Safety Evaluation Report, Revision 1

for the AUC LLC
Reno Creek ISR Project, Campbell County, Wyoming
Materials License No. SUA-1602

Docket No. 040-09092

AUC LLC Reno Creek

U.S. Nuclear Regulatory Commission

Office of Nuclear Materials Safety and Safeguards

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LIST OF ACRONYMS AND ABBREVIATIONS

Ac	acre
ACFM	actual cubic feet per meter
ACL	alternative concentration limit
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954, as amended
ALARA	as low as is reasonably achievable
ALI	annual limit on intake
ANSI	American National Standards Institute
APE	area of potential effects
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
AUC	AUC LLC
BAT	best available technology
bgs	below ground surface
BLM	Bureau of Land Management
BPT	best practicable technology
Bq	becquerel
CAP	corrective action program
CBM	coal bed methane
CEDE	committed effective dose equivalent
CEO	Chief Executive Officer
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHB	contact head boundary
cm	centimeter
CO_2	carbon dioxide
cpm	counts per minute
CPP	central processing plant
D&D	decontamination and decommissioning
DAC	derived air concentration
DC	dose coefficient
DCF	dose conversion factor
DDE	deep dose equivalent
DDW	deep disposal well
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
DQO	data quality objectives
DO	designated operator
EA	environmental assessment
EHS	Environment, Health, and Safety
EHSM	Environment, Health, and Safety Manager
EIS	environmental impact statement

List of Acronyms and Abbreviations (continued)

EMT	emergency medical technician
EPA	U.S. Environmental Protection Agency
ER	environmental report
FONSI	finding of no significant impact
FR	*Federal Register*
Ft	feet
ft/d	feet per day
ft/s	feet per second
g/cm^3	grams per cubic centimeter
GEIS	Generic Environmental Impact Statement
GM	Geiger - Muller
gpd/ft	gallons per day per foot
gpm	gallons per minute
GPS	Global Positioning System
ha	hectare
HPIC	high-pressure ionization chamber
HPT	health physics technician
HV	high velocity
HVAC	heating, ventilation, and air conditioning systems
H_2O_2	hydrogen peroxide
IBC	International Building Code
ICRP	International Commission on Radiological Protection
in	inch
lpm	liters per minute
ISR	in situ recovery
IX	ion exchange
JFD	joint frequency distribution
Kg	kilogram
km	kilometer
km^2	square kilometers
L	liter
lb	pound
lb/ft^3	pound per cubic foot
LLD	lower limit of detection
Lpm	liters per minute

List of Acronyms and Abbreviations (continued)

m	meter
m^2	square meter
m^2/d	square meter per day
m^3	cubic meter
m^3/h	cubic meter per hour
m^3/s	cubic meter per second
m/s	meter per second
ma	million years ago
man-Sv	man-sievert
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	minimum detection limits
Mg	milligram
mg/L	milligram per liter
mi	mile
mi^2	square miles
MIT	mechanical integrity testing
mm	millimeter
MOU	memorandum of understanding
mph	miles per hour
mR/hr	milliroengtens per hour
mrem	millirem
mrem/yr	millirem per year
mSv	millisievert
$NaHCO_3$	sodium bicarbonate
Na_2CO_3	sodium carbonate
NaI	sodium iodide
NCDC	National Climatic Data Center
NEPA	National Environmental Protection Act
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NVLAP	National Voluntary Laboratory Accreditation Program
NWS	National Weather Service
OSHA	U.S. Occupational Safety and Health Administration
OSL	optically stimulated luminescence
Pb-210	lead-210
pCi	picocurie
pCi/G	picocurie per gram
pCi/L	picocurie per liter

List of Acronyms and Abbreviations (continued)

person-rem/yr	person-rem per year
PM	project manager
Po-210	polonium-210
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
psi	pounds per square inch
PV	pore volumes
PU	production unit
PZA	production zone aquifer
QA	quality assurance
QAP	Quality Assurance Plan
QC	quality control
R&D	research and development
Ra-226	radium-226
Ra-228	radium-228
RAI	request for additional information
RAP	Restoration Action Plan
rem	roentgen equivalent man
RG	regulatory guide
RME	Rocky Mountain Energy
Rn-222	radon-222
RO	reverse osmosis
RWP	radiation work permit
RPP	Radiation Protection Program
RSO	radiation safety officer
RST	radiation safety technician
SEIS	Supplemental Environmental Impact Statement
SEMS	structures, equipment, or monitoring systems
SER	safety evaluation report
SERP	Safety and Environmental Review Panel
SPT	standard penetration tests
SHPO	State Historic Preservation Office
SOP	standard operating procedure
SRP	Standard Review Plan
Sv	sievert
Sv/Bq	sievert per becquerel
TEDE	total effective dose equivalent
TER	technical evaluation report
Th-230	thorium-230
TLD	thermoluminescent dosimeter
TG	Technical Guide
TR	technical report
TWA	time-weighted average

List of Acronyms and Abbreviations (continued)

UBC	Uniform Building Code
UCL	upper control limit
UIC	Underground Injection Control
µg	microgram
U-nat	natural uranium
U_3O_8	uranium oxide
UO_2	uranium dioxide
UO_3	uranium trioxide
$UO_2(CO_3)_2^{2-}$	uranyl dicarbonate
$UO_2(CO_3)_3^{4-}$	uranyl tricarbonate
USDW	underground source of drinking water
UPS	uninterruptible power supply
U.S.	United States
USGS	U.S. Geological Survey
WDEQ LQD	Wyoming Department of Environmental Quality-Land Quality Division
WDEQ-SHWD	Wyoming Department of Environmental Quality-Solid and Hazardous Waste Division
WDEQ-WQD	Wyoming Department of Environmental Quality-Water Quality Division
WY	Wyoming
WYPDES	Wyoming Pollutant Discharge Elimination System

INTRODUCTION

On October 3, 2012, AUC LLC (hereinafter AUC, or the applicant), submitted a license application to the U.S. Nuclear Regulatory Commission (NRC) to construct and operate the Reno Creek Project (Proposed Project), which is a proposed uranium in situ recovery (ISR) facility located in Campbell County, Wyoming (AUC, 2012). The application consists of a technical report (TR) and an environmental report (ER), as amended with supplemental information (AUC, 2014a; AUC, 2014b; AUC, 2015a; AUC, 2015b; AUC, 2015c; and AUC, 2016d).

The Atomic Energy Act of 1954, as amended (AEA, or the Act), authorizes the NRC to issue licenses, either as a general or specific license, to qualified applicants for the receipt, possession, and use of byproduct and source materials resulting from the removal of uranium ore from its place of deposit in nature. An NRC-specific license is issued to a commercial uranium or thorium ISR facility pursuant to NRC implementing regulations listed in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material." In accordance with 10 CFR 40.32, "General requirements for issuance of specific licenses," the NRC is required to make several findings when issuing a license for an ISR operation. This SER addresses the following required findings:

- The application is for a purpose authorized by the AEA.
- 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 staff's analyses of the Proposed Project license application TR and supplemental information for compliance with requirements listed above, and with applicable requirements and objectives set forth in 10 CFR Part 20, "Standards for Protection against Radiation," 10 CFR Part 40, and 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 Concentration of Source Material from Ores Processed Primarily for Their Source Material Content." The staff performed its safety review using review procedures and acceptance criteria in NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications" (hereinafter NRC, 2003, or SRP).

Because the issuance of a license is a major Federal action, the NRC is obligated to address environmental impacts of the proposed action in accordance with the National Environmental Policy Act (NEPA). The NRC implementing regulations meeting requirements of NEPA are found in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." A supplemental environmental impact statement to NUREG-1910, "Generic Environmental Impact Statement for In Situ Leach Uranium Milling Facilities" (NRC, 2009) is being prepared in parallel with this SER to evaluate the environmental impacts of the proposed action in accordance with requirements of 10 CFR Part 51.

The staff's analysis throughout this SER refers to actions that the applicant will take if a license is issued.

The staff's review of this application for the Proposed Project 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. The facility-specific license conditions and standard license conditions that the staff applies to all ISR facilities are presented in Appendix A of this SER.

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 supports the issuance of a license authorizing the construction and operation of the facility provided the conditions identified in Appendix A of this SER are included in the license. The staff provided a draft license, including all the license conditions in Appendix A of this SER, to AUC on July 8, 2015 (NRC, 2015a). By Email dated December 12, 2016, AUC agreed to a revision of these license conditions (AUC, 2016e).

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

SECTION 1

PROPOSED ACTIVITIES

1.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the summary of the proposed activities at the Reno Creek Project (Proposed Project) comply with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40.31, which describes the general requirements for issuance of a specific license.

1.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40.31 using the acceptance criteria in Standard Review Plan (SRP) Section 1.3 (NRC, 2003).

1.3 Staff Review and Analysis

Information in this Safety Evaluation Report (SER) section, unless otherwise stated, is from technical report (TR) Section 1 (Proposed Activities) (AUC, 2012). The staff examined the applicant's summary of proposed activities to determine if the information meets the acceptance criteria in SRP Section 1.3.

The applicant proposes to construct and operate an in-situ recovery (ISR) facility at the Proposed Project located in Campbell County, Wyoming. The Proposed Project is approximately 12 kilometers (km) (7.5 miles [mi]) southwest of the town of Wright, 50 km (31 mi) northeast of Edgerton, and 66 km (41 mi) south of Gillette, as illustrated in TR Figure 1-1 (SER Figure 1-1), and the Proposed Project area encompasses approximately 2451 hectares (ha) (6,057 acres [ac]) as illustrated in TR Figure 1-2 (SER Figure 1-2). Surface ownership within the Proposed Project area includes private and State-owned lands with no Federal surface ownership or management. Mineral holdings consist of Federal unpatented mining claims, private (fee) mineral leases, and State mineral leases. The applicant has executed surface use agreements with all landowners who hold surface ownership in the Proposed Project area, including the State of Wyoming (AUC, 2012).

In TR Section 1, the applicant presents a summary of the proposed activities and states that the Proposed Project will consist of:

- a series of sequentially developed production units (12 total) consisting of injection and recovery wells to inject lixiviant and to recover pregnant lixiviant;
- horizontal and vertical excursion monitoring well networks for detection of recovery solutions outside of the ore body/recovery zones;

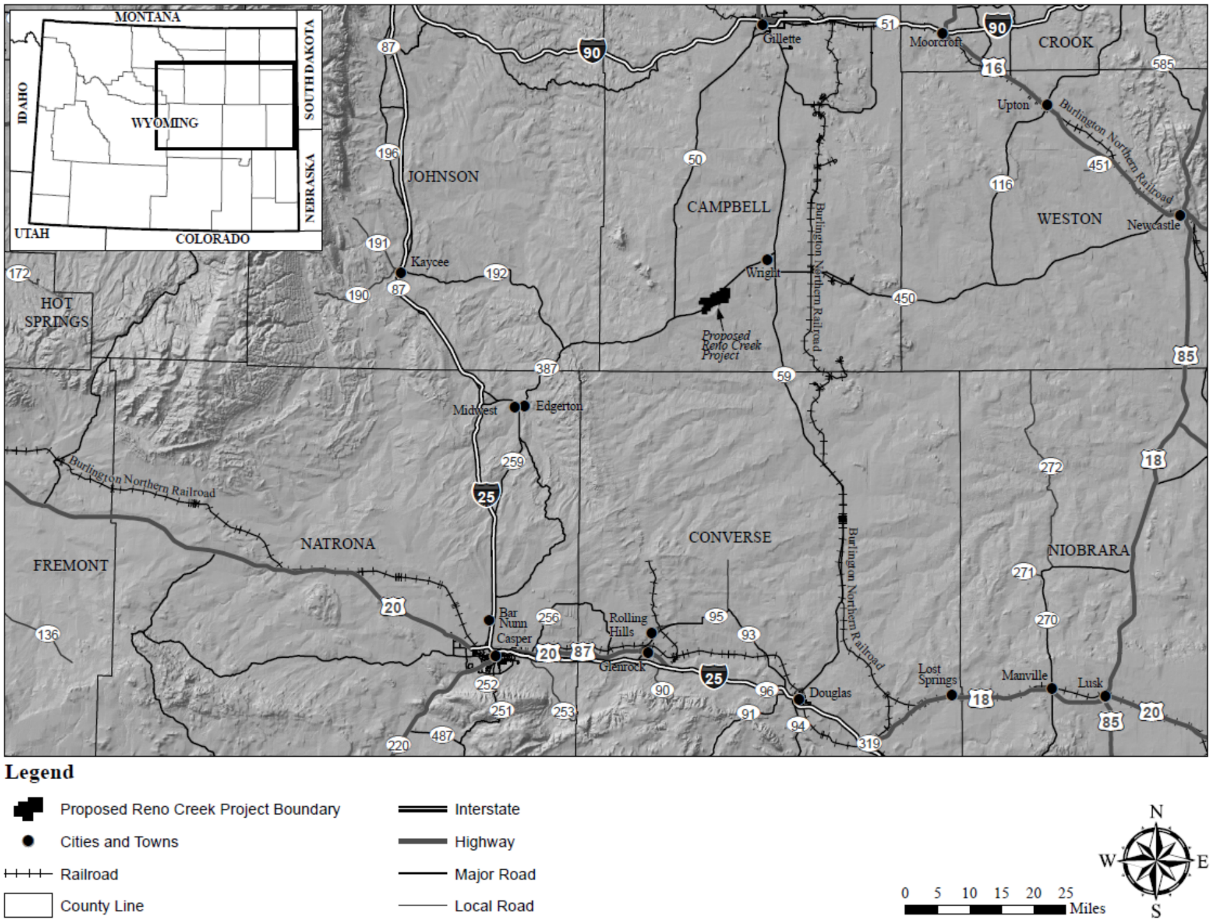

Figure 1-1 Proposed Project general location
Source: TR Figure 1-1 (AUC, 2012)

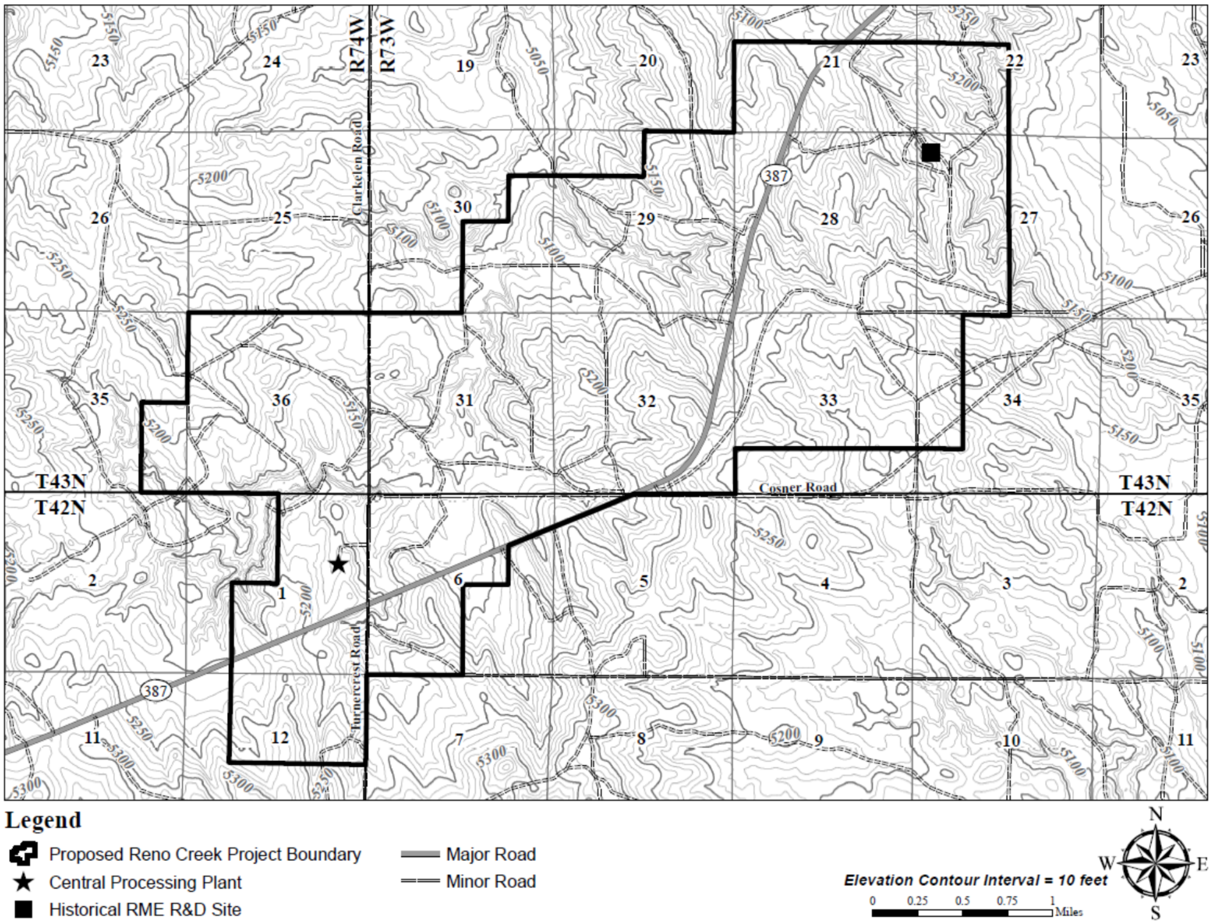

Figure 1-2 Proposed Project map
Source: TR Figure 1-2 (AUC, 2012)

- central processing plant (CPP) consisting of pressurized, downflow ion exchange (IX) columns, resin stripping or elution circuit, precipitation circuit, and yellowcake drying and packaging facilities. The CPP will also be used to facilitate the necessary solutions and processes for groundwater restoration after recovery has ceased;
- a CPP which will be equipped to receive and process equivalent feed, pursuant to U.S. Nuclear Regulatory Commission (NRC) Regulatory Information Summary 2012-06 (RIS, 2012);
- onsite laboratory, office and maintenance building, reagent storage facilities, and other facilities or areas used to house work areas or equipment storage; and
- up to four Class I Underground Injection Control (UIC) deep disposal wells (DDWs) to dispose of liquid 11e.(2) byproduct material generated during ISR operations with backup storage pond capacity.

In TR Section 1.3, the applicant provides the following overview of the corporate entities involved. In 2004, Strathmore Minerals (former site owner) staked and filed new Federal unpatented mining claims and renewed private mineral leases and a State of Wyoming mineral lease within the Proposed Project area. In May 2007, Strathmore entered into a joint venture partnership with American Uranium Corporation of Nevada, to bring the Reno Creek property to a full-scale ISR operation. Strathmore then formed AUC LLC, a United States (U.S.) corporation, to hold all of the Reno Creek assets and be the operator of the joint venture with American Uranium. In 2010, Pacific Road Capital (Australian company) and Bayswater Uranium (Canadian company) jointly formed AUC Holdings, Inc., a U.S.-based corporation, which then acquired AUC LLC, the Proposed Project, and other uranium assets in the vicinity from Strathmore and American Uranium. All active mining claims and fee mineral leases were transferred from Strathmore to AUC LLC during the sale to AUC Holdings. AUC LLC is 100-percent-owned by AUC Holdings, Inc. (AUC, 2015a). AUC LLC will be the holder of the NRC license, and its managers and employees will be solely responsible for complying with the NRC's financial and technical regulations under 10 CFR Part 40, Appendix A Criteria, specific license conditions, and relevant guidance and policy (AUC, 2012).

In TR Section 1.6, the applicant provides a general description of the ore body and states that the economic uranium deposits occur in medium to coarse-grained sands of the Wasatch Formation, and this formation is approximately 152.4 to 213.3 meters [m] (500 to 700 feet [ft]) thick in the Proposed Project area. Uranium mineralization is confined to the sandy units and clay/sand boundaries in the lower part of the formation. The uranium deposits are generally found within sand units ranging from 15.2 to 60.9 m (50 to 200 ft) in thickness and at depths ranging from 51.8 to 137.2 m (170 to 450 ft) below ground surface. Individual mineralized units are variable in thickness, ranging from 0.3 to 9.1 m (1 to 30 ft) thick. AUC estimates the total uranium content in the ore body at the Proposed Project to be approximately 7.1 million kilograms (kg) (15.7 million pounds [lb]) with an average grade of approximately 0.065 percent uranium oxide (U_3O_8).

In situ recovery (ISR) involves extracting uranium from underground ore bodies, without bringing the ore-bearing sandstone to the surface, by injecting a leaching solution though wells into underground ore bodies to dissolve the uranium. In TR Section 1.7, the applicant states that the proposed leaching solution consists of an oxidant (such as gaseous oxygen or hydrogen peroxide), and a complexing agent (such as sodium carbonate or carbon dioxide) that enhances uranium's solubility and mobility. The leaching solution is recovered from the subsurface through extraction wells and pumped though a system of underground pipes to the CPP. At the CPP, two processes are used produce the yellowcake. In the first process, uranium-rich leaching solutions are pumped through resins which selectively capture uranium from the solutions (then these solutions are refortified with the oxidizing and complexing agents and recirculated into the injection wells to extract more uranium). The second process chemically removes the uranium from the resins. These processes are repeated until uranium recovery from the ore body is no longer economical. In TR Section 1.8, the applicant requests that the Proposed Project be licensed to operate a pressurized downflow IX system with a maximum capacity of 41,639 liters per minute (lpm) (11,000 gallons per minute [gpm]) (and produce up to 907,185 kg [2 million lb]) of yellowcake per year.

The applicant's anticipated schedule for construction, operation, restoration, decommissioning, and reclamation at the Proposed Project is illustrated in TR Figure 1-3. In TR Section 1.9, the applicant states that the total project lifespan is expected to be approximately 16 years; however, the duration of operations may be extended by processing uranium-loaded IX resins from AUC-owned and/or -operated satellite facilities or other companies. The applicant states that the schedule is subject to change due to production schedules, variations with production area recoveries, CPP issues, economic conditions, etc. The applicant further states that the exact annual production schedules will be updated in annual reports to the NRC and Wyoming Department of Environmental Quality (WDEQ) Land Quality Division (LQD).

In TR Section 1.10, the applicant states that the Proposed Project operations will generate byproduct material as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended (AEA). Liquid byproduct material generated from the production and restoration operations at the Proposed Project will be disposed through deep well injection regulated by the WDEQ. Solid byproduct material, such as production equipment and piping, will be shipped to an NRC-approved 11e.(2) disposal facility. The applicant commits to securing an agreement with such a facility prior to the start of operations. Solid waste such as trash and spent equipment parts not associated with uranium recovery will be collected and stored onsite and periodically removed to an offsite sanitary landfill permitted by the WDEQ Solid & Hazardous Waste Division. Hazardous waste such as solvents and degreasers will be recycled or disposed of offsite at a permitted hazardous waste facility or by other U.S. Environmental Protection Agency (EPA)-approved disposal methods. Domestic sewage disposal systems will be permitted through the WDEQ Water Quality Division (WQD). The applicant plans to use conventional septic/leach field systems for domestic sewage disposal.

According to the applicant, once extraction is completed in a wellfield, restoration will begin. Similar to production unit (PU) construction, groundwater restoration will be a phased approach, and it is anticipated that two to three PUs will be in various stages of active restoration or stability monitoring at one time. As AUC completes uranium recovery operations in each PU, it will sequentially commence groundwater restoration. Following completion of groundwater restoration, AUC will conduct stability monitoring and obtain final approval from WDEQ and the NRC. At this stage, AUC will commence decommissioning of the PU based on an NRC-approved decommissioning plan. Therefore, PUs will be decommissioned in a timely manner consistent with 10 CFR 40.42. Once groundwater restoration, decontamination and decommissioning, and reclamation activities conclude and AUC has met the requirements of 10 CFR 40, Appendix A, Criterion 6(6), the site will be released for unrestricted use (AUC, 2015a).

In TR Section 1.13, the applicant commits to having an approved financial assurance arrangement in place prior to startup of operations. The applicant states that the financial assurance arrangement will be consistent with requirements of 10 CFR Part 40, Appendix A, Criterion 9, and will include estimated costs for groundwater restoration, radiological decontamination, facility decommissioning, and surface reclamation of sites, structures, and equipment used during operations of the Proposed Project. The methodology for estimating reclamation cost and potential financial assurance arrangements is discussed in TR Section 6 and in the Restoration Action Plan found in TR Addendum 6-A. The financial assurance amount will be revised prior to the commencement of licensed activities and annually thereafter to reflect the estimated costs of final reclamation activities for the Proposed Project. Pursuant to these requirements, AUC will comply with Criterion 9 requirements for these annual financial assurance updates and will have in place an NRC-approved financial assurance mechanism after receiving its NRC license but before beginning active ISR operations (AUC, 2012).

In TR Section 1.2, the applicant summarized ISR testing (Pattern 2) conducted at the Proposed Project using a sodium carbonate (Na_2CO_3)/sodium bicarbonate ($NaHCO_3$) lixiviant and hydrogen peroxide (H_2O_2) oxidant. This testing was conducted by Rocky Mountain Energy (RME), who acquired the Proposed Project area in the late 1960’s, and subsequently delineated uranium deposits based on exploration drilling. The pilot testing pattern was constructed as a modified 5-spot, consisting of two recovery wells, four injection wells, and six monitor wells, and operated from October 1980 to December 1980. The results, coupled with column leach test results, led to the decision to use carbonate lixiviant for further testing and commercial development. Restoration of the test pattern began in December 1980. Analysis of water quality data following completion of the restoration program indicated that restoration of groundwater affected during ISR was successful. All parameters returned to baseline ranges with the exception of pH, uranium, and vanadium. Of these parameters, all were either below WDEQ Class I Groundwater Standards (domestic use) or do not have Class I maximum concentration limits. This pilot test culminated in regulatory signoff in June 1983 with the approval of carbonate leaching for commercial operations at the Proposed Project. TR Addendum 1A includes a summary of RME's pilot plant testing.

In TR Section 1.6, the applicant estimates, for the purpose of this license application, mineral resources of approximately 7.1 kg (15.7 million lb) of uranium at an average grade of approximately 0.065 percent U_3O_8. The applicant states that, based on AUC analysis and a review of NUREG-1910, "Generic Environmental Impact Statement for In Situ Leach Milling Facilities" (GEIS) (NRC, 2009), the Proposed Project's ore body closely resembles the roll-front deposits assessed previously by the NRC in the Nebraska–South Dakota–Wyoming Region, which includes the Proposed Project area, as well as those in all of the other ISR GEIS regional analyses.

In TR Section 1.7.2, the applicant states that the amenability to ISR of the uranium deposits in the Proposed Project has been demonstrated through a successful site-specific pilot test, as discussed above. The applicant adds that existing nearby ISR projects in the Powder River Basin in Wyoming (Christensen Ranch, Irigaray, Smith Ranch–Highland and several pilot-scale projects) demonstrate that ISR methods can efficiently extract uranium from roll-front deposits in a cost effective manner with minimal environmental impacts. The applicant concludes that ISR processes can be conducted with no significant risk to the public health or safety, and the affected aquifer can be successfully restored to meet both State and Federal regulatory requirements.

Other Federal, State, and local permits, licenses, and approvals are required prior to the possible start of operations, including:

- Permit to Mine issued by the WDEQ
- Source Materials License issued by the NRC
- UIC permit for the Class I & Class III wells from the WDEQ
- aquifer exemptions from the EPA
- permit to construct a holding (storage) pond (40 CFR 61.07) from the EPA

Should the Commission issue a source material license, the applicant proposes to initiate construction immediately thereafter.

1.4 Evaluation Findings

The staff has completed its review of the summary of the planned activities at the Proposed Project in situ leach facility. The review included an evaluation based on the methods and procedures described in the SRP Section 1.2 and the acceptance criteria outlined in SRP Section 1.3.

The applicant has described the proposed activities at the Reno Creek in situ leach facility, including (i) corporate entities involved; (ii) location of the proposed facility; (iii) land ownership; (iv) ore-body locations and estimated uranium content; (v) proposed solution extraction method and process; (vi) operating plans, design throughput, and annual uranium production; (vii) schedules for construction, startup, and duration of operations; (viii) waste management and disposal plans; (ix) groundwater quality restoration, decommissioning, and land reclamation plans; and (x) surety arrangements covering facility decommissioning, groundwater quality restoration, and site reclamation. The applicant has also included a summary of results of ISR pilot testing at the Proposed Project site.

Based on the information in the application and the detailed review conducted of the summary of proposed activities at the Proposed Project site, the staff concludes that the summary of proposed activities is in compliance with 10 CFR 40.31, which describes the general requirements for the issuance of a specific license.

SECTION 2

SITE CHARACTERIZATION

2.1 Site Location and Layout

2.1.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the site location and layout are consistent with the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 40.32(c), which describes the general requirements for issuance of a specific license.

2.1.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with applicable requirements of 10 CFR Part 40 using acceptance criteria in Standard Review Plan (SRP) Section 2.1.3 (NRC, 2003).

2.1.3 Staff Review and Analysis

Information in this Safety Evaluation Report (SER) section, unless otherwise stated, is from technical report (TR) Section 2.1 (AUC, 2012). In this TR section, the applicant describes the site location and layout and states that the Reno Creek Project (Proposed Project) is situated in the southern portion of the Powder River Basin, in the Pumpkin Buttes Uranium District in Campbell County, Wyoming, within the Wyoming East Mining Region as defined in NUREG-1910, "Generic Environmental Impact Statement for In Situ Uranium Leach Milling Facilities" (GEIS) (NRC, 2009) and the project area comprises approximately 2,451 hectares (ha) (6,057 acres [ac]) of all or portions of the following sections:

Section	Township	Range
5 & 6	42 North	73 West
1 &12	42 North	74 West
21, 22, 27, 28, 29, 30, 31, 32, 33, & 34	43 North	73 West
35 & 36	43 North	74 West

This section of the application identifies natural features near the Proposed Project which include the Pumpkin Buttes located 12 kilometers (km) (7.5 miles [mi]) northwest of the project boundary and the Thunder Basin National Grassland, which bisects the eastern half of the Proposed Project boundary. It states that the Proposed Project boundary is situated in a semiarid area with elevations ranging 1536 to 1614 meters (m) (5,041 to 5,296 feet (ft)) above mean sea level with 78 m (255 ft) of vertical relief across the project area. It further states that the project area is at the headwaters of the Belle Fourche and Cheyenne Rivers, which are both classified as ephemeral (a drainage feature that only carries surface runoff in direct response to precipitation) within the Proposed Project boundary.

The applicant states that the Proposed Project consists of 157 AUC-owned unpatented lode mining claims (SC1-47, WR 3-80, BFR 1-18, 21-83), one AUC-held State of Wyoming mineral lease, and two AUC-held private mineral leases (AUC, 2015a). The narrative discussion in Section 2.1 of the application is supported by additional information, including a map of nearby population centers, highways, and county boundaries (TR Figure 1-1); illustrations depicting site surface and mineral ownership (TR Figures 2.1-1 and 2.1-2), and a contour map of the site showing the Proposed Project boundary and the location of the planned central processing plans (CPP), production units (wellfields and header houses), trunk lines, deep disposal wells (DDWs), utility corridors, and access roads in the Proposed Project area (TR Figure 2.1-3).

According to the applicant, controlled areas will be fenced to limit access to project-associated operations and is estimated to encompass 195 ha (481 ac) or approximately 8 percent of the Proposed Project area. Anticipated controlled areas include all fenced areas around the CPP, wellfields, backup pond, and DDWs. Production unit (PU) perimeter ring monitoring wells will be located outside of the fenced wellfield areas and are not included within the controlled areas. AUC will control access to perimeter ring monitoring wells by installing protective locked covers on these wells (AUC, 2015a).

The applicant states that there currently is one residence (the Taffner homestead) located within the Proposed Project boundary (environmental report (ER) Figure 3.1-1) and five residential sites located within the 8-km (5-mi) land use review area outside of the Proposed Project boundary (AUC, 2012). Based on landowner correspondence, there are currently two occupants at the Taffner homestead and approximately eight occupants currently living in the five residences located outside the project boundary. The Taffner homestead is currently located where the proposed CPP will be located. In response to the staff's request for additional information, AUC committed to acquire the Taffner property prior to CPP construction, and it will not thereafter be used as a residence. The domestic water well located at the Taffner residence will be plugged in accordance with Wyoming Department of Environmental Quality (WDEQ) Rules and Regulations and will not be used for consumption once construction begins. AUC will provide the U.S. Nuclear Regulatory Commission (NRC) with a copy of the property title transfer and/or other contract documents following the acquisition of the Taffner property. In addition, AUC will notify the NRC when the plug and abandonment report for the Taffner domestic well has been filed with the Wyoming State Engineers Office (AUC, 2015a). AUC subsequently notified and submitted documentation to the NRC that satisfy these commitments (AUC, 2016a).

The applicant provides data based on information obtained from published sources, and data obtained from nonpublished sources and/or generated by the applicant to support its conceptual model of the setting and/or designs of the proposed facility. In TR Section 2.1, the applicant states that the maps used in this application were derived from United States Geological Survey (USGS) 7.5-minute topographic quadrangle maps, geospatial data from the Wyoming Geographic Information Science Center, and the Environmental Systems Research Institute, Inc.'s, web-based imagery.

The staff conducted several site visits of the Proposed Project site, including a November 2011 preapplication-submission audit (NRC, 2011) and a site visit in September 2013 to aid the staff's review of the application. Through site visits, the staff verified that general aspects of the application (e.g., geographic setting, location of meteorological stations) are consistent with descriptions and mapping in the application.

2.1.4 Evaluation Findings

The staff has completed its review of the site characterization information regarding site location and layout at the Reno Creek in situ leach facility. This review included an evaluation using the review procedures in SRP Section 2.1.2 and the acceptance criteria outlined in SRP Section 2.1.3.

The applicant has described the site location and layout with appropriately scaled and labeled maps showing site layout, principal facilities and structures, regional location, geology, boundaries, exclusion areas and fences, applicant property including leases and adjacent properties, nearby population centers and transportation links, and topography. References are cited.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the acceptance criteria of SRP Section 2.1.3 and the requirements of 10 CFR 40.32(c).

Section 2.2 Meteorology

This section discusses the meteorological conditions of the region surrounding and including the Proposed Project. Meteorological data are used to select environmental monitoring locations, assess the impact of operations on the environment, and perform radiological dose assessments.

2.2.1 Regulatory Requirements

The staff of the NRC determines if the applicant has demonstrated that the meteorology program, which is part of the site monitoring programs required by Criterion 7 of Appendix A, “Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Waste Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content,” to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, “Domestic Licensing of Source Material,” is sufficiently complete to allow for estimating doses to workers and members of the public.

2.2.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7, using the acceptance criteria in SRP Section 2.5.3 (NRC, 2003).

2.2.3 Staff Review and Analysis

The following sections present the staff’s review and analysis of various aspects of the meteorological conditions and monitoring at the Proposed Project. The aspects reviewed in the following sections include regional meteorological conditions; onsite meteorological conditions, including those representative of long-term conditions at and near the site; air quality; and meteorological data quality.

