination before removal from the restricted and controlled areas. The applicant has identified survey equipment that are capable of detecting the types of contamination anticipated at the Moore Ranch facility. Therefore, the staff finds the type of instrumentation acceptable.

5.7.7.4 Evaluation Findings

The staff reviewed the contamination control program for the proposed Moore Ranch facility in accordance with Section 5.7.6.3 of the standard review plan. The applicant has identified controls for preventing contamination from leaving a restricted area using appropriate survey equipment and instrumentation. Contamination surveys will be conducted in clean areas and personnel and equipment exiting the restricted area will be monitored. Furthermore, the range, sensitivity, and calibration of monitoring equipment will protect the health and safety of employees during the full scope of facility operations. Action levels have been identified for personnel and hand-carried items, and these levels can account for radionuclides other than natural uranium that may be present in the facility. However, the applicant has not provided the methods that will be used to detect beta/gamma contamination at the facility. Therefore, the staff is imposing a license condition to ensure compliance with Subpart F of 10 CFR Part 20 and Enclosure 2 to Policy and Guidance Directive 83-23 (NRC, 1983) during operations. This condition must be met prior to commencement of operations:

> The licensee shall develop a survey program for beta/gamma contamination for personnel contamination from restricted areas, and beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of Section 5.7.6.3 of the standard review plan and the requirements of Subparts B, C, and F, of 10 CFR Part 20.

5.7.7.5 References

NRC, 1983. Policy and Guidance Directive 83-23, “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,” November 1983, Office of Nuclear Material Safety and Safeguards, ADAMS Accession No. ML030650166.

NRC, 2009. Meeting Summary for Public Meeting Held in Denver, Colorado November 17-18, 2009, ADAMS Accession No. ML093510155.

5.7.8 Airborne Effluent and Environmental Monitoring Program

5.7.8.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed airborne effluent and environmental monitoring program for the Moore Ranch facility meets the requirements of 10 CFR 20.1003, 10 CFR 20.1301, 10 CFR 20.1302, 10 CFR 20.1101(d), 10 CFR 20.1501 10 CFR 40.65, and Criteria 7 and 8 of Appendix A to 10 CFR Part 40. Criterion 8 is applicable to the Moore Ranch facility only insofar as it requires controlling the hazards of emissions from yellowcake drying and packaging operations there.

5.7.8.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.7.7.3 of the standard review plan. Regulatory Guide 4.14 and Regulatory Guide 8.37 (NRC, 1993) provide guidance on how compliance with the applicable regulations can be demonstrated.

5.7.8.3 Staff Review and Analysis

The following sections discuss the applicant's proposed airborne effluent and environmental monitoring program. This includes radiation monitoring outside of the plant area during operations and environmental monitoring around the facility.

5.7.8.3.1 Airborne Effluent Monitoring

The applicant provides a layout of the CPP in Figure 3.2-1 and Figure 3.2-2 of the technical report. Four main areas are identified, which include the ion exchange area, precipitation area, the yellowcake dryer and packaging area, and the yellowcake storage area. Also, the control room/office, change out room/bathroom, and laboratory area are also located in the CPP. The staff notes that the yellowcake dryer and packaging area is separated by a wall and door from the ion exchange area, precipitation area, and the yellowcake storage area. The applicant has not provided sufficient information regarding the effluent pathway of the air in these areas and the manner in which effluent air is monitored. The staff cannot determine if the air from the yellowcake dryer and packaging area communicates with the air from the other sections of the central plant and if the air does not communicate between these two areas, the methods used to monitor the air effluent from each area.

The applicant stated, in Section 4.1 of the technical report, that potential radiological air particulate effluents will consist primarily of dried yellowcake in the drying and packaging area of the CPP (see Figures 3.2-1 and 3.2-2 of the Technical Report). The drying and packaging area includes the vacuum dryer system and the packaging area immediately below the vacuum dryer. When the yellowcake is dry, it is directed through an enclosed chute and deposited directly into a sealed hood on the drum for packaging. Air is vented through a sock filter to a condenser and the vacuum pump system.

The applicant references NUREG/CR-6733 as the basis for identifying the technologies used for drying and packaging yellowcake. The applicant also cites NUREG-1910, which states that there are no uranium releases from vacuum dryer technology. Notwithstanding the information in NUREG-1910, the applicant needs to demonstrate that potential airborne uranium releases from the processing facilities that could result from uranium surface contamination, yellowcake packaging operations, and maintenance activities do not exceed 10 CFR 20, Appendix B, Table 2 effluent concentrations or the applicable 10 CFR 20.1301 pubic dose limits in the unrestricted areas. These potential releases also need to be demonstrated ALARA. With the exception of yellowcake packaging operations, operations frequently occur while the processing facilities doors are open and ventilation systems are removing air from the building. These are potential pathways that could result in airborne radioactivity outside the CPP. Accordingly, the staff cannot determine from the information provided that the applicant will comply with 10 CFR 20.1302, 10 CFR 20.1501 and 10 CFR 40, Appendix A, Criterion 7 during operations.

The staff has determined that the CPP has a potential to release uranium and uranium daughter particulate activity to unrestricted areas and that the applicant has not demonstrated that it can meet the dose constraint of 10 mrem/yr for particulates, excluding radon-222 and its daughters as defined in 10 CFR 20.1101(d). The staff has determined that a license condition is warranted to meet this standard, as discussed in Section 4.1.4 of this SER.

The applicant stated in Section 4.1 of the technical report that separate ventilation systems will be installed for all indoor unsealed process tanks and vessels where radon-222 or process fumes would be expected. This system will consist of an air duct or piping system connected to the top of each of the process tanks. The applicant did not demonstrate that the air ducts or the piping system connected to the top of each of the process tanks are monitored consistent with Regulatory Guide 8.37 and Table 2 of Regulatory Guide 4.14 under "other stacks" or demonstrate why it is not necessary to do so. The staff cannot conclude that the applicant's effluent monitoring program for gaseous effluents is in compliance with 10 CFR 20.1101(d), 10 CFR 1302(a), Criteria 8 of Appendix A to 10 CFR Part 40, and 10 CFR 40.65, nor can it conclude that it is consistent with Regulatory Guide 4.14 and Regulatory Guide 8.37. The staff has determined that a license condition is warranted to meet these standards. This license condition is discussed in Section 4.1.4 of this SER.

5.7.8.3.2 Environmental Monitoring

5.7.8.3.2.1 Air Particulate Sampling

Table 2 of Regulatory Guide 4.14 suggests that air particulate samplers should be installed at the following locations:

- near the site boundaries;
- in different sectors that have the highest predicted concentrations of airborne particulates;
- at the nearest residence or structure(s) that can be occupied; and
- in one control location, which should be in the least prevalent wind direction from the site.

Air particulate sampling should be continuous with weekly filter changes and quarterly composite by location for natural uranium, radium-226, thorium-230, and lead-210 analysis. The applicant identified four air particulate sampling locations in Figure 5.7-2 of the technical report.

The applicant shows the air particulate sampling locations in Figure 5.7-2; however, these locations are not identified by sector or distance. Descriptions of these locations are as follows:

- MRA-1 - approximately 1.5 km (0.93 mi) from the CPP in the east-southeast sector
- MRA-2 - approximately 1.3 km (0.81 mi) from the CPP, bordering the northeast and east-northeast sector
- MRA-3 - approximately 2.4 km (1.49 mi) from the CPP in the south-southwest sector
- MRA-4 - approximately 2.5 km (1.55 mi) from the CPP in the west-southwest sector (control location)

Based on the information provided, the staff does not concur with the sampling locations. According to the applicant, the predominant wind direction is from the southwest to west sectors, and the predominant wind directions from these sectors represents 40 percent of the total wind direction distribution annually. Considering this wind data, the staff does not concur with the applicant's conclusion that location MRA-1 is well positioned to monitor potential airborne emissions from the site carried by winds from the west. MRA-1 is monitoring winds from the west-northwest sector not the west sector, which is not one of the three predominant wind directions.

In addition, the staff does not concur with the applicant's conclusion that MRA-3 is well positioned to monitor potential airborne emissions from the north and north-northeast sectors. The staff determined that MRA-3 is monitoring winds from the north-northeast sector, which is not one of three. The staff cannot determine if MRA-3 represents the highest predicted concentration. The staff has determined that the wind from the north-northeast sector is also not one of the three predominant wind directions.

Typically, the highest predicted concentration would be that receptor point at the boundary between the controlled area and the unrestricted area. Furthermore, the three sectors with the highest calculated concentration would represent the highest predicted concentration and, thus, the proper location of air particulate sampling and co-location of other sampling medium. The applicant has not clearly defined the controlled areas and the unrestricted area, and, therefore, the staff has concluded that the applicant has not demonstrated that these air particulate sampling stations are in sectors representing the highest predicted concentrations. This failure to identify the locations of the three air particulate sampling station in different sectors that have the highest predicted concentrations of airborne particulate warrants a license condition. This condition is presented in Section 5.7.8.4 of this SER.

The applicant has also not identified an air particulate sampling location at the nearest residence or inhabitable structure. Failure to identify an air particulate sampling location at the nearest residence or inhabitable structure warrants a license condition, which is presented in Section 5.7.8.4 of this SER.

The applicant will collect weekly air particulate samples and composite quarterly for analysis at a contract laboratory for natural uranium, radium-226, thorium-230 and lead-210. This frequency of collection and analytical parameters are consistent with Table 2 of Regulatory Guide 4.14, therefore, the staff finds this acceptable.

5.7.8.3.2.2 Air Radon Sampling

Table 2 of Regulatory Guide 4.14 suggests that radon-222 sampling be conducted at five or more locations using the same locations used for air particulate sampling, except the analytical frequency should be monthly. The applicant identified 10 radon sampling locations in Figure 5.7-2 of the technical report; however, the applicant does not appear to have placed radon sampling stations at the same locations used for air particulate sampling. The staff has identified this issue as a license condition, and the license condition is discussed in Section 5.7.8.3.2.1 of this SER.

The applicant identified MR-1 as the control location; however, this location is not the same as MRA-4, which is a control location for air particulate sampling. Regulatory Guide 4.14 suggests colocating radon stations with air particulate stations. Colocating radon and air particulate sampling stations, as well as direct radiation and soil sampling, allows staff to evaluate all dose pathways for each sampling media at one location and determine the TEDE at that receptor point. TEDE determination, as defined by 10 CFR 20.1003, means the summation of all possible external doses and all possible internal doses. Sampling locations that are not colocated may result in different concentrations contributed from different sources (i.e., the well field versus the CPP) resulting in a partial TEDE. The staff has determined that the applicant needs to colocate all sampling media, as described in Regulatory Guide 4.14. The staff has identified this issue as a license condition, and the license condition is discussed in Section 5.7.8.3.2.1 of this SER.

The applicant shows the air radon sampling locations in Figure 5.7-2; however, similar to the air particulate sampling stations, these locations are not identified by sector and distance. The staff cannot conclude that the applicant has placed the three site boundary radon gas samplers in locations that have the highest predicted concentrations of radon that is consistent with Regulatory Guide 4.14. Therefore, the staff cannot determine if the placement of the three site boundary radon gas samplers is acceptable. The staff has identified this issue as a license condition, and the license condition is discussed in Section 5.7.8.3.2.1 of this SER.

5.7.8.3.2.3 Soil Sampling

Table 2 of Regulatory Guide 4.14 suggests that soil sampling be conducted in five or more locations that are the same as for air particulate sampling. It suggests collecting annual grab samples and analyzing them for natural uranium, radium-226, and lead-210. The applicant stated that the surface soil sampling will be conducted on an annual basis at the locations of the four air particulate sampling locations. These samples will be grab samples at a depth up to 5 cm and will be analyzed for natural uranium, radium-226, and lead-210.