2.2.3.1 Regional Meteorological Conditions

The applicant stated in TR Section 2.5.1 (AUC, 2012) that the Proposed Project is located in a semiarid or steppe climate, and the region is generally characterized by cold harsh winters, hot dry summers, warm moist springs, and cool autumns.

The applicant stated in TR Section 2.5.2.1 (AUC, 2012) that the temperature extremes range from approximately -25º F to 100º F and an annual average temperature of 46 degrees Fahrenheit (F). The applicant provided regional monthly average temperatures for the year 2011 for the Gillette Airport site, the Casper Airport site, the Antelope Mine site, and the Glenrock Mine site in TR Figure 2.5-2 (AUC, 2012). The staff reviewed the regional monthly average temperature data in TR Figure 2.5-2 (AUC, 2012) and determined that the applicant provided regional temperatures consistent with SRP Acceptance Criterion 2.5.3(1) (NRC, 2003).

The applicant stated in TR Section 2.5.2.3 (AUC, 2012) that the annual average precipitation ranged from 28 to 38 centimeters (cm) (11 to 15 in) with summer thunderstorms producing roughly 45 percent of the precipitation. The applicant provided regional monthly average precipitation for the year 2011 for the Gillette Airport site and Antelope Mine Site in TR Figure 2.5-9 (AUC, 2012). The staff reviewed the regional monthly average precipitation in TR Figure 2.5-9 (AUC, 2012) and determined that the month of May in 2011 provided the highest precipitation. The highest monthly precipitation in May 2011 was approximately 8.9 cm (3.5 in) for the Gillette Airport site and 13 cm (5 in) for the Antelope Mine site. The staff determined that the difference between the applicant's statement in TR Section 2.5.2.3 (AUC, 2012) and the data provided in TR Figure 2.5-9 (AUC, 2012) was that the applicant's statement covered a longer time period (several years) and the precipitation data in TR Figure 2.5-9 only covered the year 2011. Therefore, the staff has determined that the applicant provided regional precipitation consistent with SRP Acceptance Criterion 2.5.3(1) (NRC, 2003).

In TR Section 2.5.2.4 (AUC, 2012), the applicant stated that the annual average wind speed in Wyoming is 12.9 mph (miles per hour). The applicant provided regional monthly average wind speeds for the Gillette Airport site, the Casper Airport site, the Antelope Mine site, and the Glenrock Mine site in TR Figure 2.5-16 (AUC, 2012). The staff reviewed the regional monthly average wind speed in TR Figure 2.5-16 (AUC, 2012) and determined that the lowest monthly average wind speed is in July, with average monthly wind speeds ranging from approximately 8.5 to 12 mph to approximately 11 to 18 mph in December for all the sites. The applicant provided the annual wind rose for the Casper Airport site (2004 to 2011), the Antelope Mine Site (1986 to 2011), and the Glenrock Mine site (1996 to 2010) in TR Figures 2.5-13 through 2.5-15 (AUC, 2012).

The staff reviewed the wind roses in TR Figures 2.5-13 thru 2.5-15 and determined that the wind direction in each wind rose is slightly different in terms of maximum wind direction. The wind rose is presented as a percent joint frequency distribution. For example, the maximum wind rose for the Casper Airport (2004–2011), which was reported from the southwest, at approximately 21 percent, differed from the maximum wind rose for the Antelope Mine site (1986 to 2011), which was reported from the west at approximately 15 percent. The maximum wind rose for the Glenrock Mine site (1996 to 2010) was reported as west-southwest at approximately 20 percent. The longer time period of the data collection would account for the variation and difference in data when compared to a single year (i.e., 2011). Studies have shown that it is possible to observe spatial and temporal differences in meteorological variables (i.e., precipitation, wind speed) over a wide range of climate conditions in subhumid and semiarid areas (Carmargo and Hubbard, 1999). Thus, the staff anticipates a difference in meteorological variables within regional meteorological monitoring stations. This is evident from the regional meteorological data collected by the applicant. Therefore, the staff has determined that the applicant provided regional wind speed and wind direction consistent with SRP Acceptance Criterion 2.5.3(1) (NRC, 2003).

In TR Section 2.5.3.6, the applicant provided the mixing heights as established by the Air Quality Division of the WDEQ as a function of stability class. The applicant stated that the annual average mixing height is 1,110 m (3,642 ft), with an average morning mixing height of 333 m (1,093 ft) and an afternoon mixing height of 1,547 m (5,075 ft) (AUC, 2012).

The staff finds that the applicant provided a description of the general climate of the region and regional meteorological data on temperature, precipitation, relative humidity, wind speed, and wind direction from several regional meteorological sites, as well as the average mixing heights. The staff determined that the applicant meets SRP Acceptance Criterion 2.5.3(1) (NRC, 2003), and therefore, the staff finds the regional meteorological conditions acceptable.

2.2.3.2 Onsite Meteorological Conditions

The staff determined that the applicant has installed an onsite meteorological station and collected approximately 1 year of meteorological data. The staff has determined that the onsite meteorological data are useful for determining the environmental sampling locations at the Proposed Project site, and the applicant did not rely on other meteorological stations for determining the onsite environmental sampling locations.

The applicant stated in TR Section 2.5.3.1 that the average site temperature during the baseline monitoring period, which ranged from October 2010 to October 2011, was 44.2 degrees F. The applicant stated in TR Section 2.5.3.1 that the site's maximum high temperature was 95.9 degrees F and the lowest temperature was -25.1 degrees F; these data are shown in TR Table 2.5-6 (AUC, 2012). The staff reviewed the monthly temperatures in Table 2.5-6 and determined that the extreme and annual average temperatures recorded at the onsite meteorological stations are consistent with the regional extreme and annual average temperatures reported in SER Section 2.2.3.1.

The applicant stated in TR Section 2.5.3.3 (AUC, 2012) that the site's total precipitation for the baseline year (October 2010 to October 2011) was 34 cm (13.4 in). The applicant provided in TR Figure 2.5-21 (AUC, 2012) the monthly precipitation for the baseline year. The staff reviewed the monthly precipitation data in TR Figure 2.5-21 (AUC, 2012) and observed that the highest precipitation occurred in the fifth month of the baseline year. The staff determined that the approximate total amount of precipitation for the baseline monitoring period at the onsite meteorological station is consistent with the regional precipitation reported in SER Section 2.2.3.1.

The applicant provided a site wind summary, which includes the annual average wind speed and average wind speed by sectors in TR Figures 2.5-23 through 2.5-29 and reported that the annual average wind speed was 13.5 mph with a maximum of 42 mph and a minimum of 1.1 mph. The applicant also reported in TR Figure 2.5-29 that the data recovery for wind speed, sigma theta, and wind direction was greater than 99 percent (AUC, 2012). Regulatory Guide (RG) 3.63 (NRC, 1988a) recommends a data recovery of 90 percent or greater. The staff reviewed the wind summary data in TR Figure 2.5-29 and determined that the data recovery is consistent with the recommended data recovery in RG 3.63 (NRC, 1988a) and is therefore acceptable. The staff also determined that the annual average wind speed is consistent with the annual average regional wind speed reported in SER Section 2.2.3.1.

The applicant stated in TR Section 2.5.3.5 that the winds are predominantly from the west-southwest and southwest with secondary modes from the northwest/north-northwest and southeast directions. The applicant provided annual and quarterly wind roses in TR Figures 2.5-24 through Figure 2.5-28 (AUC, 2012). The staff reviewed the wind rose in Figure 2.5-24 and determined that percent frequency of the three highest wind directions are the west-southwest at approximately 15 percent, southwest at approximately 13 percent, and northwest at approximately 9 percent. The staff evaluated the environmental sampling locations based on the onsite meteorological wind rose data in this section of the SER with the preoperational environmental sampling locations in SER Section 2.6.

The applicant provided annual and quarterly joint frequency distribution in TR Tables 2.5-7 through 2.5-11 for each stability class (AUC, 2012). The staff reviewed the Proposed Project baseline year joint frequency distribution in TR Table 2.5-7 (AUC, 2012) and determined that the sum of the joint frequency distributions was approximately 100 percent and that stability Class D represented approximately 71.5 percent of the joint frequency distribution. The staff determined that the annual joint frequency distribution is used in the MILDOS calculation to compute the projected concentration of contaminants released into the environment and the radiation dose to members of the public. The MILDOS computer code calculates the dose commitment received by individuals and the general population within an 80 km (50 mi) radius of an operating uranium facility.

The applicant stated in TR Section 2.2.1 (AUC, 2012) that the Proposed Project landscapes are characterized by a flat to gently rolling topography with small ephemeral drainages and large, open upland grassland with sagebrush shrubland, which are typical landscapes, and the Pumpkin Buttes are visible from the site at a range of 11.3–22.5 km (7–14 mi). Buttes are tall natural structures or objects located in relatively flat or rolling hills that have the potential to influence local weather patterns (i.e., wind speed and wind direction). The applicant stated that the nearest significant topographic features are the Pumpkin Buttes, located approximately 16.1 km (10 mi) west of the Proposed Project site, and are approximately 305 m (1,000 ft) higher in elevation. According to the applicant, given this 50:1 aspect ratio and the relatively small area occupied by the Pumpkin Buttes, the Proposed Project site is too far away to be influenced meteorologically (AUC, 2014a). The applicant provided wind roses for several nearby locations and indicated that the Reno Creek wind rose closely resembles the wind rose from the Moore Ranch in situ recovery (ISR) Project, located 24.1 km (15 mi) south-southwest of the Proposed Project site, and nearly resembles the wind rose from the Antelope Mine, which is located 32.2 km (20 mi) southeast of the Proposed Project site (AUC, 2014a). The staff reviewed the wind roses provided by the applicant and determined that they are nearly identical to each other, and the Pumpkin Buttes do not affect the site meteorology. The staff has reasonable assurance that the Pumpkin Buttes will not affect the onsite meteorology. The applicant stated in TR Section 2.5.3.7 (AUC, 2012) that there are no major bodies of water affecting the meteorology of the Proposed Project site. The staff reviewed TR Figure 1-1 (AUC, 2012) and determined that there are no major bodies of water within a 32.2 km (20-mi) perimeter that will adversely affect the Proposed Project. This is consistent with SRP Acceptance Criterion 2.5.3(2) (NRC, 2003).

RG 3.63 recommends that 12 consecutive months of meteorological data be representative of long-term (e.g., 30 years) meteorological conditions at the site. Since new applicants do not have 30 years of long-term meteorological data, the guidance recommends using short-term and long-term meteorological data at a nearby National Weather Service (NWS) station. The U.S. Environmental Protection Agency (EPA) defines representativeness as the extent to which a set of measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application (EPA, 2000). EPA further stated that there are no generally accepted analytical or statistical techniques to determine the representativeness of meteorological data or monitoring sites (EPA, 2000).

In an attempt to demonstrate that the onsite meteorological data is representative of a different space-time domain, the applicant provided supplementary data in ML15002A082 (Appendix D) of package ML15002A077 (AUC, 2015a) that included the combination of visual graphical displays, a hypothetical statistical test (chi-square), and a linear correlation for wind speed, wind direction, and stability class from the Antelope Mine meteorological station. The applicant selected Antelope Mine for the following reasons: (1) it is within 32.2 km (20 mi) of the applicant site and has nearly identical elevation and rolling terrain, (2) it has 27 years of data, (3) it has a high recovery rate (93 percent), and (4) it has a low instrument threshold and high data resolution when compared to a nearby NWS station.

The staff has previously determined that the wind speed and wind direction are the two most important meteorological parameters for determining representativeness. The stability class includes both wind speed and wind direction, and it is an important parameter for dose assessment. For the purpose of demonstrating representativeness, only wind speed and wind direction are considered for compliance with RG 3.63. The wind speed is divided into seven groups and the wind direction is divided into 17 groups. The wind speed and the wind direction account for periods of calm as a separate group.

Although EPA indicated that there are no generally acceptable analytical or statistical tests to demonstrate representativeness, the staff used the collective sum of each of the applicant's methods to make a reasonable judgment as to whether the results are representative. The staff reviewed the applicant's visual evidence (Figure 1), the chi-square test (Table 2 and Table 3), and the correlation analysis (Figure 7 and Figure 8) in ML15002A082 (Appendix D) of package ML15002A077 (AUC, 2015a). To further support the data, the applicant also provided annual onsite wind roses over a 4-year period (Figure 12) (AUC, 2015a).[1]

The visual graphical displays are shown in Figure 1 in ML15002A082 (Appendix D) of package ML15002A077 (AUC, 2015a). The visual graphs provide a general overview and comparison of the relationship between the data sets. The applicant converted both the 27 years and 1 year of hourly data into a frequency (percent fraction) of the two data sets for comparative purposes. If the 27 years of hourly data were not converted into a frequency, the comparison with the 1 year of hourly data would result in a large distortion of hourly data between the two data sets. The set with 27 years of hourly data would have 236,520 hours of data, compared to 8,760 hours for the 1-year data set. Thus, the conversion of both data sets into a frequency allows one to make a more equal comparison based on a percent. The staff reviewed Figure 1 for both wind speed and wind direction and determined the frequency for each group to be comparable, and therefore indicating representativeness.

[1] The visual graphs and the wind roses are considered qualitative, and the chi-square test and correlation analysis are considered quantitative statistical tests.

The chi-square test was performed for both the wind speed and the wind direction, as shown in Table 2 and Table 3 in ML15002A082 of package ML15002A077 (AUC, 2015a). The chi-square test determines if there is a statistical difference between two or more populations or data sets. To perform the chi-square test, the 27 year hourly data were normalized (based on the frequency) to represent 8,760 hours per year (1 year) for comparison with the 1 year hourly data (also 8,760 hours per year). The conversion of the long-term frequency data back to an annualized 1 year of hourly data results in a fair comparison with the short-term annualized 1 year hourly data. The staff reviewed the results of the chi-square test in Table 2 and Table 3 and confirmed that the applicant used appropriate methodology to determine that there is no statistical difference between the two data sets.

A correlation analysis was performed for both wind speed and wind direction as shown in Figure 7 and Figure 8 in ML15002A082 of package ML15002A077 (AUC, 2015a). A correlation analysis attempts to demonstrate the strength of the association between two populations or data sets on two opposing axes (i.e., x-axis and y-axis). Unlike the regression analysis, the x-axis and y-axis do not represent the independent and dependent values. The data set can be interchangeable on either axis. The data in the correlation analysis are expressed as a frequency for both the short-term and long-term data set. Again, the conversion of the hourly data into a frequency allows one to observe a relationship between the two data sets for both wind speed and wind direction on a graph. The applicant used an R-square (R^2) value to demonstrate that the data is representative. An R^2 value that is greater than 0.9 (90 percent) suggest that there is a strong association between the two data sets. The association between two data sets in a correlation analysis is usually expressed as R, but the R^2 value applies a more stringent standard. For example, if $R = 0.9$, the R^2 value would be 0.81 ($0.9 \times 0.9 = 0.81$). The applicant computed an R^2 value of 0.98 (98 percent) for wind speed and an R^2 value of 0.96 (96 percent) for wind direction. The staff reviewed the graphs in Figure 7 and Figure 8 and confirmed that there is a strong association between the two data sets.

The staff also reviewed the 4 years of onsite annual wind roses as provided in Figure 12 in ML15002A082 of package ML15002A077 (AUC, 2015a). The wind rose is another graphical illustration of the data. In this case, the data do not represent short-term or long-term data sets but what has been collected to date onsite. Therefore, the staff determined that the four onsite annual wind roses represent an adequate length of time and show a consistent pattern.

Based on the collective review of the qualitative and quantitative methods provided by the applicant, and because there are no generally accepted analytical or statistical techniques to determine representativeness, in the staff’s technical judgment, all the methods are consistent with each other and the collective sum of the methods demonstrates representativeness consistent with RG 3.63. This is consistent with SRP Acceptance Criterion 2.5.3(3). Therefore, the staff has reasonable assurance that the onsite wind speed and wind direction are representative of the concurrent meteorological station (i.e., the station at the Antelope Mine site). The staff has determined that the methods provided by the applicant are acceptable because each individual evaluation or assessment supports the others and there is no contradiction between the various evaluations and assessments.

2.2.3.3 Meteorological Data Quality

The applicant stated in TR Section 2.5.3 that the height of the meteorological tower was 10 m (32.8 ft), that it was installed on October 6, 2010, and that the instruments and specifications are identified in TR Table 2.5-5 (AUC, 2012). The staff reviewed the meteorological instruments, as identified in TR Table 2.5-5 (AUC, 2012) with the accuracies as suggested in RG 3.63

(NRC, 1988a). The staff determined that the instruments and accuracies meet or exceed the recommended instruments and accuracies in RG 3.63, and therefore, the staff finds this acceptable. In conjunction with the instruments and specifications, the applicant provided a list of all meteorological stations in TR Table 2.5-1, and this list includes the agency, latitude, longitude, elevation, years of operation, and meteorological parameters for each of the stations (AUC, 2012).

The staff finds that the applicant provided sources of all meteorological and air quality data, which are documented in open file reports or other published documents. The staff determined that the applicant has demonstrated that there are other meteorological stations within a 50 mile radius of the Proposed Project site consistent with RG 3.63 which meets SRP Acceptance Criterion 2.5.3(5) (NRC, 2003). TR Section 2.5.4 also provides a description of air quality consistent with SRP Acceptance Criterion 2.5.3(4). Air quality is evaluated in more detail in Chapters 3.7 and 4.7 of the NRC's draft supplemental environmental impact statement for the Proposed Project.

2.2.4 Evaluation Findings

The staff has completed its review of the site meteorology for the Proposed Project. This review included an evaluation using the review procedures in the SRP Section 2.5.2 and the acceptance criteria outlined in SRP Section 2.5.3, where applicable.

The applicant has acceptably described the site meteorology by providing data from the NWS, military, or other stations recognized as standard installations located within 80 km (50 mi) of the site, including available joint frequency distribution data on (i) wind direction and speed, (ii) stability class, (iii) period of record, (iv) height of data measurement, and (v) average inversion height. The data cover a sufficient time period to constrain long-term trends and support atmospheric dispersion modeling. The applicant has provided acceptable onsite meteorological data, if necessary, including (i) descriptions of instruments, (ii) locations and heights of instruments, and (iii) joint frequency distributions. The joint-frequency data presented are for a minimum of 1 year, with a joint data recovery of 90 percent or more. Additional data on (i) annual average mixing layer heights, (ii) the regional climate, and (iii) total precipitation and evaporation by month have been provided. The applicant has noted any effect of nearby water bodies or terrain on meteorological measurements. The applicant has acceptably demonstrated that meteorological data used for assessing environmental impacts are representative of long-term meteorological conditions at the site. The applicant's report on the existing air quality at the site and nearby is acceptable.

Based on the information provided in the application, and the detailed review conducted of the regional and site meteorology for the Proposed Project, the staff concludes that the information is acceptable to allow an evaluation of the spread of airborne contamination at the site and the development of conceptual and numerical models.

2.3 Geology and Seismology

2.3.1 Regulatory Requirements

General requirements for contents of an application for a specific license issued under 10 CFR Part 40 are listed in 10 CFR 40.31. Section 10 CFR 40.31(h) specifies that an application must clearly demonstrate how requirements and objectives set forth in 10 CFR Part 40, Appendix A, are addressed. Technical Criteria 1, 5B, 5F, 5G, and 7 of

10 CFR Part 40, Appendix A, set forth requirements and objectives for a suitable geological and seismological setting at a uranium recovery facility.[2] Furthermore, 10 CFR 40.41(c) requires that a 10 CFR Part 40 licensee have the ability to confine the licensee's possession and use of source and byproduct material to locations and purposes authorized by the license. At an ISR facility, meeting these requirements includes determining that the geological and seismological settings are appropriate to confine the regulated material to the designated areas in the subsurface.

Based on guidance in RG 3.46 (NRC, 1982) and SRP Section 2.6 (NRC, 2003), an application should provide descriptions of the geological and seismological settings and a demonstration of the licensee's thorough understanding of those settings in sufficient detail to give a clear perspective and orientation to the site-specific material presented.

2.3.2 Regulatory Acceptance Criteria

The staff reviews the application for compliance with the applicable requirements of 10 CFR 40.31(h); 10 CFR 40.41(c); and 10 CFR Part 40, Appendix A, Criteria 1, 5B, 5F, 5G, and 7, using review procedures in SRP Section 2.6.2 and the acceptance criteria in SRP Section 2.6.3 (NRC, 2003).

Information in the application, as reviewed and verified by the staff, will be deemed acceptable, provided the staff determines, with reasonable assurance, that a license issued based on the application meets the above regulatory requirements, and, pursuant to 10 CFR 40.32, can conclude that (1) the Proposed Project is for a purpose authorized by the Atomic Energy Act of 1954 (as amended) (AEA), (2) 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, (3) the proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property, and (4) issuance of a license will not be inimical to the common defense and security or to the health and safety of the public.

2.3.3 Staff Review and Analysis

Unless otherwise stated, information reported in this SER Section is from TR Section 2.6 (AUC, 2012).

The following subsections present the staff's review and analysis of various aspects of the geology and seismology for the Proposed Project. The information reviewed for the following subsections includes geographic setting, regional geology, site geology, soils, and seismology.

2.3.3.1 Geographic Setting

The Proposed Project is located within an area historically referred to either as the "Pumpkin Buttes Uranium District," "Pumpkin Buttes District," or "Pumpkin Buttes Area" of the Powder River Basin in southwestern Campbell County, Wyoming (AUC, 2012; NRC, 2009). The

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[2] Criteria in Appendix A are written for a conventional mill setting. The conventional mill setting differs from an ISR setting in that (1) at a conventional mill, all activities conducted under the license are performed above ground, whereas, at ISR settings, the uranium extraction from the ore is performed in situ (or in the subsurface), and (2) at a conventional mill, a solid byproduct material, the mill tailings, is stored above ground in a tailings pile, whereas, at ISR settings, no mill tailings are generated. The staff is applying these criteria to ISR facilities, because 10 CFR 40.31(h) specifies that the applicant must meet not only the requirements but the objectives of the technical criteria in Appendix A.

Powder River Basin is a geological, structural basin and is widely known for its mineral resources, including coal, coal-bed methane (CBM), oil and gas production, and uranium (Anna, 1986). The topography throughout most of the Powder River Basin, including that at the location of the Proposed Project, consists of rolling hills with little topographic relief. Ground surface elevations in most of the Powder River Basin are between 1,067 and 1,828 m (3,500 and 6,000 ft) above mean sea level (MSL) (ENSR, 2006). The topographic elevation at the Proposed Project is approximately 1,585 m (5,200 ft) above MSL (AUC, 2012). Based on contours shown on Addendum 2.7-A, TR Figure 2.7A-4 (AUC, 2012), ground-surface elevations within the Proposed Project area vary between 1,540 and 1,600 m (5,050 and 5,240 ft) above MSL.

Structurally, the Powder River Basin is an asymmetrical synclinal structure (i.e., the structural axis is located nearer its western perimeter rather than in the center of the basin) with a thick (up to 6,100 m [20,000 ft]) accumulation of Phanerozoic age (younger than 540 million years ago [ma]) sedimentary consolidated rocks (AUC, 2012). At the Proposed Project area, the depth to the Precambrian basement (thickness of sedimentary consolidated rocks) is estimated at 5,182 m (17,000 ft) (AUC, 2012). The structural axis for the Powder River Basin is located west of the Proposed Project area. The structural orientation of the sedimentary bedding at the Proposed Project site has a shallow (0.5 to 3 degree) northwestwardly dip towards the basin axis.

The name “Pumpkin Buttes” is a reference to the prominent geographic features in the area (i.e., the Pumpkin Buttes) (NRC, 2009). The Pumpkin Buttes are the topographically highest feature within the Powder River Basin, extending approximately 305 m (1,000 ft) vertically above the surface elevation of the surrounding areas (Sharp et al., 1964). The Pumpkin Buttes consist of a series of approximately four individual buttes, described as the North Butte, Middle Buttes (two), and the South Butte. The buttes lie along a northwestern-southeastern trend and are capped by the White River Formation. The buttes are erosional remnants of the younger sediments, as in the past, the White River Formation covered much of the southern portion of the Powder River Basin (Love, 1952). The buttes are capped by the only remnants of the White River Formation mapped within the Powder River Basin. Uranium deposits have been identified in the subsurface of the Pumpkin Buttes area since 1951 (Love, 1952; NRC, 2009; Sharp et al., 1964).

The staff reviewed information provided by the applicant on the geographic setting and finds that the description and characterization as presented by the applicant is consistent with published data. The geographic divisions of the observed landforms at the earth’s surface provide a constraint on the conceptual model for the geologic, hydrogeologic, and seismologic setting. The staff finds that the geographic setting is consistent with the applicant’s conceptual model of the geologic and seismologic model for the Proposed Project, as discussed below.

2.3.3.2 Regional Geology

The applicant discusses the regional geology in the area of the Proposed Project in terms of stratigraphy and structural features (AUC, 2012). The applicant reports that the regional stratigraphy consists of the following:

- a regional basement of Precambrian-age (older than 540 ma) crystalline metamorphic and igneous lithologies at a depth of 5,334 m (17,500 ft) below the ground surface;

- significant thicknesses of Phanerozoic-age (540 to 2 ma) sedimentary lithologies, primarily fine-grained siliciclastic consolidated rocks; and
- a thin veneer of Quaternary-age (less than 2 ma) unconsolidated colluvium or alluvium, limited largely to the present-day major ephemeral drainages.

A regional stratigraphic column depicting the general stratigraphy with depth at the basin axis is shown on SER Figure 2.3-1. Approximately one-half of the stratigraphic column is composed of lithologies younger than the Upper Cretaceous Mesaverde Formation. Those younger lithologies are depicted as the Lewis Shale, Fox Hills Sandstone, Lance Formation, Fort Union Formation, Wasatch Formation, and White River Formation. In general, these formations consist of interbedded shales and sandstones. The youngest formations, largely the Wasatch Formation, also contain several prominent coal seams, which, in the immediate area, are the production zones for CBM; other areas of the Powder River Basin, where the coal seams are located near the surface, are the source of coal production. The coal seams serve as useful marker beds for stratigraphic correlation between boreholes. Lithologies older than (below) the Upper Cretaceous Mesaverde Formation also consist of shales and sandstones, although the percentage of shales (finer-grained lithologies) in these formations increase over those found in the younger (overlying) lithologies. The oldest formations include evaporates (carbonates and gypsum).

The applicant presents a geophysical log for an oil and gas well located within one-half mile of the Proposed Project as a regional type log (SER Figure 2.3-2). The log depicts the geophysical signature of the subsurface strata to a depth of approximately 3,200 m (10,500 ft). The applicant superimposed on that log locations of various geological formations, as well as the horizons significant to the Proposed Project. These horizons include the Felix Coal (in the upper confining unit), the production zone, the Badger Coal (top of the Fort Union Formation and production zone for the nearby CBM wells), the Wyodak Coal, the zone for the Town of Wright Fort Union Water Supply Wells, and the planned injection zone for the Proposed Project Class I injection wells (SER Figure 2.3-2).

Structurally, the regional geology consists of sediments deposited in the southern portion of Powder River Basin (AUC, 2012). In general, the older sediments that were deposited during the Paleozoic or Early Mesozoic Eras reflect deposition in a shallow marine environment. That shallow marine environment extended throughout Wyoming beyond the present-day footprint of the Powder River Basin. During the Early Mesozoic Era to the middle of the Upper Cretaceous Period, the sediments in the Powder River Basin reflect deposition in a distal, quiescent environment, such as that in a deep marine setting, and, again, extended beyond the footprint of the Powder River Basin. Starting with the Upper Cretaceous Fox Hills and extending throughout the overlying stratigraphic column, the youngest sediments in the basin reflect deposition in the near shore to coastal fluvial environments. It is during this time that the Powder River Basin began to form as an intermontane basin in response to the Laramide Orogeny. Although the youngest (or comparable) lithologies are found in other basins in the region, the deposition of those sediments occurred syngenetically with the folding and subsidence of the basin. As a result, the orientation and thickness of the younger formations vary spatially within the basin (AUC, 2012).

The applicant presents a regional bedrock geologic map depicting the surficial expression of the bedrock lithologies (SER Figure 2.3-3) and a structural contour map on the top of the Fort Union Formation (SER Figure 2.3-4). As discussed by the applicant (AUC, 2012), the regional bedrock map depicts several key features: (1) the bedrock at the ground surface throughout this region of the Powder River Basin is the Wasatch Formation, specifically the Lower Wasatch

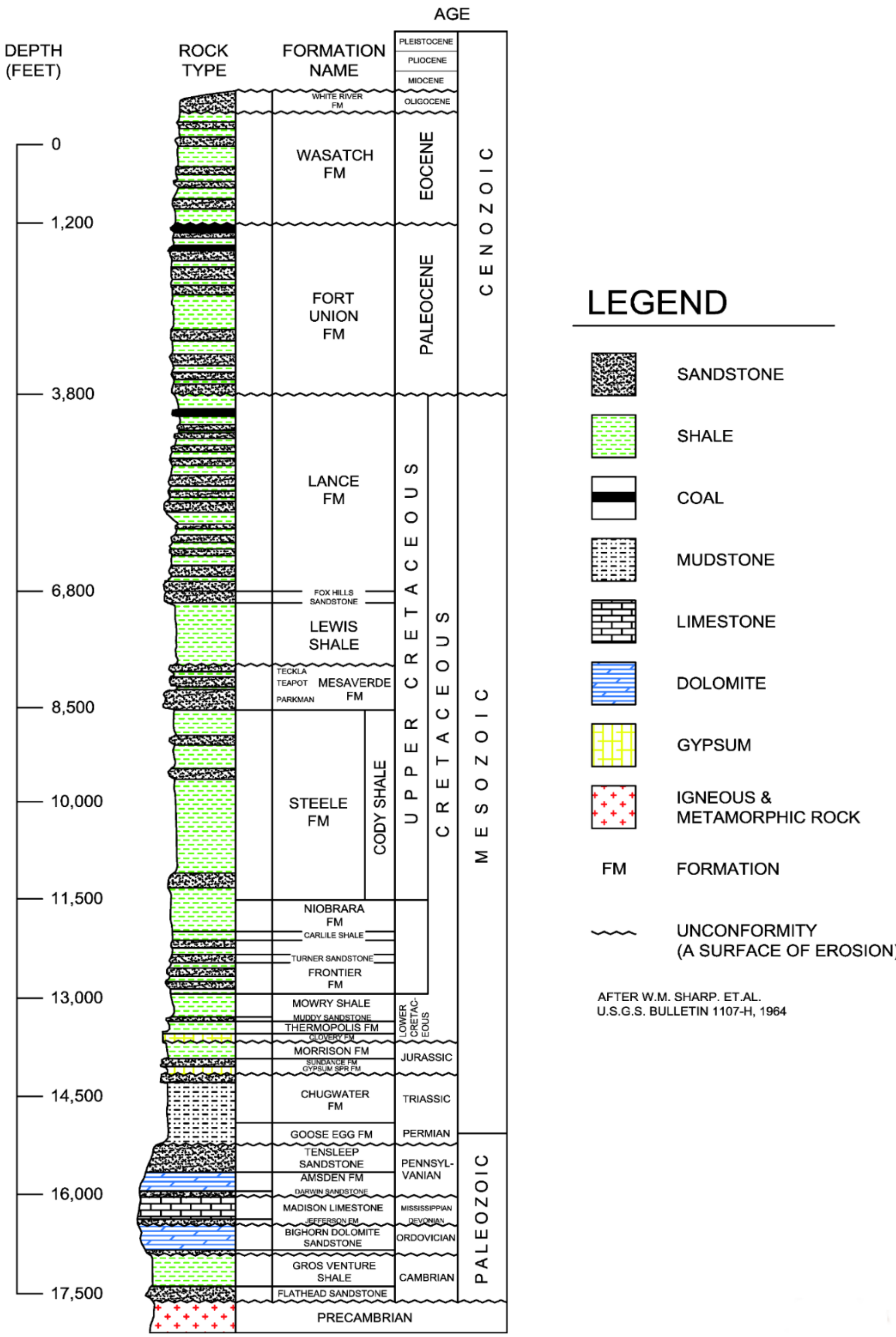

Figure 2.3-1 Regional Stratigraphic Column

SOURCE: AUC (2012) Addendum 2.6-A Figure 2.6A-3

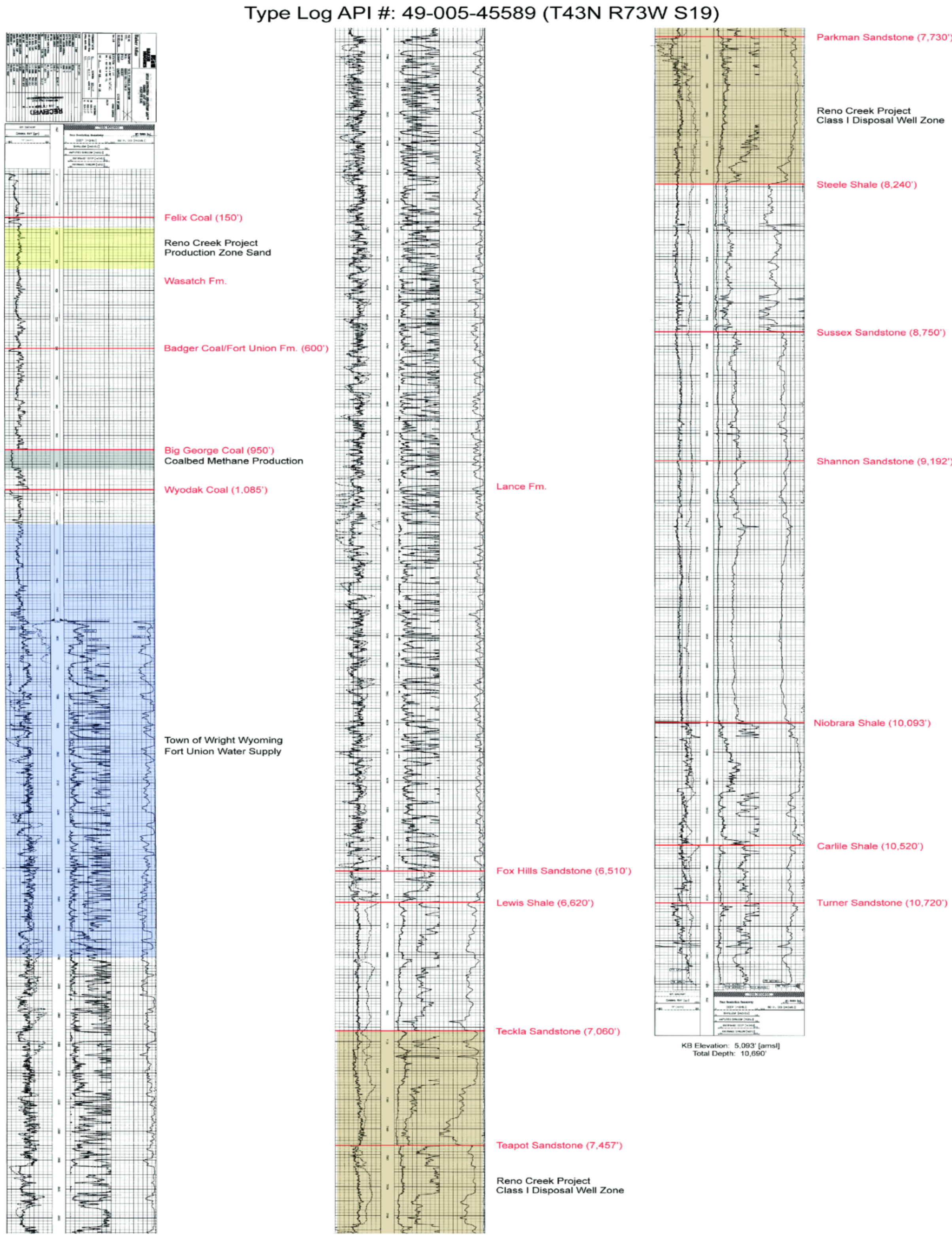

Figure 2.3-2 Regional Type-Geophysical Log

SOURCE: AUC (2012) Addendum 2.6-A Figure 2.6A-4

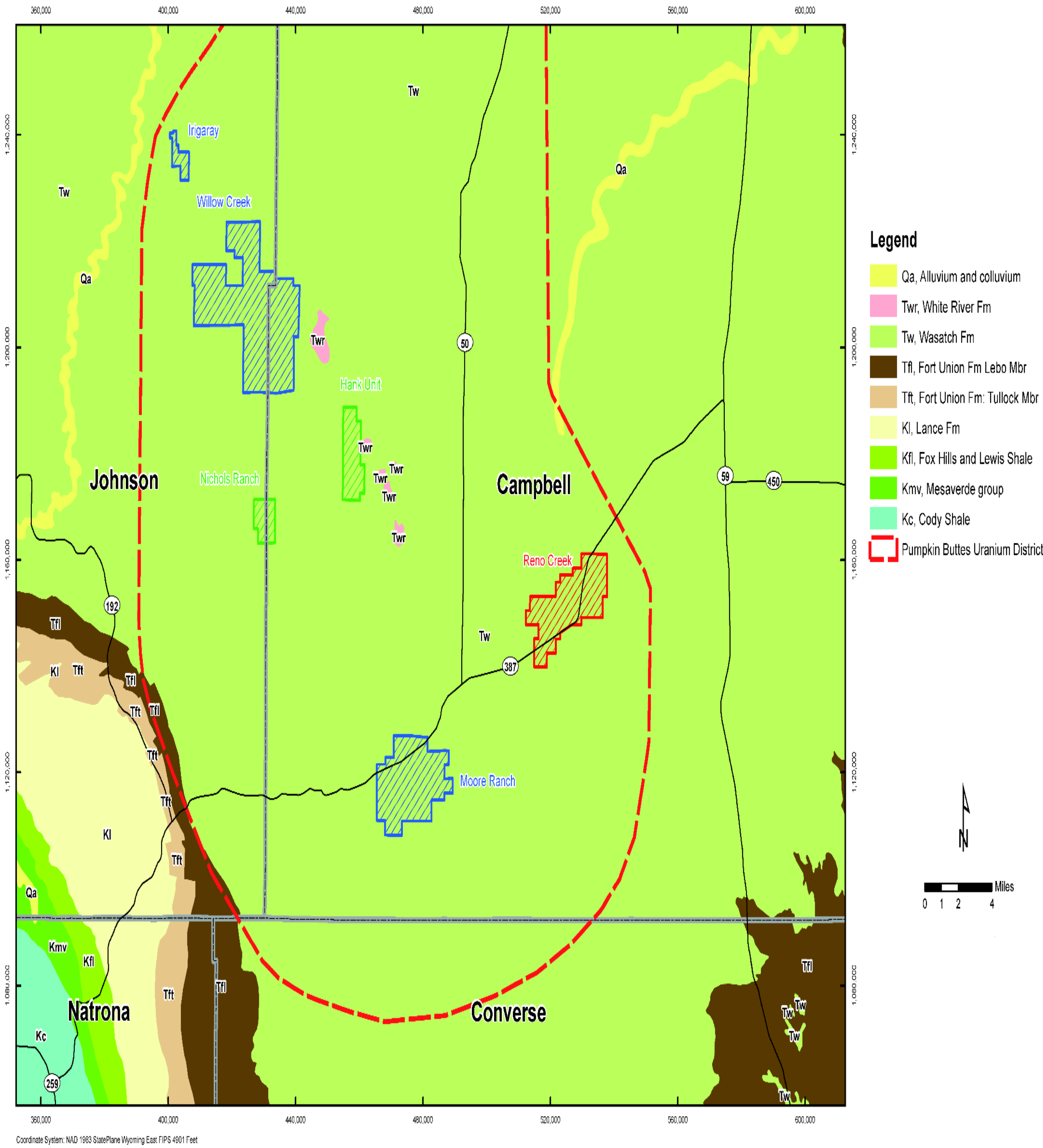

Figure 2.3-3 Geologic Map
SOURCE: AUC (2012) Addendum 2.6-A Figure 2.6A-1

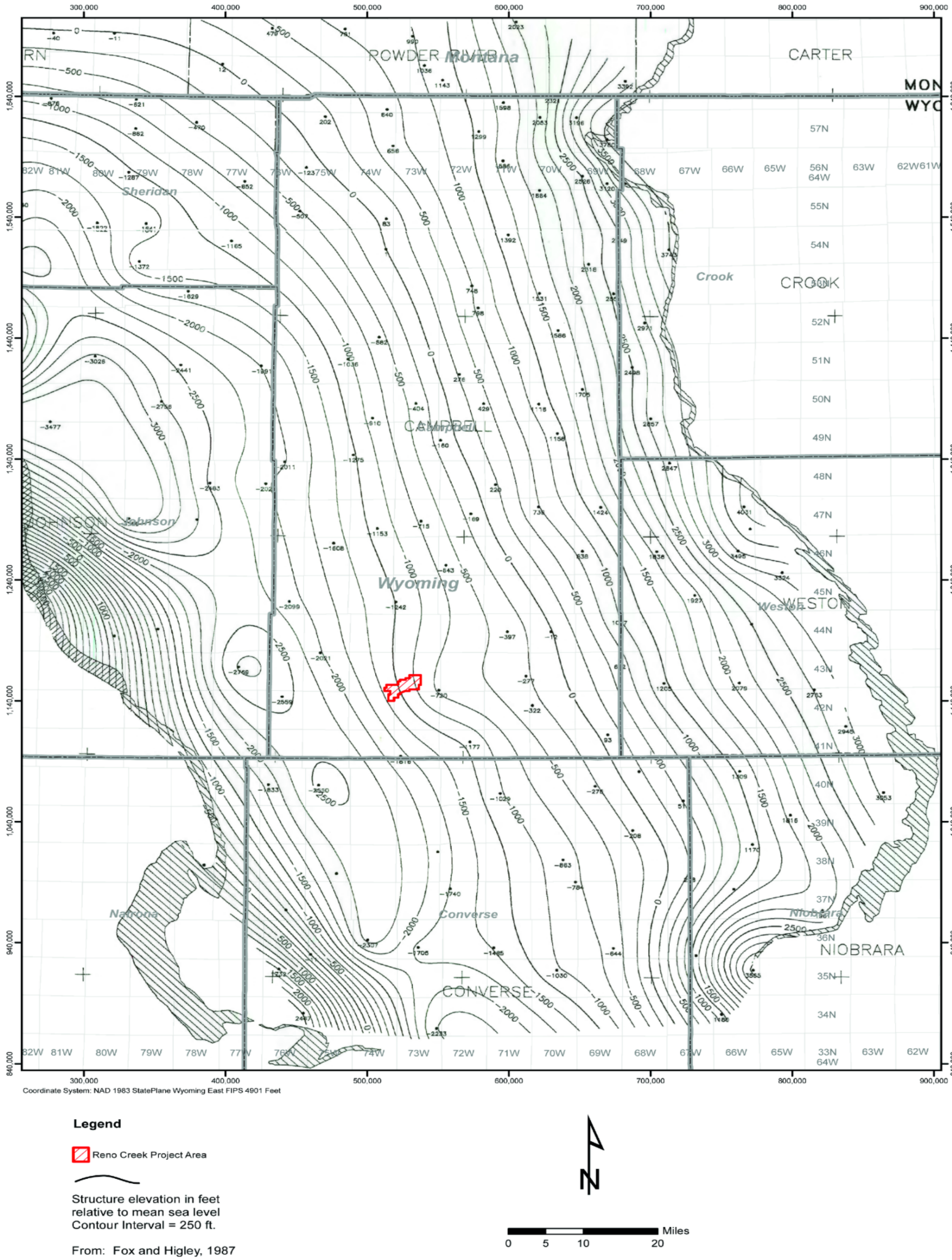

Figure 2.3-4 Top of the Fox Hills Sandstone Structural Contour Map

SOURCE: AUC (2012) Addendum 2.6-A Figure 2.6A-2

Formation, (2) the surface expression of older formation has been mapped along the margins of the Powder River Basin, (3) the mapped recent alluvium is limited in extent, (4) the relationship of the Proposed Project to other existing ISR licensed facilities, and (5) the relationship of the Proposed Project to the Pumpkin Buttes Uranium District. The structural contour map depicts: (1) the asymmetrical synclinal structure to the Powder River Basin, (2) location and orientation of the synclinal axis, (3) steep northeasterly dipping beds west of the axis, (4) less steep west-northwesterly dipping beds east of the axis, and (5) location of the Proposed Project east of the axis on the less-steep northwesterly digging beds.

In the development of the groundwater numeric model, the applicant included a figure that depicted the trace of the nearby outcrops of the Felix Coal seam (AUC, 2012). The outcrops are located approximately 2 to 4 miles south-southeast of the Proposed Project. The orientation, taking into account the topography, indicates a northwesterly dipping orientation to the Felix Coal seam, consistent with the orientation of the Fox Hills Formation.

The applicant reports that no faulting is evident at the Proposed Project site. The predominant geologically related energy and mineral products produced from the Powder River Basin consist of coal, CBM, oil and gas, bentonite, and uranium.

The staff reviewed the regional geologic information supplied by the applicant against existing independent documentation. The information supplied by the applicant correctly reflects that from independent sources.

2.3.3.3 Site-Specific Geology

The Proposed Project is located within the southern portion of the Powder River Basin east of the basin synclinal axis. The applicant reports that the bedding orientation has a slight northwestward dip of between 10.6 and 18.3 m (35 and 60 ft) per mile (AUC, 2012). Based on the contiguous nature of the Felix Coal seams within the subsurface without any significant offsets and without any other evidence of faulting, the applicant concludes that no faulting is evident at the Proposed Project area.

The geologic setting affected by the Proposed Project is the near-surface portion of the Wasatch Formation, at depths ranging from 52 to 137 m (170 to 450 ft) below grade (AUC, 2012). This portion of the Wasatch Formation is the lower Wasatch Formation; the upper Wasatch Formation has been eroded in the area of the Proposed Project as well as regionally throughout the Powder River Basin. The lower Wasatch Formation consists of fluvial-derived fine-grained interbedded arkosic sandstones, siltstones, and mudstones with minor coal beds. The applicant reports that the entire lower Wasatch Formation at the Proposed Project extends vertically from ground surface to a depth of approximately 152 to 213 m (500 to 700 ft) below grade.

Underlying the Wasatch Formation is the Fort Union Formation. The contact between the Fort Union and Wasatch Formations is the Badger Coal (SER Figure 2.3-2). The Badger Coal is equivalent to the Roland Coal mapped elsewhere in the Powder River Basin (AUC, 2012). The Fort Union Formation consists of clay-rich shales and sandstones with some extensive coal beds (AUC, 2012). The notable coal beds in the Fort Union Formation include the Big George Coal and the Wyodak Coal. The Big George Coal is the zone for CBM production in the Proposed Project and immediately surrounding area. The Big George Coal seam is approximately 305 to 335.3 m (1,000 to 1,100 ft) below grade, or approximately183 m (600 ft) below the base of the Proposed Project production zone (AUC, 2012). In addition to the coal beds, the Fort Union Formation is a source of groundwater for potable, livestock watering, agricultural, or industrial water supplies. The applicant reports that the Town of Wright has municipal water supply wells screened in the Fort Union Formation. The total thickness of the Fort Union Formation in the southwestern portion of the Powder River Basin is 884 m (2,900 ft) (AUC, 2012).

Older formations that exist below the Fort Union Formation at the Proposed Project area include the Lance Formation, Fox Hills Formation, Lewis Shale, Teckla Sandstone, Teapot Sandstone, Parkman Sandstone, Steele Shale, Sussex Sandstone, Shannon Sandstone, Niobrara Shale, Carlile Shale, and Turner Sandstone (see SER Figure 2.3-2). The Fox Hills and Lance Formations reflect a depositional environment that transitioned from marine to nonmarine (near-shore fluvial) environments at the end of the Cretaceous Period (AUC, 2012). The older (deeper) strata consist of a thick sequence of shales and sandstones, the shales reflecting submarine deposition during marine transgressions and the sandstones reflecting deposition during marine regressions.

The Teckla, Teapot, and Parkman sandstones have been referred to individually as formations or members of the Mesaverde Formation. These sandstones are the target receiver formations for the injection of byproduct material through AUC's Class I DDWs. In the area of the Proposed Project, the Mesaverde Formation and deeper sandstones host oil and gas deposits, as well.

2.3.3.4 Division of the Lower Wasatch Formation by the Applicant

The applicant divided the Lower Wasatch Formation directly affected by the ISR operations into a Shallow Monitoring (SM), Overlying Monitoring (OM), Overlying Aquitard (OA), Production Zone Aquifer (PZA), Underlying Aquitard (UA) and Underlying Monitoring (UM) units (AUC, 2012). The SM unit is a 3 to 6 m (10- to 20 ft)-thick sandstone at depths between 12.2 and 24.4 m (40 and 80 ft) below grade. The applicant reports that this unit is not contiguous throughout the Proposed Project area. This unit may be only partially saturated and, at some locations where wells were installed, is dry.

The OM unit is the first significant sandstone above the Felix Coal (AUC, 2012). The applicant considers the OM unit as the overlying aquifer for ISR monitoring proposes and the uppermost aquifer. The applicant also reports that the OM unit sandstones are discontinuous, found within the OA unit, and difficult to correlate over distances exceeding a few thousand feet. The OM unit is best developed within the central portion of the Proposed Project area at which it attains a thickness of approximately 27.4 m (90 ft). Based on the applicant's cross sections, the distance from the base of the OM unit to the top of the PZA unit is approximately 12.2, 27.4, 9.1, and 30.4 m (40, 90, 30, and 100 ft) at the locations of well clusters 1, 3, 4, and 5, respectively. These thicknesses are consistent with the applicant's isopach contour map for the OA, on which the thicknesses of the OA listed for all borings varied from 5.7 to 36.2 m (19 to 119 ft) (AUC, 2012).

The applicant defines the OA unit of laterally contiguous silt- and clay-rich mudstones, thin coal seams, and discontinuous sandstones from the top of the PZA unit to the base of the OM unit (AUC, 2012). The OA unit has thicknesses ranging from 5.7 to 36.2 m (19 to 119 ft). The Felix coal seam(s) form a laterally contiguous marker bed in the lower OA unit through the Proposed Project area. In the eastern portion of the Proposed Project area, the Felix coal consists of two seams, an upper and lower seam, separated by 1.5 m (5 ft) of mudstone. In the western portion of the Proposed Project area, the Upper Felix Coal seam either pinches out or “climbs in” the section (AUC, 2012). The thickness of each seam is 1.5 to 3 m (5 to 10 ft).

The PZA unit contains the uranium mineralization. The PZA unit consists of laterally contiguous, multiple stacked sandstones with intermittent mudstone lenses. The most dominant mudstone is a 1.5 to 9.1 m (5 to 30 ft) lense found in the central portion of the project area that separates the PZA unit into an upper and lower unit. Other less prominent mudstone lenses are found in the PZA unit in other areas of the Proposed Project. The total thickness of the PZA unit ranges between 22.8 and 67 m (75 and 220 ft).

The individual sandstone lenses within the PZA vary from 1.5 to 6 m (5 to 20 ft) thick and generally display a fining-up sequence (AUC, 2012). The uranium mineralization can occur within any of the individual sandstone lenses, but the most economically significant deposits generally occur in the lower half of the PZA unit.

The staff reviewed the applicant’s description of the site geology and finds it acceptable, because the applicant provides the information and characterization of site-specific data recommended by the SRP (NRC, 2003), and the applicant’s conceptual site model is consistent with the data.

2.3.3.5 Historic Drill Holes

The applicant reports that approximately 2,665 plugged wells exist within the Proposed Project area and approximately 215 additional drill holes exist within the 0.8 km (0.5 mi) buffer of the Proposed Project area boundary, installed by the former mineral lease owners/operators between the 1960s and the early 2000s (AUC, 2012). The applicant has installed 807 drill holes, 45 of which were cased and developed as wells and currently exist; the remaining 762 drill holes were plugged and abandoned in accordance with the State of Wyoming regulations. All future exploration and delineation drill holes will be capped, sealed, or plugged in accordance with the State of Wyoming regulations.

In response to the NRC’s administrative acceptance review, the applicant provided the 1982 Hydrogeologic Integrity Evaluation of the Proposed Project area prepared by a former operator, Rocky Mountain Energy (AUC, 2013a). In the application (AUC, 2012), the applicant summarizes the conclusions of that report: for the 33 abandoned drill holes that were reentered, pressure tests conducted at obstructions that were encountered demonstrated that the obstructions withheld a surface-gaged pressure of up to 120 to 150 pounds per square inch (psi). One obstruction, at the depths of the mudstones in the OA, consistently held the highest pressures. The applicant attributed these obstructions to the self-sealing nature of swelling clays found in the mudstones (AUC, 2012).

After the license is issued, the applicant proposes to (1) open drill holes to their total depth and perform geophysical logging on abandoned drill holes that may yield information beneficial to AUC, (2) plug old drill holes near future production units, if the hydrogeologic testing indicates that leakage through the old drill holes “might” be a problem, (3) not plug drill holes, because the 1982 Hydrogeologic Integrity Evaluation Report documents a “strong” indication that re-plugging of old drill holes “may not” be necessary, and (4) plug any old “open” hole that may be encountered while working anywhere in the Proposed Project area (AUC, 2012). In the open issues discussion with the applicant, the staff expressed reservations about that commitment fulfilling a reasonable assurance determination that the historic drill holes will not act as a conduit in the future because of the caveats/conditions and the conditional phrasing that the applicant used. During the open issue discussions, the staff stated that many drill holes abandoned in Wyoming in the past may be self-sealing; however, it is the staff's position that drill holes should be abandoned to today's standard to minimize the potential for fluid migration. The applicant agreed to a license condition that requires abandonment of all historic drill holes within a wellfield before testing for a wellfield hydrogeologic data package. The license condition is presented in SER Section 2.3.4.

Based on that license condition and the description of the existing drill holes, the staff has reasonable assurance that potential hazards associated with the unwanted migration of fluids through an improperly abandoned drill hole will be minimized.

2.3.3.6 Soils

The applicant described and mapped the soils within the Proposed Project area based on a soil survey conducted in 2010 and 2011 (AUC, 2012), and a previous large-scale soil survey conducted by the U.S. Department of Agriculture, Natural Resource Conservation Service, in 1972 and 1991. A map of soils was provided for the area in ER Addendum 3.3-A (AUC, 2012). The soils in the Proposed Project area are reportedly 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. The applicant reports no unsuitable material for a plant-growth medium at the 31 sampling locations studied; however, the material at seven sampling locations was marginal. No prime farmland was identified in the Natural Resources Conservation Service (NRCS) letter (Addendum 3.3-G to the Environmental Report; AUC, 2012).[3] The soils within the Proposed Project area exhibited a slight to severe wind and water erosion hazard; the soils are more susceptible to erosion from wind than water (AUC, 2012).

Based on the discussion provided above, the staff finds that the application adequately described the soils within the Proposed Project area by including detailed mapping, properly identifying and labeling various soil classifications consistent with established standards, physical sampling at a sufficient number of site-representative locations, and providing documentation from a recognized agency on potential use for the site soils. The properties of the soils in the area of the proposed backup pond are discussed in SER Section 4.2.3

2.3.3.7 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 (AUC, 2012). 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 in which the Proposed Project area is located; therefore, no fault-specific analysis was possible. The applicant did provide a floating or random earthquake analysis, and published data which indicated the largest floating earthquake for the province where Campbell County is located would have an average magnitude of 6.25. If this earthquake were placed within15 km (9.32 mi) of any structure in Campbell County, it would be estimated to create an acceleration of 15 percent of gravity (0.15 g), which is a Level VI earthquake, and would be expected to create light to moderate damage (AUC, 2012).

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[3] The NRCS uses historical irrigation activities as evidence that the soils are amenable to farming (i.e., prime farmland).

The applicant reports that recent USGS probabilistic acceleration maps for Wyoming were published in 2000 (AUC, 2012). These maps, which were replicated in the application, display the 500-year, 1,000-year, and 2,500-year probabilistic accelerations for Wyoming. The applicant estimates that the peak horizontal acceleration for Campbell County ranges from 8 to 20 percent of gravity, based on the 2,500-year probability. That acceleration includes earthquakes classified up to a Level VII. Because the existing building codes are based on the 2,500-year probability, the applicant concludes the damage to buildings constructed in compliance with those codes and their contents will be negligible to moderate.

The staff reviewed the applicant's information and finds it acceptable, because it is consistent with the published data. The staff was not able to access the specific reference of the applicant (i.e., "Case, James C. and J. Annette Green, 2000, Earthquakes in Wyoming, Wyoming State Geological Survey Information. Website: http://waterplan.state.wy.us/BAG/-snake/briefbook/eq_brochure.pdf. Accessed October 2010") but verified that the information is consistent with a more up-to-date published mapping (Peterson et al, 2014).

2.3.4 Evaluation Findings

The staff finds that the Proposed Project application provided site characterization of the geography, geology, soils, and seismology at the Proposed Project in accordance with review procedures in SRP Section 2.6.2 and acceptance criteria in SRP Section 2.6.3 (NRC, 2003). The information provided in this section meets the regulatory requirements listed in SER Section 2.3.1, because the applicant has adequately described the geology and seismology by providing (a) a description of the local and regional stratigraphy, (b) 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, (c) a geologic and geochemical description of the mineralized zone and the geologic units adjacent to the mineralized zone, (d) a description of the local and regional geologic structure, (e) a discussion of the seismicity and seismic history of the region, (f) a generalized stratigraphic column that includes the thickness of rock units, a representation of rock units, and a definition of mineralized horizon, and (g) a description and map of the soils.

The applicant has provided documentation on all known historic exploratory drill holes. The applicant states that based on historic testing performed by others, it is likely that the historic exploratory drill holes will be self-sealing and that re-abandonment would be on a selective basis. Such a selective process was insufficient for staff (AUC, 2015c). Consequently, the staff will require that the historic drill holes be shown to have been or will be abandoned in the vicinity of a wellfield before the conduct of principal activities at that wellfield. The applicant has committed to abandoning all historic drill holes that could be a pathway for lixiviant migration to the overlying aquifer. The staff will memorialize that commitment in License Condition 10.11.

2.4 Hydrology

2.4.1 Regulatory Requirements

General requirements for contents of an application for a specific license issued under 10 CFR Part 40 are listed in 10 CFR 40.31. Section 10 CFR 40.31(h) specifies that an application must clearly demonstrate how requirements and objectives set forth in 10 CFR Part 40, Appendix A, are addressed. Technical Criteria 1, 5B, 5F, 5G, and 7 of 10 CFR Part 40, Appendix A, set forth requirements and objectives for a suitable hydrologic setting for a uranium recovery facility.[4] Furthermore, 10 CFR 40.41(c) requires that a 10 CFR Part 40 licensee have the ability to confine the licensee's possession and use of source and byproduct material to locations and purposes authorized by the license. At an ISR facility, meeting this requirement includes determining that the hydrologic setting is appropriate to confine the regulated material to the designated areas in the subsurface.

Based on guidance in RG 3.46 (NRC, 1982) and SRP Section 2.7 (NRC, 2003), an application should provide a sufficient description of the hydrologic setting and a demonstration of the licensee's thorough understanding of that setting.

The staff is required to determine that the application has provided sufficient data on the hydrologic setting and a clear demonstration of the applicant's thorough understanding of the setting to meet the above regulatory requirements.

2.4.2 Regulatory Acceptance Criteria

The staff reviews the application for compliance with the applicable requirements of 10 CFR 40.31(h), 10 CFR 40.41(c), and 10 CFR Part 40, Appendix A, Criteria 1, 5B, 5F, 5G, and 7, using review procedures in Section 2.7.2, acceptance criteria in SRP Section 2.7.3 (NRC, 2003), and guidance in RG 3.46 (NRC, 1982).

Information in the application, as reviewed and verified by the staff, will be deemed acceptable, provided the staff determines, with reasonable assurance, that a license issued based on the application meets the above regulatory requirements, and, pursuant to 10 CFR 40.32, can conclude that (1) the Proposed Project is for a purpose authorized by the AEA, (2) 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, (3) the proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property, and (4) issuance of a license will not be inimical to the common defense and security or to the health and safety of the public.

2.4.3 Staff Review and Analysis

Unless otherwise stated, information reported in this SER Section is from TR Section 2 (AUC, 2012).

The following sections present the staff's review and analysis of various aspects of the surface water and groundwater hydrology at, and in the vicinity of, the Proposed Project.

2.4.3.1 Regional Surface Water

The Proposed Project area is located in the Belle Fourche River and Cheyenne River drainage basins, both of which are tributaries to the Missouri River (AUC, 2012). Approximately 90 percent of the Proposed Project area is within the Belle Fourche River basin, whereas only

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[4] Criteria in Appendix A are written for a conventional mill setting. The conventional mill setting differs from an ISR setting in that (1) at a conventional mill, all activities conducted under the license are performed above ground whereas, at ISR settings, the uranium extraction from the ore is performed in situ (or in the subsurface), and (2) at a conventional mill, a solid byproduct material, the mill tailings, is stored above ground in a tailings pile whereas, at ISR settings, no mill tailings are generated. The staff is applying these criteria to ISR facilities, because 10 CFR 40.31(h) specifies that the applicant meet not only the requirements but the objectives of the technical criteria in Appendix A.

the eastern portion of the area is located within the Cheyenne River Basin (SER Figure 2.4-1). The Belle Fourche River joins the Cheyenne River in South Dakota (AUC, 2012).

The applicant reports historical data from five national gaging stations located downstream of the Proposed Project area (AUC, 2012). The headwaters to the Bell Fourche and Cheyenne Rivers are located in close proximity to the Proposed Project area where no upstream national gaging station exists. Based on the available historical data (1978 to 1983) for the gaging station that was located on the Belle Fourche River, approximately 43.4 km (27 mi) from the Proposed Project area, the average daily flow was 0.12 cubic meter per second (cms) (4.33 cubic ft per second [cfs]), with an annual maximum peak flow of 159 cms (5,630 cfs) (AUC, 2012).

The applicant provides a table of all surface water rights within 3.2 km (2 mi) of the Proposed Project area, based on a query to the State of Wyoming State Engineer's Office (AUC, 2012). Based on the applicant's table, the staff determined that 111 permits for surface water rights are found within 3.2 km (2 mi) of the Proposed Project. The permits include those with a status of cancelled, expired, rejected, incomplete, complete, unadjudicated, adjudicated, and no status. The listed uses are largely for livestock watering; however, the listed uses for several, primarily older, permits include domestic water supply and irrigation. The applicant reports that the current uses are largely "devoted" to livestock watering for cattle, which are rotated among the various pastures (AUC, 2012).

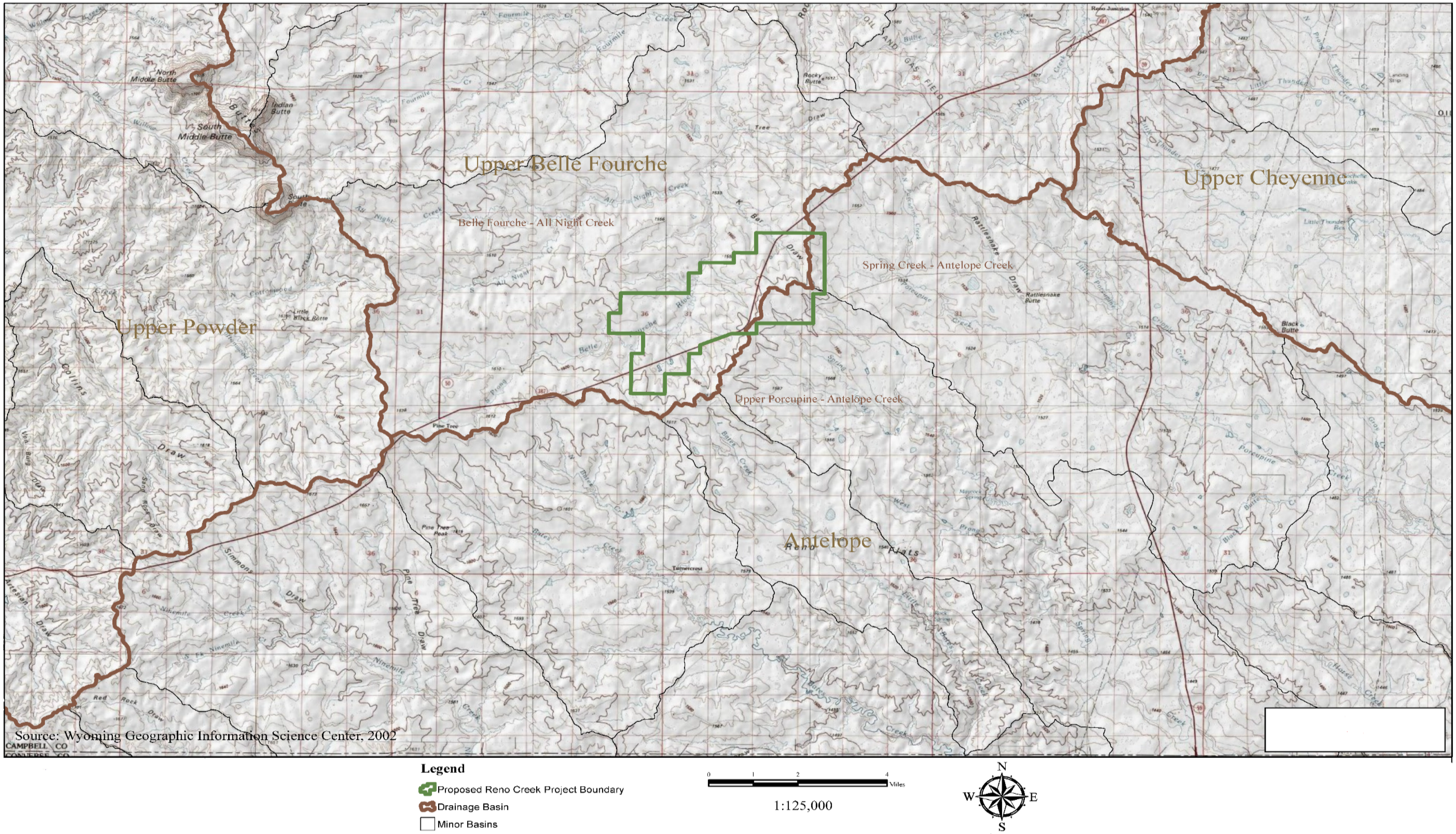
The applicant reports that surface discharge from CBM operations contribute to small pools of water during the dry summer months (AUC, 2012). Sixty-three State-issued Wyoming Pollutant Discharge Elimination System (WYPDES) permits are located within 3.2 km (2 mi) of the Proposed Project area. The permits are associated with oil and gas or CBM production (AUC, 2012).

2.4.3.2 Site Surface Water

The applicant reports that all stream channels within the Proposed Project area are ephemeral, with the predominant source of surface water being summer thunderstorms and spring snowmelt (AUC, 2012). The Proposed Project area consists of at least portions of 29 individual watershed basins (SER Figure 2.4-2).

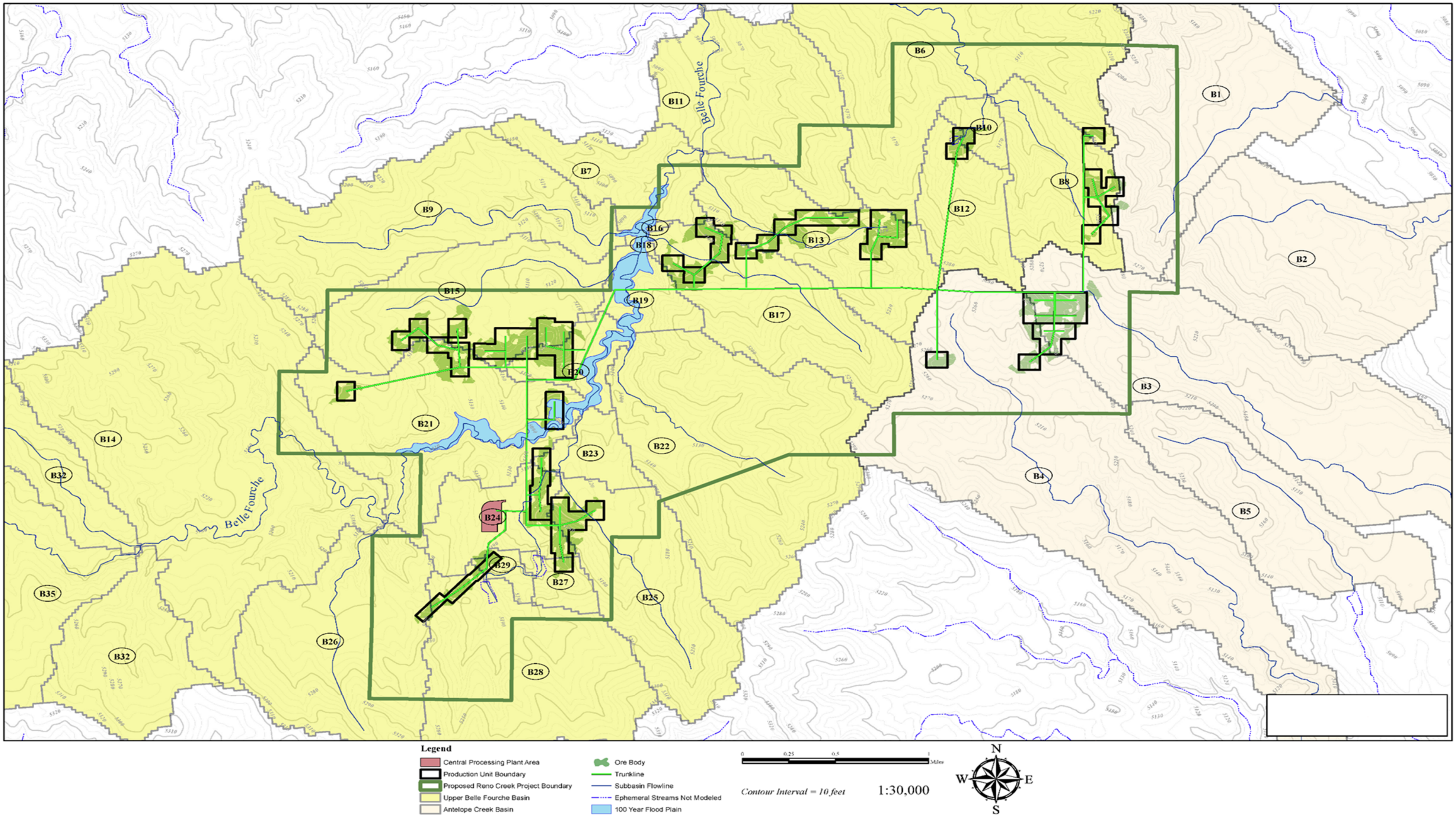
The applicant estimates the peak runoff using the computer modeling program HEC-HMS, which was developed by the U.S. Army Corps of Engineers (ACE, 2013). The inputs to the HEC-HMS model consisted of published recurring precipitation events for the area and site-specific characteristics of the watersheds (AUC, 2012). For the 100-year, 24-hour storm precipitation event of 10.7 cm (4.2 in), the applicant estimates a peak discharge between 77 and 77.8 cms (2,720 and 2,749 cfs) in the Belle Fourche River at its most downstream location along the boundary of the Proposed Project area, and a peak discharge of 23.6 cms (835 cfs) in the stream nearest the location of the CPP.