Because the staff cannot conclude that the applicant has placed the three site boundary air particulate samplers in locations consistent with Regulatory Guide 4.14, the staff cannot determine if the proposed soil sampling locations are consistent with Regulatory Guide 4.14. Therefore, the staff cannot determine if the placement of the three site boundary soil samples are acceptable. The staff has identified this issue as a license condition, and the license condition is discussed in Section 5.7.8.3.2.1 of this SER.

5.7.8.3.2.4 Sediment Sampling

Table 2 of Regulatory Guide 4.14 suggests that sediment sampling be conducted as an annual grab sample in one or two surface water sampling locations from each water body. Sediment samples should be analyzed for natural uranium, thorium-230, radium-226, and lead-210. The applicant stated that operational sediment sampling will be conducted on an annual basis, and sample locations will include each of the surface water sampling locations. Sediment samples will be analyzed for natural uranium, thorium-230, radium-226, and lead-210. The staff has determined that the applicant is consistent with Regulatory Guide 4.14, therefore, the staff finds this acceptable.

5.7.8.3.2.5 Food and Fish Sampling

The applicant provided acceptable justification for not sampling fish during preoperations and indicated that fish sampling will not be conducted during operations. This is discussed in Section 2.6 of this SER. The applicant has also provided sufficient justification for not conducting food (crop) sampling.

5.7.8.3.2.6 Vegetation Sampling

Table 2 of Regulatory Guide 4.14 suggests collecting three or more samples for vegetation or forage from animal grazing areas near the site in the direction of the highest predicted airborne radionuclide concentration. Samples should be collected three times during the grazing season, and samples should be analyzed for radium-226 and lead-210. The applicant is proposing not to perform operational vegetation sampling and refers to Footnote O of Table 2 of Regulatory Guide 4.14, as the basis for not conducting vegetation sampling. This footnote states that vegetation and forage sampling should be performed only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway, Furthermore, an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 percent of the applicable radiation protection standards.

The applicant states that this pathway was evaluated and is discussed further in Section 7.3 of the technical report. The staff reviewed dose predictions provided in the application, which demonstrate that the expected TEDE at 1.5 km (0.93 mi) and 3.4 km (2.11 mi) are less than 5 percent of the 10 CFR 20.1301 limit. Associated doses attributable to the meat ingestion pathway ranged from 0.003 to 0.5 percent of the estimated TEDE for a receptor. Therefore, the staff has determined that the vegetation ingestion is not an important pathway for public dose and contributes less than 5 percent of the applicable radiation protection standard of 100 mrem/yr.

5.7.8.3.2.7 Direct Radiation

The applicant states that direct radiation (gamma exposure rate) will be conducted at the air particulate monitoring stations, MRA-1 through MRA-4. Gamma radiation will be monitored continuously using the InLight dosimeter from Landauer, which has an LLD of 0.1 millirem. These dosimeters will be exchanged quarterly. This direct radiation program is consistent with Regulatory Guide 4.14, and the staff determined that the direct radiation program is acceptable, with the exception of the sampling locations, as discussed above. Since the staff cannot conclude that the applicant has placed the three site boundary air particulate samplers in locations consistent with Regulatory Guide 4.14, it cannot determine if the proposed direct radiation monitoring locations are consistent with Regulatory Guide 4.14. Therefore, the staff cannot determine if the placement of the three site boundary direct radiation monitors are acceptable. The staff has identified this issue as a license condition, and the license condition is discussed in Section 5.7.8.3.2.1 of this SER.

5.7.8.4 Evaluation Findings

The staff reviewed the airborne effluent and environmental monitoring program of the proposed Moore Ranch facility in accordance with Section 5.7.7.3 of the standard review plan. The applicant will sample radon, air particulates, surface soils, and direct radiation. The applicant provided justification for not sampling food (crop), fish, and vegetation. The applicant's programs are for the most part consistent with guidance in Regulatory Guide 4.14. However, the applicant has not clearly defined the controlled areas and the unrestricted area, and, therefore, the staff has concluded that the applicant has not demonstrated that these air particulate sampling stations are in sectors representing the highest predicted concentrations. Because the applicant has not demonstrated that the three air particulate sampling station in different sectors that have the highest predicted concentrations of airborne particulate, the staff is imposing the following license condition to ensure proper placement of the sampling stations:

> Consistent with Regulatory Guide 4.14, the licensee shall establish air particulate sampling stations in the three sectors with the highest predicted concentration and colocate radon air samplers and direct radiation and soil sampling with the air particulate sampling stations.

Additionally, the applicant has also not identified an air particulate sampling location at the nearest residence or inhabitable structure. Therefore, the staff is imposing the following license condition to ensure that an air particulate sampling location is established at the nearest residence or inhabitable structure:

> Consistent with Regulatory Guide 4.14, the licensee shall establish an air particulate sampling location at the nearest residence or occupiable structure. In conjunction with the air particulate sampling location, the licensee shall colocate passive radon monitors with the air particulate sampling location. The air particulate sampling location and other colocated sampling media must be operational prior to commencement of operations. The licensee must notify the NRC, in writing, upon establishing an operational air particulate sampling location and include the sector and distance from the CPP.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by the requirement of the noted license conditions, meet the applicable acceptance criteria of Section 5.7.7.3 of the standard review plan and the requirements of the applicable sections of 10 CFR Parts 20 and 40.

5.7.8.5 Reference

NRC, 1993. "ALARA Levels for Effluents from Materials Facilities," Regulatory Guide 8.37. Washington, DC: July 1993.

5.7.9 Ground Water and Surface Water Monitoring Programs

5.7.9.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed ground water and surface water monitoring program for the Moore Ranch facility meets the requirements of 10 CFR 40.32(c), 10 CFR 40.41(c), 10 CFR Part 40, Appendix A, Criterion 5B(5), and 10 CFR Part 40, Appendix A, Criterion 5D.

5.7.9.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 5.7.8.3 of the standard review plan.

5.7.9.3 Staff Review and Analysis

The applicant has described the ground water and surface water monitoring programs to be implemented at the Moore Ranch facility during production operations. Preoperational monitoring is conducted as part of the site characterization and is addressed in Chapter 2 of this SER, whereas restoration monitoring is conducted during ground water restoration and is addressed in Section 6.1 of this SER. The following sections address baseline well sampling, operational monitoring, upper control limits, pumping tests, well field hydrologic packages, excursions, and other sampling.

5.7.9.3.1 Baseline Well Sampling

The applicant stated that to establish baseline water quality within a well field, the 70 sand production zone wells will be sampled four times prior to well field operation, with a minimum of 2 weeks between samples. One well in 3 acres will be selected for sampling. In the first and second sampling, the wells will be sampled for all of the water quality parameters provided in Table 5.7-1 of the technical report based on WDEQ Guideline 8. If certain analytes are not detected in the first two samples, the applicant has proposed eliminating these elements from testing in the remaining samples. This approach is not acceptable to the staff as it results in the possibility that baseline water quality could be established by two samples, which may not be a sufficient number to establish an average. Through a standard license condition, the applicant will be required to obtain four samples for each constituent identified in Guideline 8. The samples shall be obtained at least 14 days apart.

The applicant will use the well field averaging of production zone wells to establish the baseline water quality for a well field. If the sampling results show that the ground water falls into different classes across a well field, the data will not be averaged for the entire region but will be separated into subzones. Data within these subzones will be averaged. The final average and range of baseline values for each analyte will be used to determine the restoration target values (RTVs). This approach to averaging baseline ground water quality is consistent with the guidance in NUREG-1569 and, therefore, is acceptable to the staff.

The applicant provided a detailed discussion of standard operating procedures for well sampling to be used at the Moore Ranch facility. The procedures address water level determination, well sampling techniques, sample preservation, sampling documentation, and QA/QC. A comprehensive QA plan was provided in Addendum 5-A, "Wyoming ISR Operations Quality Assurance Plan (Quality Assurance Plan or QAP)," of the technical report. These standard operating procedures and the QA plan are consistent with the guidance in NUREG-1569 and, therefore, are acceptable to the staff.

5.7.9.3.2 Operational Monitoring

Monitoring well rings will be established around each well field to monitor for horizontal excursions from the 70 sand production zone during ISR operations. The applicant conducted numerical ground water flow modeling using a sitewide model to determine the appropriate distance and spacing of the individual wells in this ring. This modeling was described in the application and discussed in Section 3.1 of this SER. These simulations showed that during anticipated operations, the well field would be in hydraulic communication with monitoring wells spaced 500 feet away from the edge of the well field and 500 feet apart. Also, the simulations showed that an excursion would be detected on this monitoring ring well spacing.

Monitoring wells will also be established in the 72 sand overlying aquifer and the 68 sand underlying aquifer at a spacing of one well per 1.62 hectare (4 acres) for the proposed well fields to detect vertical excursions. In the areas where the 68 sand and the 70 sand coalesce in Well Field 2, the applicant stated that it would treat them as one production aquifer. It would, therefore, install monitoring wells at a spacing of one well per 1.21 hectare (3 acres) in the 68 sand to provide additional monitoring to detect any excursions in the area where the two sands coalesce. Monitoring wells would also be installed in the underlying 60 sand aquifer in the region where the 68 and 70 sands coalesce in Well Field 2 at a spacing of one well every 1.62 hectare (4 acres). The applicant indicated that the location of the wells in the 68 and 60 sands will be determined during well field planning and submitted to WDEQ in the well field hydrologic data package. The staff cannot conclude that there will be adequate monitoring of this region of Well Field 2 without reviewing the number and location of the monitoring wells in the 68 and 60 sands. Therefore, by license condition, the applicant will also provide the well field hydrologic data package to the NRC for review and approval. This license condition is initially discussed in Section 2.4.3.2.2 of this SER.

The applicant stated that all operational monitoring wells will be sampled four times prior to well field operation, with a minimum of 2 weeks between samples to establish baseline water quality. It stated that in the first sampling, all wells will be tested for all of the water quality parameters provided in Table 5.7-1 of the technical report based on WDEQ Guideline 8. Subsequent samples will only be tested for the proposed UCL parameters of chloride, conductivity, and total alkalinity. The staff concludes that this sampling is not sufficient to establish baseline water quality in the overlying, underlying, and surrounding extraction zone aquifers. An acceptable baseline water quality evaluation requires at least four separate measurements of all parameters provided in Table 5.7-1 at the operational monitoring wells. This baseline is critical to establish restoration targets for these aquifers if they are contaminated by leaks, spills or excursions. Therefore, through a standard license condition, the applicant will be required to conduct the same baseline water quality analysis as is done for the 70 sand production zone wells.

5.7.9.3.3 Upper Control Limits

The applicant will develop UCLs for each overlying/underlying aquifer and in the monitoring well ring surrounding the 70 sand production zone, as a means of detecting excursions. UCL constituents chosen for indicators of excursions are chloride, conductivity, and total alkalinity. Water levels will be measured but not used as an excursion indicator. UCLs will be set at baseline mean concentration plus five standard deviations for each excursion indicator. In situations where baseline for chloride is low and consistent, the applicant will consider setting the UCL at baseline plus 15 mg/l. These indicator parameters and UCL's are consistent with industry practices. Therefore, the staff finds these indicators and UCLs acceptable for monitoring excursions outside the production zone and in the overlying and underlying aquifers.

In Section 2.4 of this SER, the staff expressed a concern that the 72 sand may have been impacted in the past by CBM-produced water discharge and may also be impacted in the future. CBM discharge, as described in the application, contains high values of TDS and bicarbonate, which can influence the UCL indicator values of conductivity and alkalinity. The applicant stated that, based on its analysis of water quality in the 72 sand at four monitoring wells across the well fields, there is currently no apparent impact from CBM-produced water and concluded these indicators are appropriate. The staff has determined that this monitoring is not sufficient to make this conclusion for all of the 72 sand. The staff concludes that this determination may only be made after a thorough evaluation of the baseline water quality of the 72 sand has been conducted to determine if there are areas of impact, especially near CBM-produced water discharge points. This will be required by the standard license condition related to baseline well field monitoring discussed in Section 5.7.9.3.2 of this SER.

The applicant stated that if an apparent excursion from ISR operations is detected by the proposed UCL monitoring in the 72 sand, it will trigger an additional investigation to determine whether the elevated readings reflect an excursion from ISR operations, or if the elevated readings are being caused by CBM activities, or by some other source. This investigation will include the evaluation of additional indicator parameters, including uranium. Because dissolved uranium is typically low in CBM waters, the applicant stated that dissolved uranium may be particularly suited to distinguish between impacts from ISR spills, leaks, or excursions. The staff agrees that dissolved uranium should be a useful indicator for this purpose.

5.7.9.3.4 Pumping Tests and Well Field Hydrologic Data Packages

After installation of all wells and completion of all baseline water quality sampling and well field characterization, the applicant will conduct pumping tests to verify communication between the well field and the monitoring well ring. As discussed in Section 3.1 of this SER, the applicant used ground water flow model simulations to demonstrate that the cone of depression will reach the monitoring well ring under anticipated operating scenarios. A sitewide model was also used to run hydrologic test design simulations to determine how to conduct these pumping tests. This combination of pumping tests and modeling to demonstrate communication with the monitoring well ring in the 70 sand unconfined (unsaturated) aquifer is acceptable to the staff.

After well field testing is completed, the applicant stated that it will prepare a well field hydrologic data package for each well field and provide it to the WDEQ for review and approval before ISR operations begin. Under the NRC's performance-based license requirements, the applicant intends to use a SERP to review the well field hydrologic package internally to ensure that the planned extraction activities do not conflict with the NRC license or regulations. The staff finds there are outstanding issues (as discussed above in Section 2.4 on ground water hydrology; Section 2.6 on ground water quality; Section 3.1 for ISR operations; Section 5.7.9 for monitoring; and Section 6.1 below for restoration) that will only be resolved after well field testing has been completed. For Well Field 1, these issues will require that staff review the hydrologic package before ISR operations begin in this well field. Due to the more complex conditions in Well Field 2, the staff will need to review and approve the hydrologic data package before ISR operations begin in this well field. These findings are reflected in the license condition set forth in Section 2.4.3.2.2 of this SER. The inclusion of this license condition is necessary for the staff to conclude that ISR operations at the Moore Ranch facility can be conducted in a manner that is protective of public health, safety, and the environment.

5.7.9.3.5 Excursions

Once ISR operations are approved and begin, the applicant stated that monitoring will consist of sampling all the monitoring wells twice monthly at least 10 days apart for the excursion indicators. If concentrations of two of any three excursion indicators exceed UCLs, the well(s) will be resampled within 24 hours for verification. The verification sample will be split and analyzed in duplicate to assess analytical error. If a second sample does not verify the excursion, a third sample will be taken within 48 hours. If the neither the second nor third sample confirms an exceedance, the first sample will be considered in error. If either the second or third sample confirms an exceedance, the well in question will be placed on excursion status. The NRC project manager will be notified within 24 hours by phone or e-mail and in writing within 30 days. This approach to excursion verification is accepted practice by the NRC.

Once an excursion is verified, the applicant will implement corrective actions. These include investigating the probable cause, adjusting production/injection rates to produce an inward gradient away from the offending well, pumping individual wells to recover more lixiviant, or suspending injection in the area adjacent to the well on excursion. Sampling will also be increased to once every 7 days. Using ground water flow modeling, the applicant demonstrated that an excursion could be reversed within a relatively short period of time and would not lead to excessive dewatering in the unconfined (unsaturated) aquifer as discussed in Section 3.1 of this SER.

The applicant stated an excursion will be considered corrected when the excursion indicators do not exceed the UCLs. If the concentration of UCLs does not begin to decline after 60 days, the applicant will submit an excursion correction plan and compliance schedule to the NRC. Also, the applicant will update its financial assurance for cleanup of excursions, which remain for more than 60 days as discussed in NUREG-1569. The staff concludes that the procedures for detecting, correcting, and reporting excursions are consistent with the guidance in NUREG-1569. Therefore, the staff finds these procedures acceptable.

5.7.9.3.6 Other Sampling

In addition to well field monitoring, all private wells within 1 km (0.62 mi) of the well field area boundaries will be sampled quarterly for natural uranium and radium-226. Wells will be purged before sampling. Samples will be taken when pH and specific conductivity are stable.

The applicant will also sample surface water during operations within the license area. All preoperational surface water sample points shown in Figure 2.7-1 of the technical report will continue to be monitored quarterly when water is present. Samples will be analyzed for lead-210, radium-226, thorium-230, natural uranium, and polonium-210. Surface water monitoring results will be submitted in the semiannual monitoring reports to the NRC. The staff finds the proposed surface water sampling to be consistent with the guidance in NUREG-1569 and, therefore, is acceptable.

5.7.9.4 Evaluation Findings

The staff reviewed the ground water and surface water monitoring programs of the proposed Moore Ranch facility in accordance with Section 5.7.8.3 of the standard review plan. The applicant has defined a sampling program for the following environs:

- Any surface water body that lies within the facility boundary, including downstream sampling locations.
- Well field baseline water quality sampling programs, including the number and timing of samples, constituents sampled, and appropriate statistical methods.
- Operational ground water monitoring programs, including the appropriate location and spacing of monitoring wells, monitoring frequency, and criteria for determining the presence of an excursion.
- Additional indicator testing, including uranium, for excursions detected in the 72 sand to distinguish between excursions from ISR operations from those of CBM activities.

Appropriate well field test procedures are established, and, by license condition, the applicant will provide the well field hydrologic data packages to the NRC for review and approval per the license condition discussed in Section 2.4.3.2.2. Furthermore, the applicant has prepared an excursion corrective action plan, including notification of NRC and subsequent reporting in the event of an excursion. The staff notes that under 10 CFR Part 40.65 the applicant will be required to submit semiannual effluent monitoring reports that identifies the quantity of principal radionuclides released to unrestricted areas in liquid (including groundwater) and gaseous effluents.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.7.8.3 of the standard review plan and are in compliance with the following regulations:

- 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life and property;
- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license;
- 10 CFR Part 40, Appendix A, Criterion 5B(5), which provide concentration limits for hazardous constituents ; and
- 10 CFR Part 40, Appendix A, Criterion 5D, which requires a ground water corrective action program.

5.7.10 Quality Assurance

5.7.10.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed quality assurance program for the Moore Ranch facility meets the requirements of 10 CFR 20.1101, and 10 CFR 20 Subpart L and Subpart M.

5.7.10.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 5.7.9.3 of the standard review plan. Regulatory Guide 4.15 (NRC, 2007) provides guidance on demonstrating compliance with the applicable regulations.

5.7.10.3 Staff Review and Analysis

This section discusses the proposed QA programs for radiological and nonradiological monitoring activities. QA comprises all those planned and systematic actions that are necessary to provide adequate confidence in the assessment of monitoring results. QC comprises those QA actions that provide a means to measure and control the characteristics of measurement equipment and processes to meet established standards; QA includes QC. QA is necessary to ensure that all radiological and nonradiological measurements that support the radiological and nonradiological monitoring programs are reasonably valid and of a defined quality.

5.7.10.3.1 Radiological and Nonradiological Monitoring Programs

Regulatory Guide 4.15 describes a method that is acceptable for use in designing and implementing programs to ensure the quality of the results of measurements of radioactive materials in the effluents from, and environment outside of, facilities that process, use, or store radioactive materials during all phases of the facility's lifecycle. Section B of Regulatory Guide 4.15 states that every organization actually performing effluent and environmental monitoring, whether an NRC licensee or the licensee's contractors, should include the QA program elements in this guide. Section C of Regulatory Guide 4.15 states that, in addition to its own program, a licensee should require any contractor or subcontractor performing monitoring activities for the licensee to provide a QA program and to routinely provide program data summaries consistent with the provisions of this guide.

The applicant provided a QA program that will be implemented at the Moore Ranch facility for all relevant operational monitoring and analytical procedures and will include the following items, as provided in Addendum 5-A of the technical report:

- formal delineation of organizational structure and management responsibilities, including both the review and approval of written procedures, and the monitoring of data/reports;minimum qualifications and training programs for individuals performing radiological monitoring and for those individuals with the QA program;written procedures for QA activities, including activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting;

- QC in the laboratory, including outside laboratory QA/QC programs and procedures covering statistical data evaluation, instrument calibration, duplicate sample programs, and spike sample programs; and

- provisions for periodic management audits to verify that the QA program is effectively implemented to verify compliance with applicable rules, regulations, and license requirements and to protect employees by maintaining effluent releases and exposures ALARA.

5.7.10.3.2 Organizational Structure and Responsibilities of Managerial and Operational Personnel

The applicant identified five key positions of the organization in the QAP including the Sr. VP, the Director of Environmental and Regulatory Affairs, the Manager of Wyoming Environmental and Regulatory Affairs, the senior environmental specialist (SES), and the RSO. The RSO has the responsibility for the overall management of the radiation safety program, including the implementation of the QA program requirements related to radiation safety programs. Regulatory Position 1 of Regulatory Guide 4.15 states that persons and organizations performing QA functions should have sufficient authority and organizational freedom to identify quality problems; to initiate, recommend, or provide solutions; and to verify the implementation of solutions. The staff has determined that this organizational structure provides the QA manager sufficient authority and organizational freedom to implement the QA program. However, the current organization chart for the facility does not identify the QA manager. Therefore, the applicant will be required to update the organization chart through the license condition presented in Section 5.7.10.4 of this SER.

5.7.10.3.3 Specification of Qualifications of Personnel

The applicant stated that personnel will be qualified to perform their assigned job through meeting basic job description requirements, education standards, experience, and ongoing performance reviews. The SES is responsible for determining site-required training and for communicating the requirements to appropriate managers. QA staff that performs independent assessments of environmental monitoring activities or management systems will be qualified as lead assessors. Laboratories used for analysis of samples collected for characterization, compliance, or other purposes will be required to pass an audit or be certified by the National Environmental Laboratory Accreditation Conference. The applicant stated that managers are responsible for determining the training needs of their staff. The proposed qualifications of personnel and laboratories are consistent with Regulatory Guide 4.15. Therefore, the staff finds the proposed qualifications acceptable.

5.7.10.3.4 Operating Procedures and Instructions

In the data generation and acquisition section of its QAP, the applicant addressed the aspects of measurement system design and implementation to ensure that appropriate methods for sampling, analysis, data handling, and QC are employed and will be thoroughly documented. The applicant stated that the type and quality of data provided to appropriate regulatory agencies will be sufficient to document the performance of the uranium recovery operation and the later attainment of reclamation and restoration goals. The applicant listed the data quality objectives as follows:

- Data will be of sufficient quality to withstand scientific and legal scrutiny.
- Data will be acquired in accordance with procedures appropriate to their intended use.
- Data will be of known quality and precision.

The applicant stated that the site-specific environmental monitoring plan defined in the application describes the sample location and the sampling frequency and types of analysis. The applicant will review the environmental monitoring plan every 5 years and will update the plan as necessary. Any updates to the environmental monitoring plan that eliminate or modify monitoring parameters, locations, or frequencies specified in the technical report will be made through a license amendment.

The applicant stated that sampling methods will follow procedures based on nationally recognized consensus standards such as EPA methods, American Society for Testing and Materials standards, or instrument manufacturer's recommended procedures. The RSO will be responsible for ensuring that field measurements and samples are properly documented, occur at the prescribed frequency and location, and are obtained in compliance with procedures and requirements specified. Standard Operating Procedures for sampling activities will be developed and maintained on site by the applicant. Changes to the Standard Operating Procedures will be approved by the RSO prior to implementation.