The applicant estimated the hydraulic depths in Belle Fourche stream channels using the computer program HEC-RAS, which was developed by the U.S. Army Corps of Engineers (ACE, 2010). Inputs to the HEC-RAS model included the peak flows determined by the HEC-HMS model for the 24-hour, 100-year storm event and 49 site-specific cross-sectional areas of the stream channel developed by the applicant (AUC, 2012). The extent of the 100-year flood event in the Bell Fourche River on the Proposed Project area is shown in SER Figure 2.4-2.



SOURCE: AUC (2012) Addendum 2.7-A Figure 2.7A-1

Figure 2.4-1 Surface Water Drainage Map



SOURCE: AUC (2012) Addendum 2.7-A Figure 2.7A-4

Figure 2.4-2 Predicted 100-Year Flood Inundation Map

The applicant did not perform a flood analysis on the remaining watersheds, because the applicant concluded that the runoff conditions for these small drainage areas do not warrant a flood analysis (AUC, 2012).

For the analyses of surface water quality, the applicant reported data from 21 onsite sampling locations (AUC, 2012). Of the total, 16 sampling locations were dry at least 6 months during the sampling efforts, with two locations being dry throughout the effort. The samples were analyzed for parameters that included all of the recommended parameters for site characterization in the SRP (NRC, 2003), radionuclides as recommended in RG 4.14 (NRC, 1980), field stabilization parameters recommended for low-flow sampling (ASTM, 1992), and several additional parameters (e.g., silica and ammonia).

The results varied from a dilute composition, as expected, for rainwater to water with a high total dissolved solids (TDS) dominated by elevated sodium bicarbonate (AUC, 2012). The applicant compared the high TDS waters to the quality of CBM effluents, providing the results in tabular form for each sampling location and a piper diagram evaluating the major ions in surface water and CBM effluents.

Nine CBM discharges are permitted within the Proposed Project area (AUC, 2012). The applicant provided a figure depicting the location of the discharges with surface-water sampling locations.

2.4.3.3 Regional Hydrogeology

The applicant reports that the Proposed Project lies within a region referred to as the Northern Great Plains Aquifer System (AUC, 2012). The Northern Great Plains Aquifer System is a geographical area that encompasses Montana, Wyoming, North Dakota, and South Dakota (Busby et al., 1995), and consists of a series of regional aquifers including, from oldest to youngest, a Cambrian-Ordovician Aquifer, the Madison Aquifer, a Pennsylvanian Aquifer, a Lower Cretaceous Aquifer, and an Upper Cretaceous-Tertiary aquifer. On a regional scale, those aquifers are discussed as individual aquifers, as each is separated by a significant thickness of a low permeable horizon. However, within the Northern Great Plains area, portions of the regional aquifers may have been isolated from themselves due to the various intermontane basins (e.g., Powder River Basin) that developed during subsequent or contemporaneous tectonic activities (e.g., Laramide Orogeny). Furthermore, because of the variation in stratigraphic thickness or depths to a specific formation (aquifer) within a basin, the chemical quality of each individual regional aquifer may vary significantly, even within a basin (AUC, 2012).

The applicant identifies the regional aquifer system in the Powder River Basin as aquifers in the Lower and Upper Paleozoic, Lower and Upper Cretaceous, and Lower Tertiary strata (AUC, 2012). For the setting of the Proposed Project, the applicant focuses on the Upper Cretaceous aquifer, which includes the Fox Hills and Lance Formations, and the Lower Tertiary aquifer, which includes the Fort Union and Wasatch Formations. The applicant reports that aquifers existing below the Upper Cretaceous aquifer, specifically below the Fox Hills Formation (1) lie below the regional confining unit of the Lewis Shale, (2) are generally too deep to be developed for water supplies for economic reasons, and (3) generally contain elevated dissolved solids that prohibit development as a potable water supply (AUC, 2012). The applicant reports that the Lewis Shale (also known as the Pierre Shale in other localities) is approximately 274 m (900-ft) thick. The applicant reports that, regionally, the Lewis Shale does not yield usable volumes of groundwater, although several sandy zones within the Lewis Shale may yield as much as 37.8 liters per minute (Lpm) (10 gallons per minute [gpm]) (AUC, 2012).

The applicant states that the Lower Tertiary aquifer of the Fort Union and Wasatch Formations consists of semiconsolidated to consolidated sandstone beds interbedded with shales, mudstones, siltstones, lignite, and coal (AUC, 2012). The transmissivity of the Lower Tertiary aquifer is variable and directly related to the thickness and continuity of sandstone units within the formations. Some of the thicker coal seams may also yield groundwater, particularly if the coal is fractured or has been burned, forming permeable clinker zones. The regional groundwater flow in the Lower Tertiary aquifer is generally north-northeastward in direction from the recharge areas along the southern Powder River Basin margins (AUC, 2012).

According to the applicant (AUC, 2012), many individual domestic or livestock water supply wells are completed in the Fort Union at shallow depths (less than 152.4 m [500 ft]). Those wells target individual sand lenses that are capable of yielding suitable water quality and water quantities of 75.7 Lpm (20 gpm). For wells screened deeper in the Fort Union Formation, the applicant reports that well yields of up to 567.8 Lpm (150 gpm) are possible with specific capacities typically ranging from 1.1 to 3.4 Lpm/ft (0.3 to 0.9 gpm/ft). The water quality is characterized as sodium bicarbonate to sodium sulfate type with TDS concentrations commonly ranging from 500 to 1,500 mg/L (AUC, 2012). The Fort Union Aquifer is used as a municipal water supply for the City of Wright and as a supplemental supply for the City of Gillette (AUC, 2012).

Wells screened in both the Wasatch and Fort Union Formations may have yields up to 946 Lpm (250 gpm) (AUC, 2012). For the Wasatch Formation alone, the applicant reports that well yields of 37.8 to 189 Lpm (10 to 50 gpm) are reported in the northern areas of the Powder River Basin and that yields of up to 1,893 Lpm (500 gpm) are reported in the southern areas. The specific capacity of wells screened in the Wasatch in the southern areas ranges from 15 to 53 Lpm/ft (4 to 14 gpm/ft). The water quality is characterized as sodium bicarbonate to sodium sulfate type with TDS concentrations commonly ranging from 500 to 1,500 mg/L (AUC, 2012).

The Upper Cretaceous aquifer is found in the Fox Hills and Lance Formations, which consist of consolidated sandstone interbedded with shales, siltstones, and occasional coal seams that generally increase in number in the stratigraphically higher sections (AUC, 2012). The Fox Hills Formation is generally massively bedded sandstone, and yields for wells completed solely in the Fox Hills Formation may be as much as 757 Lpm (200 gpm), although relatively thin compared to sandstones found in the Lance Formation. The Lance Formation consists of shales and siltstones with lenticular sandstones and thin coal seams. Yields for wells screened only in the Lance Formation are generally low (less than 75.7 Lpm [20 gpm]) but may be sufficient for individual domestic or livestock water supply wells (AUC, 2012).

In general, the Fox Hills and Lance Formations are considered to be regionally connected and thus to be a single aquifer (AUC, 2012). For wells screened in the combined Lance/Fox Hills aquifer, the applicant reports yields of up to 1,438 Lpm (380 gpm), transmissivities of 13 to 270 ft^2/day, and a specific capacity of 0.1 to 2.0 gpm/ft. Groundwater flow in the Upper Cretaceous aquifer is similar in direction to that for the Lower Tertiary aquifer.

Regional groundwater recharge to the Upper Cretaceous and Lower Tertiary aquifers is primarily through infiltration in the outcrop areas of the respective formations. Direct infiltration of surface water to the formations at depth is less important, due to the existence of relatively impermeable intervening mudstone lenses (AUC, 2012). Data from other ISR facilities in

Wyoming indicate vertical hydraulic conductivities of mudstones of approximately 10^{-8} cm/s [$3x10^{-4}$ ft/day] (AUC, 2012).

Regional groundwater discharge may be occurring to local larger stream channels, primarily the shallowest (Wasatch and Fort Union) aquifers. Regional groundwater flow in all aquifers within the Powder River Basin is northward, is stratigraphically controlled, and is ultimately discharging to streams in Montana, where the subsurface stratigraphy outcrops.

The applicant provides regional potentiometric surface contour maps for the Upper Cretaceous and Lower Tertiary aquifers in the Powder River Basin (AUC, 2012). The contours for the Upper Cretaceous Fox Hills-Lance system depict northerly flow, with an approximate potentiometric head of 1,402 m (4,600 ft) above MSL at the location of the Proposed Project area. The contours for the Lower Tertiary Tullock Aquifer System (Lower Fort Union) depict northeasterly flow with an approximate potentiometric head of 1,341 m (4,400 ft) above MSL at the location of the Proposed Project area. The contours for the Lower Tertiary Tullock Aquifer System (Lower Fort Union) depict northeasterly flow with an approximate potentiometric head of 1,372 m (4,500 ft) above MSL at the location of the Proposed Project area. The contours for the Lower Tertiary Lebo Shale (Middle Fort Union) depict northerly flow with an approximate potentiometric head of 1,433 m (4,700 ft) above MSL at the location of the Proposed Project area. The contours for the Lower Tertiary Tongue River Aquifer System (Upper Fort Union) depict northerly to northeasterly flow with an approximate potentiometric head of 1,524 m (5,000 ft) above MSL at the location of the Proposed Project area. In general, the potentiometric head decreases with depth (AUC, 2012).

2.4.3.4 Site Hydrogeology

The applicant documents and describes the site-specific hydrogeology based on its geologic conceptual model of the subsurface strata (See SER Section 2.3), water levels measured at various onsite monitoring wells, pumping test data and analyses, geotechnical data from core samples collected from selected borings, a review of historical pumping test data, and a review of historical integrity testing data (AUC, 2012).

As discussed in more detailed in SER Section 2.3, the applicant divides the subsurface site stratigraphy of the Wasatch Formation significant to the in situ operations into the SM, OM, PZA, and UM hydrostatigraphic units (AUC, 2012). Each unit may be capable of transmitting usable quantities of groundwater and, as such, the applicant installed clusters of four individual wells screened in one of the four subsurface units at seven locations within the Proposed Project area. In addition to the well clusters, the applicant installed two monitoring wells in the Felix Coal (within the overlying aquitard) and 14 wells in the production aquifer (PZA unit). The 14 additional wells include 1 monitoring well in the deeper portion of the production aquifer at a location at which the aquifer is bifurcated by a mudstone Production Zone Monitoring (PZM) 4 (PZM4 well cluster), and 13 monitoring wells in the production aquifer near or adjacent to four of the seven well clusters. The well completion details for the onsite monitoring wells are summarized in SER Table 2.4-1 (see page 2-37). The locations of the monitoring wells are shown in SER Figure 2.4-3.

In TR Addendum 2.7-D, the applicant presents results of four multiwell and 10 single-well, constant-rate pumping tests performed to verify the site conceptual model and estimate the hydraulic properties for the various hydrostratigraphic units (AUC, 2012). The multiwell pumping tests consist of wells pumping from the PZA aquifer, whereas the single-well pumping test consists of pumping from two shallow wells (SM3 and SM5) and at wells in the overlying

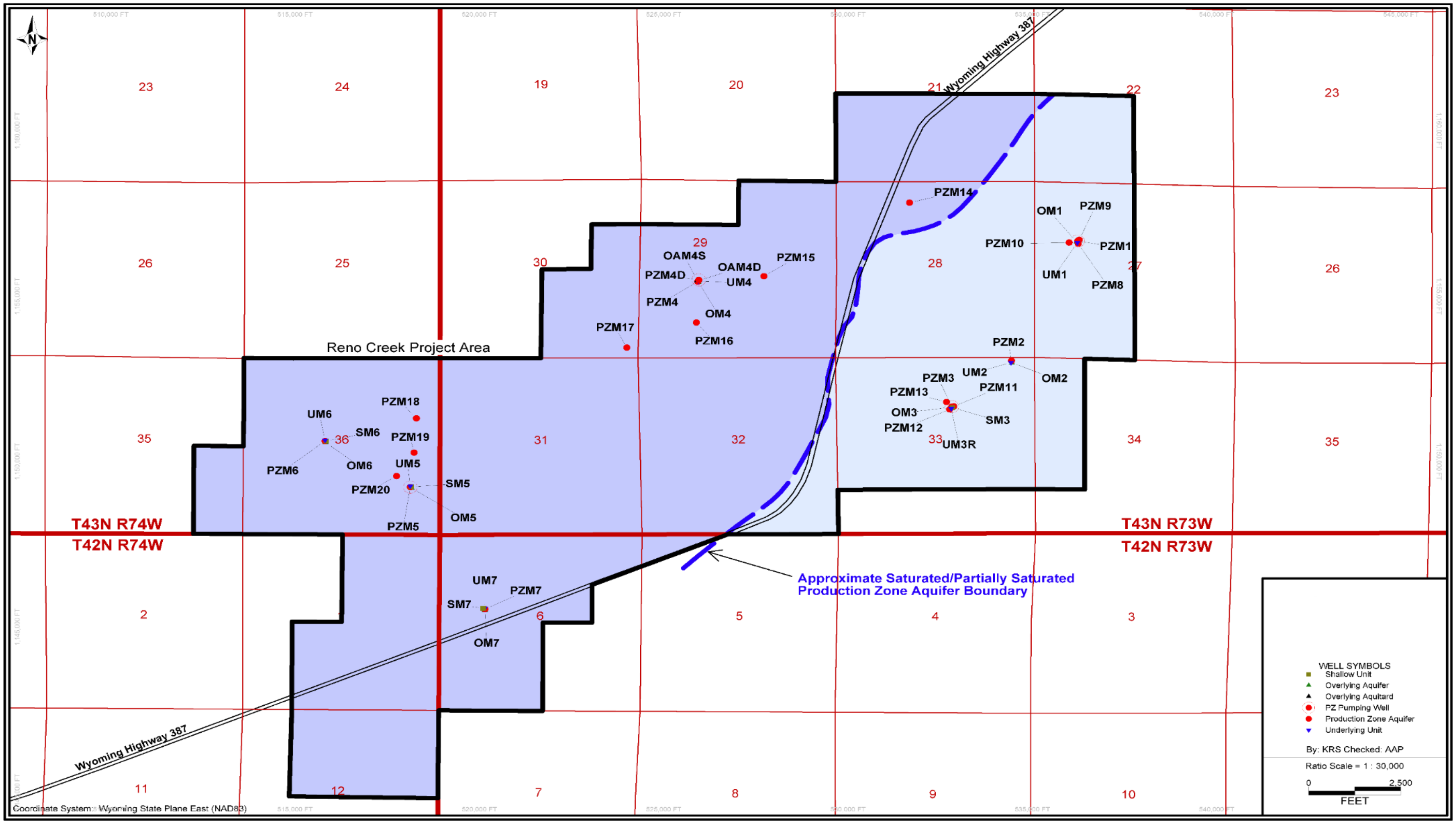


Figure 2.4-3 Well Location Map

SOURCE: AUC (2012) Addendum 2.7-B Figure 2.7B-6

and underlying aquifers at four well-cluster locations (PZM1, PZM3, PZM4, and PZM5). The multiwell pumping tests include a background phase, pumping phase, and recovery phase at four well clusters (PZM1, PZM3, PZM4 and PZM5), two of which were locations at which the PZA unit was only partially saturated. The single-well pumping tests generally did not include a background phase. The water levels were measured at 5-minute intervals electronically by dataloggers installed in the pumping and monitoring wells.

For the multiwell pumping tests in the PZA unit, the pumping rates ranged from 33.6 to 53.4 Lpm (8.9 to 14.1 gpm), the pumping period ranged from 1.8 to 7.9 days, and the maximum drawdowns at the pumping well at the end of the pumping phase ranged from 9.7 to 36.3 m (32 to 119 ft) (AUC, 2012). For the pumping tests conducted at the partially saturated portions of the PZA unit, the pumping rates, duration, and maximum drawdowns for the multiwell pumping tests were generally less than 37.8 Lpm (10 gpm), 3 days, and 14.3 m (47 ft), respectively. No drawdown attributed to the pumping was observed in wells screened in the overlying or underlying aquifers during the multiwell pumping tests; however, slight increases in head were observed in the overlying aquifer (including the Felix Coal), which the applicant attributed to the “Noordbergum effect”[5] at pumping tests in which the PZA unit is fully saturated (i.e., PZM4 and PZM5 well clusters), in the underlying aquifer at well cluster location PZM4, and in the shallow aquifer at well cluster location PZM5 (AUC, 2012).

For the single-well pumping tests in the SM unit, the pumping rates ranged from 2.3 to 6.4 Lpm (0.6 to 1.7 gpm), the pumping period ranged from 9 to 19 minutes, and the maximum drawdowns at the pumping well at the end of the pumping phase ranged from 2.5 to approximately 3 m (8.4 to approximately 10 ft) (AUC, 2012). The wells were generally pumped dry (to the level of the pump intake). A significant portion of the water pumped from the well was from wellbore storage at the SM wells (AUC, 2012).

For the single-well pumping tests in the OM unit, the pumping rates ranged from 9.8 to 13.6 Lmp (2.6 to 3.6 gpm), the pumping period ranged from 28 to 189 minutes, and the maximum drawdowns at the pumping well at the end of the pumping phase ranged from 1.8 to 7.2 m (6 to 23.7 ft) (AUC, 2012).[6]

For the single-well pumping tests in the UM unit, the pumping rates ranged from 7.2 to 23.1 Lpm (1.9 to 6.1 gpm), the pumping period ranged from 12 to 27 minutes, and the maximum drawdowns at the pumping well at the end of the pumping phase ranged from 29.8 to 57.3 m (98 to 188 ft) (AUC, 2012). A significant portion of the water pumped from the well was from wellbore storage at the UM wells (AUC, 2012).

Methods used to analyze the pumping test data include corrections to water levels due to effects of changes in barometric pressure and Theis drawdown and recovery model curve matching, including drawdown/recovery corrections for unconfined aquifers[7] (Jacob, 1947;

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5 The Noordbergum Effect is a rise in water levels at observation wells monitored in the upper or lower zones relative to the pumping zone. The rise is attributed to compression and poroelastic response of the surround aquitard due to deformation rather than hydraulic response. The result is a rise in water pressure due to an increase in pore pressure.

6 The applicant reported a maximum drawdown of 30.6 m (100.5 ft) for the single-well pumping test at well UM4. However, based on TR Addendum 2.7-D, Figure 11.9, the 30.6 m (100.5 ft) is the depth to water at the end of the test. Because the depth to water at the start of the test was approximately 28.8 m (94.5 ft), the maximum drawdown should have been1.8 m (6 ft) rather than 30.6 m (100.5 ft). The applicant’s analysis of the data is consistent with a drawdown of less than 1.8 m (6 ft).

7 Theis curve matching is a method to determine hydraulic properties of the aquifer based on a comparison of the responses of water levels in a well during a pumping test to a family of curves.

Kruseman and Ridder, 1990; Theis, 1935). Based on the applicant's graphs presented in TR Addendum 2.7D, Appendix D, the applicant also used the Cooper-Jacob and Hantush-Jacob methods for analyzing pumping test data (Cooper and Jacob, 1946; Hantush and Jacob, 1955). The applicant used commercially available software (AQTESOLV) to perform the pumping test data analyses.

2.4.3.4.1 SM Unit Hydrogeologic Properties

The SM unit is the uppermost or most shallow hydrogeologic unit. The applicant installed seven SM wells, four of which (SM3, SM5, SM6, and SM7) had sufficient water for measuring water levels and sampling, whereas the remaining three wells (SM1,SM2, and SM4) remained dry during the "installation" testing period (AUC, 2012). In general, the SM wells are constructed in thin, noncontiguous sandstones that were generally only partially saturated. The applicant characterizes the potentiometric surface at the SM unit as a perched water table. The perched water table in the SM wells is found at depths from 11 to 22 m (36 to 72 ft) below grade (between elevations of 1,548 and 1,583 m (5,079 and 5,192 ft) above MSL and saturated thicknesses between 2.4 to 4.3 m (8 and 14 ft). Based on the applicant's testing, the estimated transmissivities for the SM aquifer range from 1.5 x 10^{-4} to 3.2 x 10^{-4} square centimeters per second (cm^2/s) (0.014 to 0.3 square ft per day [ft^2/day), yielding a corresponding range of hydraulic conductivities from 3.5 x 10^{-7} to 7.0 x 10^{-5} cm/s (0.001 to 0.2 ft/day). The applicant reports that the specific capacity of the SM wells ranged from 0.07 to 0.13 gpm per foot (gpm/ft) of drawdown.

In TR Addendum 2.7D, Appendix D, the applicant reports that most water pumped during the short-duration, low-yielding, single-well pumping tests at both SM wells was from wellbore storage rather than the aquifer. Based on the low yields during the pumping tests, the applicant states that the SM aquifer does not meet the definition of an aquifer in 10 CFR Part 40, Appendix A (i.e., a geologic formation capable of yielding a significant amount of groundwater to wells).

2.4.3.4.2 OM Unit Hydrogeologic Properties

The applicant characterizes the OM unit as the overlying aquifer to the production unit and the "uppermost" aquifer (AUC, 2012). The applicant's designation that the OM unit is the uppermost aquifer is based on (1) SM being dry at three locations, (2) the applicant's assertion that the SM unit does not meet the definition of an aquifer, and (3) the applicant's assertion that the SM unit reflects perched water table conditions.

The OM unit is not a single unit throughout the Proposed Project area but a series of units with variable thicknesses and depths (AUC, 2012). The thickness of the OM unit at the OM wells varies from 3.65 to 18.3 m (12 to 60 ft) and the depths to the top to the OM aquifer range from 21 to 69 m (69 to 227 ft) below grade. Based on the applicant's cross sections and well completion reports, at wells at which a pumping test was performed, the OM unit is fully saturated at two locations (OM3 and OM5) and only partially saturated at two locations (OM1 and OM4). At wells at which a pumping test was not conducted, the OM unit is only partially saturated at one location (OM7) and fully saturated at two locations (OM2 and OM6). The potentiometric head at the OM wells varied from 1,531 to 1,562 m (5,024 to 5,126 ft) above Mean Sea Level (AUC, 2012). The applicant reports variable transmissivities for the OM unit ranging from 5.4 x 10^{-3} to 68 x 10^{-1} cm^2/s (0.5 to 63 ft^2/day) with corresponding hydraulic conductivies ranging from 1.8 x 10^{-5} to 3.6 x 10^{-4} cm/s (0.05 to 1.03 ft/day). Based on the single-well pumping tests, the specific capacity of the OM wells varies from 0.14 to 0.63 gpm/ft.

Due to the noncontiguous nature of the individual sand lenses screened by the OM wells, the applicant reports that a potentiometric isopleth contour map for the OM aquifer was not possible (AUC, 2012).

2.4.3.4.3 PZA Unit Hydraulic Properties

Based on the applicant's isopach mapping, the thickness of the PZA unit varies from 23 m (75 ft) in the western and eastern portions of the Proposed Project area to 61 m (200 ft) within the central one-third portion of the Proposed Project area. In the central portion, specifically at well cluster PZM4, the applicant reports that the PZA unit bifurcates to an upper and lower unit, due to the presence of a significant mudstone lense. The applicant describes the PZA unit as contiguous throughout the Proposed Project area, although it is only partially saturated in the eastern portions (SER Figure 2.4-3). Based on the applicant's cross sections (AUC, 2012), in areas in which the PZA unit is partially saturated, the saturated thickness above the proposed ore body is between 9.1 and 27.4 m (30 and 90 ft). In areas in which the PZA is fully saturated, the potentiometric head above the ore body ranges from 18.3 to 61 m (60 to 200 ft).

The applicant reports that the testing at the PZM wells yields transmissivity values for the PZA unit generally between 1.1 and 3.2 cm^2/s (105 and 298 ft^2/day), storativity values between $1.3x10^{-4}$ and $2.6x10^{-3}$, and hydraulic conductivity values between 2.5×10^{-4} and 2.7×10^{-3} cm/s (0.7 and 7.7 ft/day). An isolated higher transmissivity value was calculated, based on the observed drawdown at well PZM13 14.3 cm^2/s (1,327 ft^2/day at PZM13). In TR Table 6.2, the applicant estimates the groundwater velocity in the PZA unit at between 0.91 and 9.1 m (3 and 30 ft) per year (AUC, 2012).

The potentiometric heads for the PZA wells are between 1,505 and 1,522 m (4,939 and 4,992 ft) above MSL. Based on the contours of the potentiometric surface, groundwater flow in the PZA is to the northeast.

2.4.3.4.4 UM Unit Hydraulic Properties

The applicant reports that the UM unit is the first noncontiguous, "relatively ratty," thin (3- to 6.1-m [10- to 20-ft]) thick sandstone underlying the PZA unit (AUC, 2012). The UM unit is fully saturated with the saturated thickness at the UM wells ranging between 4.3 and 5.2 m (14 and 17 ft). The top elevation of the UM unit is between 1,432 and 1,473 m (4,698 and 4,834 ft) above MSL. The potentiometric head is between 1,503 and 1,521 m (4,932 and 4,990 ft) above MSL.

The transmissivity of the UM is estimated at 7.5×10^{-4} to 4.8×10^{-3} cm^2/s (0.07 to 0.44 ft^2/day) with a corresponding hydraulic conductivity between $1.8 \times 10^{-6} \times 7.0 \times 10^{-6}$ cm/s (0.005 and 0.02 ft/day) (AUC, 2012). In TR Addendum 2.7-D, the applicant reports specific capacities for the UM wells ranging between 0.02 and 0.06 gpm/ft. Based on the lack of sustainable yields and low transmissivities, the applicant concludes that the UM unit does not meet the definition of an aquifer found in Appendix A to 10 CFR Part 40 or WDEQ Guideline 8.

2.4.3.4.5 Underlying and Overlying Aquitards Hydraulic Properties

The applicant reports results of permeability tests conducted on selected core samples of the overlying (OA) and underlying (UA) aquitards (AUC, 2012). For the OA, the applicant reports a single-point, vertical permeability analysis (to brine) of 0.000877 millidarcies (md). Based on an inspection of the applicant's isopleth mapping, the thickness of the OA ranges from 5.2 to 35 m

(17 to 115 ft).[8] The thickness of the OA throughout most of the Proposed Project area ranges between 7.6 and 15.2 m (25 and 50 ft), and is generally thinnest in the central portion of the Proposed Project area. At the well clusters at which a pumping test was conducted, the applicant reports that the thickness of the OA ranges between 10.6 and 30.5 m (35 and 100 ft).

For the UA, the applicant reports Klinkenberg[9] vertical air permeability results ranging from 5.2 to 10.1 md and a brine permeability result of 0.000584 md. The applicant reports that the underlying aquitard is laterally contiguous, with an approximate thickness of 91.4 to 122 m (300 to 400 ft), extending to the underlying Badger Coal.[10] The underlying unit (UM unit) is contained within the UA (AUC, 2012). The thickness to the UM at the well clusters where a pumping test was conducted ranges from 10.6 to 32 m (35 to 105 ft). The minimum thickness from the UA to the UM unit is 3 m (10 ft).[11]

2.4.3.4.6 Groundwater Levels and Potentiometric Surface

The applicant reports depth to water measured at various monitoring wells for various activities. The reported activities include pumping tests, groundwater sampling, and routine monitoring to assess the potentiometric surface, groundwater flow direction, and hydraulic gradient for the four hydrostatic units (AUC, 2012). The following discussion focuses on the latter data set.

The applicant reports the depth to water and corresponding groundwater elevations for 42 onsite monitoring wells and one monitoring well in the All Night Creek well cluster installed by BLM to assess the CBM effects. The All Night Creek well cluster is located within the Proposed Project area. The measurements were made with various frequencies (generally once every 2 months) and lengths of time (generally less than 1 year) in the period from February 7, 2011, to March 13, 2012. Water levels were also reported for six wells monitored during the background period for the pumping test conducted during December 2010 at well PZM-1.

The range in potentiometric heads measured at the monitoring wells for the various units is as follows:

SM	1,548 to 1,583 m (5,079 to 5,192 ft) above MSL
OM	1,531 to 1,562 m (5,024 to 5,126 ft) above MSL
PZA	1,504 to 1,522 m (4,939 to 4,992 ft) above MSL
UM	1,503 to 1,521 m (4,932 to 4,990 ft) above MSL

8 The range reported in this SER excludes a thickness of 58.2 m (191 ft) reported on the isopach map because it was reported at a single location surrounded by data points that were less than 35 m (115 ft) and the applicant reports in the narrative of values of up to 30.5 meters (100 feet).

9 The Klinkenberg permeability is the corrected permeability after testing of a sample's permeability using gases to account for the lack of drag on the gas along the pore face. The drag would be encountered by fluids such as groundwater.

10 The range of 91.4 to 122 m (300 to 400 ft) differs from the 45.7 to 76.2 m (150 to 250 ft) reported in TR Section 2.6, inspection of the isopach mapping 46 to 81.6 m (151 to 268 ft), and type logs. This deviation is acceptable because the reference point differs for each (i.e., the range of 91.4 to 122 m (300 to 400 ft) is from the bottom of the production aquifer to the Badger coal where the other ranges are measured from the bottom of the production aquifer to the top of the underlying unit, which is a discontinuous, thin sand lense within the underlying unit. The primary issue is the minimum depth to the underlying unit.

11 The applicant includes a statement of a minimum thickness of 3 m (10 ft) and references the isopach map that depicts a minimum thickness of 46 m (151 ft). The isopach map is based on a selected number of wells. The staff assumes that the minimum 3 m (10-ft) thickness refers to the interval between the bottom of the PZA unit and the top of the UM unit as shown by stratigraphic thicknesses on the cross-sections. This assumption does not need to be verified because the 3 m (10 ft) thickness was used in staff's analysis.

The applicant reports that water levels in the SM unit reflect perched conditions, and the unit is fully to partially saturated. The water levels in the OM and PZA units reflect partial to fully saturated conditions. For the PZA unit, the applicant depicts an estimated boundary between fully and partially saturated conditions based on the water levels (SER Figure 2.4-3).

The applicant states that potentiometric surfaces could not be constructed for the SM, OM, and UM units because of the discontinuous nature of the sandstones screened by the various wells (AUC, 2012).

The applicant provided two potentiometric surface contour maps for the PZA (AUC, 2012). The first map is based on water levels measured by the applicant during August 2011 (SER Figure 2.4-4). The potentiometric surface contours depicted on that map indicate northeasterly flow with hydraulic gradients between 0.0017 to 0.0027 ft per foot. The flattening of the gradient is observed in the center of the Proposed Project area, which, the applicant states, is likely related to the presence of thicker and more transmissive sands.

The second potentiometric surface contour map is based on water levels measured by a prior operator in October 1993 (SER Figure 2.4-5). The applicant states that flow directions and hydraulic gradients for the 1993 surface are similar to those based on the August 2011 surface (AUC, 2012).

The applicant presents hydrographs for the wells at well cluster PZM5 (AUC, 2012). The hydrographs are based on data collected over an approximately 8-month (wells SM-5, OM-5, and UM-5) or 10-month (well PZM-5) period. The applicant provides no discussion of the trends in the hydrographs.

2.4.3.4.7 Vertical gradients

The applicant states that potentiometric heads in the wells at the six well clusters exhibit a consistent downward gradient throughout the Proposed Project area (AUC, 2012). Based on data presented in TR Addendum 2.7-B, Table 2.7B-8, the potentiometric head differences between the OM unit and the PZA unit varied between 16 and 50.4 m (52.5 and 165.4 ft), yielding vertical gradients between 0.34 and 0.71. The potentiometric head differences between the PZA unit and the UM unit varied between 0.6 and 10.8 m (2.2 and 35.6 ft), yielding vertical gradients between 0.02 and 0.26.

2.4.3.4.8 Porosity

The applicant determined porosity for the various hydrologic units based on core samples (AUC, 2012). For the OM unit, the porosity measurements ranged from 32.3 to 34.4 percent. For the PZA unit, the total porosity measurements ranged from 12.67 to 34.43 percent. The applicant states that six core samples yielded a total porosity of between 32.3 and 34.4 percent, whereas two samples from a highly cemented sample yielded porosity values between 12.6 and 15.07 percent. For one of the latter samples that yielded a total porosity of 31.8 percent, the applicant evaluated the effective porosity, which was 23.7 percent. For the UM unit, the total porosity ranged from 21.95 to 29.92 percent.