Personnel responsible for collecting and analyzing samples will comply with the requirements of all approved written procedures or other instructions. Any deviation from approved field procedures must be authorized by the RSO. The applicant indicated that the RSO will be notified of any changes to subcontract laboratory procedures, and the RSO will be informed of, and review changes to, laboratory procedures.

The applicant described the preparation and decontamination requirements for the sampling equipment. This included a brief discussion of requirements for sample containers, preservation, and holding times. The applicant has addressed cross-contamination of samples in its QAP and will develop protocols for cleaning of equipment and sample containers. The staff notes that the proposed operating procedures and instructions are consistent with Regulatory Guide 4.15 and finds them acceptable.

5.7.10.3.5 Records

The applicant stated that the requirements for documentation and records management apply to the preparation, review, approval, issue, use, and revision of documents or forms that prescribe processes, specify requirements, or establish design. The applicant stated that field and laboratory data will be sufficiently documented to provide a scientifically defensible record of the activities and analyses performed. Records of field variance reports, internal reviews, field and laboratory records of tests and analyses, field logs, chain of custody forms, and project reports will be used in interpreting and assessing the usability of the data. A site-specific records management plan shall be prepared to identify the records to be generated, file locations, and retention schedules for the site, which will establish requirements for preparing, preserving, and storing records. The applicant indicated that preparation, issuance, and revisions to project documents and forms will be controlled so that current and correct information is available at the work location. Project documents (e.g., plans, procedures, drawings, and forms) and subsequent revisions will be reviewed for adequacy and approved before being issued for use. The applicant has identified the records that will need to be maintained for at least three years as well as records that will be maintained until the license is terminated. The proposed documentation and records management system is consistent with Regulatory Guide 4.15. Therefore, the staff finds this acceptable.

5.7.10.3.6 Quality Control

The applicant described the sample handling, custody, and shipping requirements. A field custodian will be responsible for the care, packaging, and custody of a sample until it is transferred to a laboratory. Samples will be assigned unique numbers and appropriately labeled. Chain of custody forms will be used to list all samples and the transfer of samples. Samples will be stored according to their requirements and will be kept in locked containers or buildings when they are out of control of their custodian. Custody seals will be placed on the outside of the container if it is in a location where access is not solely controlled by the custodian. All samples will be labeled, packaged, and transported in accordance with applicable DOT requirements. The chain of custody form will accompany samples sent or transported to an analytical laboratory.

The applicant provided procedures for receipt of samples at the subcontract analytical laboratory. It stated that upon receipt, the laboratory will be responsible for the care, custody, archiving, and disposal of samples. It stated that any laboratory that analyzes samples will have written a QA/QC program that ensures reliability and validity of all analyses. It stated that subcontracted laboratories will be required to pass appropriate audits or be certified. The intent of the on-site laboratory is to provide process control; the on-site laboratory will not be an accredited laboratory.

The applicant described QC practices to ensure that the data quality objectives were met. Field QA/QC practices for the collection of samples will include duplicates, equipment rinsate blanks, trip blanks, and additional volumes of ground water for spike duplicates. These field QC samples will be specifically identified. The laboratory will also perform internal system checks and analyze control samples to check laboratory QC.

The applicant stated that it would perform proper maintenance and calibration and will ensure the proper use of equipment and instruments to ensure data quality. Field and laboratory equipment and instruments will be maintained and calibrated at approved intervals of sufficient frequency and in a manner consistent with manufacturers' specifications. All calibration and calibration checks will be performed based on approved written procedures. Calibration standards will be based on the National Institute of Standards and Technology or other recognized standards. The SES will be responsible for overall maintenance, operation, calibration, and repairs made to field and laboratory equipment, instruments, and tools. The SES will also be responsible for ensuring that any of these actions are adequately documented in the field or laboratory.

The applicant stated that all supplies and consumables used in the field and laboratory will be inspected for integrity, cleanliness, and compliance with specified tolerances. Expired materials will not be used and will be properly disposed. Inventories of supplies will be maintained. The SES will be responsible for all inspection activities and inventories of supplies and consumables.

The applicant includes functions such as the physical check of instruments, battery checks, response source checks, calibration verification, and background measurements as part of the QC program. Other QC checks can include, if applicable, high-voltage checks, efficiency/correction factors, reliability factors, and the determination of LLD. The staff has determined that the applicant incorporated QC checks consistent with Regulatory Guide 4.15, and the staff finds this to be acceptable.

The applicant stated that the environmental specialist will be responsible for managing project data. This will include field data books, data from samples submitted to an analytical laboratory, and electronic data that are archived in the project records. The proposed QC activities are consistent with Regulatory Guide 4.15.

5.7.10.3.7 Verification and Validation

The verification and validation (V&V) of certain aspects and support activities of the measurement process or monitoring program are essential to the QA program. These aspects and activities include data and computer software V&V and project method validation. Project method validation is the demonstration that a method using a performance-based method selection is capable of providing analytical results to meet criteria in the analytical protocol specification. Acceptable method validation is necessary before the radiological analysis of samples or the taking of measurements in a monitoring program.

The applicant stated that technical data, including field data and the results of laboratory analyses, will be routinely verified and validated to ensure that the data are of sufficient quality and quantity to meet the project's intended data needs. Field data will be initially screened for completeness, transcription errors, compliance with procedures, and accuracy of calculations.

Corrections will be appropriately documented in field and other data forms with the approval of the SES. Laboratory records will be checked to assess completeness of the laboratory data package. The data will then be validated by qualified personnel. QC data provided in the data package (e.g., method blanks and spikes) will be evaluated to determine if they are acceptable. If not, the data will be evaluated to determine if corrective actions are necessary. Corrective actions include reanalysis of the data by the laboratory or resampling.

Data that pass this screening process will then be evaluated by a qualified individual who will determine if the data are acceptable or require followup. If a data point is questioned, the applicant may request any or all of the following: laboratory check of calculation and dilutions, sample reanalysis, resampling, comparison to results from the next sampling event, and data qualification. Based on the results of the followup action, the SES will make a final determination of the validity of the data point.

The applicant stated that results of data validation efforts will be documented and summarized in the site-specific validation reports. The applicant indicated that the SES will be responsible for initiating the review, verification, validation, and screening associated with field and/or laboratory data. The applicant indicated that this will include field measurement data, laboratory data, QC samples, the qualification of data and corrective actions, and the determination of anomalous data. The proposed data V&V activities are consistent with Regulatory Guide 4.15. Therefore, the staff finds them acceptable.

5.7.10.3.8 Assessments and Audits

Assessments, audits, and surveillances are elements used to evaluate the initial and ongoing effectiveness of the QA program to monitor and control the quality of a radiological monitoring program. Management having responsibility in the area being reviewed should document and review the results of these activities. Audits of the QA programs of contractors providing materials, supplies, or services affecting the quality of the laboratory’s operations should be performed periodically.

The applicant indicated that all personnel must continually seek to improve the quality of their work. The applicant stated that it will use quality improvement to encourage innovation and continuous improvement and to foster a “no fault” attitude, assessment, and response action that will be under the direction of the director of environmental and regulatory affairs who is responsible for scheduling and administering the internal assessment plan. The applicant stated that the quality improvement actions (e.g., planning, lessons learned, nonconformance reporting, tracking and followup, and reviews) will be documented and reported to management. The proposed quality improvement, assessment, and oversight activities are consistent with Regulatory Guide 4.15. Therefore, the staff finds them acceptable.

5.7.10.3.9 Preventive and Corrective Actions

Integral components of a QA program include identifying areas for improvement, defining performance or programmatic deficiencies, and initiating appropriate corrective or preventive actions. The QA program for radiological effluent and environmental monitoring programs should contain both a continuous-improvement program and a program for implementing corrective actions when conditions adverse to quality have been identified.

The applicant proposed a corrective action program that includes the process of identifying, recommending, approving, and implementing measures to improve unacceptable procedures and sampling practices that may affect data quality. The applicant states that all proposed and implemented corrective actions will be documented through the site SERP process and that items requiring immediate corrective actions will be implemented with the approval of the RSO and modifications documented through the SERP process.

The applicant also stated that during any field sampling activity, the field personnel will be responsible for documenting and reporting all QA nonconformance and suspected deficiencies associated with the sampling being conducted. The applicant indicated that all nonconformance and/or deficiencies will be documented in the field log book or sheets and reported to the RSO. The applicant indicated that if the problem is associated with field measurement sampling equipment, the field personnel will take the appropriate corrective actions. The applicant states that if the field corrective actions are not sufficient to correct the deficiency, personnel may suspend field activities until the problem can be resolved. Any time field activities have been suspended due to QA deficiencies, the RSO shall be notified. The applicant states that field corrective actions will be documented in the field sampling log book or field sampling sheets.

5.7.10.4 Evaluation Findings

The staff reviewed the quality assurance program of the proposed Moore Ranch facility in accordance with Section 5.7.9.3 of the standard review plan. The applicant has addressed the organizational structure and management responsibilities, personnel training, the use of QC methods, and provisions for periodic management audits and has committed to providing written procedures and protocols to those activities that are important to QA. Acceptable aspects of these QA elements are identified in Regulatory Guide 4.15.

This organizational structure provides the QA manager sufficient authority and organizational freedom to implement the QA program. However, the current organization chart for the facility does not identify the QA manager. Therefore, the staff is imposing the following license condition to ensure that the organization chart clearly identifies the QA manager position:

The licensee shall submit an updated organizational chart identifying the QA manager position. Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of Section 5.7.9.3 of the standard review plan and meet the requirements of 10 CFR 20.1101, 10 CFR 20 Subpart L, and Subpart M.

5.7.10.5 Reference

NRC, 2007. "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment," Revision 2, Regulatory Guide 4.15. Washington, DC: July 2007.

6. GROUND WATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 Plans and Schedules for Ground Water Quality Restoration

6.1.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed plans and schedules for ground water quality restoration for the Moore Ranch facility meet the requirements of 10 CFR 40.32(c), 10 CFR Part 40.42, and Criterion 5B(5) of Appendix A to 10 CFR Part 40.

6.1.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.1.3 of the standard review plan.

6.1.3 Staff Review and Analysis

This section discusses the plans for proposed ground water quality restoration activities at the Moore Ranch facility. 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.

6.1.3.1 Restoration Standards

Ground water quality – i.e., concentrations of hazardous constituents – must be restored to the standards identified in Criterion 5B(5) of Appendix A to 10 CFR Part 40. Those standards are background concentration or the maximum values for ground water protection in the Criterion 5C Table, whichever level is higher; 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 constituents in the production zone to these standards. The staff finds this commitment to be consistent with the regulations, and will include an additional requirement as a license condition. This license condition is presented in Section 6.1.4 of this SER.

As stated above, ACLs are one of the applicable ground water restoration standards. In order for a licensee to receive approval to use ACLs, it must first demonstrate that – for the constituents at issue in the well field being restored -- it has made reasonable effort to return those constituents to background or to the Table 5C values – whichever level is higher. A request to establish ACLs is a license amendment application submitted by the licensee and is subject to a technical and environmental review. ACLs that present no significant hazards may be proposed for NRC consideration. The NRC may establish a well field-specific ACL for a constituent only if it finds that the proposed limit is ALARA, and that the proposed limit would not pose a substantial present or potential hazard to human health or the environment as long as the ACL is not exceeded. The many factors that the NRC must consider 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).

Further, in considering ACL requests, particular importance is placed on protecting underground sources of drinking water (USDWs) in the area around the ISR facility, and the staff in this regard also considers -- in accordance with Criterion 5B(4) -- the exempted aquifer determinations made by the EPA. In this regard, before an ISR applicant or 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. 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."