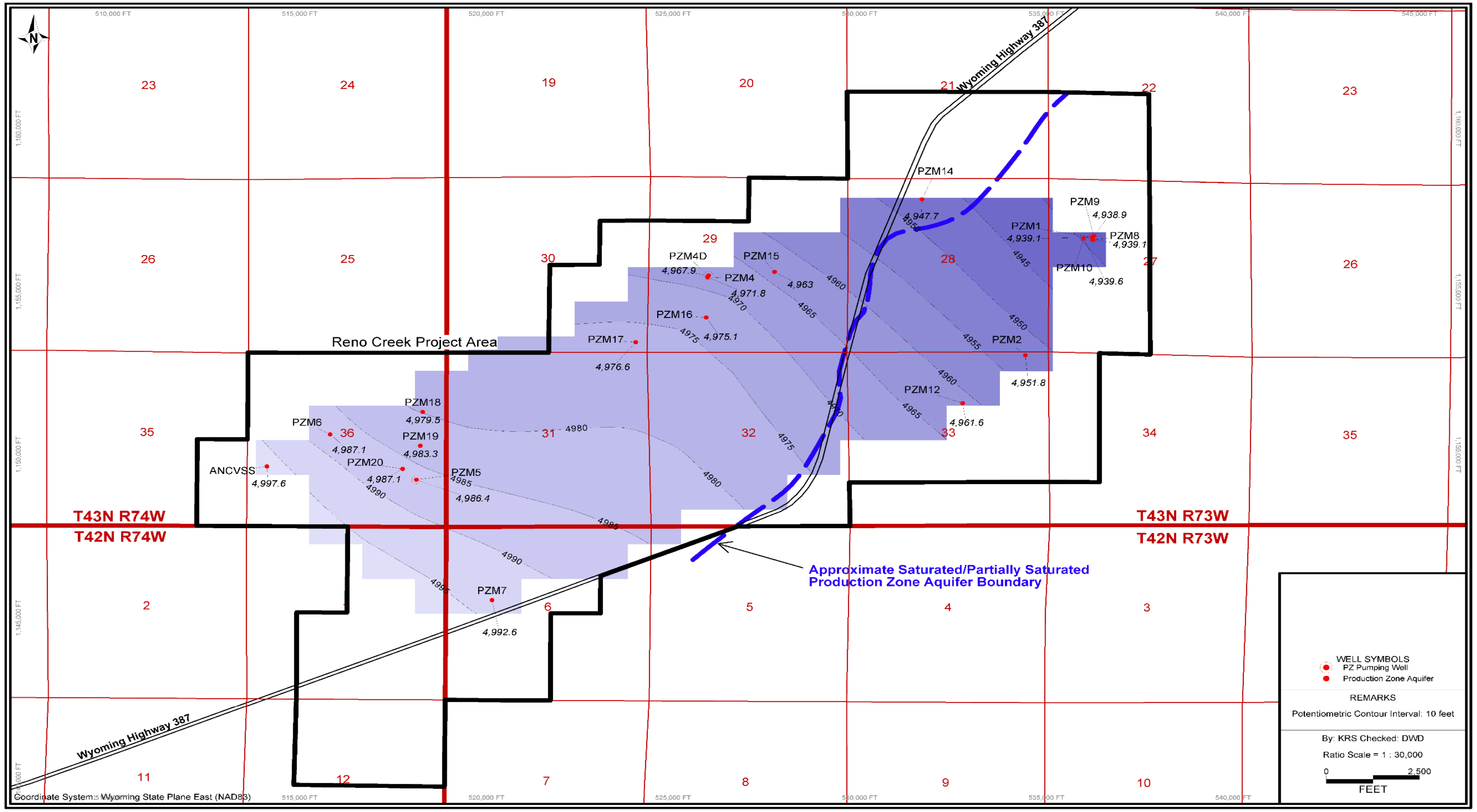

Figure 2.4-4 2011 PZA Potentiometric Surface Contour Map
SOURCE: AUC (2012) Addendum 2.7-B Figure 2.7B-11

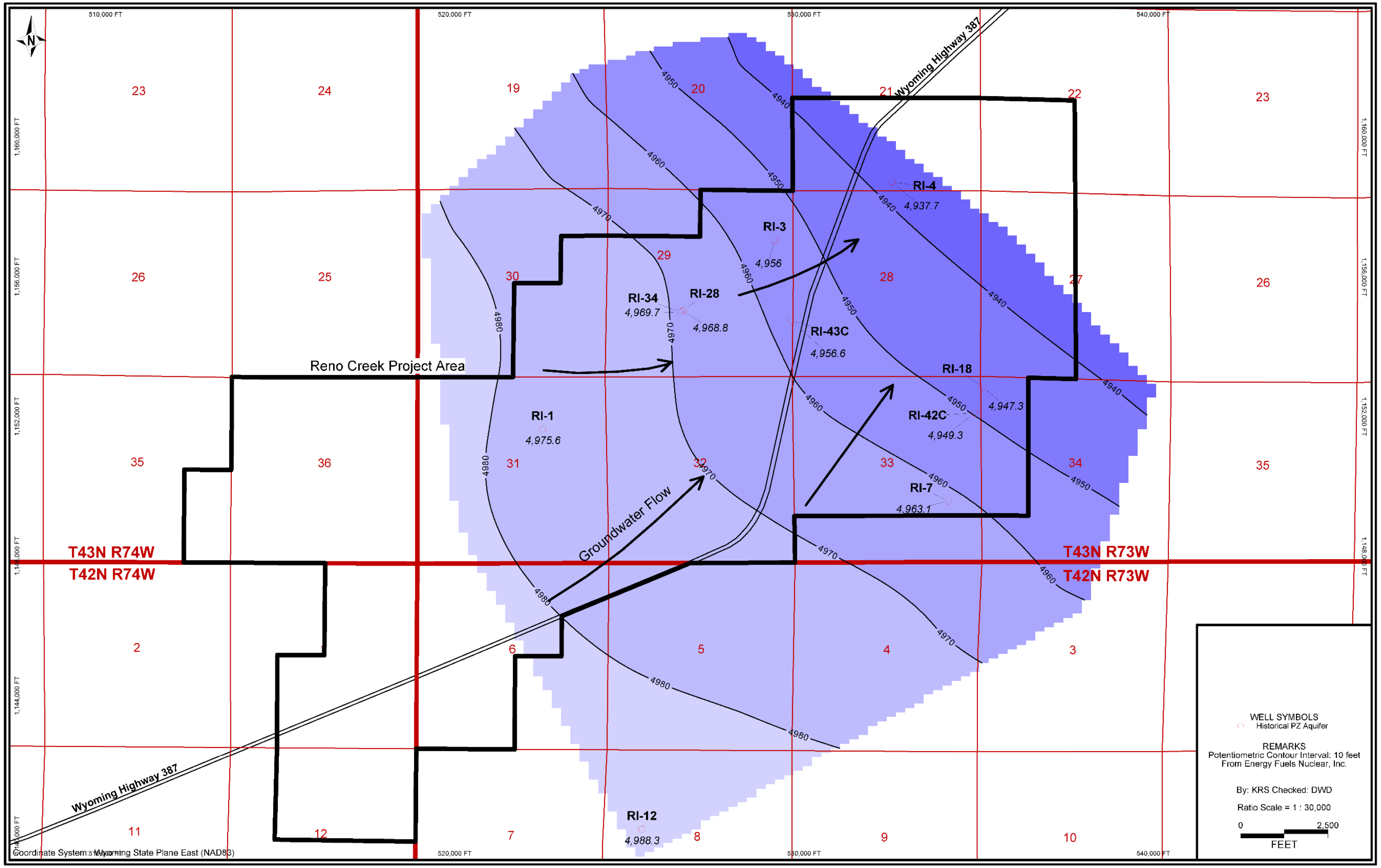

Figure 2.4-5 1993 PZA Potentiometric Surface Contour Map

SOURCE: AUC (2012) Addendum 2.7-B Figure 2.7B-10

Well ID	Screened Aquifer Zone	UTM Easting (m)	UTM Northing (m)	TOC Elev (ft amsl)	Ground Surf Elev (ft amsl)	Casing Nominal OD (in)	Casing Depth (ft)	Top of Filter Pack (ft)	Top of Screen (ft)	Bottom of Screen (ft)	Ream Bit Diameter (in)	Total Ream Depth (ft)	Screen O.D. (in)	Screen type	Screen slot size (in)	Date Installed
SM3	Water Table	448983.47	4834242.53	5260.94	5258.24	4.5	50	44	50	80	8.75	80	4.5	Factory Slot PVC	0.03	7/7/2011
SM5	Water Table	444508.65	4833523.55	5115.90	5114.20	4.5	30	24	30	50	8.75	50	4.5	Factory Slot PVC	0.03	8/18/2010
SM6	Water Table	443806.22	4833944.88	5183.20	5180.40	4.5	60	54	60	80	8.75	80	4.5	Factory Slot PVC	0.03	9/7/2010
SM7	Water Table	445099.77	4832403.42	5176.73	5174.23	4.5	55	50	55	75	8.75	78	4.5	Factory Slot PVC	0.03	8/29/2011
OM1	Overlying	450012.64	4835767.75	5229.94	5227.44	4.95	190.5	182	191	211	9	211	4.95	Factory Slot PVC	0.03	9/28/2010
OM2	Overlying	449474.19	4834655.12	5258.68	5256.38	4.95	201	na	201	221	8.75	211	3.5	Factory Slot PVC	0.03	7/1/2011
OM3	Overlying	448966.40	4834246.63	5262.27	5259.97	4.95	150	na	150	170	8.75	160	3.5	Factory Slot PVC	0.03	7/1/2011
OM4	Overlying	446885.57	4835402.26	5118.72	5116.02	4.95	157	151	157	177	9	180	4.95	Factory Slot PVC	0.03	12/2/2010
OM5	Overlying	444509.29	4833511.60	5115.94	5113.34	4.95	69	64	69	84	9	84	4.95	Factory Slot PVC	0.03	8/18/2010
OM6	Overlying	443799.99	4833933.40	5185.60	5182.70	4.95	227	219	227	237	9	238	4.95	Factory Slot PVC	0.03	9/21/2010
OM7	Overlying	445114.05	4832384.84	5176.20	5173.50	4.95	130	na	130	150	8.75	140	3.5	Factory Slot PVC	0.03	7/8/2011
OAM4D	Over Aquitard (L. Felix)	446891.37	4835418.40	5121.19	5118.29	4.5	201	198	201	206	8.75	208	4.5	Factory Slot PVC	0.03	4/13/2011
OAM4S	Over Aquitard (U. Felix)	446875.72	4835417.14	5119.30	5117.10	4.5	191	na	191	194	8.75	196	4.5	Factory Slot PVC	0.03	4/14/2011
PZM1	Production Zone	450020.53	4835774.59	5230.87	5228.77	5.563	354	288	354	384	9.875	384	6.078	W.O.P PVC	0.03	10/12/2010
PZM2	L. Production Zone	449471.85	4834673.21	5257.39	5255.19	4.95	350	na	350	370	8.75	360	3.5	Factory Slot PVC	0.03	6/29/2011
PZM3	Production Zone	448977.53	4834252.22	5261.99	5259.64	5.563	372	285	372	412	9.875	415	6.025	W.O.P PVC	0.03	8/3/2011
PZM4	U. Production Zone	446880.12	4835407.82	5118.83	5116.03	5.563	235	na	235	255	9.875	266	3.5	Factory Slot PVC	0.03	7/1/2011
PZM4D	L. Production Zone	446888.05	4835423.13	5120.47	5118.47	4.95	311	na	311	371	9	325	3.5	W.O.P PVC	0.03	6/23/2011
PZM5	Production Zone	444500.11	4833519.92	5115.12	5113.22	5.563	260	182	260	330	9.875	331	5.75	W.O.P PVC	0.03	8/17/2010
PZM6	Production Zone	443796.94	4833944.84	5184.59	5181.79	4.95	335	329	335	355	9.875	359	4.95	Factory Slot PVC	0.03	9/2/2010
PZM7	Production Zone	445114.61	4832395.37	5176.66	5173.76	4.95	298	na	298	318	8.75	309	3.5	Factory Slot PVC	0.03	7/6/2011
PZM8	Production Zone	450025.08	4835750.34	5227.18	5224.38	4.95	305	288	305	340	9	340	4.95	Factory Slot PVC	0.03	9/27/2010
PZM9	Production Zone	450033.27	4835786.67	5230.71	5228.31	4.95	310	304	310	330	9	330	4.95	Factory Slot PVC	0.03	9/30/2010
PZM10	Production Zone	449950.24	4835761.90	5228.64	5225.84	4.95	300	295	300	320	9	320	4.95	Factory Slot PVC	0.03	10/4/2010
PZM11	Production Zone	448993.33	4834253.77	5257.53	5255.23	4.95	365	na	365	385	8.75	385	3.5	Factory Slot PVC	0.03	7/28/2011
PZM12	Production Zone	448959.27	4834227.03	5257.94	5255.44	4.95	370	na	370	390	8.75	390	3.5	Factory Slot PVC	0.03	7/27/2011
PZM13	Production Zone	448934.25	4834294.74	5260.51	5258.19	4.95	357	na	357	377	8.75	377	3.5	Factory Slot PVC	0.02	8/2/2011
PZM14	Production Zone	448631.93	4836132.02	5146.36	5143.86	4.95	327	319	327	347	9	347	4.95	Factory Slot PVC	0.03	2/15/2011
PZM15	Production Zone	447426.65	4835456.68	5189.17	5186.77	4.95	420	403	420	440	9	443	4.95	Factory Slot PVC	0.03	10/20/2010
PZM16	Production Zone	446868.00	4835031.05	5112.56	5109.76	4.95	295	277	295	315	9	318	4.95	Factory Slot PVC	0.03	12/13/2010
PZM17	Production Zone	446292.35	4834801.05	5104.46	5101.62	4.95	296	289	296	316	9	319	4.95	Factory Slot PVC	0.03	12/15/2010
PZM18	Production Zone	444551.66	4834153.18	5142.89	5139.99	4.95	250	243	250	270	9	270	4.95	Factory Slot PVC	0.03	9/10/2010
PZM19	Production Zone	444531.96	4833837.72	5140.41	5137.51	4.95	312	306	312	332	9	335	4.95	Factory Slot PVC	0.03	12/8/2010
PZM20	Production Zone	444386.76	4833621.39	5138.49	5135.69	5.563	312	na	312	332	9.875	312	4.5	Factory Slot PVC	0.03	1/27/2011
UM1	Underlying	450018.14	4835759.96	5228.51	5226.01	4.95	430	420	430	450	9	450	4.95	Factory Slot PVC	0.03	10/7/2010
UM2	Underlying	449467.36	4834656.74	5259.45	5256.95	4.95	423	na	423	443	8.75	433	3.5	Factory Slot PVC	0.03	7/6/2011
UM3r	Underlying	448974.50	4834243.34	5262.25	5259.66	4.95	460	na	460	480	8.75	470	3.5	Factory Slot PVC	0.03	10/6/2011
UM4	Underlying	446885.23	4835413.09	5120.17	5117.67	4.95	410	404	410	430	9	434	4.95	Factory Slot PVC	0.03	11/18/2010
UM5	Underlying	444499.68	4833529.21	5116.67	5113.67	4.95	424	418	424	444	9	445	4.95	Factory Slot PVC	0.03	8/28/2010
UM6	Underlying	443796.29	4833954.10	5183.46	5181.06	4.95	415	NA	415	435	9	435	4.95	Factory Slot PVC	0.03	9/1/2010
UM7	Underlying	445114.00	4832405.15	5176.66	5174.06	4.95	385	na	385	405	8.75	405	3.5	Factory Slot PVC	0.03	7/7/2011

Table 2.4-1 Well Completion Details

SOURCE: AUC (2012) Addendum 2.7-B, Table 2.7B-1; For Completion Dates, Addendum 2.7-D, Appendix E

2.4.3.4.9 Historic Hydrogeology Tests (1978-1982; 1993)

The applicant provides data on historical pumping tests conducted by earlier operators (AUC, 2012). The tests were conducted in 1979, 1981, 1982, and 1993. The historical pumping tests consist of five multiwell pumping tests in the PZA unit, 16 single-well pumping tests in the PZA unit, and three single-well pumping tests in the OM unit. For the pumping tests conducted in the PZA unit, the constant-rate pumping rates varied between 21.5 and 169.5 Lpm (5.7 and 44.8 gpm) and the duration of the pumping tests varied between 38 and 2,580 minutes. Based on various analytical models fitted to the test data, the transmissivity for the PZA unit ranged between 4.9 x 10^{-1} to 9.4 cm^2/s (45 and 868 ft^2/day), the storativity ranged from 5.5E-05 to 6.0E-02, and the estimated horizontal hydraulic conductivity ranged between 2.1 x 10^{-4} and 1.8 x 10^{-3} cm/s (0.6 and 5.1 ft/day).

For the pumping tests conducted in the OM Unit, the constant-rate pumping rates varied between 3.7and 16.3 Lpm (1.0 and 4.3 gpm) and the duration of the pumping tests varied between 20 and 77 minutes. Based on various analytical models fitted to the test data, the transmissivity for the OM Unit ranged between 2.2 x 10^{-3} and 1.8 cm^2/s (0.2 and 164 ft^2/day) and the estimated horizontal hydraulic conductivity ranged between 1.0 x 10^{-5} and 2.9 x 10^{-2} cm/s (0.03 and 2.7 ft/day). Because only single-well pumping tests were conducted in the OM unit, the data did not yield information on storativity.

2.4.3.4.10 1982 Hydrogeologic Integrity Study of the Historic Drill Holes

The applicant provides a summary discussion on the hydrogeologic integrity testing conducted by a former operator during 1982 (AUC, 2012) and a redacted version of that report in TR Addendum 2.7-E (AUC, 2013a). In essence, the integrity testing consisted of reentering exploratory drill holes completed prior to that time and examining the strength of the seal that formed at various mudstone-rich horizons. The testing demonstrated that one mudstone, in particular, that was associated with the Felix Coal seam (overlying confining unit) was able to form a seal that withstood pressures of 150 psi applied at the well head.

The applicant concludes that the 1982 Hydrogeologic Integrity Study demonstrates that the abandoned drill holes do not provide a conduit for the migration of fluids between the various hydrogeologic units (AUC, 2012).

2.4.3.4.11 Hydrologic Impacts Associated with the Coal-Bed Methane Operations

The applicant evaluates the potential impacts of CBM production on or by the proposed license operations (AUC, 2012). The applicant cites a study by the Wyoming Geological Survey and the BLM (Clarey, 2009). One well cluster used for that study was the All Night Creek well cluster that is located within the Proposed Project area (AUC, 2012). The applicant reports that the maximum drawdown in the Big George Coal Seam is approximately 183 m (600 ft); zero to minimal drawdown has been observed in the overlying sand aquifers, one of which is equivalent to the applicant's designated PZA, during the previous 9 years of monitoring. Therefore, the applicant expects no hydraulic communication between the proposed ISR activity and CBM development (AUC, 2012).

2.4.3.4.12 Numeric Groundwater Flow Model

In TR Addendum 2.7-D (AUC, 2012), AUC presents results of a numerical groundwater flow model developed in support of its application. The model was a one-layer finite difference

MODFLOW model. The geometry (top and bottom of the layer) was based on onsite borehole data which were projected out from the project area covering a total area of approximately 389.5 km^2 (242 square miles). By virtue of a single-layer model, the top and bottom of the model, which correspond to contact of the production aquifer with the upper and lower confining unit, respectively, are no-flow boundary conditions. The thickness of the model was generally between 33.5 and 36.5 m (110 and 120 ft).

For hydraulic properties, AUC used the concept of zones (i.e., hydraulic property values were constant within a specific zone but the values differed between zones) (AUC, 2012). One zone was used for the model outside of the immediate area of the Proposed Project area, whereas approximately 20 zones defined the hydraulic properties within and immediately adjacent to the Proposed Project area. The hydraulic conductivities for the zones varied between 5.6×10^{-5} and 2.1×10^{-3} cm/s (0.16 and 6.0 ft/day), the storativity ranged from 5.3×10^{-5} to 8×10^{-4}, and the specific yield ranged from 0.013 to 0.015.

The boundary conditions consist of general head boundary (GHB) conditions along the model perimeter of the active cells to reflect groundwater flow into or out of the model (AUC, 2012). Parameters defining the GHB were determined from a calibration steady-state simulation and held constant for subsequent simulations that were developed to test various onsite conditions. AUC used constant flux boundary conditions to simulate pumping/injection wells at selected wells for the subsequent verification and predictive simulations. The latter simulations were performed under transient conditions.

AUC performed a calibration simulation, three verification simulations, and seven predictive simulations (AUC, 2012). The calibration simulation consisted of a steady-state simulation and the calibration targets were static water levels at 12 monitoring wells located throughout the Proposed Project area. The verification simulations consisted of three transient simulations using pumping and observation data at three of the four locations at which AUC performed pumping tests. Six of the seven transient predictive simulations focused on particle pathlines for excursion timing, excursion correction, and flare estimation at locations of two proposed wellfields—one proposed wellfield in the fully saturated portion of the aquifer and the other wellfield in the partially saturated portion of the aquifer (three simulations at each wellfield)[12]. For those simulations, AUC assigned a porosity value of 0.24 for the entire model. The seventh predictive simulation was a transient simulation, which AUC named the “Life of the Mine” (LOM) simulation (AUC, 2012). For the LOM simulation, AUC determined the net (consumptive) withdrawal during an established schedule for the Proposed Project, using both production and restoration.

In response to requests for additional information (RAIs), AUC provided additional or modified simulations (AUC, 2013b). The additional simulations consisted of sensitivity simulations for the various hydraulic properties. The modified simulation consisted of removal of GHB conditions along the southeastern perimeter of the model. For the LOM simulation, though the staff requested that the LOM simulation include the maximum production rate of 41,639 Lpm (11,000 gpm), AUC responded that the net maximum bleed of 1 percent was used, and it did not provide any modification (for discussion on staff’s evaluation, see staff’s evaluation below).

From the modelling effort AUC reached the following conclusions:

- The model was properly calibrated and verified.

[12] Flare is the percentage of area beyond the wellfield physical area which fluids migrate.

- The predictive simulations for the perimeter excursion wells support the proposed 122 to 152.4 m (400-and 500-ft) distance and spacing.

- The predictive simulations for flare demonstrate a horizontal flare factor of 1.14 that is appropriate.

- The LOM simulation predicts maximum drawdowns between (5.79 and 10.4 m) (19 and 34 ft) at wellfields in the partially saturated aquifer and between 6.1 and 16.7 m (20 and 55 ft) at wellfields in the fully saturated portion of the aquifer.

- The LOM simulation predicts 2.13 to 3.35 m (7 to 11 ft) of residual drawdown within the Proposed Project area 5 years after active restoration is complete.

The staff reviewed the modelling effort and results and finds that the results for the predictive simulations may be biased, due to model construction and lack of consistency with several details in the applicant's "conceptual site model."

Based on the staff's review, the potential biases in the model are as follows:

- production rates during LOM Simulation
- one-layer model
- GHB conditions
- specific yield
- heterogeneity of the aquifer

Specific details of the review are discussed below. Furthermore, because of the perceived potential biases, the staff modified the applicant's model construction to evaluate a more reasonable predictive estimate of the maximum likely impacts. Documentation of the staff's modifications and discussion of the applicability of the resulting predictive simulations are also presented below.

<u>Production Rates used for the LOM Simulation.</u> In the RAIs, staff requested that the applicant take account of the maximum requested production rate of 41,639 Lpm (11,000 gpm) during the production (in the RAIs, staff incorrectly referred to a maximum bleed rate of 3 percent instead of 1.5 percent). The intent of staff's request was to determine the most conservative drawdown. The applicant responded that the maximum production rate with a 1 percent bleed was used.

Staff further evaluated the LOM simulation. For 4 years of the 11-year simulation of the production, the equivalent rates were above 37,853 Lpm (10,000 gpm) with the maximum of 40,336 Lpm (10, 656 gpm), for 3 years of the 11-year simulation the production rates were above 34,068 Lpm (9,000 gpm), and for the remaining 4 years of the production simulation, the rates were less than 24,983 Lpm (6,600 gpm). For the latter four years simulated the initial 2-year startup period and the final two years of production at the mine; staff agrees that the rates are representative of the likely rates and does not expect that the maximum production rate would be achievable with the limited wellfields.

For the remaining seven years of the production schedule, staff evaluated the net bleed used in the model. During that time, several wellfields were in restoration. The net withdrawal rate during that time was 492 Lpm (130 gpm) to 556 Lpm (147 gpm), which is consistent with the water mass balance of 545 Lpm (144 gpm) (see Figure 3.6 of the TR (AUC, 2012a). Staff finds that the net withdrawal rate used in the model provides a reasonable conservative estimate of the consumptive use and thus is acceptable for this evaluation.

One-Layer Model. A one-layer flow model is commonly used in groundwater studies in which flow is predominantly two dimensional. For most ISR settings, and as is the case for the Proposed Project, the injection and production are generally limited to a portion of the "aquifer." Most aquifers for ISR settings, as is the case for the Proposed Project, are comprised of fluvial deposits that have heterogeneities, some of which contribute to a vertical anisotropy. The applicant acknowledged the heterogeneity of the PZA throughout the application.

> Sandstones within the PZA that host the uranium mineralization are commonly crossbedded, graded sequences fining upward from very coarse at the base to fine grained at the top, representing sedimentary cycles from 1.5 to 6.1 m (5 to 20 ft) thick. Stacking of depositional cycles has resulted in sand body accumulations over 61 m (200 ft) thick. (TR page 2.6-9)
>
> In the central portion of the Proposed Project area, the PZA is divided into an upper sandstone and a lower sandstone by a 1.5 to 9.1 m (5 to 30 ft) thick mudstone. This division occurs locally in other portions of the project as well, and multiple mudstone lenses of limited lateral extent are commonly observed throughout the Proposed Project area. (TR page 2.6-9)
> …non-uniform distribution of drawdown [during the pumping test at PZM1] is related to depositional heterogeneities present at depth. (TR page 2.7-44)
>
> …complex and heterogeneous system of stratified fluvial deposits. (TR page 2.7-62)
>
> It is likely that aquifer heterogeneities, which are not unexpected in the fluvial depositional environment of the lower Wasatch, are the cause for this asymmetrical radial drawdown response. (TR Addendum 2.7-D, page 18)
>
> Based on geologic information during drilling, it was observed that in the area west of PZM5, the PZA is coarser grained and gravel deposits were noted. It is postulated that at later time, a higher transmissive portion of the aquifer (i.e., more permeable sand) is encountered, thus decreasing the rate of drawdown with time for these observation wells. (TR Addendum 2.7-D, page 30)
>
> A definitive analysis of PZM17 could not be conducted due to the later time data (due to pump problems), but the data suggest that the transmissivity in this well is higher than at well PZM16. (TR Addendum 2.7-D, page 26)
>
> In order to account for the completion interval of the PZM5 pumping well, which is completed across the entire PZA, an estimated flow was apportioned for the lower sand of the PZA. This was necessary to complete analysis of observation wells PZM20 and PZM19, both of which are completed in the lower PZA. Flow in the lower PZA was estimated at seven gpm (of the total 10 gpm that was pumped) based on the curve match provided by Theis drawdown analysis. Because of the need to estimate flow in the lower PZA, the PZM5 pump test analysis is considered more qualitative than quantitative. (TR Addendum 2.7-D, page 30)

A previous study by another licensee demonstrates that the vertical anisotropy of an aquifer has impacts on the extent of both vertical and horizontal flare factors (RAMC, 2001). Because of the dependency of the flare on the vertical anisotropy, the flare analysis, as well as the corrective actions following an excursion as performed by a one-layer model, may not reflect site conditions.

The one-layer model also affects the storage values used by the model. For the layer type used in the model, if the model predicted that potentiometric head in a cell is below the top of the cell, then the storage value used by the model is the specific yield. Use of this value may not be correct for this setting (see discussion below on Specific Yield).

<u>General Head Boundary Conditions</u>. The model includes GHB conditions located along the perimeter of active cells. GHB conditions are commonly used in models to estimate flow into and out of a model. GHB conditions are more flexible than constant head boundary (CHB) conditions, because both flux and head at the cell are allowed to change. For a CHB condition, only flux is allowed to change. The applicant acknowledged this fact with the following statement:

> GHBs were used because the groundwater elevation at those boundaries can change in response to simulated stresses. (TR Addendum 2.7-C, page 7)

The applicant's figures that displayed model-predicted drawdown contours for the LOM simulation had a minimum contour of 1.5 m (5 ft) without displaying contours less than that. However, if drawdowns less than 1.5 m (5 ft) were contoured, the contours would not cross any perimeter cells (i.e., as set up by the applicant, the model predicted zero drawdown at the perimeter cells for any predictive simulation stressing the model domain). This is known as boundary condition effects and should be avoided or evaluated by a sensitivity analysis of the effects on the predictive simulation (ASTM, 2008; 2010). In this case, the GHB conditions were actually acting like CHB conditions, contrary to the statement above, and may have a significant impact on the predictive simulations (Franke and Reilly, 1987).

Using CHB conditions, in and of itself, does not invalidate the model results. In this case, the applicant states, and the staff agrees, that the model construction, which extended the model area several miles from the area where the hydraulic stresses were applied, minimized boundary effects on the model predictions. To evaluate the impacts, the staff reviewed changes in the water mass balance flux rates determined for the GHBs and storage for the steady-state and LOM simulations. The change in flux rate for the GHB was approximately 14 percent of the production withdrawal, whereas 86 percent of production was derived from storage (see the specific yield discussion below).

By definition, GHBs are based on flow to a cell located at a distance from specified head (see page 11.1 in McDonald and Harbaugh, 1988). The GHBs in the model developed by AUC had the distance to the specified head approaching 0 m (0 ft). As a result, the GHBs that were developed had extremely high conductance terms and as a result were, in essence, CHBs. The staff modified the GHB conditions, such that the specified head was expected to be some distance from the cells, and reran the predictive simulations. As was expected, the 1.83 m (6-ft) drawdown contour extended to the northern perimeter of the model, extending beyond the modeled area (which contrasts with the zero drawdown as the model was set up by the applicant). The change in maximum drawdown for a particular stress period in the LOM simulations increased by several feet. The staff's conclusion was that the GHB conditions, as defined by the applicant, had a significant impact on the extent of the regional drawdown but may have had minor impact on the maximum drawdown predicted at the wellfield. To evaluate the potential, the staff developed a modified version of the applicant's model for this analysis as discussed below.

Specific Yield. AUC used values of 0.013 to 0.015 for specific yield in its model (AUC, 2012). For any MODFLOW model, specific yield rather than storativity is used for cells in which the model-predicted potentiometric head is below the top of the cell. Therefore, all cells located within the "partially saturated" portion of the aquifer use specific yield rather than storativity because of the single-layer model.

The general range in specific yield is 0.01 to 0.30, which is generally attributed to gravity drainage in partially saturated aquifers, whereas that for storativity of confined aquifers is 0.005 through 0.00005, which is attributed to elastic behavior of the aquifer matrix (Freeze and Cherry, 1979). AUC could not determine specific yield from the pumping test data, because the storage values from AUC's pumping tests were more consistent with storativity generally associated with confined (fully saturated) aquifers. The specific yield values used by AUC in the numeric flow model were those derived from pumping tests at a nearby uranium recover facility.

The staff attributes the observed responses during AUC's pumping tests to the vertical anisotropy in the aquifer. The vertical anisotropy is a result of fine grained horizons. The fine grained horizons muted responses from gravity drainage (which is the specific yield) to only the very uppermost layer. The applicant recognizes this by stating:

> The PZA at the PZM-1 well is partially saturated but geologically confined by a relatively thick mudstone (page 2.7-43)

MODFLOW models apply specific yield to the entire cell if the model heads are below the top of the cell (i.e, partially saturated cell) or storativity if the model heads are above the top of the cell (i.e., fully saturated cell). For a one-layer model where the model heads are below the top of the cell, the model will use the specific yield. However, this condition is not applicable to modeling a partially saturated aquifer with vertical anisotropy for which the response during a pumping test is consistent with specific yield.

Heterogeneity of the Aquifer. As discussed above, AUC documents that the PZA aquifer is heterogeneous throughout the application (AUC, 2012). In the numerical flow model, that heterogeneity is simulated by using 23 roughly cylindrical zones, each extending vertically through the PZA. The hydraulic properties within each zone are homogeneous; however, the properties vary from zone to zone, reflecting the heterogeneity of the aquifer. The complexities to the heterogeneity in an aquifer are likely greater than can be simulated by any numeric model, especially a single-layer model.

The staff recognizes that the applicant's model setup to address the heterogeneities of this aquifer provides a solution to predict what could be expected during operations. However, the applicant's model setup to explain the heterogeneities with roughly cylindrical zones is not consistent with the conceptual model that the heterogeneities are attributed to a fluvial setting. In a fluvial depositional environment, one would expect heterogeneities to be long and narrow, reflecting flow in streams. As discussed below, the staff developed a modified version of the applicant's model based on expected geometry of the heterogeneities.

Another concern of staff with the heterogeneities was the fact that the model was calibrated but the hydraulic properties in many of the zones not directly stressed and thus not constrained during the calibration process. For example, during the calibration process, the model was verified based on results of the pumping test at well PZM5 (a verification simulation is one in which after calibrating a model under one stress condition, the model is tested for its predictive capabilities under another stress simulation). The pumping test at PZM5 yielded the lowest hydraulic properties for the aquifer. However, the model setup only had the narrowest of zones, the properties of which were directly affected by the model verification. The surrounding zones in the model had higher hydraulic property values but were not subject to direct calibration or verification. The problem is that the stresses for the predictive simulations concentrated on those surrounding zones which were not calibrated or verified. Although the range of values used in the surrounding zones were consistent with those detected at pumping tests conducted elsewhere, the question is whether the low hydraulic properties at PZM extended to the surrounding zones and thus the predictive simulation results may have limited applicability.

To evaluate the information in light of this limitation, the staff reviewed the applicant's data. First, information obtained from low-flow sampling can be qualitatively used to estimate the transmissivity of the aquifer at the location of the well that was being sampled. Review of the low-flow sampling data suggests that the transmissivity at most wells in the western portion of the Proposed Project area have "low recharge." Second, wells PZM7 and PZM18, which are widely separated, have extremely high pH levels (greater than 9.5) and water quality sampling at several wells reported a "sulfur odor" during several sampling events. This information is pertinent, in that the applicant reports that the historical first pilot test performed by others in the 1970s was unsatisfactory because of a severe loss of permeability to the formation due to the reaction of acid, which was used during the first pilot test, with the host formation calcite. The data from recent water-quality testing suggest pyrite or other sulfide minerals may be oxidizing under the naturally occurring conditions, resulting in the sulfur odor, high pH, and potentially lower permeability. This naturally occurring condition is not expected to be as severe as if acid were added to the aquifer, but the result would be a lowering of the permeability, if sulfate minerals are precipitating into the aquifer matrix pore spaces. Finally, the applicant attributes differences in test results between the current and historic pumping tests as follows:

> The lower [transmissivity] at this location within the ore body is not unexpected, as ore generally accumulates in the less permeable channel sands.

Based on the staff's review of the data, it appears that the low hydraulic properties extend to the surrounding zones. Therefore, the applicant's model setup of having a narrow zone of low hydraulic properties around well PZM5 may not be appropriate for the predictive simulations which stressed the surrounding zones because those zones were assigned artificially high values.

The staff elected to develop a modified version of the applicant's model to address the above-stated limitations. The staff's revisions are documented below.