As discussed in Section 2 of the SER, the applicant has already collected preliminary baseline water quality data in accordance with Criterion 7 of Appendix A to 10 CFR Part 40. After an ISR license is issued but before ISR operations begin, injection and production wells from which additional water quality data can be collected will be sampled and analyzed. Based on this additional data, the licensee will set its restoration target values (RTVs) for the Moore Ranch facility well fields.

RTV's are the primary restoration standard at ISR facilities, and must be established in accordance with the requirements discussed above in Criterion 5B(5) of Appendix A to 10 CFR Part 40. These RTVs will be based on the average baseline (i.e., background) 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. 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 after completion of each well field in the planned production zone. This additional sampling will occur after an ISR license is issued but before ISR operations begin. As described in Section 5.7.9.3.1 of this SER, the applicant will subdivide a well field into zones and establish different RTVs in each zone, if water quality differs substantially over an entire well field. By license condition, the licensee will be required to submit the Well Field 1 hydrologic data package for NRC review, and will be required to submit the Well Field 2 hydrologic data package for NRC review and approval. Both of these data packages will include the RTVs for each well field. This license condition is initially discussed above in Section 2.4.3.2.2 of this SER.

6.1.3.2 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 6.1.3.7 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 brine 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.

6.1.3.3 Effectiveness of Ground Water Restoration Methods

The applicant reported that the restoration methods proposed for the Moore Ranch facility have been successfully applied to existing ISRs at Irigaray and Christensen Ranch in the PRB. Considering the similar geological setting and type of lixiviant, the applicant stated that the same restoration practices should be successful at the Moore Ranch facility. To further support the suitability of its proposed restoration methods at the Moore Ranch facility, 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 facility was that the 70 sand is an unconfined (unsaturated) aquifer with higher conductivity. The staff finds the Uranium One Irigaray and Christensen Ranch ISRs to be acceptable analogs for restoration for Moore Ranch facility because of the similar geologic and hydrogeologic conditions at the sites.

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

6.1.3.4 Pore Volume Estimates

6.1.3.4.1 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 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, resulting in an 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 the Moore Ranch facility, where the saturated thickness of the unconfined (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 unconfined (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.

6.1.3.4.2 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 of this SER, 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 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.

6.1.3.4.3 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 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 Uranium One Irigaray and Christensen Ranch ISRs as presented in Addendum 6.1-A of the technical report. The applicant provided evidence to the staff that these ISRs were acceptable analogs for Moore Ranch facility 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. The applicant 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. The applicant 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 the Moore Ranch facility 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 the Moore Ranch facility. The 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 restoration strategy.

6.1.3.5 Ground Water Restoration Monitoring

The applicant stated that because lixiviant injection will be discontinued during restoration, the possibility of an excursion will be lower during restoration than 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.

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.

6.1.3.6 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 the Moore Ranch facility. 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 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.

6.1.3.7 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.

The applicant 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. The applicant 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.

6.1.3.8 Well Field Plugging and Abandonment

The applicant 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.

6.1.3.9 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 based on the known conditions at the site and are, therefore, acceptable to the staff. The 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 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 6.1.4 of this SER.

6.1.4 Evaluation Findings

The staff reviewed the plans and schedules for ground water quality restoration of the proposed Moore Ranch facility in accordance with Section 6.1.3 of the standard review plan. The applicant provided an approach that includes a mix of ground water transfer and ground water treatment to restore ground water quality. 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 the standards in 10 CFR Part 40, Appendix A, Criterion 5(B)5. The staff will impose this requirement as a license condition to ensure that the proper ground water restoration standards are in place at the facility:

> Ground Water Restoration. 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 ground water 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 40.42.
>
> Hazardous constituents in the ground water shall be restored to the numerical ground water protection standards as required by 10 CFR 40, Appendix A, Criterion 5(B)(5). In submitting any license amendment application requesting review of proposed alternate concentration limits (ACLs) pursuant to Criterion 5(B)(6), the licensee must also show that it has first made reasonable effort to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater).
>
> 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.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by the noted license condition, meet the applicable acceptance criteria of Section 6.1.3 of the standard review plan and the requirements of 10 CFR 40.32(c), 10 CFR Part 40.42, and Criterion 5B(5) of Appendix A to 10 CFR Part 40.

6.2 Plans for Reclaiming Disturbed Lands

6.2.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed plans for reclaiming disturbed lands for the Moore Ranch facility meet the requirements of 10 CFR 40.42 and Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.2.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.2.3 of the standard review plan.

6.2.3 Staff Review and Analysis

The applicant has provided a site-wide general decommissioning plan and its initial cost estimate for restoring the Moore Ranch facility at the end of ISR operations. A more detailed decommissioning plan will be submitted at least 12 months prior to any planned final site decommissioning, in accordance with 10 CFR 40.42 and the license condition set forth below. This detailed decommissioning plan will account for actual as-built conditions which may differ from initial licensing plans, and will account for spills, areas of radionuclide deposition, and other soil contamination issues as discussed further in Section 6.4 of this SER. Additionally, the detailed decommissioning plan will account for any presently unanticipated ground water conditions. This requirement is reflected in the license condition presented in Section 6.2.4 of this SER.

Unless an alternative use is justified and is approved by the State and the landowner, the applicant has committed to return all lands disturbed by its ISR operations to the preoperational land use (i.e., livestock grazing). This commitment extends to restoration of the preoperational wildlife habitat. After reclamation activities are complete, there will be no restrictions on surface use. The soils, vegetation, and radiological baseline data would be used as a guide in final reclamation. Reclamation activities for disturbed lands would consist of plugging and abandoning all wells, establishing soil cleanup criteria, surveying for contaminated soils and removing contaminated soils to a licensed disposal facility, performing final surveys, recontouring disturbed areas, salvaging and replacing topsoil, and revegetating disturbed areas. As discussed in Section 4.2 of this SER, the applicant does not have an approved waste disposal agreement for solid byproduct material in place at this time. A license condition will require that an agreement be in place prior to commencement of operations. Additionally, the applicant will be required to comply with the 10 CFR 40.42(k)(1) and 10 CFR 40.42(k)(2) requirements that source material be properly disposed of at the end of ISR operations, and that reasonable effort will then be made to eliminate residual radioactive contamination.

The applicant has provided acceptable plans for a prereclamation radiation survey that uses instrumentation and techniques similar to the preoperational survey used to establish baseline site conditions allowing for a direct comparison to identify contaminated areas. Areas to be evaluated include well field surfaces, structures in process and storage areas, onsite transportation routes, previous spill areas, and any other onsite areas that may be contaminated by ISR operations. The applicant has defined appropriate procedures for the prereclamation survey and the means used to identify areas for cleanup using the acquired data.

Cleanup criteria identified for soils are consistent with the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40 and include a consideration of ALARA goals and the chemical toxicity of uranium. All solid byproduct material waste would be disposed of offsite at a facility licensed by the NRC or an Agreement State. This would appropriately control, minimize, or eliminate the post-closure release of nonradiological hazardous constituents, such as selenium, contained in solid byproduct material.

Final, post-reclamation radiological soil conditions would be documented through GPS-based gamma surveys, and the results compared to preoperational baseline survey data to verify successful cleanup. Recontouring land where surface disturbance has taken place will restore it to a configuration that will blend in with the natural terrain and will be consistent with the pre-extraction land use. No major changes to the topography will occur during operations.

The applicant has committed to a health physics and radiation safety program that will follow ALARA principles and will follow the applicable sections of Regulatory Guide 8.30. Radiation safety during decommissioning will follow the program presented in Section 5 of the technical report.

6.2.4 Evaluation Findings

The staff reviewed the plans for reclaiming disturbed lands of the proposed Moore Ranch facility in accordance with Section 6.2.3 of the standard review plan. The applicant described various aspects of reclamation activities at the site including: plugging and abandoning all wells, establishing soil cleanup criteria, surveying for contaminated soils and removing contaminated soils to a licensed disposal facility, performing final surveys, recontouring disturbed areas, salvaging and replacing topsoil, and revegetating disturbed areas. The applicant described the techniques that will be used to conduct the prereclamation survey to identify potentially contaminated areas. This information provides a site-wide general decommissioning plan that identifies the anticipated conditions at the end of operations. However, the plan does not account for actual as-built conditions which may differ from initial licensing plans, spills, areas of radionuclide deposition, or other soil contamination issues that may arise during operations. Therefore, the staff is imposing the following license condition to ensure that a detailed decommissioning plan is submitted prior to final site decommissioning:

> At least 12 months prior to initiation of any planned final site decommissioning, the licensee shall submit a detailed decommissioning plan for NRC review and approval. The plan shall represent as-built conditions at the Moore Ranch facility.

Criterion 2 requires that byproduct material from in situ extraction operations should be disposed of at existing large mill tailings disposal sites. The staff also notes that a license condition (see Section 4.2 of this SER) would provide that the applicant meet Criterion 2 of Appendix A to 10 CFR Part 40, under which the applicant will be required to have in place, before ISR operations begin, an agreement for disposal of solid byproduct materials at a licensed facility offsite.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by information to be submitted in accordance with the noted license conditions, meet the applicable acceptance criteria of Section 6.2.3 of the standard review plan and the requirements of 10 CFR 40.42 and Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.3 Removal and Disposal of Structures, Waste Material, and Equipment

6.3.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed plans for removal and disposal of structures, waste material and equipment for the Moore Ranch facility meet the requirements of 10 CFR 40.32(c).

6.3.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.3.3 of the standard review plan.

6.3.3 Staff Review and Analysis

Prior to CPP decommissioning, a preliminary radiological survey would be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. All accessible surfaces will be washed with high-pressure water to remove loose contamination before decommissioning activities proceed. Moore Ranch facility process equipment would be decontaminated, dismantled, and released for use at another facility. Using these practices, the applicant will attempt to minimize the amount of solid byproduct material that would be generated. Materials that cannot be used at another facility will be properly disposed.

The applicant would have a contamination control program in place to control residual contamination. The contamination control program would be consistent with the program used during operations but would be focused on structures and equipment for identifying potential hazards associated with decommissioning. Salvageable building materials, equipment, pipe, and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with NRC guidance. The applicant has identified the contamination control limits, which are discussed in Section 5.7.7 of this SER.

The applicant has established an acceptable program for the measurement and control of residual contamination on structures and equipment, which is discussed in Section 5.7.7 of this SER. The applicant has made acceptable plans for measurements of radioactivity on the interior surfaces of pipes, drain lines, and ductwork by including plans to measure at all traps and other access points where contamination is likely to be representative of systemwide contamination. All premises, equipment, or scrap likely to be contaminated, but that cannot be measured, will be assumed to be contaminated in excess of limits and will be treated accordingly. For all site areas, equipment, or scrap containing radiological contamination in excess of specified limits, detailed, specific information describing such contamination will be provided. The applicant will provide a detailed health and safety analysis that reflects that the contamination and any use of the premises, equipment, or scrap will not result in an unacceptable risk to the health and safety of the public or the environment.

Before release of the property for unrestricted use, the applicant will conduct a comprehensive radiation survey to establish that any contamination is within the 10 CFR Part 20 limits. Although the applicant indicates that an agreement for disposal of solid byproduct material will be in place before construction of the Moore Ranch facility commences, the agreement is not in place yet. The initial license will have a condition requiring verification of the solid byproduct material disposal agreement prior to the commencement of operations (see Section 4.2 of this SER).

6.3.4 Evaluation Findings

The staff reviewed the plans for removal and disposal of structures, waste material, and equipment for the proposed Moore Ranch facility in accordance with Section 6.3.3 of the standard review plan. The applicant described the activities associated with decommissioning buildings and equipment, including: radiological surveys to identify potential contamination, contamination control, and disposal of materials. Based upon the review conducted by the staff as indicated above, the information provided in the application and supplemented by the license condition discussed in Section 4.2 of this SER, meets the applicable acceptance criteria of Section 6.3.3 of the standard review plan and the requirements of 10 CFR 40.32(c).