<u>Staff's Modification of the Mode</u>l. The staff developed a modified version of the applicant's numeric groundwater-flow model as follows:

<u>Model Setup</u>. The model setup that was used for the staff's modification was one in which the GHB conditions were removed from the south and southeastern perimeter of the model area in response to the RAI (AUC, 2013b).

Layers. The single layer in the applicant's model was divided into five layers, each layer representing one-fifth of the original thickness of each cell.

General Head Boundary Conditions. The specified head and conductance values used for the GHB conditions were modified as follows: First, a specified head was randomly assumed—for GHBs along the upgradient perimeter (southwestern and western perimeter), the specified head was1,600 m (5,250 ft) above MSL; for the GHBs along the downgradient perimeter, the specified head was 1,446, 1,384, 1,382, or 1,381 m (4,746, 4,540, 4,535, or 4,530 ft) above MSL. Second, the conductance term was modified to calibrate the model during the steady-state simulation using the same targets as were used by the applicant. The selection of the above heads permitted a reasonable "distance" from the cells to the specified head.

For a conservative analysis, the model by staff used the configuration of GHBs similar to the applicant's simulation referred to as "No Flow in SE Edge", which was submitted in response to the staff's RAIs. In essence, these simulation minimized the number of GHBs by not including those along the southern and southeastern perimeter of the model area.

Hydraulic Properties. The number of hydraulic property zones was reduced to six as follows:

- one zone representing the averaged properties in the model area outside of the project area
- one zone representing the higher permeable zone in the eastern portion of the Proposed Project area (extended throughout the model area), based on the pumping test at PZM3
- three zones in each section representing the central portion:
  - Layer 1—average properties (same as above)
  - Layer 2—mudstone
  - Layers 3 and 4—intermediate permeability based on the pumping test at PZM4D
  - Layer 5—slightly higher permeable zone
- one zone for the western portion of the Proposed Project area, based on the pumping test at PZM5

The staff also evaluated the possibility of preferred migration paths. As discussed above, the applicant's conceptual model suggested that preferred areas with higher transmissivities could better explain the data observed during the pumping tests at PZM4D and PZM5. At the location of PZM4D, the staff included a zone with higher hydraulic conductivity in Layer 5. At the location of PZM5, the staff included a narrow zone of limited extent of higher hydraulic conductivity in Layer 3. The impacts of those zones on the results are discussed below.

Storage. Use of a five-layer model in MODFLOW-SURFACT resulted in a memory allocation error. Therefore, the staff used MODFLOW-2000 in lieu of MODFLOW-SURFACT. One difference between MODFLOW-2000 and MODFLOW-SURFACT is how each version of the software uses the primary storage term. For MODFLOW-2000, the primary storage term is the specific storage, which is storage per unit thickness of an aquifer, and for MODFLOW-SURFACT, the primary storage term is storativity, which is unitless. The two terms are related in that the storativity is the specific storage times the thickness of the aquifer.

Because the applicant used MODFLOW-SURFACT, the primary storage term for a cell was storativity. To closely approximate this value, for staff's modified version of the model using MODFLOW-2000, the primary storage term for each cell, which was the specific storage, was the storativity used by the applicant in its model divided by the approximate thickness of the cell. The specific storage was a parameter modified during calibration of staff's modified version of the model using the pumping test simulations.

Initial Heads and Inactive Cells. The staff's revision to the applicant's model was based on no GHBs located in the southern and southeastern perimeter of the modeled area. As a result, a large number of cells in the southeastern area were dry. A difficulty with the MODFLOW software is determining a solution for a simulation with a large number of dry cells if the rewetting feature is activated. To alleviate this difficulty, the vast majority of the cells that would be dry were made inactive—only those cells along the margin of the dry cells were allowed to be active and thus subject to rewetting.

To establish the inactive cells, the staff used the model-predicted potentiometric head from the single-layer model to establish the baseline. The heads were compared to the bottom elevations in the five-layer model. If the potentiometric head was below the bottom elevation, then that cell was made inactive.

Pumping test simulations. Three simulations were performed to calibrate the revised hydraulic property zones based on data from three pumping tests (PZM3, PZM4D, and PZM5). For each simulation, constant flux boundary conditions were used to model the withdrawal at the pumping wells.

Data from the observation wells for each pumping test were used as targets to calibrate the simulation. The data for each target consisted of a representative hydrograph of the drawdown at varying times during the pumping test period. The model was visually calibrated to best fit those hydrographs.

The calibration of the steady-state simulation to the targets is poorer than that reported by the applicant for its version of the model. The range in residuals for the staff's modified version of the model was -2.4 to 1.6 m (-7.88 to 5.46 ft), compared to the range in residuals for the applicant's model of -1.8 to 1.3 m (-5.99 to 4.16 ft). The poorer fit to the data for the staff's version is attributed to its lower number of hydraulic property zones.

Predictive Life-of-Mine Simulation. The staff used the applicant's setup for the LOM simulation without modifying the stress period setup, number of pumping wells, or flux from the wells. Depending upon the estimated depth to a specific wellfield, the constant flux boundary conditions were assigned to Layer 3, 4, and/or 5. Several constant flux boundary conditions were used to distribute the pumping over various layers within the model, because the screened zone for a pumping well may have crossed several layers.

The predictive simulations from staff's modified version of the model yielded significantly greater maximum drawdown in the fully saturated aquifer and slightly less maximum drawdown in the partially saturated aquifer than the applicant's predictive simulation.

Discussion of Results. The purpose of the staff's revisions to the numerical model was to establish a model using conservative parameters consistent with the applicant's conceptual site model for the project and reported data. Specifically, the applicant's pumping test data at PZM5 yielded low hydraulic conductivities, but the applicant's model did not extend those properties to the proposed locations of the nearby production areas—the staff's revisions extended the low conductivity to the proposed production areas, consistent with the applicant's conceptual model. The applicant's model was a single layer and thus could not simulate vertical flow nor account for vertical heterogeneities in the aquifer—the staff's revisions developed a five-layer model that incorporated some aspects of the vertical heterogeneity and flow, consistent with the reported data. The applicant's model accounted for horizontal heterogeneities by using large areas of varying properties—the staff's revisions tested the potential for preferred migration path, consistent with a fluvial depositional environment. The applicant's model resulted in the use of large storage values in the partially saturated portion of the aquifer—the staff's revision to a five-layer model reduced the usage of large storage values to a limited interval, and thus the effective storage of the model was consistent with the observed data. The applicant's model contained GHBs that were effectively CHBs—the staff's revision modified the GHB to minimize any boundary effect.

As a result of the staff revisions, the model-predicted drawdowns during the LOM simulation were greater than those predicted by the applicant's version. For example, the applicant reports a maximum drawdown of 16.7 m (55 ft) at Production Unit 10 at the end of Year 9 (AUC, 2012). For comparison, the applicant's model without the GHBs in the southeast corner yielded a maximum drawdown of 17 m (56 ft). The staff's modified version of the model predicted a maximum drawdown of 28.9 m (95 ft).

The greater drawdowns suggest that a significantly larger portion of the available water column will be used by normal operations than estimated by the applicant's model. Should an excursion arise, then any additional drawdown (pumping) to correct the upset condition would be limited by (1) the reduced available water column and (2) the limited area of influence due to the lower hydraulic conductivities. This impacts AUC's argument that using a 152.4 m (500-ft) distance to the perimeter wells would be adequate in the fully saturated portion of the aquifer based on its modeling results. In contrast, a 122 m (400 ft) distance to the perimeter wells would be equally applicable to both fully saturated and partially saturated portions of the aquifer.

Another aspect of evaluating the distance to and spacing of the perimeter wells is the probability of an excursion migrating past the monitoring wells. In homogeneous aquifers, the flow for an excursion would be more or less radial; therefore, the distance to and spacing between monitoring wells is less of an issue. However, if the aquifer is heterogeneous and preferred migration paths exist, then the probability discussed in NUREG/CR-6733 (Mackin et al., 2001) is significant. The probability of detection is based on the width of the excursion, in this case, the width of the preferred migration path. If the width of the preferred path is greater than 152.4 m (500 ft), then a spacing of either 122 or 152.4 m (400 or 500 ft) would be adequate. However, if the width of a preferred path is less than 152.4 m (500 ft), then a spacing of 122 m (400 ft) has a higher probability of intersecting the path and thus detecting the excursion relative to a spacing of 152.4 m (500 ft). In fluvial environments, the width of a channel sand deposit, which is consistent with the applicant's conceptual model, could be a preferred path and be less than 152.4 m (500 ft). Guidance in NUREG/CR-6733 indicates a 400-foot spacing is adequate for ISR facilities at geologic settings similar to that at the Reno Creek site (Mackin et al., 2001),

For the reasons noted above, the staff finds the applicant's rationale and justification for a 152.4 m (500 ft) spacing distance of the perimeter wells in the fully saturated portion of the aquifer to be inadequate. The licensee was provided staff's modified version of the model to review. Although, in the licensee's opinion, staff's modified version of the model did not provide a compelling argument for the spacing, the licensee agreed with the proposed 400-ft spacing due to the potential for preferred pathways (AUC, 2015c). Therefore, the staff will include a license condition that requires a 122 m (400 ft) distance to, and spacing of the perimeter wells for, a wellfield in either the fully or partially saturated portions of the aquifer.

The staff's revisions to the model also afforded an evaluation of potential vertical hydraulic conductivities of the aquifer, specifically the mudstones within the aquifer at the location of well PZM4D. Based on the model results, the vertical hydraulic conductivity of the mudstone is estimated at 7×10^{-6} cm/s (0.02 ft/day). Similar low values were used for the vertical conductivity of more transmissive zones that modeled sandstones and siltstones, suggesting that those zones have a vertical anisotropy of the aquifer approaching a ratio of horizontal:vertical conductivity of 100:1. Based on previous modeling efforts by others (RAMC, 2001), aquifers with an anisotropy of 100:1 likely have negligible vertical flare and a horizontal flare factor of approximately 1.7 for the proposed geometry to the proposed wellfields. The staff has reasonable assurance that the applicant's proposed flare factor of 1.44 would be reevaluated as the wellfields are completed. The staff typically evaluates the appropriateness of the flare factor during the annual financial assurance updates based on the actual construction of a wellfield and the operating experience.

2.4.3.5 Staff Review

Overview

SRP Acceptance Criteria 2.7.3(3) and 2.7.3(5) provide guidance for the staff in evaluating an applicant's conceptual hydrogeologic model of groundwater flow in the potentially affected aquifers. As is discussed below, the staff finds that the applicant has adequately described, assessed, and developed a hydrogeologic conceptual model and provided sufficient supporting data. As described above and summarized below, while the applicant provided an interpretation of the data, in several areas, the staff questioned whether the applicant's interpretation provided sufficient conservatism need for a regulatory approval. Consequently, the staff's independent review of the applicant's data included clarifications of several issues associated with the applicant's conclusions as well as development of a modified version of the applicant's numeric model to evaluate the setting using more-conservative parameters. As a result, though the staff did not modify the applicant's overall conceptual hydrogeologic model, the staff's clarifications provide a more conservative interpretation for a degree of safety needed for a reasonable assurance determination by the staff.

The minor clarifications are the following:

- SM unit is the uppermost aquifer
- potentiometric surface for the OM and UM units
- permeability of the aquitards

The clarifications are discussed in depth below.

Regional Hydrogeology

The staff reviewed the applicant's description of the regional hydrogeology and the referenced source documents. The applicant provided an accurate characterization of the published documents and properly superimposed the Proposed Project area onto the regional mapping. The applicant did provide inaccurate information in several references; however, the staff was able to identify the source material from portions of the applicant's reference (e.g., "USGS, 1996" is "Hsieh, 1996"). Therefore, the staff finds that the applicant's description of the regional hydrogeology is acceptable.

Site Hydrogeology

The staff finds that the applicant's site hydrogeologic conceptual model is consistent with the reported data, including the historical data, and that the applicant used proper techniques in collecting and analyzing the data. The staff finds the applicant used proper well installation techniques and supplied acceptable data on the well locations, depths, and screened intervals. The applicant provided a sufficient number of potentiometric measurements to determine the potentiometric surface in the mineralized zone. The applicant provided a sufficient number of hydrogeologic cross sections in sufficient detail to demonstrate continuity of the ore zone throughout the property and isolation of the ore zone from the overlying aquifers.

The applicant's numeric groundwater flow model provided a foundation upon which responses to future stresses (e.g., consumptive use, containment, excursion monitoring) could be evaluated. The staff identified assumptions in the applicant's numeric model that led to a less conservative analysis than desired by staff or possibly bias in the model predictive simulations. However, the staff was able to develop a modified version of the applicant's model, which provided a conservative analysis of the site hydrogeology.

The staff agrees that the OM aquifer, as defined as the first sandstone above the Felix Coal, will serve as an acceptable overlying aquifer, as proposed by the applicant. Although the staff agrees with the applicant that contouring the potentiometric surface for the OM aquifer using the entire dataset presented in the application would have yielded confusing and possible misleading groundwater-flow directions within the OM aquifer, the staff did evaluate the probable flow directions and gradient by eliminating apparent anomalous data points in the applicant's data (see clarifying discussion below). The staff's estimated flow directions are consistent with the historical data. The staff estimates that flow in the OM aquifer in the central and eastern portions of the Proposed Project area is west to northwest in direction. Based on the range of reported hydraulic conductivities for the OM unit of 1.8×10^{-5} to 1.8×10^{-4} cm/s (0.05 to 0.5 ft/day), an estimated ambient hydraulic gradient of 0.02 (based on 75-ft drop in head over an estimated distance of 1,219 m (4,000 ft) from well OM3 towards well OM4), and a reported effective porosity of 0.14, the staff estimates a groundwater velocity in the central and eastern portions of the Proposed Project area between 0.09 and 1.0 m (0.3 and 3 ft) per year. In the western portion of the Proposed Project area, the exact flow direction is not accurately defined and may include local easterly flow.

The staff has determined that the level of detail provided by the applicant, with the staff's clarification, is sufficient to characterize the OM aquifer for the license application. Based on discussions, the applicant commits to providing detailed potentiometric surface and flow direction analyses for the OM aquifer in future wellfield data packages (AUC, 2015c). This commitment ensures that proper mapping will be included in future well field date packages. The staff will enumerate, in a license condition, a requirement that a potentiometric surface isopleth contour map for the overlying aquifer be included in future wellfield data packages. (See License Condition 10.12 in SER Section 5.7.8.9).

The staff finds that the applicant's data support its conceptual model indicating that the PZA unit is a suitable aquifer for ISR operations. The PZA unit is contiguous throughout the Proposed Project area, although slightly thicker in the central portion in the vicinity of well cluster PZM4, where a substantial mudstone also bifurcates the aquifer. The estimated hydraulic conductivities for the PZA unit are between 1.4×10^{-4} and 2.7×10^{-3} cm/s (0.4 and 7.7 ft/day), which are suitable for typical ISR operations. The aquifer varies from partially to fully saturated from east to west with a maximum hydraulic head above the top of the saturated zone of between 27.4 and 61 m (90 and 200 ft). The fact that the aquifer is partially saturated is not unique for ISR operations but does present operational constraints, which the staff discusses in SER Section 3.0. The staff agrees with the applicant's calculation that groundwater velocities in the PZA unit are expected to be between 0.9 and 9.1 m (3 and 30 ft) per year under ambient conditions.

The staff finds that the applicant's data support its conceptual model that the UM unit does not meet the definition of an aquifer. The staff agrees that the long-term sustainable yield for an UM well is 1.13 Lpm (0.3 gpm) or less, which is below the threshold of 3.78 Lpm (1 gpm) in the EPA guidelines for establishing an underground source of drinking water. Furthermore, the recovery rates from the single-well pumping tests at the UM wells indicate less than 90 percent recovery in 24 hours. This criterion is a guideline from USGS for establishing whether or not a monitoring well can be sampled.

The staff finds that the applicant has established that the UA is found through the Proposed Project area with a minimum thickness of 45.7 to 76.2 m (150 to 250 ft). Using the vertical hydraulic conductivity of 3.0×10^{-8} cm/s (8.6×10^{-5} ft/day) (see the staff's clarification below), an effective porosity of 0.25, and a conservative overpressure of 150 ft of water, the time required for groundwater to migrate through the underlying aquitard is over 8 years. Therefore, the staff agrees with the applicant that monitoring the UM is not warranted.

<u>Staff's Clarifications</u>

SM Unit is the Uppermost Aquifer

The applicant characterizes the SM unit as being dry at three locations, being "perched" at locations at which groundwater was found, and not meeting the definition of an aquifer, due to the lack of sustainable well yields and calculated low transmissivities. Based on these conditions, the applicant asserts that the SM unit is not the uppermost aquifer. The staff disagrees with the applicant's characterization that the SM unit is not the uppermost aquifer. First, the fact that the SM unit was dry at three locations is likely an artifact of the applicant's methods for defining the SM unit. The applicant states that test borings were air-drilled to approximately 21.3 m (70 ft), and, if 1.5 m (5 ft) of water infiltrated into a temporary well after a few days, then a permanent well was installed (page 2.6-10 (AUC, 2012)). The fact that a boring was dry may be because the SM unit was deeper than 21.3 m (70 ft) at a specific location.

Second, the applicant's argument that the SM unit reflects a perched aquifer is not persuasive. A perched aquifer is defined as saturated, generally unconfined, groundwater, which is <u>separated</u> from the main body of saturated lithologies by an unsaturated zone. Based on the applicant's data, the SM unit at three of the four well cluster locations (PZM5, 6, and 7) with groundwater likely meets this requirement. On the other hand, at one location (PZM3), the potentiometric head in the OM unit is above the base of the SM unit, suggesting continuous saturation from the SM unit to the underlying OM unit. The same argument (i.e., a perched aquifer) can be made for the OM aquifer, where the potentiometric head in the underlying unit is below the base of the OM unit (at well cluster locations PZM1, 2, 3, 5, and 7). However, the applicant does not make the argument that the OM unit is perched.

The fact that a perched aquifer is separated from the main body of groundwater implies that the groundwater is localized and its connection and thus potential to affect any sensitive receptors is minimized. Therefore, the perched aquifer may not be the uppermost aquifer or true water-table aquifer. The fact that individual aquifers in the Powder River Basin are isolated by the substantial thickness of low permeable materials complicates the textbook descriptions, such as perched. While the staff has not reached a contrary conclusion from the applicant's description, the fact is that groundwater in the SM unit may be used (see discussions below), may discharge to surface water, and is likely to be affected if a well fails its mechanical integrity testing at a shallow depth or a spill occurs in the near-surface environment. In such cases, the applicant would be required to characterize and remediate the SM unit, if warranted. Such an obligation is negated by an argument that the SM unit is a perched aquifer.

Guidance in the SRP suggests that monitoring in aquifers "above the first overlying aquifer may not be required when (i) the aquifers are separated from the production zone by thick aquitards, (ii) a high quality mechanical integrity well testing program will be implemented, or (iii) the aquifers are unsubstantial producers of water or of poor water quality." The staff's evaluation is that the SM unit is separated from the PZA aquifer by a substantial thickness of fine grained material, AUC will be implementing a high quality MIT program, and the SM unit yield is minimal for an aquifer. Therefore, the staff agrees that routine monitoring of the SM unit during operations under the excursion monitoring program is not warranted.

Finally, the applicant's argument that the SM unit does not meet the definition of an aquifer because of its low transmissivity and low yields of the SM wells is too qualitative and not consistent with the data. While the calculated transmissivities for the SM unit are low, the transmissivities are higher than those calculated for the UM unit. In addition, unlike the UM unit, a well in the SM unit may yield long-term usable quantities of groundwater. The applicant has failed to provide information on the long-term sustainable yield of the SM unit. Furthermore, the applicant reports that two nearby livestock water supply wells (GW-1 and GW-11) are reportedly screened at shallow depths (less than 27.4 m [90 ft]), which correspond to depths equivalent to the SM unit. The fact that wells are using the SM unit for water supply sources contradicts the argument that the SM unit does not meet the definition of an aquifer.

Therefore, for reasons stated above and the fact that groundwater in the SM unit has the highest potential to discharge to nearby stream channels, the staff disagrees with the applicant and finds that the SM unit is the uppermost aquifer if, at any specific location, the SM unit, or similar shallow sandstone, contains groundwater. The staff agrees with the applicant that the OM unit is the uppermost aquifer, if the OM unit is the highest sandstone containing groundwater. The applicant has committed to monitoring the uppermost aquifer, whether it is the SM or OM unit, in the event of a spill or leak (AUC, 2015c)

Potentiometric Surface for the OM and UM units

The applicant stated that a potentiometric surface could not be constructed for the OM and UM aquifers and presented figures only depicting the observed groundwater elevations at the respective wells. The applicant's reported rationale for not constructing a potentiometric surface was the discontinuous nature of the sandstones that define the aquifers.

The staff finds that the applicant's rationale for not constructing a potentiometric surface and thus not estimating groundwater-flow directions in the OM and UM units is not persuasive. The staff agrees that contouring of the entire data set would not be useful, based on the seemingly incongruous distribution of the groundwater elevations for the OM and UM wells. However, groundwater elevations for the underlying aquifer (UM unit) as reported on TR Addendum 2.7-B, Figure 2.7B-9 suggest a pattern (north-northeasterly groundwater flow) if data for well UM5 are excluded.

The data for well UM5 may need to be excluded based on its screened depth relative to the other UM wells. As reported by the applicant, both on a regional and a local scale, potentiometric head varies with depth, specifically, the potentiometric head decreases with depth. The staff reviewed the data for the site (well completion table and cross sections) and found that the top of the well screen for well UM5 was approximately 30.5 m (100 ft) below the bottom of the well screen for the PZA unit at well cluster PZM5, whereas at the other well cluster locations, the top of the UM well screen was between 12.2 and 18.3 m (40 and 60 ft) below the base of the PZA unit. In addition, based on the staff's review of the cross section depicted in TR Addendum 2.6-A, Figure 2.6A-14, the geophysical signature of the UM unit depicted at boring RC0005 (well cluster PZM5) is similar to the geophysical signature 13.7 m (45 ft) below the applicant's UM unit at boring RC0006 (well cluster PZM6).

The staff concludes that the potentiometric head at well UM5 reflects the head in sandstone approximately 15.2 m (50 ft) below the sandstones reported for the other UM wells. Therefore, the staff concludes that well UM5 should be excluded from the data set in contouring the potentiometric surface for the UM unit as well UM5 is located at a different elevation and stratigraphy than the other UM wells.

A similar analysis for the OM unit is more complex. The staff finds acceptable, in part, the applicant's description that the OM unit is a series of discrete sandstone units for which a single unit may not be contiguous throughout the Proposed Project area based on a review of the geologic cross sections in the application. The staff also finds that contouring the data, as depicted in TR Figure 2.7B-3, would yield a complex groundwater-flow pattern with mounding at the location of well OM5. However, the staff disagrees with the applicant that the complexities do not warrant an analysis beyond a statement that "[a] potentiometric surface map of this aquifer could not be constructed due to the discontinuous nature of this aquifer across the project area" (TR page 2.7-29, AUC, 2012). On a wellfield basis, the "project area" complexities should be minimized such that an evaluation of groundwater flow pattern would be evaluated.

In the central and eastern portions of the Proposed Project area, the groundwater elevations indicate northwesterly groundwater-flow directions. Such flow directions are consistent with the historical data. In the western area of the Proposed Project area (west of highway 387), groundwater elevations suggest a more complex flow regime. (Note that the historical data did not extend into this area.) However, the data indicate that the OM unit is isolated from the PZA unit and has similar gradient and transmissivity as in the central and eastern portions of the Proposed Project area. Given the similarities in properties, and the licensee's commitment to adequately define flow directions and gradients for the OM unit in the detailed hydrogeologic package for any wellfield to be constructed, the staff finds that the information presented is sufficient for a reasonable assurance determination required for approval of a license application. The staff memorializes the licensee's commitment in License Condition 10.12 described in SER Section 5.7.8.4.

Vertical Hydraulic Conductivity of the Aquitards

The applicant reports the permeability from core samples of the aquifer. However, permeability is an intrinsic property of the aquifer matrix and is commonly used where fluids of differing properties are involved (e.g., oil and gas versus water). For ISR operations, the hydraulic conductivity of the aquifer (relating to groundwater flow) would be a better descriptive term to inform the regulator or public. Hydraulic conductivity is a function not only of the intrinsic properties of the aquifer matrix but also properties of the fluid, in this case groundwater. The specific properties that affect the hydraulic conductivity are the viscosity and density of the fluid. Based on the fluid properties for conditions expected in the aquifer, the relationship between permeability (in md) and hydraulic conductivity is the following:

$$1 \text{ md} = 9.1 \times 10^{-7} \text{ cm/s } (2.6 \times 10^{-3} \text{ ft/day})$$

The applicant reports two sets of permeability data. One is relative to air (5 to 10 md); the other set is relative to brine (0.0006 to 0.0009 md). The applicant states that it regards the brine permeability as the more appropriate method and regards the air permeability results as qualitative. Based on the applicant's brine permeability, the estimated vertical hydraulic conductivity of the aquitards is 7×10^{-11} cm/s (2×10^{-6} ft/day).

In the staff's judgement, the air permeability values are accurate and likely represent higher permeability siltstones in the aquitards. However, in general, an air permeability value for a particular sample is higher than the fluid permeability for that sample. The calculation of a fluid permeability from an air permeability is performed by using a Klinkenberg correction factor (Klinkenberg, 1941; Tanikawa and Schimamoto, 2006; Rushing et al., 2004). In very low permeable formations, as is the case here, the air permeability values may be 1 to 2 orders of magnitude higher than the fluid permeability (Ziarani and Aguilera, 2012). Therefore, assuming two groups of permeability (one for the mudstones and one for the siltstones) and each group represents 50 percent of the aquitard, the staff estimates a vertical hydraulic conductivity for the aquitards at 3.0×10^{-8} cm^2/s (8.6×10^{-5} ft/day). This value is consistent with the estimated vertical conductivity of mudstone aquifers at other ISR facilities (see discussion above). This estimate is approximately 430 times higher than the applicant's estimate. However, at these values, flow through the aquitard is negligible (the difference given the thickness of the aquitard would be thousands of years versus millions of years).

2.4.4 Evaluation Findings

The staff completed its review of the hydrologic site characterization information for the Proposed Project. The review included an evaluation using the review procedures in SRP Section 2.7.2 and the acceptance criteria outlined in SRP Section 2.7.3 (NRC, 2003).

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

- locations of drainages in and around the license area
- peak flood estimates for appropriate recurrence intervals for all drainages
- a flood potential analysis for the facilities
- descriptions of techniques to protect structures and equipment from flooding (see SER Section 3)

Based on a detailed review of the surface water hydrology at the Proposed Project, the staff concludes that the information provided by the applicant meets the acceptance criteria in the SRP (NRC, 2003).

The applicant has acceptably described the groundwater hydrology by providing the following:

- a description of the regional hydrogeology
- a description of the site-specific hydrogeology

- a description of the overlying aquifer, extraction zone, and underlying aquifer hydrogeology using potentiometric surface maps with acceptable contour intervals, based on an appropriate number of monitoring wells
- site-specific groundwater modeling, as modified by the staff, to represent current hydrogeologic conditions at the site and to assess drawdowns during the life of the mine

Based on a detailed review of the groundwater hydrology at the Proposed Project, the staff concludes that the information provided by the applicant is acceptable, except for the staff's determination that the spacing and distance of 122 m (400 ft) is more appropriate than the 152.4 m (500 ft) proposed by the applicant. The applicant committed to the 122 m (400 ft) requirement in response to open issues (AUC, 2015c). The 122 m (400 ft) requirement will be memorialized in a license condition (see License Condition 11.3 in SER Section 5.7.8.4).

2.5 Background Surface Water and Groundwater Quality

2.5.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the characterization of surface and groundwater quality at the Proposed Project has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7, using the review procedures in SRP Sections 2.7.2 and 2.9.2 and acceptance criteria in SRP Sections 2.7.3 and 2.9.3 (NRC, 2003).

2.5.3 Staff Review and Analysis

2.5.3.1 Surface Water

The applicant provided background surface-water-quality data within the Proposed Project area (AUC, 2012). The surface-water samples were collected from 21 sampling locations beginning in the fall of 2010. Of the 21 sampling locations, 16 locations were dry at least 6 months of the year. All of the sampling points were located in the drainages and surface-water impoundments. The surface-water samples were analyzed for all analytes listed in SRP Table 2.7.3-1 (NRC, 2003) and radionuclides listed in RG 4.14 (NRC, 1980a).

The applicant provided the surface-water-quality results on a parameter-by-parameter basis for all sampling locations (AUC, 2012). Due to the ephemeral nature of the surface-water bodies, the applicant did not perform a statistical evaluation of the data. The applicant provided an analysis of the major ions in the surface-water samples through piper diagrams.

The applicant reports that nine WYPDES permits exist within the Proposed Project area (AUC, 2012). The WYPDES permits are for discharges from oil and gas or CBM production. Several surface-water sampling locations of the applicant are located close to a WYPDES discharge. The applicant provides a qualitative analysis of the potential impacts of the WYPDES discharges on the surface-water quality.

2.5.3.2 Groundwater

2.5.3.2.1 Regional Groundwater Quality

The applicant provides a summary of the groundwater quality for the shallow, regionally significant aquifers. The predominant aquifers used for water supplies are the relatively shallow (less than 152.4 m [500 ft deep]) Upper Cretaceous and Tertiary Formations (AUC, 2012). Those formations include the Wasatch Formation, Fort Union Formation, Fox Hills/Hell Creek Formations, and the Lance Formation. The overlying, unconsolidated Quaternary Alluvium may also be used for water supplies; however, the limited extent, largely to the present-day stream channels, and shallow depths, tends to limit the potential for alluvium to be an adequate long-term water supply.

The applicant reports that, in general, shallow livestock and domestic water supply wells and springs have TDS concentrations of less than 500 milligrams per liter (mg/L) (AUC, 2012). (TDS concentrations are a general indicatory of the water quality. The EPA has set a secondary standard for TDS at a concentration of 500 mg/L under the National Secondary Drinking Water Regulations). The applicant further reports that TDS concentrations (and thus groundwater quality) are affected as groundwater flows through the host formations due to reactions of the groundwater with the formation rocks. The dominant reactions in the shallow aquifers are cation exchange and sulfate reduction. In TR Addendum 2.7-B, Table 2.7B-21, the applicant provides a summary of the range of TDS concentrations in the Upper Cretaceous and Lower Tertiary formations. The range in TDS concentrations is similar for the various formations, with a minimum TDS concentration of 106 to 3,340 mg/L, maximum TDS concentration of 2,850 to 8,200 mg/L, and an average between 1,100 and 2,128 mg/L (AUC, 2012).

In addition to TDS, the applicant reports that iron and manganese concentrations commonly exceed the respective secondary standard and that trace metal concentrations are generally low because of reactions with sulfides (AUC, 2012). The applicant reported exceedences of the respective secondary standards for selenium, lead, arsenic, barium, and cadmium for less than 4 percent of the wells tested from one report (Lowry et al., 1986).

<u>Wasatch and Fort Union Aquifer</u>

In some cases, groundwater in the Wasatch and Fort Union Formations is discussed as a single aquifer resource, whereas workers separate the formations as distinct aquifers. For this application, the applicant discusses the regional setting both as a single Wasatch/Fort Union aquifer system and as individual aquifers in a Lower Tertiary Aquifer System.

The applicant reports that, due to the variable, discontinuous, and lenticular nature of sandstone lenses in the Wasatch/Fort Union aquifer, the water quality is highly variable over relatively short distances (AUC, 2012). TDS concentrations range from 250 to 6,000 mg/L with little correlation between well depth and TDS concentration. Groundwater with TDS concentrations less than 500 mg/L are enriched in bicarbonate, whereas groundwater with TDS concentrations above 500 mg/L are more enriched with sodium. Deeper wells generally show an increase in sodium (AUC, 2012).

Lance and Fox Hills Aquifer

In general, groundwater in the Lance and Fox Hills formations is discussed as a single aquifer (Merewether, 1996). The applicant reports that groundwater quality data for the Lance/Fox Hills aquifer are sparse compared to the outcrop areas near the margins of the Powder River Basin (AUC, 2012). In the outcrop areas, TDS concentrations range from 350 to 3,500 mg/L, with variable major ion compositions. In the central basin areas, the groundwater quality is typically a sodium bicarbonate-sulfate composition.

2.5.3.2.2 Site-Specific Groundwater Quality

The applicant presents site-characterization, groundwater-quality data for samples collected from: (1) monitoring wells installed and sampled by the applicant within the Proposed Project area (2010 through 2012), (2) monitoring wells installed and sampled by a former operator/applicant (1979 through 1991), and (3) existing nearby water supply wells sampled by the applicant (2010 through 2012). The data for each group as reported by the applicant are discussed below.

Newly Installed wells

As discussed in SER Section 2.7, the applicant installed 35 onsite wells: 21 wells in the PZA unit (wells designated with the PZM prefix) and 7 wells in each of the overlying (wells designated with the OM prefix), underlying (wells designated with the UM prefix), and shallow (wells designated with the SM prefix) hydrostratigraphic units.[13] Based on Addendum 2.7-B, TR Table 2.7B-31b, the applicant included only 10 of the 21 wells installed in the PZA unit as part of the baseline water-quality data for that unit (i.e., collection of four quarters of data from each of the wells); the other 11 wells were used for hydrogeologic testing. The applicant included all seven wells in each of the overlying, underlying, and shallow units for characterization of those respective units. The applicant reports that three wells in the shallow SM unit were dry and hence no samples were collected (AUC, 2012).

The applicant summarizes the water for each of the four sampling events for each well in table form (AUC, 2012). The applicant provides a summary table for the range of the constituents analyzed for each of the units.

The applicant provides a comparison of the water-quality constituent results on an individual well basis to water-quality criteria for which a criterion has been established or proposed (AUC, 2012). The criteria include WDEQ Class I, II, or III Standards, and the National Primary Maximum Contaminant Levels (MCLs) and Secondary Standards, as established by EPA. A summary of the exceedences of the MCLs are as follows:

SM unit:	radon (3 wells), gross alpha (2 wells)
OM unit:	radon (3 wells), gross alpha (2 wells)
PZA unit:	uranium (5 wells), arsenic (3 wells), cadmium (1 well), lead (1 well), radium (9 wells), radon (10 wells), gross alpha (10 wells)
UM unit:	radon (3 wells), gross alpha (2 wells), arsenic (3 wells), radium (1 well)

[13] The applicant refers to the various units at which wells were screened as hydrostratigraphic units rather than aquifers. The applicant argues that, based on low yields/transmissivities, two units (the SM and UM units) do not meet the definition of an aquifer (i.e., yielding a significant amount of groundwater to wells or springs). However, in its responses to RAIs, the applicant also referred to the SM unit as the water table aquifer.

All wells exceeded the secondary standards for one or more of the following: iron, manganese, sulfate, TDS, or pH (AUC, 2012). The applicant estimates that the WDEQ class of use designation for wells will either be Class III or Class IV; however, for the PZM wells, the applicant estimates that the designation will only be Class IV. A Class III well as designated by the State of Wyoming is suitable for livestock watering, whereas a Class IV well is suitable for industrial use only.

In TR Section 2.9.8.1, the applicant discusses methods used to collect the groundwater samples from the onsite monitoring wells. The applicant reports that the groundwater samples were collected using EPA-approved low-flow procedures. According to the applicant, the low-flow procedures allow for sample collection after selected water-quality parameters in the purge water rather than purge three well volumes. The parameters monitored for stabilization include pH, temperature, and conductivity. The applicant states that all sampling methods were conducted in compliance with quality assurance/quality control guidance in applicable NUREGs and RGs (AUC, 2012).

In addition to the baseline sampling, the applicant reports water quality for several other PZM wells. In TR Addendum 2.7-B, Table 2.7B-31b, the applicant reports that water-quality samples were collected at eight additional PZM wells, but TR Addendum 2.7-B, Table 2.7B-31a lists nine wells. The additional wells were generally sampled only once (the exception is PZM4, which was sampled twice) and for several wells, only a subset of analytes.

In TR Section 2.9.8.2, the applicant states that the groundwater sampling at the onsite wells and nearby water-supply wells was initiated in August 2010. The exact dates of sampling are only found in the water-quality summary tables for the various wells. The sampling from the onsite wells was initiated in September 2010 and completed in May 2012.

The applicant analyzes groundwater quality through the use of piper diagrams (AUC, 2012). The applicant's overall summary is that (1) groundwater quality of the PZA unit is relatively consistent in composition, with sodium and sulfate as the dominant ions, (2) groundwater quality in the UM unit tends to have higher sodium levels (compared to the PZA unit), with more variation in sulfate or carbonate as the major anion, and (3) groundwater quality in the OM and SM units often have higher calcium levels (compared to the PZA unit), with a large degree of variation.

The applicant also presents stiff diagrams of the water quality from the four hydrostratigraphic units along a selected cross section (AUC, 2012). The applicant states that the stiff diagrams demonstrate (1) a consistent fingerprint of the PZM wells, (2) the dilute nature of the underlying (UM) wells, and (3) the tendency for the uppermost aquifer (SM aquifer) and overlying aquifer (OM aquifer) to have a greater proportion of divalent cations (calcium and magnesium) and the greatest degree of variation. The applicant attributes the variation in the upper two units to the discontinuous nature of the more permeable "aquifers" and an abundance of low permeable mudstones.

Historical data

The applicant discusses the comparison of the historical data from the previous operators with data collected by the applicant from the onsite monitoring wells. The applicant provides a caveat for the comparison in that the historical data lack precise well completion information and laboratory reports to review. The applicant stated that the comparison should be used "mainly to confirm" the data collected by the applicant from the onsite wells.

The applicant provides a summary table of the historical water quality and analyzes the data using piper diagrams. The applicant states that the historical data are consistent with the data collected from the onsite wells and supports the applicant's conclusions. The applicant assigns historic wells that had a suffix designation with a "U" to correspond to the OM aquifer. The applicant states that, although one historic well, RI-2, was assigned to the production zone, the low levels of uranium and radium may suggest it represents the overlying unit (AUC, 2012).

Nearby Water Supply Wells

The applicant sampled water quality from 15 nearby privately owned water supply wells. The applicant presents the analytical results for each sampling location in table form. The sampling was generally performed quarterly; however, for approximately half of the wells, the second sampling event was approximately 1 year after the first event. The applicant did not document the sampling method used. The applicant estimates that one well is screened in the water table aquifer, two wells are screened in the overlying aquifer, four wells are screened in the production aquifer, two wells are screened in the underlying aquifer and six wells do not have data to estimate the screened horizon. The applicant provides a table listing the ranges of constituent concentrations for each well.

The applicant provides a comparison of the water-quality constituent results on an individual-well basis to the water-quality criteria for which a criterion has been established or proposed. The criteria include the applicant's WDEQ Class I, II, or III Standards and the National Primary MCLs and Secondary Standards, as established by EPA. A summary of the exceedences of the MCLs are as follows:

Water Table:	radon (1 well)
OA:	radon (2 wells), radium (1 well)
PZA:	radon (4 wells), gross alpha (3 wells), uranium (2 wells), radium (1 well)
UM:	gross alpha (1 well)
Unknown:	radon (3 wells), gross alpha (1 well), lead (1 well)

All wells exceeded the national secondary standards for one or more of the following: iron, manganese, sulfate, TDS, or pH (AUC, 2012). The applicant estimates that the WDEQ class of use designation for the wells will either be Class III or Class IV.

2.5.3.3 Staff Review

The staff reviewed the groundwater quality information provided by the applicant with regards to meeting SRP Acceptance Criterion 2.7.3(4) that applications provide reasonably comprehensive chemical and radiochemical analyses of water samples to characterize the preoperational baseline conditions for the mineralized and surrounding aquifers (NRC, 2003).

The staff reviewed and verified the applicant's references on the water quality of the regional aquifers (Feathers et al., 1981; Lowry et al., 1986; Rankl and Lowry, 1990). The staff finds that the applicant accurately conveyed the information from the referenced articles. Therefore, the description of the regional water quality is acceptable.

The suite of constituents analyzed for each well exceeded the list of constituents in TR Addendum 2.7-B, Table 2.7B-22, which is based, in part, on the list recommended by the SRP for site characterization. The additional constituents consist largely of radon and radon progeny. Because the constituents exceed those recommended in guidance, and the site conditions do not warrant any additional site-specific analyte, the staff finds the suite of constituents analyzed by the applicant acceptable.

The staff finds that the groundwater characterization data set is comprehensive but may be biased due to (1) sampling locations for the PZM wells that were within the designated ore body, (2) sampling frequency and duration that may not truly reflect seasonal variation, and (3) purging minimal volumes during the sampling.

First, as can be seen by TR Figure 2.9-1, all PZM wells sampled for baseline characterization, except well PZM6, are located within the mapped areas of “ore bodies.” Furthermore, the wells’ screen lengths were 6.1 m (20 ft) except for well PZM8, which was 10.6 m (35 ft). The total thickness of the PZA unit ranges between 23 and 61 m (75 and 220 ft). Locating the wells within with limited screen lengths to highly mineralized horizons may bias the analytical results to higher concentrations, notably for the uranium and associated radiological constituents, which are expected to be more concentrated in the aquifer matrix in the mineralized area.

The staff evaluated this potential bias by comparing the analytical results for wells screened in the PZA unit with the historical data and the nearby water supply wells, which are screened in the entire ore body unit and outside of the mineralized areas. The staff’s comparison of the results yielded the following: the range in concentrations for most parameters was identical for the data sets except for increases in radium and possibly uranium at the PZM wells and slight decreases in aluminum, iron, and manganese concentrations. Given the similarity in data sets, the staff finds that the applicant’s potential bias in having sampling locations in the PZM unit near or within mineralized areas can be accounted for and thus is acceptable for site characterization purposes. The exception is well PZM2. The first two samples collected from well PZM2 had significantly higher pH levels and significantly lower uranium concentrations compared to the final two sampling events, suggesting that the well was not fully developed or not fully purged before these two sampling events. The staff will include a preoperational license condition requiring the applicant to resample this well for the two abnormal sampling results prior to any major site construction. This license condition is identified in SER Section 2.5.4.

Second, the sampling events for the applicant’s site characterization data consisted of four sampling events for each well. In most cases, the interval for all subsequent sampling events was not uniform at a 3-month interval (i.e., quarterly). In general, the interval between most sampling events that the applicant performed was 2 months. The staff guidance on sampling frequencies for site characterization data in the SRP is confusing, as the criterion requires the staff to evaluate potential seasonal fluctuations in quality (which implies at least annual sampling) but suggests a sampling interval of 15 days is acceptable. Using 2-month intervals, which the applicant used, results in obtaining water quality only during an 8-month period out of a year. The staff finds that this 8-month period is acceptable for this site as the sampling interval was sufficient to obtain independent samples.

The applicant used low-flow sampling procedures to sample the onsite monitoring wells for site characterization.[14] The applicant did not describe the sampling method beyond general statements in the application that the method was consistent with an EPA-approved method. The applicant did provide the field sampling data sheets and laboratory reports for the sampling events (AUC, 2012). In addition, in response to RAIs, the applicant provided additional information on the low-flow sampling methodology (AUC, 2013b). The applicant stated that studies have shown that comparative results are obtained regardless of placement of the pump within the well screen (i.e., top, middle, or bottom); that AUC's well construction methods allow for proper placement of pumps within the well screen; and that the sampling team established the volume of the pump and discharge tubing to calculate minimum purge volumes, optimal discharge rates to minimize mobilization of solids and stabilize drawdown, and time required to evacuate one volume of the flow-through cell to establish the frequency of water-quality parameter measurements (AUC, 2013b). Based on the staff's review of the data sheets, purging of a well under the low-flow sampling protocols consisted of the following:

Flow rates:	100 to 400 milliliters per minute
Stabilization parameters:	eH was not used as a stabilization parameter
Drawdown:	generally greater than 0.30 m (1 ft)—the drawdown did not stabilize, particularly for low-yielding wells (e.g., all UM wells)
Purge volumes:	3. 78 to 18.9 L (1 to 5 gallons)

This low-flow sampling method differs from those used by previous applicants for site characterization and by existing licensees for their groundwater protection monitoring programs. Although this purge method is listed as an acceptable method by various established standards (ASTM, 1992), and the staff will accept this purging method for site characterization purposes as the samples were representative of the composite aquifer, the staff finds that this purging and sampling method is not acceptable as sampling protocols for the operational groundwater protection monitoring programs for the reasons stated below.

The low-flow sampling was developed as a low-stress method of sampling shallow small-diameter wells in lieu of the more conventional sampling method using a bailer. Sampling with a bailer typically resulted in mixing the stagnant water in a well and creating an artificial head that resulted in (1) purging 3-well volumes to minimize the impact of the stagnant water chemistry of the sample, and (2) sediment-laden samples. The sediment-laden samples would be artificially filtered to remove the suspended sediments that resulted from the sampling method and would not be reflective of the quality of groundwater in the aquifer. The low-stress sampling procedures used low-flow techniques that created minimal drawdown, which did not induce artificial sediment flow, and, because the pump was in the well screen, did not require purging 3-well volumes before sampling because it did not stir up the standing water column, especially if the sampling equipment is "dedicated" (i.e., is permanently installed in the well). In lieu of a specified purge volume, the low-flow sampling methodology bases the extent of purging on stabilizing selected parameters generally measured in the discharge.

The methodology has become more accepted as a standard or perhaps preferred sampling technique. In some circles, workers have offered passive sampling devices, which are based

[14] It should be noted that sampling of SM wells was simply a "grab" sample (i.e., no purge), because of the small saturated thickness, and that the sampling conducted at well UM3R was more of the conventional method after a purge of 0.2 well volumes.

on flow through the well under natural conditions. For this type of sampling methodology, no purging is required.

The sampling methodology performed at existing ISR facilities is a hybrid. Typically, a submersible electrical pump is installed in a well above a well screen and purges 1- to 3-well volumes before sampling. A selected set of indicator parameters is measured at the end of the purging to show that the quality has stabilized. In general, based on the amount of standing water column in a well, the volume that is purged for a typical ISR well is between several tens and a few hundred gallons of groundwater. In general, a discharge permit is required to discharge purge water onto the ground, or, in cases where the quality may be degraded, collected in portable tanks and brought back to the processing plant and placed with the process or waste water stream.

As noted in the responses to the RAIs (AUC, 2013b), the applicant used dedicated bladder pumps to perform the purging and sampling of the site characterization wells and provided a significant rationale as to why low-flow sampling is appropriate. In addition, the applicant states that wells will be purged before sample collection but does not specify its proposed procedures. However, in TR Section 5.7.8.1.5, the applicant states that "low-flow purging may be used in certain instances" (AUC, 2012). Based on the level of detail on the benefits of low-flow sampling, the staff anticipates the applicant will use the low-flow purging and sampling methodology as its preferred method. The staff does not agree with the applicant that low-flow purging and sampling techniques are appropriate for the groundwater protection monitoring program for the following reasons.

First, the pump has to be placed within the well screen in order for the method to obtain representative samples from the aquifer. As noted on the field data, for one pump that had to be repaired, placing the pump in a well in which the screen is telescoped is difficult, especially for the depth of wells at the Proposed Project. Second, in a review of the field data sheet, of the 39 wells sampled on a quarterly basis, the equipment at three wells developed a leak in a line or bladder, which made the sampling equipment inoperable. The root cause for failure was not discussed but could be related to chemistry or high hydraulic pressures. Third, sediment-laden samples have not been a problem for monitoring wells at most ISR facilities as the well completions at ISR facilities and semi-consolidated nature of formations generally do not yield samples with artificially high sediment load during sampling as is the problem associated with sampling of unconsolidated formations. Fourth, although the applicant states that volumes of the pump and discharge line were used to establish minimum purge volumes, the staff cannot confirm the calculations. It is the staff's understanding that the smallest discharge line is 3/8 inch in diameter. For the typical depth of 105 m (345 ft) for main wells in the PZA unit, the volume for a 105 m (345-ft) long, 1 cm (3/8-in) diameter discharge line is 7.57 L (2 gallons). In many cases, for the sampling performed by the applicant, the purge volume was less than 5.67 L (1.5 gallons). Fifth, the applicant cites references for low-flow sampling but almost all papers evaluating low-flow sampling are based on the assumption that the well has reached steady state (i.e., the volume of groundwater entering a well is equal to the discharge from the pump). In the case of the applicant, most wells did not reach steady-state conditions. Most importantly, the applicant has not demonstrated the impacts on the groundwater protection monitoring programs, specifically the excursion monitoring program. While the previous sampling methods have been shown to be effective, even for dilution based on fully penetrating wells, the staff is uncertain that the same, upper control limits would be effective under the low-flow sampling techniques. Consequently, the staff has determined that the low-flow purging and sampling methodology is not appropriate for the groundwater protection monitoring programs, and therefore the applicant will not be permitted to use that sampling method in its groundwater monitoring program.

Finally, the staff wishes to clarify two comparisons made by the applicant to established standards. First, the applicant compared radon to an EPA maximum containment level (MCL). However, radon does not have an approved MCL. EPA does have proposed regulations for a radon MCL, but those regulations were not promulgated. Second, the applicant compared the gross alpha activity measured in the groundwater directly to the MCL standard. However, for a proper comparison, if the gross alpha activity exceeds the MCL standard, then contributions to activity by radon and uranium must be subtracted from the total activity. Due to the analytical method used, radon should have been removed; thus, uranium is the only parameter to be accounted for. Based on levels of uranium detected, if its activity were subtracted from the total gross alpha, the resultant net activity may be less than the MCL standard.

2.5.4 Evaluation Findings

The staff reviewed the preoperational surface-water quality at the Proposed Project area in accordance with applicable Section 2.7.3 of the SRP. 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 groundwater quality for the underlying, overlying, and shallow units. The applicant has initially addressed the issue of impacts of CBM-produced water on the surface water. 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 preoperational license condition listed below, meets the applicable acceptance criteria of SRP Section 2.7.3 and the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

To complete the preoperational baseline water quality, the staff will require the applicant to resample well PZM2 for two sampling events as specified in License Condition 12.12. The licensee will submit the data prior to staff scheduling a pre-operational inspection.

2.6 Background Radiological Characteristics

This section discusses the background radiological characteristics of the surrounding environment. The background radiological characteristics are used to evaluate the potential radiological impact of operations on the environment. This includes 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 are in compliance with 10 CFR Part 40, Appendix A, Criterion 7.

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 in SRP Section 2.9.3

(NRC, 2003). Also, as discussed in RG 4.14 (NRC, 1980a), the preoperational monitoring program needs to include at least 12 consecutive months of data, in accordance with 10 CFR Part 40, Appendix A, Criterion 7, including the submittal of complete environmental monitoring before any major site construction.

2.6.3 Staff Review and Analysis

2.6.3.1 Air (Particulate and Radon) Sampling

RG 4.14 (NRC, 1980a) 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. Factors to consider in determining sampling locations include: (1) average meteorological conditions (windspeed, wind direction, and atmospheric stability), (2) prevailing wind direction, (3) site boundaries nearest to the mill, (4) direction of nearest occupiable structure, and (5) location of estimated maximum concentrations of radioactive materials.

RG 4.14 (NRC, 1980a) recommends that air radon, soil samples, and direct radiation measurements be collected at the same locations as the air particulate monitoring station and that the samples and measurements should be collected at locations in compass sectors that originate from the center of the milling area. The applicant stated in TR Section 2.9.7 (AUC, 2012) that no tailings impoundment will be created during the Proposed Project. The staff has determined that the center would be the proposed mill area (i.e., proposed CPP).

The applicant stated that the locations of the air particulate and radon monitoring stations are located in TR Figure 2.9-1 (AUC, 2012). The staff reviewed the sampling locations in TR Figure 2.9-1 (AUC, 2012) and determined that the locations of the air particulate (air radon, soil, and direct radiation) sampling stations are consistent with the recommended locations, as defined in RG 4.14 (NRC, 1980a) with respect to the revised center of the proposed mill area (CPP).

For operations, RG 4.14, Table 2 (NRC, 1980a), states that the three locations at or near the site boundaries in different sectors that have the highest predicted concentrations of airborne particulates, as well as preoperational sampling, should be the same as operational locations. The staff determined that the current air sampling stations identified in TR Figure 2.9-1 and AUC responses to RAIs (AUC, 2012, AUC 2015a) are consistent with the site selection as recommended in RG 4.14 for air particulate sampling for both preoperational and operational locations, using the central processing facility as identified in TR Figure 2.9-1 (AUC, 2012, AUC 2015a). In SER Section 2.2, the staff determined that the three highest wind rose sectors (winds from) are the west-southwest sector, the southwest sector, and the northwest sector. The staff determined that the three sectors with the highest airborne particulate concentrations, based on the above wind rose sectors for air particulate sampling, are the east-northeast sector, the northeast sector, and the southeast sector. The applicant stated that, in July 2012, it moved three of its five air sampling stations (AM-4, AM-5, and AM-6) to new locations and began a new air particulate, radon, soil, and integrated gamma sampling program. The revised sampling locations are AM-4-2, AM-6-2, AM-7, and AM-8 (AUC, 2015a). The revised monitoring locations were selected based on wind rose data from the onsite meteorological monitoring program and the proposed CPP location. Monitoring continued at all five of the air sampling stations into November 2013, a total of 16 months.

In addition to these changes, the applicant reviewed the current air sampling station locations and has determined that air sampling station AM 5-2 is not in a location that meets the RG 4.14 recommendation. Therefore, AUC proposes relocating this air sampling station to a location southeast of the CPP and renaming this air sampling station AM#7. Also, the applicant proposes the relocation of air sampling station AM-1 in the vicinity of the Leavitt Ranch House and renaming it AM-8. AUC will begin collecting 12 months of preoperational data from these two new sampling locations (AUC, 2015a).

Although the applicant had established and collected environmental data from a set of environmental air sampling stations based on the original location of the CPP, the staff has determined that the applicant revised the location of the CPP and made significant changes to the sampling locations for air particulates (which also included air radon, soil, and direct radiation). TR Figure 2.9-1 shows these changes of air sampling locations. The staff reviewed the revised air sampling stations in TR Figure 2.9-1 and determined that the applicant has adequately selected the air sampling stations in the locations of three sectors with the highest concentrations, consistent with SRP Acceptance Criterion 2.9.3(1) and RG 4.14. The staff has reasonable assurance that the revised air sampling locations (including air particulate, air radon, soil, and direct radiation) are located in a manner consistent with the principal wind directions reviewed in TR Section 2.5. Because of the significant changes in the sampling locations due to the relocation of the CPP, and the applicant's commitment to provide results from the data collected from AM-7 and AM-8 and results from other sampling media, the staff has determined that a license condition is warranted to ensure that all preoperational environmental data are completed before the facility begins operations. This license condition is addressed in the evaluation findings in SER Section 2.6.4.

RG 4.14, Table 1 (NRC, 1980a), states that the frequency for air particulate sampling is a filter change weekly or more frequently, as required by dust loading. Dust loading can adversely affect the activity on the filter, as certain radioactive particles (i.e., alpha and beta) on the filter can be absorbed by the dust before reaching the detector. If dust loading is present on an air filter, the amount of dust should be accounted for to correct for the true activity on the filter. The applicant stated that preoperational air sampling was continuous and filters were initially collected weekly, but filter replacement testing was extended to monthly in 2011. The applicant indicated that the change in filter replacement was due to cost-efficiency and safety for personnel working in a sometimes harsh site environment (AUC, 2012). The applicant indicated that the filter size was increased to 101.6 millimeters (mm) (4 in) from 47 mm (1.85 in) (AUC, 2012). The applicant provided a technical basis in TR Addendum 2.9-C (AUC, 2012). The applicant provided flow-rate results of several air sampling units (AM-1, AM-3, AM-4, AM-5, AM-6, AM-4-2, AM-5-2, AM-6-2, and all air samplers combined) over several years (i.e., 2010 to 2012), where both the 47-mm (1.85 in) and the 101.6-mm (4-inch) filters were used (AUC, 2014a). The staff reviewed the results and determined that the change from a 47 mm (1.85 in) to a 101.6 mm (4 in) filter size did not produce any significant change to the flow rate. When viewing the flow-rate results for all air sampling combined, as well as the individual air sampling units, the flow rate remained consistently between 28-42 Lpm. The staff has determined that the use of the 101.6-mm (4-in) filter at a flow rate of 30-25 liters per minute is sufficient to operate over a 4-week sampling period, and dust loading should not adversely affect the activity on the air filters. The staff has reasonable assurance that the applicant can operate for a 4-week sampling period and not adversely affect the flow rate due to dust loading. Therefore the staff has determined that the applicant is consistent with SRP Acceptance Criterion 2.9.3(1) (NRC, 2003) and RG 4.14 (NRC, 1980a) and that the change in the size of the air filter from 47 mm (1.85 in) for a 1-week sampling period to 101.6 mm (4 in) for a 4-week sampling period is acceptable.

RG 4.14 (NRC, 1980a) states that a complete preoperational report with 12 consecutive months of data will be submitted before beginning milling operations for air particulate samples for each location. The air particulate samples should be collected weekly and composite quarterly, and analyzed for natural uranium, Ra-226, Th-230, and Pb-210. The applicant collected air particulate samples quarterly for 12 consecutive months and analyzed the samples quarterly for natural uranium, Ra-226, Th-230, and Pb-210, and provided the results in TR Table 2.9-12 through TR Table 2.9-15 (AUC, 2012). The staff reviewed the information and results, as provided in TR Table 2.9-12 through TR Table 1.9-15, and determined that the applicant met the recommendations for frequency and analysis of air particulate sampling as described in RG 4.14 (NRC, 1980a), with the exception of the license condition identified in this section of the SER.

RG 4.14 (NRC, 1980a) states that a complete preoperational report with 12 consecutive months of data will be submitted before beginning milling operations for air radon samples for each location. The air radon samples should be placed in the same locations as for air particulate samples, collected monthly, and analyzed for Rn-222. The applicant collected air radon samples quarterly for 12 consecutive months and analyzed the samples for Rn-222; the results are provided in TR Table 2.9-11 (AUC, 2012). The staff reviewed the information and results, as provided in TR Table 2.9-11 (AUC, 2012), and observed that the applicant collected air radon quarterly, as opposed to a monthly collection, as recommended in RG 4.14 (NRC, 1980a). The staff has determined that the quarterly collection of air radon, as opposed to monthly, is acceptable. The staff recognizes that the 10 CFR Part 20, Table 2, limits for Rn-222 with daughters in air (0.1 pCi/L) may be very difficult to achieve with a collection frequency of 1 month. A longer collection period (i.e., quarterly) allows more “tracks” to be detected in radon collection devices. The greater number of “tracks” detected in a radon collection device increases the sensitivity and the probability of detection and thus provides a higher quality result. Therefore, the staff has determined that the quarterly collection of air radon is acceptable. The staff has determined that the applicant met the recommendations for the frequency and analysis of air radon sampling as described in RG 4.14 (NRC, 1980a), with the exception of the license condition identified in this section of the SER.

2.6.3.2 Radon Flux

RG 4.14 (NRC, 1980a) states that up to 10 measurements should be taken at the center of a reference location and at distances of 750 m (2,461 ft) and 1500 m (4,921 ft) in each of four directions during each of 3 months to analyze for Rn-222 flux. The applicant stated in TR Section 2.9.7 (AUC, 2012) that baseline radon flux measurements are neither appropriate nor necessary to support this application. The applicant stated that no uranium tailings impoundment will be created during the Proposed Project. The staff reviewed this application and other applications (NRC, 2014b) and determined that radon flux measurements are not necessary. The staff has determined that application(s) that do not include a plan to install and operate tailings impoundments do not require radon flux measurements. The staff has determined that the purpose of radon flux measurements is to demonstrate compliance with 10 CFR Part 40, Appendix A, Criterion 6, when a cover is installed over a tailings impoundment or wastes at the end of milling operations to close the waste disposal area. No tailings impoundments are planned for the Proposed Project, so the measurement of radon flux for environmental monitoring is not applicable. Therefore, the staff finds acceptable the applicant’s decision to not conduct radon flux measurements during preoperations and operations.

2.6.3.3 Direct Radiation

RG 4.14 (NRC, 1980a) states that up to a total of 80 direct radiation measurements (gamma exposure rate) should be taken at 150 m (492 ft) intervals to a distance of 1500 m (4,921 ft) in each of eight directions from the center of the milling area or at a point equidistant from the milling area and tailings disposal area before site construction, using passive integrating devices or portable survey instruments. In addition to these direct radiation measurements, RG 4.14 (NRC, 1980a) states that five or more direct radiation measurements should be taken in the same locations as for air particulates before site construction, using passive integrated devices, a pressurized ionization chamber, or portable survey instruments. The applicant stated in TR Section 2.9.5 (AUC, 2012) that passive monitoring of gamma doses at the site used highly sensitive optically stimulated luminescent dosimeters, that these passive devices were collected quarterly at the air particulate monitoring stations, and that the results were provided in TR Table 2.9-10 (AUC, 2012). The staff reviewed the information and results, as provided in TR Table 2.9-10 (AUC, 2012), and observed that the applicant collected direct radiation measurements quarterly at each sampling location for 12 consecutive months for exposure (expressed in millirem). The staff has determined that the applicant met the recommendations for frequency and analysis of direct radiation, as described in RG 4.14 (NRC, 1980a), with the exception of the license condition identified in this section of the SER.

The applicant indicated, in TR Section 2.9.2 (AUC, 2012), that it conducted an extensive gamma radiation baseline survey with some soil sampling before construction using all-terrain vehicles, gamma survey meters, and a global positioning system. Surface and subsurface soil samples were also collected at 15-cm depths up to 1 meter and were analyzed for Ra-226 and other radionuclides (AUC, 2012). The applicant stated in TR Section 2.9.2.2.1 that more than 134,000 valid gamma radiation exposure data points were collected with an exposure rate range of 7.4 to 23 micro-roentgens per hour, and that exposure rates were corrected with a Bicron micro-rem meter and expressed as a dose rate. The applicant also stated in TR Section 2.9.2.2.3 (AUC, 2012) that soil concentrations were correlated with the dose rates at 13 selected locations. The applicant stated in TR Section 2.9.2.3 (AUC, 2012) that the baseline gamma exposure and dose rates provided in TR Figures 2.9-9 and 2.9-12 (AUC, 2012) can be used during and after operations to evaluate changes associated with facility operations. The staff has determined that the gamma radiation baseline survey exceeds the recommendations for direct radiation measurements as described in RG 4.14 (NRC, 1980a). The staff recognizes the value of the gamma radiation baseline survey, as the results can serve to support future decontamination of the site. The staff finds the gamma radiation baseline survey method and results acceptable.

2.6.3.4 Soil Sampling

RG 4.14 (NRC, 1980a) states that up to 40 surface soil samples should be collected at 300-m (984 ft) intervals to a distance of 1,500 m (4,921 ft) in each of eight directions from the center of the milling area, that five subsurface soil samples should be collected at the center reference locations and at distances of 750 m (2,461 ft) in each of four directions once before site construction, and that all samples must be analyzed for Ra-226 and 10 percent of the samples for natural uranium, Th-230, and Pb-210 for both surface and subsurface soils. In addition to these soil samples, RG 4.14 (NRC, 1980a) states that five or more surface soil samples should be taken at the same locations as for air particulates before site construction and analyzed for natural uranium, Ra-226, Th-230, and Pb-210.

The applicant stated in TR Section 2.9.3 that surface soil samples were collected along transects in eight compass directions from a proposed processing plant location at 300-m intervals, and in addition, surface soil samples were collected at five air particulate monitoring stations at a depth of 5 cm (2 in). In TR Section 2.9.3, the surface soil samples were analyzed for Ra-226, with 10 percent of the surface soil samples analyzed for Ra-226, natural uranium, Th-230, and Pb-210. The applicant indicated that subsurface soil samples were taken at the center, and at 750 m (2,461 ft) in the north, south, east, and west directions of a potential CPP location; that samples were collected in approximately 15-cm (6 in) increments to a depth of 1 m (39.4 in); and that samples were analyzed for Ra-226, natural uranium, Th-230, and Pb-210. The results of the surface and subsurface soil samples were reported in TR Table 2.9-4 and TR Table 2.9-6 (AUC, 2012).

The staff reviewed the information and results, as provided in TR Table 2.9-4 and TR Table 2.9-6 (AUC, 2012) and observed that the applicant collected surface soil and subsurface soil samples at each location, including the air particulate sampling stations, before the construction of the proposed facility, and the staff has determined that the applicant met the recommendations for frequency and analysis of surface and subsurface soil sampling, as described in RG 4.14 (NRC, 1980a), with the exception of the license condition identified in this section of the SER. The staff has determined that the applicant has collected soil sampling at depths of 5 and 15 cm (2 and 6 in), consistent with SRP Acceptance Criterion 2.9.3(2) (NRC, 2003) and RG 4.14 (NRC, 1980a), and therefore the soil sampling program is acceptable.

2.6.3.5 Sediment Sampling

RG 4.14 (NRC, 1980a) recommends that an upstream and a downstream sediment sample passing through the site or from offsite surface waters that may be subject to direct runoff from potentially contaminated areas be collected once during the spring runoff and in late summer for locations disturbed by construction and that the samples be analyzed for natural uranium, Ra-226, Th-230, and Pb-210. RG 4.14 (NRC, 1980a) also recommends that a sediment sample from an onsite water impoundment (e.g., lakes, ponds), or offsite impoundments that may be subject to direct surface runoff from potentially contaminated areas be collected once before site construction and that it be analyzed for natural uranium, Ra-226, Th-230, and Pb-210.

The applicant stated in TR Section 2.9.4 that a total of 22 sediment samples were taken in 2010 and 2011 at surface-water sampling locations; that these samples were analyzed for Ra-226, natural uranium, Th-230, and Pb-210; and that the results were reported in TR Table 2.9-7 and TR Table 2.9-8 (AUC, 2012). The applicant identified the sampling locations in TR Figure 2.9-1 (AUC, 2012).

The staff has determined that the applicant has collected a sufficient number of sediment samples from multiple sediment sampling points that exceeded the recommended number of sampling points as described in RG 4.14 (NRC, 1980a). The staff has determined that there are a sufficient number of sediment sampling points to detect potential contamination due to surface runoff or overflow from water impoundments. The staff reviewed the information and results, as provided in TR Table 2.9-7 and TR Table 2.9-8 (AUC, 2012), and determined that the applicant met the recommendation for sampling location, frequency, and analysis for sediment sampling, as described in RG 4.14 (NRC, 1980a).

2.6.3.6 Vegetation, Food, and Fish Sampling

RG 4.14 (NRC, 1980a) recommends three vegetation samples be taken semiannually in grazing areas near the site in different sectors that will have the highest predicted air particulate concentrations during the grazing season; three of each type of food crop or livestock raised within 3 km (1.86 mi) of the site at time of harvest; and fish sampling in each body of water from lakes, rivers, and streams in the site environs that may be subject to seepage or direct surface runoff from potentially contaminated areas. These samples (vegetation, crops, and fish) should be analyzed for natural uranium, Ra-226, Th-230, Pb-210, and Po-210.

The applicant indicated in TR Section 2.9.10 that vegetation grab samples were collected at the sampling locations identified in TR Figure 2.9-1 and that the results are provided in TR Table 2.9-24 (AUC, 2012). The applicant stated that two of the three rounds of vegetation samples were collected during the grazing season in October and November 2014 and AUC plans on collecting the third round of vegetation samples when the grazing season begins in 2015 (AUC, 2015a). The applicant stated that, rather than use the results from sampling locations RC-RAD-1, RC-RAD-2, and RC-RAD-3, it has decided to use alternate sampling locations to perform the vegetation sampling and that the locations are reflected in TR Figure 2.9-1 (Revision 4) (AUC, 2015a). The staff has determined that a license condition is warranted to ensure that all environmental sampling data are completed before facility operations. This license condition is addressed in the evaluation findings in SER Section 2.6.4.

The applicant stated that AUC will collect three samples weighing 4 kilograms (kg) (8.8 pounds [lb]) each, of frozen ground beef, for laboratory analysis to meet RG 4.14 preoperational radionuclide minimum detectable activity requirements. A local rancher who owns grazing land adjacent to the proposed CPP was to provide the beef samples to AUC from a slaughtering event in December 2014. There are no crops grown within 3 km (1.86 mi) of the proposed CPP location; therefore AUC will not perform crop sampling (AUC, 2015a). The staff has reasonable assurance that the applicant will provide the results of the livestock sampling. The staff has determined that the sampling of the livestock is consistent with SRP Acceptance Criterion 2.9.3(1) and RG 4.14. The collection and analysis of livestock samples are acceptable.

The staff reviewed TR Section 2.8.4.2.6 (AUC, 2012) and concurs with the applicant's statement that the ephemeral nature (precipitation events and subsequent runoff) of surface water and the lack of a deep-water habitat and water sources precludes the presence of fish. The staff also reviewed the annual regional and onsite precipitation data, as provided in TR Figure 2.5-9 and TR Figure 2.5-21 (AUC, 2012), and they support the applicant's statement in TR Section 2.8.4.2.6 (AUC, 2012). The staff finds acceptable the applicant's decision not to collect fish samples, due to the ephemeral nature of surface water and the lack of a year-round water habitat.