6.4 Methodologies for Conducting Postreclamation and Decommissioning Radiological Surveys

6.4.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed methodologies for conducting post reclamation and decommissioning radiological surveys for the Moore Ranch facility meet the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.4.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.4.3 of the standard review plan.

6.4.3 Staff Review and Analysis

The following sections discuss the procedures used by the applicant for establishing dose criteria for radium contaminated soil.

6.4.3.1 Cleanup Criteria

6.4.3.1.1 Determination of the Radium Benchmark Dose

The applicant used the RESRAD Version 6.3 computer code to model the site and calculate the annual dose from the current radium cleanup standards; the residential farmer scenario was used in assessing the radiological impact. Input parameters and results are provided in Appendix C of the technical report. Several sensitivity analyses were conducted with various input parameters to evaluate the impact on the radiological dose, and the applicant modeled the maximum annual dose over a 1,000-year time span. The maximum dose from radium-226 contaminated soil at the 5-pCi/g above background cleanup standard, as determined by RESRAD, for the residential farmer scenario was 39.5 mrem/yr at t = 0 years. This dose from the radium-226 was used to determine the natural uranium radiological end point soil standard.

The applicant stated that the two major dose pathways were external exposure and plant ingestion. Radon is not included in the dose calculation because it is assumed that the progeny (i.e., decay products) of radium are at acceptable levels when the radium standard is achieved. The aquatic pathway was not considered in the RESRAD calculation because the surface water bodies on the site are ephemeral in nature and do not support large aquatic species, such as fish and/or edible crustaceans. Also, lactating animals for human consumption do not reside within or near the license boundaries. Therefore, the aquatic and milk pathways were not considered in the RESRAD calculations.

The staff has determined that the farmer scenario is a conservative radiation exposure dose scenario and that the applicant’s method for determining the radium benchmark dose is consistent with Criterion 6(6) of Appendix A to 10 CFR Part 40 and with Appendix E to NUREG-1569. Therefore, the staff therefore finds the calculation of the radium benchmark dose acceptable.

6.4.3.1.2 Determination of the Natural Uranium Soil Standard

The applicant used RESRAD to calculate the maximum dose from an assumed preset concentration of natural uranium in soil distinguishable from background. This dose was used to calculate a ratio of concentration (pCi/g) per unit dose (mrem/yr). This ratio was then multiplied by the radium benchmark dose of 39.5 mrem/yr to develop a uranium limit of 526 pCi/g of natural uranium in soil. The applicant will apply this natural uranium limit with the radium-226 limit using the unity rule that is described in 10 CFR Part 40, Appendix A, Criterion 6(6) to ensure that the radium benchmark dose is not exceeded when more than one radionuclide is present in the soil. The staff has determined that the applicant demonstrated an acceptable approach to deriving and implementing a natural uranium soil cleanup limit that would ensure soils contaminated with byproduct material containing concentrations of uranium and radium that were remediated to the proposed limits would result in a TEDE that would not exceed the above standard (benchmark dose) and would be at levels that are ALARA. Therefore, the staff finds the natural uranium soil standard acceptable.

6.4.3.1.3 Uranium Chemical Toxicity Assessment

The applicant evaluated the uranium chemical toxicity effects from uranium exposure to determine the appropriate cleanup level for uranium in soils. The farmer scenario was used for this analysis, which assumes that in the future a farm will be located on the site. The applicant's analysis indicates that soil containing 526 pCi/g of natural uranium would result in an intake of approximately 0.14 mg/d. Based on its analysis, the applicant proposes the soil cleanup criteria and goals for radium-226 and natural uranium (in pCi/g) in Table 6.4-2 of the technical report. The applicant is proposing a limit of 225 pCi/g of natural uranium with a goal of 150 pCi/g in both the surface and subsurface soil, which is lower than the 526 pCi/g used to compute the radium benchmark dose. The staff concurs that the approach is acceptable, and the staff accepts these limits.

6.4.3.2 Excavation Control Monitoring

The applicant plans to use hand-held and GPS-based gamma surveys to guide its later soil remediation efforts by monitoring excavations with hand-held detection systems to guide the removal of contaminated material. Excavation would continue to the point where the applicant can determine that a high probability exists that an area meets the cleanup criteria. In the case where uranium is suspected to be the only radionuclide of concern, other instruments for detecting low-energy radiation are available and will be sensitive to the low-energy x rays emitted by natural uranium. The applicant stated that final confirmation that remediated soils meet the established cleanup criteria will be performed via soil sampling.

6.4.3.3 Surface Soil Cleanup Verification and Sampling Plan

The applicant states that surface soils cleanup will be restricted to a few areas where there are known spills. Such areas could include those under and around header houses, wellheads, buried pipelines that contain radioactive material, radioactive material storage areas, deep well disposal facilities, and liquid byproduct material storage areas. The applicant states that pre-reclamation surveys will be conducted, as described in Section 6.2.1 of the technical report in areas where known contamination has occurred or the potential for unknown soil contamination exists. In these areas soil samples will be collected from 100-m^2 grid blocks that exceed a gamma action limit, which is not defined in the application. The staff has determined that a license condition is warranted to demonstrate how the gamma action limits will relate to the calculated radium benchmark dose. This explanation should include the preoperational gamma surveys and other pathways as determined from the preoperational environmental monitoring. In addition, the applicant needs to provide assurance at a 95-percent confidence level that the soil units meet the cleanup guidelines. These items will be addressed in the detailed decommissioning plan required by the license condition presented in Section 6.2.4 of this SER.

6.4.3.4 Removal of Process Buildings and Equipment

Criterion 6(6) of Appendix A to 10 CFR Part 40 states in part:

> Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable.

In Section 6.3 of the technical report, the applicant states that based on the results of the preliminary radiological surveys, gross decontamination techniques will be used to remove loose contamination before decommissioning activities proceed. The applicant indicates that the majority of the process equipment in the process building will be reusable, as well as the building itself. The applicant does not discuss in its application how – with respect to radionuclides other than radium in soil and surface activity on remaining structures – the above requirement will be met. The staff has determined that a license condition is warranted to demonstrate the manner in which the radium benchmark dose will be applied to the surface activity on remaining structures and whether the radium benchmark dose meets the limits in Criterion 6(6) of Appendix A to 10 CFR Part 40. The applicant will be required to address this issue in the detailed decommissioning plan that will be required by the license condition presented in Section 6.2.4 of this SER.

6.4.3.5 Quality Assurance

The applicant's quality assurance plans are discussed in Section 5.7.10 of this SER.

6.4.4 Evaluation Findings

The staff reviewed the methodologies for conducting postreclamation and decommissioning radiological surveys for the proposed Moore Ranch facility in accordance with Section 6.4.3 of the standard review plan. The applicant has developed methodologies for verification of cleanup (final status survey plan) that demonstrate that the radium concentration will not exceed 5 pCi/g in the upper 15 cm (5.9 inches) of soil and will not exceed 15 pCi/g in subsequent 15-cm (5.9-inch) layers. The cleanup of other residual radionuclides in soil will meet the criteria developed with the radium benchmark dose approach (Appendix E), including a demonstration of ALARA and the application of the unity test of Criterion 6(6) of Appendix A to 10 CFR Part 40, where applicable. The applicant discusses the excavation control monitoring and the surface soil cleanup verification and sampling plant.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by the license condition presented in Section 6.2.4 of this SER meets the applicable acceptance criteria of Section 6.4.3 of the standard review plan and the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.5 <u>Financial Assurance</u>

6.5.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed financial assurance for the Moore Ranch facility meets the requirements of Criterion 9 of Appendix A to 10 CFR Part 40.

6.5.2 Regulatory Acceptance Criteria

The application was reviewed for consistency with applicable regulations of 10 CFR Part 40 using the acceptance criteria presented in Section 6.5.3 of the standard review plan.

6.5.3 Staff Review and Analysis

The applicant states it would maintain a financial assurance instrument in the form of an irrevocable letter of credit to cover the costs of ground water restoration; decommissioning, dismantling, and disposal of all buildings and other facilities; and reclamation and revegetation of affected areas. The applicant has provided a financial assurance estimate of $17,678,880 based on 2008 dollars. The documentation includes a breakdown of the costs, the basis for the cost estimates; and a minimum 15-percent contingency. The estimate includes costs for ground water restoration, equipment removal and disposal, building demolition and disposal, well field building and equipment removal and disposal, well abandonment, soil removal and disposal, topsoil replacement and revegetation, and other miscellaneous reclamation costs.

The estimate includes both well fields, and the activities included in the cost estimate are consistent with what is planned and what is known about the site. The cost estimates provided by the applicant roughly follow the outline provided in Appendix C of the standard review plan.

The applicant has committed to (1) annually adjusting the financial assurance value, (2) automatically extending the financial assurance arrangement if the NRC has not approved the proposed revision 30 days prior to the expiration date, (3) revising the financial assurance instrument within 3 months of NRC approval of a revised closure (decommissioning) plan if estimated costs exceed the amount of the existing financial assurance estimate, (4) submitting (for NRC review) an updated financial assurance instrument to cover any planned expansion or operational change not included in the annual update at least 90 days prior to beginning associated construction, and (5) providing copies of financial assurance-related information submitted to the State of Wyoming and a copy of the State's review or the final arrangement to the NRC. These commitments will be included as license conditions, which is presented in Section 6.5.4 of this SER.

The staff notes that the financial assurance amount has been provided in 2008 dollars. The initial license will have a condition requiring submittal of an updated estimate prior to initiation of operations. This condition is presented in Section 6.5.4 of this SER.

The type of financial instrument proposed is consistent with Criterion 9 of Appendix A to 10 CFR Part 40 and is, therefore, acceptable to the staff. The applicant has established an acceptable financial assurance cost estimate based on the requirements in Criterion 9 of Appendix A to 10 CFR Part 40. Also, the applicant has committed to providing appropriate assurance that sufficient funds would be available for completion of the reclamation plan by an independent contractor. Financial analyses have been provided for all the activities in the reclamation plan or in Sections 6.1 to 6.4 of the standard review plan. Assumptions for the financial assurance analysis were based on site conditions, including experiences with generally accepted industry practices and research and development at the site. The values used in the current financial assurance analysis are based on current dollars at the time of the analysis, and reasonable costs for the required reclamation activities are defined.

6.5.4 Evaluation Findings

The staff reviewed the financial assurance aspects of the proposed Moore Ranch facility in accordance with Section 6.5.3 of the standard review plan. The applicant provided a detailed cost estimate to cover the costs of ground water restoration; decommissioning, dismantling, and disposal of all buildings and other facilities; and reclamation and revegetation of affected areas. The applicant identified the financial assurance mechanism that will be used at the facility. The staff is imposing the following license condition to ensure that adequate financial assurance is in place for the Moore Ranch facility prior to and during operations:

> Financial Assurance. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR 40, Appendix A, Criterion 9, adequate to cover the estimated costs, if accomplished by a third party, for decommissioning and decontamination, which includes offsite disposal of radioactive solid process or evaporation pond residues, and ground-water restoration as warranted. The surety shall also include the costs associated with all soil and water sampling analyses necessary to confirm the accomplishment of decontamination.
>
> Proposed annual updates to the financial assurance amount, consistent with Criterion 9 of Appendix A to 10 CFR Part 40, shall be provided to the NRC 90 days prior to the anniversary date (e.g., renewal date of the financial assurance instrument/vehicle). The financial assurance update renewal date for Moore Ranch will be determined following consultation with Uranium One and the State of Wyoming. If the NRC has not approved a proposed revision 30 days prior to the expiration date of the existing financial assurance arrangement, the licensee shall extend the existing arrangement, prior to expiration, for one year. Along with each proposed revision or annual update of the financial assurance estimate, the licensee shall submit supporting documentation, showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation, maintenance of a minimum 15-percent contingency, changes in engineering plans, activities performed, and any other conditions affecting the estimated costs for site closure.

Within 90 days of NRC approval of a revised closure (decommissioning) plan and its cost estimate, the licensee shall submit, for NRC review and approval, a proposed revision to the financial assurance arrangement if estimated costs exceed the amount covered in the existing arrangement. The revised financial assurance instrument shall then be in effect within 30 days of written NRC approval of the documents.

At least 90 days prior to beginning construction associated with any planned expansion or operational change that was not included in the annual financial assurance update, the licensee shall provide, for NRC approval, an updated estimate to cover the expansion or change. The licensee shall also provide the NRC with copies of financial assurance-related correspondence submitted to the State of Wyoming, a copy of the State's financial assurance review, and the final approved financial assurance arrangement. The licensee also must ensure that the financial assurance instrument, where authorized to be held by the State, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil, and water sample analyses, and ground water restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual updates should follow the outline in Appendix C to NUREG-1569 (NRC, 2003), entitled "Recommended Outline for Site-Specific In Situ Leach Facility Reclamation and Stabilization Cost Estimates."

The licensee shall continuously maintain an approved surety instrument for the Moore Ranch project, in favor of the State of Wyoming. The initial surety estimate shall be submitted for NRC review and approval within 90 days of license issuance, and the surety instrument shall be submitted for NRC review and approval 90 days prior to commencing operations.

The staff notes that the applicant submitted a financial assurance estimate for the entire facility in 2008 dollars. However, as discussed in the aforementioned license condition, the staff will require a revised estimate prior to facility startup.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by information submitted in accordance with the noted license conditions, meet the applicable acceptance criteria of Section 6.5.3 of the standard review plan and are consistent with Criterion 9 of Appendix A to 10 CFR Part 40.

7. ACCIDENTS

7.1 Regulatory Requirements

The staff will determine if the applicant has addressed potential accidents at the Moore Ranch facility and demonstrate that the facility will meet the requirements of 10 CFR 40.32(c), which requires that the applicant's proposed procedures be adequate to protect public health and minimize danger to life or property should an accident occur.

7.2 Regulatory Acceptance Criteria

The application was reviewed for consistency with applicable regulations of 10 CFR Part 40 using the acceptance criteria presented in Section 7.5.3 of the standard review plan.

7.3 Staff Review and Analysis

This chapter addresses potential accidents that could occur at the proposed Moore Ranch facility, the designs and measures proposed by the applicant to prevent accidents, and the plans and training proposed to cope with accidents. The following sections address chemical accidents, radiological release accidents, ground water contamination, well field spills, transportation accidents, fires and explosions, coalbed methane operational accidents, and natural events.

7.3.1 Chemical Accidents

The applicant considered the potential for accidents involving the following chemicals that will be used on the site: sulfuric acid, oxygen, carbon dioxide, sodium carbonate and sodium chloride, and sodium sulfide. Several designs and measures were identified, for each chemical, to prevent the occurrence of an accident. For example, sulfuric acid storage tanks will be located separately from other storage tanks to prevent chemical reactions in the event of simultaneous tank leaks. Daily shift inspections of the plant and chemical storage facilities will be conducted to try to detect potential deficiencies early. Containment of 110 percent of the storage capacity of tanks will be provided. Offloading procedures will be developed and implemented.

Additionally, the applicant stated that emergency response procedures will be developed for each chemical. Typically, they will include instructions regarding immediate notifications, evacuation procedures, perimeter establishment, personal protective equipment requirements, and reporting.

7.3.2 Radiological Release Accidents

The applicant identified tank and plant pipe failures as potential accidents that could pose radiological risk. Structures such as the CPP structure and concrete curb will contain spills from tanks and leaks from pipes. The floor sump system will direct liquids back into the plant process circuit or waste disposal system. Additionally, emergency response procedures will be developed to address tank and plant pipe failures. These procedures will include instructions regarding immediate notifications; evacuation procedures; perimeter establishment; personal protective equipment requirements; site mitigation, neutralization, and cleanup; and reporting.

The applicant has addressed the possibility of scenarios resulting in multiple tank failures such as a failure that would cause a tank to topple into another tank. To address this scenario, the applicant stated that a concrete curb will be part of the central process plant building. Consequently, the building will be able to contain approximately 344,435 liters (91,000 gallons). The two largest tanks at the CPP have a maximum combined volume of approximately 348,220 liters (92,000 gallons). The staff notes that the operational capacity of the tanks will be less than 348,220 liters (92,000 gallons) and that the two largest tanks will not be located next to each other.

The applicant has addressed potential accidents involving the vacuum dryer. The planned yellowcake dryer at the Moore Ranch facility was compared to the scenario evaluated in NUREG/CR-6733 and found that the anticipated dose at the Moore Ranch facility would be less than the dose identified in NUREG/CR-6733. As an explosion at the yellowcake dryer could have serious consequences, the applicant has committed to following the checking and logging requirements in Criterion 8 of Appendix A to 10 CFR Part 40 (to the extent that it applies); training crews for possible accidents of this type; following the manufacturer's recommendations for operation and maintenance; and having dryer operators wear respirators during operation.

7.3.3 Ground Water Contamination

The applicant stated that excursions of lixiviant have the potential to contaminate adjacent aquifers with liquid byproduct material. Monitoring and control of excursions are discussed in Section 5.7.9.3.5 of this SER.

7.3.4 Well Field Spills

The applicant stated that rupture of an injection or recovery line in a well field or a trunk line between a well field and the central plant would contaminate the ground in the area of the break. Section 3.1 of this SER contains the staff's review of well field infrastructure designs that minimize the likelihood for this type of accident, and discusses the methodology to detect leaks. The applicant stated that it will develop a response plan for well field spills that will include procedures for notification, spill containment and recovery, post spill sampling and cleanup, and reporting.

7.3.5 Transportation Accidents

The applicant considered the potential for transportation accidents involving shipments of ion exchange resins, dried yellowcake, chemicals, fuels, and radioactive wastes. Several procedures and actions were identified to prevent transportation accidents, including maintaining vehicles in good operating condition, using properly trained and licensed drivers, inspecting vehicles prior to shipment, and following DOT hazardous materials shipping provisions. The applicant stated that emergency response plans will be developed for transportation accidents. Plans will include descriptions of U.S. Department of Transportation (DOT) regulations, carrier emergency response procedures, spill kits, immediate response and notification, accident scene response, spill cleanup, the conclusion of activities, the review of accident documentation, the review of monitoring and sampling data, site abandonment, and reporting. Additionally, applicant personnel will receive training for responding to a transportation accident.

7.3.6 Fires and Explosions

The applicant stated that the hazards associated with fires or explosions are minimal because the plant will not use flammable liquids in the recovery process and because buildings and equipment are largely made of nonflammable materials such as steel and concrete. However, an accumulation of gaseous oxygen in a header house would be a potential source for a fire or explosion. To address this issue, several prevention methods were identified, including providing low-pressure shutoff valves to minimize the delivery of oxygen to a fire, equipping each header house with an exhaust fan to assist in the prevention of oxygen buildup, and establishing procedures for monitoring oxygen buildup prior to confined space or hot work.

The applicant stated that automatic detection and alarm systems and sprinkler systems will be installed in the central plant and other facilities and that fire extinguishers will be placed in all buildings and vehicles. An emergency response plan will be developed that will include descriptions of notification and evacuation procedures, personal protective equipment, general fire fighting safety rules, reporting procedures, and provisions addressing electrical and gas emergencies. Additionally, applicant personnel will receive training for responding to a fire or explosion.

7.3.7 Coalbed Methane Operational Accidents

The applicant considered the potential for methane seeps, fires, and explosions from CBM wells and the potential for seeps or ruptures of CBM pipelines. This issued is address through the designs and procedures mandated by the Bureau of Land Management, as a condition to allow CBM development, minimize the potential for accidents and address prevention and control measures.

7.3.8 Natural Events

Based on NUREG/CR-6733, the applicant concluded that the most significant risk from natural events at the proposed Moore Ranch facility is a tornado that dispersed yellowcake. The probability of a tornado occurring at the site is low (about $3x10^{-4}$ per year). The applicant stated that it will develop emergency procedures, including notification of personnel of potential severe weather, evacuation procedures, damage inspection and reporting, and the cleanup and mitigation of spills.

7.4 Evaluation Findings

The staff reviewed potential accidents that could occur at the Moore Ranch facility in accordance with Section 7.5.3 of the standard review plan. The applicant addressed the following types of accidents involving: chemicals; radiological releases; ground water contamination; well field spills; transportation; fires and explosions; coalbed methane operations; and natural events. The applicant has provided an analysis of probable accidents and their consequences, consistent with facility design, site features, and planned operations. Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 7.5.3 of the standard review plan and the requirements of 10 CFR 40.32(c).

APPENDIX A

Table of Standard License Conditions

Administrative Conditions
The authorized place of use shall be the licensee's Moore Ranch Uranium Project in Campbell County, Wyoming. The licensee shall conduct operations within the license area boundaries shown in Figure 2.1-2 of the approved license application.
The licensee shall conduct operations in accordance with the commitments, representations, and statements contained in the license application dated October 2007 (ADAMS Accession No. ML072851218, as updated), which are hereby incorporated by reference, except where superseded by specific conditions in this license. Whenever the word "will" or "shall" is used in the above referenced documents, it shall denote a requirement.
All written notices and reports sent to the Nuclear Regulatory Commission (NRC) as required under this license and by regulation shall be addressed as follows: ATTN: Document Control Desk, Director, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. An additional copy shall be submitted to: Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission, Mail Stop T-8F5, 11545 Rockville Pike, Two White Flint North, Rockville, MD 20852-2738. Incidents and events that require telephone notification shall be made to the NRC Operations Center at (301) 816-5100 (collect calls accepted).
9.4 Change, Test and Experiment License Condition A) The licensee may, without obtaining a license amendment pursuant to 10 CFR 40.44, and subject to conditions specified in (B) of this condition: i Make changes in the facility as described in the license application (as updated); ii Make changes in the procedures as described in the license application (as updated); and iii Conduct test or experiments not described in the license application (as updated). B) The licensee shall obtain a license amendment pursuant to 10 CFR 40.44 prior to implementing a proposed change, test, or experiment if the change, test, or experiment would: i Result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated); ii Result in more than a minimal increase in the likelihood of occurrence of a malfunction of a facility structure, equipment, or monitoring system (SEMS) important to safety previously evaluated in the license application (as updated); iii Result in more than a minimal increase in the consequences of an accident previously evaluated in the license application (as updated);

iv Result in more than a minimal increase in the consequences of a malfunction of an SEMS previously evaluated in the license application (as updated);

v Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);

vi Create a possibility for a malfunction of an SEMS with a different result than previously evaluated in the license application (as updated);

vii Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (FSER) or the environmental assessment (EA) or technical evaluation reports (TERs) or other analysis and evaluations for license amendments.

viii For purposes of this paragraph as applied to this license, SEMS means any SEMS which has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

C) Additionally, the licensee must obtain a license amendment unless the change, test, or experiment is consistent with NRC's previous conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TER, and EIS or EA. This would include all supplements and amendments, and TERs, EAs, EISs issued with amendments to this license.

D) The licensee's determinations concerning (B) and (C) of this condition, shall be made by a Safety and Environmental Review Panel (SERP). The SERP shall consist of a minimum of three individuals. One member of the SERP shall have expertise in management (e.g., Plant Manager) and shall be responsible for financial approval for changes; one member shall have expertise in operations and/or construction and shall have responsibility for implementing any operational changes; and one member shall be the radiation safety officer (RSO) or equivalent, with the responsibility of assuring changes conform to radiation safety and environmental requirements. Additional members may be included in the SERP, as appropriate, to address technical aspects such as ground water or surface water hydrology, specific earth sciences, and other technical disciplines. Temporary members or permanent members, other than the three above-specified individuals, may be consultants.

E) The licensee shall maintain records of any changes made pursuant to this condition until license termination. These records shall include written safety and environmental evaluations made by the SERP that provide the basis for determining changes are in compliance with (B) of this condition. The licensee shall furnish, in an annual report to the NRC, a description of such changes, tests, or experiments, including a summary of the safety and environmental evaluation of each. In addition, the licensee shall annually submit to the NRC changed pages, which shall include both a change indicator for the area changed, e.g., a bold line vertically drawn in the margin adjacent to the portion actually changed, and a page change identification (date of change or change number or both), to the operations plan and reclamation plan of the approved license application (as updated) to reflect changes made under this condition.

Release of surficially contaminated equipment, materials, or packages from restricted areas shall be in accordance with the NRC guidance document entitled "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or

Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993, or suitable alternative procedures approved by NRC prior to any such release.

Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides shall apply independently.

The licensee shall follow the guidance set forth in U.S. Nuclear Regulatory Commission, Regulatory Guides (as revised) 8.22, “Bioassay at Uranium Recovery Facilities,” and 8.30, “Health Physics Surveys in Uranium Recovery Facilities,” or NRC-approved equivalent.

The licensee shall follow the guidance set forth in Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposure at Uranium Recovery Facilities will be As Low As Is Reasonably Achievable (ALARA),” with the following exception:

A. The licensee will identify a qualified designee(s) to perform daily inspections in the absence of the RSO or HPT. The qualified designee(s) will have health physics training, and such training program will be specified by the licensee. Furthermore, the qualified designee(s) may perform daily inspections no more than two days per week, and those reports will be reviewed by health physics staff within 48 hours of completing the report. The licensee will also have a health physics staff member available by telephone while the qualified designee(s) is performing the daily inspections.

Additional exceptions are subject to review and approval by the NRC staff.

Cultural Resources. Before engaging in any developmental activity not previously assessed by the NRC, the licensee shall administer a cultural resource inventory if such survey has not been previously conducted and submitted to the NRC. All disturbances associated with the proposed development will be completed in compliance with the National Historic Preservation Act (as amended) and its implementing regulations (36 CFR 800), and the Archaeological Resources Protection Act (as amended) and its implementing regulations (43 CFR 7).

In order to ensure that no unapproved disturbance of cultural resources occurs, any work resulting in the discovery of previously unknown cultural artifacts shall cease. The artifacts shall be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance of the area shall occur until the licensee has received authorization from the NRC to proceed.

The results of the following activities, operations, or actions shall be documented: sampling; analyses; surveys or monitoring; survey/ monitoring equipment calibrations; reports on audits and inspections; all meetings and training courses; and any subsequent reviews, investigations, or corrective actions required by NRC regulation or this license. Unless otherwise specified in a license condition or applicable NRC regulation, all documentation required by this license shall be maintained until license termination, and is subject to NRC review and inspection.

The licensee is hereby exempted from the requirements of 10 CFR 20.1902(e) for areas within the facility, provided that all entrances to the facility are conspicuously posted with the words, "CAUTION: ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."

Operations, Controls, Limits, and Restrictions

The licensee shall use a lixiviant composed of native ground water, sodium carbonate, carbon dioxide gas and/or sodium bicarbonate, and dissolved oxygen, as specified in the approved license application.

Facility Throughput. The plant throughput shall not exceed a maximum flow rate of 3,000 gallons per minute, excluding restoration flow. Annual dried yellowcake production shall not

exceed 3 million pounds.
Emission controls (dryer). The licensee shall maintain effluent control systems as specified in Section 4.1 of the approved license application.
Equipment Calibration. All radiation monitoring, sampling, and detection equipment shall be recalibrated after each repair and as recommended by the manufacturer, or at least annually, whichever is more frequent. In addition, all radiation survey instruments shall be operationally checked and documented with a radiation source each day when in use.
The licensee shall implement and maintain a training program for all site employees, as described in Regulatory Guide 8.31, and as detailed in the approved license application. All training materials shall incorporate the information from current versions of 10 CFR Part 19 and 10 CFR Part 20. Additionally, classroom training shall include the subjects described in Section 2.5 of Regulatory Guide 8.31. All personnel shall attend annual refresher training, and the licensee shall conduct regular safety meetings at least every two months, as described in Section 2.5 of Regulatory Guide 8.31.
The licensee shall develop and implement written standard operating procedures (SOPs) for: (1) all operational activities involving radioactive and non-radioactive materials associated with licensed activities that are handled, processed, stored, or transported by employees; (2) all non-operational activities involving radioactive materials including in-plant radiation protection and environmental monitoring; and (3) emergency procedures for potential accident/unusual occurrences including significant equipment or facility damage, pipe breaks and spills, loss or theft of yellowcake or sealed sources, significant fires, and other natural disasters. The SOPs shall include appropriate radiation safety practices to be followed in accordance with 10 CFR Part 20. SOPs for operational activities shall enumerate pertinent radiation safety practices to be followed. A copy of the current written procedures shall be kept in the area(s) of the production facility where they are utilized.
Mechanical Integrity Tests. The licensee shall construct all wells in accordance with methods described in Section 3.1.2.4 of the approved license application. The licensee shall perform well integrity tests on each injection and production well before the wells are utilized and on wells that have been serviced with equipment or procedures that could damage the well casing. Additionally, each well shall be retested at least once every five years. Integrity tests shall be performed in accordance with Section 3.1.2.4 of the approved license application. Any failed well casing that cannot be repaired to pass the integrity test shall be appropriately plugged and abandoned in accordance with Section 6.1.8 of the approved license application.
Monitoring, Recording, and Bookkeeping Requirements
In addition to the reports required by Title 10 of the Code of Federal Regulations, the licensee shall submit the following reports related to operations at the facility: A. A quarterly report that includes the weekly excursion indicator parameter values, corrective actions taken, and the results obtained. B. A semi-annual report that discusses: status of well fields in operation (including last date of lixiviant injection), status of well fields in restoration, status of any long term excursions. C. Flow rates on each injection and production well and injection manifold pressures on the entire system shall be measured and recorded daily. These measurements shall be made available for inspection upon request.

The licensee shall submit the results of the annual review of the radiation protection program content and implementation performed in accordance with 10 CFR 20.1101(c). These results shall include an analysis of dose to individual members of the public consistent with 10 CFR 20.1301 and 10 CFR 20.1302.
Background Monitoring. Prior to injection of lixiviant in a well field, the licensee shall establish background pre-operational ground water quality data for the overlying and underlying aquifers and restoration target values (RTVs) for the ore zone aquifers for all well fields. Background water quality sampling shall provide representative pre-operational ground water quality data and restoration criteria as described in the approved license application. The data for each well field shall consist, at a minimum, of the following sampling and analyses: A. Ore Zone. Samples shall be collected from production and injection wells at a minimum density of one production or injection well per 3 acres in the 70 sand. Samples shall also be collected from all perimeter monitor wells in the 70 sand. B. Overlying and Underlying Aquifers. Samples shall be collected from all monitoring wells in the 72 sand, 68 sand, and 60 sand (in areas where the 68 and 70 sand coalesce in Well Field 2) at a minimum density of one well per 4 acres. C. Four samples shall be collected from each well. Consecutive sampling events shall be at least 14 days apart. D. The samples shall be analyzed for ammonia, nitrate, bicarbonate, boron, carbonate, fluoride, sulfate, total dissolved solids, dissolved arsenic, dissolved cadmium, dissolved calcium, dissolved chloride, dissolved chromium, total and dissolved iron, dissolved magnesium, total manganese, dissolved molybdenum, dissolved potassium, dissolved selenium, dissolved sodium, dissolved zinc, radium-226, radium-228, gross alpha, gross beta, uranium, and vanadium. E. Ground water RTVs for the ore zone aquifer shall be established on a parameter-by-parameter basis on either a well field average or well-specific basis for all constituents.
Establishment of UCLs. Prior to injection of lixiviant into a well field, the licensee shall establish upper control limits (UCLs) in designated overlying and underlying aquifer and perimeter monitoring wells. The UCLs for the following indicator parameters: chloride, conductivity, and total alkalinity shall be established by analyzing background monitoring data collected to satisfy LC 11.3. The concentrations of these UCLs shall be established for each well field by calculating the background mean concentration and adding five standard deviations. The UCL for chloride can be set at the background mean concentration and adding either five standard deviations or 15 mg/l, whichever is higher.
Excursion Monitoring. Monitoring for excursions shall occur twice monthly and at least 10 days apart. An excursion shall have occurred if, in any monitor well any two UCL parameters exceed their respective UCLs. A verification sample shall be taken within 48 hours after results of the first analyses are received. If the second sample shows that the excursion criterion is exceeded, an excursion shall be confirmed. If the second sample does not show that the excursion criterion is exceeded, a third sample shall be taken within 48 hours after the second set of sampling data was acquired. If the third sample shows that the excursion criterion is exceeded, an excursion

shall be confirmed. If the third sample does not show that the excursion criterion is exceeded, the first sample shall be considered to be an error and the well is removed from excursion status. Upon confirmation of an excursion, the licensee shall notify NRC, as discussed below, implement corrective action, and increase the sampling frequency for the indicator parameters at the excursion well to once every seven days. Corrective actions for confirmed excursions may be, but are not limited to, those described in Section 5.7.8.2 of the approved license application. An excursion is considered corrected when the concentrations of the indicator parameters are below the concentration levels defining an excursion for three consecutive weekly samples. If an excursion is not corrected within 60 days of confirmation, the licensee shall either: (a) terminate injection of lixiviant within the well field until aquifer cleanup is complete; or (b) increase the surety in an amount to cover the full third-party cost of correcting and cleaning up the excursion. The surety increase shall remain in force until the NRC has verified that the excursion has been corrected and cleaned up. The written 60-day excursion report shall identify which course of action the licensee is taking. Under no circumstances does this condition eliminate the requirement that the licensee must remediate the excursion to meet ground water protection standards as required by LC 10.9 for all constituents established per LC 11.3. The licensee shall notify the NRC Project Manager (PM) by telephone within 24 hrs of confirming a lixiviant excursion, and by letter within 7 days from the time the excursion is confirmed, pursuant to LC 11.6. A written report describing the excursion event, corrective actions taken, and the corrective action results shall be submitted to the NRC within 60 days of the excursion confirmation. For all wells that remain on excursion after 60 days, the licensee shall submit a report as discussed in LC 11.1(A).
Preoperational Conditions
Prior to commencement of operations in any well field, the licensee shall obtain all necessary permits and licenses from the appropriate regulatory authorities. The licensee shall also submit a copy of all permits for its Class I and Class III underground injection wells.
Prior to commencement of operations, the licensee shall coordinate critical emergency response requirements with local authorities, fire department, medical facilities, and other emergency services. The licensee shall document these coordination activities and maintain such documentation on-site.
The licensee shall not commence operations until the NRC performs a preoperational inspection to confirm, in part, that operating procedures and approved radiation safety and environmental monitoring programs are in place, and that preoperational testing is complete. The licensee should, at least 90 days prior to the expected commencement of operations, inform the NRC to allow for sufficient time to plan and perform the preoperational inspection.
The licensee shall identify the location, screen depth, and estimated pumping rate of any new ground water wells or new use of an existing well within the license area since the application was submitted to the NRC. The licensee shall evaluate the impact of ISR operations to potential ground water users and recommend any additional monitoring or other measures to protect ground water users. The evaluation shall be submitted to the NRC for review and approval prior to commencement of operations.
Prior to commencement of operations, the licensee shall submit the qualifications of radiation safety staff members for NRC review.