2.6.3.7 Surface and Groundwater Sampling

RG 4.14 (NRC, 1980a) recommends quarterly surface-water sampling from each large permanent onsite or offsite water impoundment that may be subject to direct surface drainage from potentially contaminated areas or that could be affected by a tailings impoundment and that they be analyzed for suspended and dissolved natural uranium, Ra-226, and Th-230. In addition to the quarterly surface-water sampling of water impoundments, RG 4.14 (NRC, 1980a) recommends monthly sampling of surface water passing through the sites or offsite surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a tailings impoundment failure, and that the samples be analyzed for suspended and dissolved natural uranium, Ra-226, and Th-230.

The applicant stated in TR Section 2.9.9 that surface-water sampling was conducted at four sampling locations as shown in TR Figure 2.9-1. The applicant stated that the surface-water sampling included perennial streams and ephemeral stream drainage channels where surface waters are present at least part of the year and that these locations are widely distributed across the site, including locations roughly upstream and downstream from the proposed facility locations. The results for dissolved and suspended radionuclides sampling in surface water were presented in TR Table 2.9-22 and TR Table 2.9-23 (AUC, 2012).

The staff determined that, in September 2010, the applicant collected samples of surface water passing through the site, as shown in TR Figure 2.9-1 (AUC, 2012), for four locations (SW 3, SW 11, SW 16, and SW 18) for dissolved and suspended natural uranium, Pb-210, Th-230, Po-210, and Ra-226 The staff reviewed the results of the surface-water sampling provided by the applicant in TR Table 2.9-22, TR Table 2.9-23, and TR Addendum 2.7-A, Table 2.7A-13 (AUC, 2012), and revised RAI responses (AUC, 2015a). The staff has determined that sampling the groundwater and surface water is consistent with SRP Acceptance Criterion 2.9.3(1) and RG 4.14. The collection and analysis of groundwater and surface samples are acceptable.

The applicant stated in TR Section 3.1.8 that the waste water management system will include up to four Class I deep disposal wells and a backup storage pond to temporarily store waste water as needed. The applicant showed a backup pond in TR Figure 3-1. The staff determined that preoperational surface-water sampling of backup storage ponds or impoundments is not required. Backup storage ponds or impoundments are constructed before plant operations and serve as a reservoir for potentially contaminated water within the site boundary. The staff has determined that the collection of preoperational surface-water samples is to establish a background level to determine if the operations of a site affect the environment where operations are not designed to have an impact. Therefore, the staff has determined that the collection of preoperational surface-water samples from a backup storage pond or impoundment is not necessary.

2.6.4 Evaluation Findings

The staff has completed its review of the characterization information regarding the background radiological characteristics at the Proposed Project. This review included an evaluation using the review procedures in SRP Section 2.9.2 and the acceptance criteria outlined in SRP Section 2.9.3.

The applicant has acceptably established the background radiological characteristics by providing (i) monitoring programs to determine background radiological characteristics that include radionuclides monitored, sampling frequency and methods, and locations, (ii) air sampling stations located consistent with the prevailing wind directions, (iii) time periods for preoperational monitoring that allow for 12 consecutive months of sampling, and (iv) radiological analysis of soil samples at 5-cm (2-inch) and 15-cm (6-inch) depths.

The applicant has committed to providing 12 months of environmental data from sampling stations AM-7 and AM-8, as well as the third and final samples for vegetation, before operations. The staff will memorialize this commitment in License Condition 12.13. The licensee shall submit all the data prior to staff scheduling a pre-operational inspection.

Based on the information provided in the application, and the detailed review of the characterization of the environmental pathways of the Proposed Project, the staff concludes, with the exception of the license conditions in this SER, that the information is acceptable to allow evaluation of all environmental pathways during operations and the impact from plant operations.

SECTION 3

DESCRIPTION OF PROPOSED FACILITY

3.1 In Situ Recovery Process and Equipment

3.1.1 Regulatory Requirements

General requirements for contents of an application for a specific license issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, “Domestic Licensing of Source Material,” are listed in 10 CFR 40.31, “Application for Specific Licenses.” Section 10 CFR 40.31(h) specifies that an application must clearly demonstrate how it addresses the requirements and objectives set forth in 10 CFR Part 40, Appendix A, “Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Waste Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content.” Technical Criterion 5E sets forth requirements and objectives for applicants to consider mill process designs that will provide the maximum practicable recycling of solutions and conservation of water in developing and conducting groundwater protection programs. Technical Criterion 7A sets forth the requirements and objectives for setting up a detection monitoring program for the U.S. Nuclear Regulatory Commission (NRC) to use for specifying the site-specific groundwater protection criteria as required by Criterion 5B(5).[15] Section 10 CFR 40.41(c) requires that a 10 CFR Part 40 licensee have the ability to confine the licensee’s possession and use of source and byproduct material to locations and purposes authorized by the license, and 10 CFR 40.32(c) requires that an applicant’s proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property. At an In Situ Recovery (ISR) facility, meeting these requirements includes determining that the applicant’s processes, equipment, and procedures are appropriate to confine the regulated material to the designated areas, including the subsurface.

The staff determines whether or not the applicant’s descriptions of ISR equipment, processes, and procedures are adequate to meet the above regulatory requirements, such that issuance of a license based on the proposed activities is not inimical to the common defense and security or to the health and safety of the public, in accordance with the requirements of 10 CFR 40.32(d).

3.1.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using review procedures in Section 3.1.2 and acceptance criteria outlined in Section 3.1.3 of the Standard Review Plan (SRP) (NRC, 2003).

[15] Criteria in Appendix A are written for a conventional mill setting. The conventional mill setting differs from an ISR setting in that (1) at a conventional mill, all activities conducted under the license are performed above ground whereas, at ISR settings, the uranium extraction from the ore is performed in situ (or in the subsurface), and (2) at a conventional mill, a solid byproduct material, the mill tailings, is stored above ground in a tailings pile whereas, at ISR settings, no mill tailings are generated. The staff is applying these criteria to ISR facilities, because 10 CFR 40.31(h) specifies that the applicant must meet not only the requirements but the objectives of the technical criteria in Appendix A.

3.1.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the ISR process and equipment for the Reno Creek Project (Proposed Project). Review areas addressed in this section of the Safety Evaluation Report (SER) include wellfield infrastructure, operations in the subsurface, and the proposed schedule for operations. Information presented in SER Section 3.1.3, unless otherwise stated, is from technical report (TR) Section 3.1 (AUC, 2012).

The staff reviews the ISR mine unit operations to ensure that the applicant will be able to conduct its ISR operations in a safe manner. To evaluate the implementation of the ISR process at the Proposed Project site, the staff reviews information on the following:

- the ore body characteristics and mine unit infrastructure (SRP Acceptance Criterion (1))
- well installation, completion, and mechanical integrity testing (MIT) (SRP Acceptance Criterion (2))
- number, location, and screened intervals of the excursion monitoring wells (SRP Acceptance Criterion (3))
- methods for timely detection and cleanup of leaks (SRP Acceptance Criterion (4))
- description of the in situ process (SRP Acceptance Criteria (5) and (10))
- proposed operating plans and schedules (SRP Acceptance Criterion (6))
- proper flood analyses (SRP Acceptance Criteria (7) and (8))
- plans for facility construction (SRP Acceptance Criterion (9))
- waste disposal agreement (SRP Acceptance Criterion (11))

SER Section 4.0 (Effluent Control Systems) and Section 5.0 (Operations) evaluate the health and safety requirements under 10 CFR Part 20, "Standards for Protection against Radiation," for the radiological aspects of those operations or features.

In TR Sections 1.0, 3.1, and 4.2 (AUC, 2012; 2015a), the applicant describes key equipment and processes to be employed at the proposed facility as follows:

- The licensed area consists of 2,451 hectacres (ha) (6,057 acres [ac]) in portions or all of Sections 35 & 36, Township 43 north (T43N), Range 74 West (R74W); Sections 21, 22, & 27 through 34, T43N, R73W; Sections 1 & 12, T42N, R74W; and Sections 5 & 6, T42N, R73W.
- The production area (wellfields and processing plant) consists of 195 ha (481 ac) within the licensed area.

- The proposed wellfields are divided into 15 production units, each unit will have one to seven wellfields, each with its own header house. The applicant estimates a total of 67 header houses (wellfields) for the project.

- Each header house will serve 15 to 30 recovery wells and 25 to 50 injection wells. Based on the anticipated number of header houses, the total number of production wells (injection and recovery) to be installed in the wellfields is estimated at 2,700 to 5,400 wells.

- The total number of monitoring wells is estimated at 600 wells.

- Fluids injected into and extracted from the production wells within a wellfield will be piped to a single header house, which includes manifolds, piping, process monitoring and controls for that specific wellfield. From the header house, the fluids are piped to the process plant through underground trunk-line piping.

- Controlled access to the Production Units (production and monitoring wells and header houses in a wellfield module and module building) will be maintained by perimeter fencing primarily to eliminate access by livestock.

- The production zone will consist of 5 mineralized roll fronts located at a distinct stratigraphic horizon within a 15.2 to 61 meter (m) (50- to 200-feet [ft]) thick sandstone within the lower Wasatch Formation. The total estimated recoverable uranium is 7.12 million kilograms (kg) (15.7 million pounds [lb]).

- The licensed area will include up to 4 deep wells for injection of liquid waste with a total design disposal capacity of 662 to 1,514 liters per minute (lpm) (175 to 400 gallons per minute [gpm]).

- The process plant area will consist of the Central Processing Plant (CPP), ancillary buildings, and one lined backup storage pond with a storage capacity of 119.1 acre-ft.

- The CPP will include the ionic exchange and elusion circuits. The maximum production throughput is proposed to be 41,650 lpm (11,000 gpm); the maximum restoration throughput is proposed to be 4,000 lpm (1,050 gpm). The annual yellow cake production rate is proposed to be 0.91 million kg (2 million lb) per year.

- In addition to typical ISR operations, the CPP is designed to handle equivalent feed for toll milling as defined in RIS-12-06 (NRC, 2012).

- The life for the Proposed Project is anticipated to be 6 years.

The following 11 topics are listed in the approximate order of the acceptance criteria in SRP Section 3.1.3 (NRC, 2003).

3.1.3.1 Ore Body

The applicant describes the ore body at the Proposed Project as stacked roll fronts formed at geochemical reduction-oxidation boundaries in fully and partially saturated sandstones within the Early Tertiary host formation, the lower Wasatch Formation (AUC, 2012). The depth to the top of the ore bodies ranges from 52 to 137 m (170 to 450 ft). The thickness of the ore bodies varies from 0.3 to 9.1 m (1 to 30 ft), with the upper and lower limbs of an ore body in less permeable zones at the top and bottom of the oxidized sandstones.[16] The aerial distribution of ore bodies within the Proposed Project is shown in TR Addendum 2.6-A, Figure 2.6A-17.

The applicant states that the roll fronts at the Proposed Project closely resemble those discussed in NRC's generic environmental impact statement (GEIS) (NRC, 2009). The staff was unable to identify the applicant's page reference from the GEIS. However, on page 3.1-7, the GEIS provides the following description:

> Roll-front deposits are ideally crescent- or C-shaped when viewed in cross section, with thin mineralization forming the tips of the crescents. Thick mineralization occurs in the center of the concave C-shaped ore body in the direction of groundwater flow. Individual mineralization fronts are typically from 0.6 m [2 ft] to more than 7.5 m [25 ft] thick and may be several hundred meters [feet] long. Fronts may coalesce to form ore bodies kilometers [miles] in length. Thin mineralized trails and more finely disseminated minerals branch off the main front and are located between fronts. High grade uranium roll-front deposits average about 0.2 percent U3O8. Lower grade ore (0.05–0.10 percent U_30_8) is commonly present on the unaltered side of the higher grade roll front.

The average grade for the ore is 650 parts per million (ppm) (0.065 percent) equivalent U_3O_8 (AUC, 2012). For this application, the total recoverable uranium from the ore bodies is estimated at 7.12 million kg (15.7 million lb) (AUC, 2012; 2015a).

The ore bodies accumulated at the down-gradient terminations of oxidized groundwater within the host sandstones (AUC, 2012). The ore bodies occur within sandstone lenses that are intermittently interbedded within siltstones or claystones. The thickness of the ore body is controlled by the thickness of the individual sandstone lense. In TR Section 2.6, the applicant reports that the sandstones hosting the ore bodies are commonly cross-bedded with an upward-fining graded sequence within thicknesses of 1.5 to 6.1 m (5 to 20 ft) (AUC, 2012).

Deposition of the sandstone lenses occurred in a fluvial environment in which the general flow in the streams was northwardly in direction. The Production Zone Aquifer (PZA) unit consists of a series of stacked, upward-fining sandstones resulting in an aggregate thickness of 61 m (200 ft) (AUC, 2012).

The applicant states that the uranium mineralization occurs as coatings on sand grains. The ore minerals include coffinite and pitchblende. Low concentrations of vanadium, molybdenum, selenium, and arsenic were detected in one or more core samples. Lenses of calcium carbonate cement occur but rarely contain "anomalous" uranium (AUC, 2012). In the supplemental information (AUC, 2013a), the applicant reports that uraninite was also identified as a uranium mineral in one core sample.

The applicant does not report the timing of the mineralization. Based on earlier work by others, the source of the uranium had been attributed to leaching from tuffaceous material in the White River Formation, which once overlaid the Wasatch Formation in this area (Love, 1952). Based

[16] In TR Section 2.6 (AUC, 2012), the applicant reports that the thickness of an ore body may be up to 12.2 m (40 ft). The difference may be attributed to grade thickness. Grade thickness is concentration of the ore body multiplied by its thickness.

on mapping by the applicant, the oxidation/reduction boundary reflects a northerly to northeasterly groundwater flow direction at the time of the ore body deposition.

The NRC staff reviewed the information in the application related to ore bodies and mineralized zones and finds it consistent with SRP Acceptance Criterion 3.1.3(1), because the information is sufficiently detailed and reflects site-specific conditions. The information is consistent with published information on the regional ore bodies (e.g., Sharp at al., 1964; Love, 1952) and historical documents submitted to the NRC by previous owners of the property (see Addendum 1-A (AUC, 2012); EFN, 1993).

Moreover, the ore body characteristics, including grade, mineralogy, and roll-front deposit types (see SER Section 2.3.3), and hydrogeologic setting (see SER Section 2.4.3) are generally consistent with those properties at existing NRC-licensed ISR facilities at which operations have been conducted in a manner that is safe for workers and protective of the public health and safety and the environment. An issue identified by the staff at the Reno Creek Project and discussed in the applicant's response to requests for information (AUC, 2015a) is the juxtaposition of mineral holdings by another firm to several of the applicant's proposed wellfields within the proposed license area (i.e., the applicant does not own the mineral rights to these areas and cannot install wells for production or ancillary equipment). The applicant states that a Memorandum of Reciprocal Monitor Well Agreement exists between the applicant and the other firm that would permit conducting corrective actions in the holdings of the other firm, should the need arise. The staff will impose a license condition that would require that the Memorandum of Reciprocal Monitor Well Agreement exist, if the applicant conducts operations within 122 m (400 ft) of the holding of the other firm (see License Condition 10.12 in SER Section 5.7.8.4).

3.1.3.2 Well Design, Testing, and Inspection

In TR Section 3.1.3.1 (AUC, 2012), the applicant describes four methods (Methods 1, 2, 3, and 4) in accordance with which the extraction, injection, and monitoring wells will be constructed (AUC, 2012). The first three methods (Methods 1, 2, and 3) consist of installing and cementing a 13 to 17 cm (5 to 6.6 in) outer diameter Standard Diameter Ratio (SDR) 17 polyvinyl chloride (PVC) casing. After the cement is cured, the screened interval is developed below the casing by under-reaming the selected interval. A smaller diameter stainless steel screen, with or without a filter pack, will be placed into the screened zone. The screen assembly is attached (sealed) to the PVC casing by K-packers. The SDR 17 PVC casing has a burst rating of 250 pounds per square inch (psi) and a hydraulic collapse rating of 224 psi. The casing is assembled in 6.1 m (20 ft) lengths, which are joined either by a threaded connection or a water-tight O-ring seal held in place by a nylon spline. Differences between methods 1, 2, and 3 is how the screened intervals are completed (Method 1 includes installing both casing and cement from ground surface to and including over screened interval, which is subsequently underreamed, Method 2 includes installing a casing and cementing from ground surface to only the top of the screened interval by leaving cuttings in the bottom of the drillhole over the screened interval. which are subsequently drilled out, and Method 3 includes a installing casing and cement from ground surface to the top of the screened zone is a drill hole that does not enter the screened horizon, and drill through the screened horizon afterward).

Method 4 well construction consists of 5.1 to 10.2 cm (2 to 4 in) diameter schedule 40 or 80 PVC casing and slotted screened material. The casings are glued together. The annular space is filled a minimum of 0.9 m (3 ft) above the top of the screen with silica sand by free fall or tremie pipe, 0.9 m (3 ft) of fine sand above the silica, approximately 1.5 m (5 ft) of coated bentonite, and the remainder of the annulus to grade filled with a cement slurry.

Construction of the injection and extraction wells will be by Method 1 (AUC, 2012). Construction of the monitoring well will be by Method 2, Method 3, or Method 4 (AUC, 2012). The applicant states that (1) the proposed methods are in accordance with Wyoming Department of Environmental Quality (WDEQ) Rules and Regulations, Chapter 11 (WDEQ, 2013), and (2) specifications embodied in Chapter 11 have been previously proposed for three ISR projects, and the NRC has recently accepted such specifications in its license approvals.

The staff reviewed the proposed methods and finds Method 1, Method 2, and Method 3 are acceptable. Those methods are essentially identical to those used for the construction of production and monitoring wells at existing ISR facilities. The well construction methods are consistent with specifications in the WDEQ Rules and Regulations (WDEQ, 2013).

As discussed below, the staff finds that the applicant's well construction Method 4 is not acceptable for wells to be installed as part of the groundwater protection monitoring program associated with the ISR operations. Well construction Method 4 is acceptable for shallow monitoring wells for the groundwater protection monitoring program at the surface impoundment (backup pond) or monitoring wells installed for nonregulatory monitoring programs (e.g., characterization of subsurface impacts due to a surface spill). Although the staff agrees with the applicant that well construction Method 4 is consistent with specifications (in most part) in WDEQ's Chapter 11 (Non-Coal) Rules and Regulations (WDEQ, 2013) and is widely used for the construction of shallow, small-diameter monitoring wells for environmental investigations (see also American Society for Testing and Materials (ASTM) D5092-04 (Reapproved 2010)) (ASTM, 2010), the staff disagrees with the applicant's suggestion that this well construction method has been proposed and approved by the NRC for this purpose at three newly licensed ISR facilities. Based on information supplied by the applicant, the staff does not have reasonable assurance that well construction Method 4 is appropriate for the groundwater monitoring programs associated with the ISR production aquifer.

The staff's nonacceptance of well construction Method 4 for groundwater excursion monitoring program associated with the ISR production aquifer is because the applicant's description of the method is too generalized. For example, placement of material in the annulus by free fall is not consistent with WDEQ's rule that specifies placement of material by tremie pipe. Furthermore, the applicant's specifications provide a "minimum" thickness of the sand filter pack but do not provide a maximum thickness. The lack of a maximum thickness may result in the sand filter pack for a well providing a conduit for fluid migration and/or difficulties for well abandonment, if the sand filter were significantly longer than the PVC screen length.

The problem with the lack of specifications is exemplified by the applicant's construction of the site characterization wells. The applicant's existing site characterization wells were completed by a mixture of methods: 27 wells were completed using well construction Method 4, whereas 14 wells were completed using well construction Method 1, 2, or 3. In general, wells completed using well construction Method 4 had sand filter packs that extend 2.1 to 5.2 m (7 to 17 ft) above the top of the screened horizon; however three wells constructed by this method had sand filter packs extending between 20 to 27 m (67 to 87 ft) above the well screen horizon. If the wells were located within an active ISR production aquifer wellfield, the sand filter pack would permit the migration of fluids significantly above the mineralized zone. In essence, this migration would greatly increase the flare of lixiviant from the mineralized zone and would likely hamper restoration activities.

Well construction Method 4 also presents a problem with well abandonment within the ISR production aquifer. The applicant's proposed abandonment procedures of filling the well casing with cement would not eliminate the sand filter pack as a potential conduit for fluid migration. In response to issues identified by the staff, the applicant committed to restricting Method 4 well construction to shallow monitoring wells and not employ this method for monitoring wells that could be affected by ISR operations (AUC, 2015c). This commitment is captured in License Condition 10.12. The staff finds that restriction acceptable because such wells cannot be a vehicle for migration of fluids from the mineralized zone to upper layers.

The applicant did not discuss well head completion details; however, the application includes the following: (1) TR Figure 3-2 depicts the well casing as extending above the ground surface, (2) WDEQ Rules and Regulations, Chapter 11, specifies that the casing of wells will extend above grade, and the applicant commits to following the Chapter 11 specifications, and (3) in TR Section 7.2.5.2, the applicant states that leak detection sensors will be included in the well head sumps (AUC, 2012). The staff will inspect the construction of the well heads during the preoperational inspection to ensure that the construction is consistent with the above commitments.

The applicant indicates that each well will be developed following its installation by air lifting, swabbing, pumping, bailing, or another acceptable method (AUC, 2012). The purpose for developing a well is to provide good communication between the well and the formation by removing drilling fluids and fine materials that may have become imbedded in the formation adjacent to the well-completion interval during well installation. The applicant will monitor well-development efficiency by measuring the stability of several parameters (pH, turbidity, and specific conductance). The applicant states that the field parameters must be stable at representative formation values before baseline sampling is initiated (AUC, 2012).

A well may need to be redeveloped during its life cycle. Redevelopment, for maintenance or enhancement, may include chemical treatment, in addition to procedures used for the initial well development (AUC, 2012). The applicant provides examples of chemicals that may be used, such as a weak acid or sodium hypochlorite (bleach).

In TR Section 7.4.2, the applicant discusses the disposition of water generated during the well construction and initial development (AUC, 2012). The discharge of the water will be to onsite mud pits constructed adjacent to the drill pad and authorized under a temporary Wyoming Pollutant Discharge Elimination System (WYPDES) permit; however, in TR Section 4.3.1.3, the applicant states that fluids generated during production well workovers are byproduct material. The applicant does not specifically discuss the disposition of water generated during any redevelopment; however the applicant states that all byproduct material, which includes production well workover fluids, will be properly disposed of through the CPP waste water system. The staff finds that the applicant's discussion on well development is acceptable because the proposed procedures are consistent with established standards (see Driscoll, 1986) and with those historically used by ISR facilities which have been shown to provide adequate protection for the health and safety for the workers, public and the environment.

The applicant states that all injection and recovery wells will undergo an initial MIT before being placed into operation (AUC, 2012). MITs will also be performed at 5-year intervals during operation and after any workovers or suspected surface or subsurface damage. MIT procedures consist of isolating the casing interval between the top of the screened horizon and ground surface using downhole packers, filling the isolated interval with water, pressurizing the water to a specified pressure, and measuring the ability of that well casing to maintain the pressure for a selected time interval.

The applicant states that the MIT pressure will be 120 percent of the maximum injection pressure (AUC, 2012). The applicant proposes to establish a maximum injection pressure on a header house basis, based on the average bottom screen elevation for wells assigned to that header house rather than an average for the entire project area (AUC, 2012). The applicant estimates the maximum injection pressure will range from 90 to 145 psi.

To pass an MIT, the applicant states that the well casing must maintain the pressure within 10 percent of the initial level for a period of 10 minutes. If the well fails this requirement, the applicant will repair and retest the well. If the applicant cannot repair the well, the applicant will plug and abandon the well. Monitoring wells that are abandoned due to an MIT failure will be replaced. The applicant will document all MITs and maintain the records on site (AUC, 2012).

The NRC staff reviewed the applicant's well design, testing, and inspection procedures and finds they are consistent with SRP Acceptance Criterion 3.1.3(2), because the proposed procedures reflect standard industry practices for ISR operations and have previously been accepted by the NRC staff as protective safety measures for such operations. The staff will include a standard license condition for conducting MITs. The license condition includes language to better define "before operations" and preliminary corrective actions (see License Condition 10.5 in SER Section 3.1.4).

The applicant committed to MITs for the initial installation of the monitoring wells but not every 5 years (AUC, 2015e). Subjecting a well to an MIT every 5 years provides assurance that the integrity of the well is maintained throughout its life. It is standard practice for the industry and consistent with guidance for a minimum frequency in NUREG\CR-6733 and NUREG-1569. This commitment will be memorialized in a license condition.

Based on its review of the regional water quality in SER Section 2.5.3, the staff identified incomplete well development of monitoring wells in low-yielding portions of the underlying and overlying units. To ensure that future monitoring wells in low-yielding units are properly developed, the staff will include a license condition that the applicant will develop a written standard operating procedure (SOP) to properly develop these wells before sampling (see License Condition 12.9 in SER Section 3.1.4). The licensee shall submit SOPs prior to staff scheduling a pre-operational inspection.

3.1.3.3 Excursion Monitoring Wells

The applicant states that the monitoring wells, including those for the excursion monitoring program, will be constructed in a manner similar to the design for the production wells (see SER Section 3.1.3.2). The applicant states that each production unit will be surrounded by perimeter monitoring wells at a spacing of 122 to 153 m (400 to 500 ft) and at an approximate distance of 122 to 153 m (400 to 500 ft) from the edge of a production unit (AUC, 2012). The distance and spacing of 122 m (400 ft) will be applied to production units in the partially saturated areas, whereas the distance and spacing of 153 m (500 ft) will be applied to production units in the fully saturated portions of the production aquifer. The applicant states that results of the numeric groundwater flow modeling support those distances (AUC, 2012). However, in response to staff issues, as discussed in SER Section 2.4.3.4.12, the applicant agreed to a license condition requiring 122 m (400 ft) spacing and distance for wells in the perimeter ring in both the fully and partially saturated areas (AUC, 2015c).

The overlying aquifer will be monitored by one well per four (4) acres of production area (AUC, 2012). No monitoring is proposed for the underlying unit, because the distance to the first sandstone body that meets the definition of an aquifer is greater than 15 m (50 ft), and hydraulic properties for the intervening aquitard effectively inhibit flow from the production aquifer. In TR Section 2.7.2.3 (AUC, 2012), the applicant described the shallow water table unit, and based on this information, the applicant did not propose monitoring within the shallowest unit for the excursion monitoring program.

The applicant did not specify whether the perimeter wells will be screened throughout the entire production zone or only partially penetrating (e.g., limited screened interval generally over the thickness of the ore body). However, in response to staff issues as discussed in SER Section 2.4.3.4.12, the applicant stated that the screens in the perimeter monitor wells will cover the intervals of the production zone aquifer (PZA) that are screened for uranium recovery operations in the production unit (AUC, 2015c).

The NRC staff reviewed the applicant's well design for the excursion monitoring program and finds it is consistent with SRP Acceptance Criterion 3.1.3(3), because the proposed design reflects standard industry practices for ISR operations that have been accepted by the NRC staff as protective safety measures for such operations with the following clarifications (see License Condition 11.3 in SER Section 5.7.8.4):

- The applicant will use a spacing and distance of 122 m (400 ft) for production units in the partially saturated portions of the PZA unit. The applicant had proposed a distance of 152.5 m (500 ft) for the fully saturated portions of the PZA unit. However, in addition to discussions in Section 2.4.3.4.12 on staff's rationale on a spacing and distance of 122 m (400 ft) for production units in the fully saturated portions of the PZA unit as well, the applicant assumed a static boundary between full and partial saturation. The boundary may move depending on the potential dewatering during operations. By having a constant spacing and distance between the wells, the need for such an evaluation of the impact of this movement is not necessary for staff's findings. Therefore, the staff will include a license condition that specifies the 122m (400 ft) spacing and distance requirement for fully and partially saturated portions of the aquifer.

- The applicant will screen the perimeter wells as partially penetrating wells at the interval(s) for which the production unit wells are screened (see License Condition 11.3).

- The applicant will monitor the overlying aquifer and ore zone perimeter monitoring wells as part of the excursion monitoring program.

The staff evaluated the operational component of the excursion monitoring program in SER Section 5.7.8.

3.1.3.4 Timely Detection and Cleanup of Leaks between Wellfield and CPP

The applicant states that the controls in the CPP and header house will include automatic shutoff valves and alarms, should an upset condition materialize, to protect against fluid spills and minimize impacts to the environment (AUC, 2012). The CPP controls will be able to remotely monitor and terminate any process in any header house; a backup system operating from a header house will provide control, should the CPP controls malfunction. The system will provide immediate notification to the facility personnel and require a manual restart to ensure oversight.

The applicant states that the operators will perform daily inspections of the header houses and wellfield areas to ensure that the systems are operating properly and that leaks that can be visually detected are identified as soon as possible (AUC, 2012). All piping will be pressure tested at operating pressures, plus a factor of safety, before use. Pressure monitoring will be conducted during operations to monitor for leaks.

The staff reviewed information regarding the applicant's design, instrumentation, alarms, and control features for the surface and near-surface piping from the wellfield and processing plant. The staff finds that this information is acceptable, because it is consistent with features used safely at existing NRC-licensed facilities for several years and includes state-of-the art adaptation to those features, and those features will provide timely detection and cleanup of leaks and spills between the CPP and wellfields. Based on the above, the staff finds the information is consistent with SRP Acceptance Criterion 3.1.3(4) because the methods for timely detection and cleanup of spills are clearly described and included in the design.

The staff will include a license condition that requires the applicant to retain information on spills for the life of the license, as well as criteria for spills to be reported in a timely manner to the NRC (see License Condition 11.6 in SER Section 5.2.4).

3.1.3.5 In Situ Leaching Process

(a) Downhole pressure

The applicant commits to using materials for the well construction with a sufficient pressure rating to withstand the maximum injection pressure, maximum external collapsing pressure, and the maximum pressure of cementing (AUC, 2012). The applicant anticipates a maximum injection pressure of 145 psi and that it will be less than the formation fracture pressure. The applicant estimates the fracture pressure gradient to be 0.8 psi/ft. Using the range of maximum bottom screen depth of 76 to 122 m (250 to 400 ft), the applicant states that the maximum allowable injection pressures will range from 90 to 145 psi across the project. The applicant proposes to calculate the maximum injection pressure for each header house rather than an average over the project area. The applicant commits to using material with minimal pressure ratings equivalent to a PVC SDR-17 11.4 to 15.2 cm (4.5 to 6.0 in) inner diameter casing.

The staff verified that selected manufacturer's specifications on the pressure rating for an SDR-17 PVC casing is between 160 and 250 psi. Furthermore, the pressure rating for the casing increases if the casing is cement lined, as the applicant proposes (see SER Section 3.1.3.2). The maximum injection pressure of 145 psi plus 122 m (400 ft) of water yields a downhole pressure of 318 psi. The fracture pressure at 122 m (400 ft) is 320 psi. The similarity in pressures (318 and 320 psi) does not provide a factor of safety. In response to a proposed draft condition (AUC, 2015d), AUC committed to using a factor of safety (e.g., 90 percent of the difference between fracture gradient (0.8 psi/ft) and hydrostatic gradient (0.433 psi/ft) in developing the maximum injection pressure (at 400 feet, the injection pressure would be 131 psi using the 90 percent factor of safety).

Based on the staff's review of the applicant's proposed equipment and the fact that similar pressures and equipment have been used at existing licensed facilities in a manner that is protective of human health and the environment, the staff finds the applicant's downhole pressures consistent with SRP Acceptance Criterion 3.1.3(5)(a).

(b) Production versus Injection Rates

The applicant commits to a production rate that would exceed the injection rate by 0.5 to 1.5 percent. At the maximum throughput of 41,640 lpm (11,000 gpm), the average difference between the production and the injection rate, which is referred to as "bleed," is equivalent to 416 lpm (110 gpm). The applicant acknowledges that the bleed is necessary to maintain hydraulic control on fluids in the production area. The applicant states that the groundwater flow model demonstrates that a 1.0 percent bleed is sufficient to maintain an inward gradient.

The applicant estimates that a header house will be connected to 15 to 30 recovery wells and 25 to 50 injection wells, and that a total of 67 header houses are planned for the project area (1 to 7 header houses for each production area; a total of 15 production areas; each wellfield has one header house)(AUC, 2012; 2015a). The operation at specific header houses will be phased, such that not all header houses are in operation at the same time (see SER Section 3.1.3.6). In TR Addendum 2.7-C (AUC, 2012), the applicant used a maximum production capacity for a production area of 13,626 lpm (3,600 gpm) in the numeric groundwater flow model life-of-mine simulation. Based on 23 recovery wells per header house and 5 header houses in a production area, the applicant's production capacity equates to an average extraction rate for a recovery well of 117 lpm (31 gpm).

The applicant states that the targets for flows to individual injection wells will be determined on a per-pattern basis and balanced on a continuous basis.

The staff reviewed the applicant's information and finds the applicant's pressure descriptions consistent with SRP Acceptance Criterion 3.1.3(5)(b), because the information is consistent with what was reported throughout the application, consistent with production flow rate regimes at existing ISR operations that have been shown to be protective of human health and the environment, and consistent with the hydrogeologic setting as discussed in SER Section 2.4.3. The staff will include a standard license condition that requires the applicant to maintain the bleed (hydraulic control) at a wellfield during its life cycle (see License Condition 10.7 in SER Section 3.1.4).

(c) Proposed Plant Material Balances and Flow Rates

The applicant provides three water balances that reflect the three operational phases. The three phases are (1) operation only, (2) concurrent operation and restoration, (3) restoration only (AUC, 2012). The flow rates used for the three phases consisted of the maximum throughputs (i.e., 41,690 lpm [11,000 gpm] for operations and 3,980 lpm [1,050 gpm] for restoration, of which 190 lpm [50 gpm] are assigned to groundwater sweep and 3,785 lpm [1,000 gpm] assigned to groundwater treatment). The bleed rates assigned to the phases are: 1.0 percent during operations only; 1.2 percent under the concurrent operation and restoration phase (1.0 percent for the wellfields in operation and up to 10 percent for wellfields in restoration); and up to 10 percent for the restoration-only phase.

On Figures 3-5 through 3-7, the applicant also depicts the CPP water supply well as an additional source of water for use at the CPP processes during the operation-only phase (19 lpm [5 gpm]) and the restoration-only phase (38 lpm [10 gpm]) (AUC, 2012). During concurrent operation and restoration phases, the additional water is not needed, because permeate from groundwater treatment is recycled for use as a water supply for CPP processes.

The resulting wastewater generation rates for the three phases noted above are 435, 545, and 395 lpm [115, 144, and 104 gpm], respectively. Waste water (brine) will be disposed of in deep disposal wells after the brine is processed through the waste water tanks. As an option, on Figures 3-5 through 3-7, the applicant also depicts the use of the backup waste water pond in the process flow diagram for the storage of waste water between the waste water tank and disposal at the deep disposal wells.

The staff reviewed the applicant's information and finds the applicant's material balance and flow rate descriptions consistent with SRP Acceptance Criterion 3.1.3(5)(c) because the information is consistent with what was reported throughout the application; consistent with material balance and flow rates regimes at existing ISR operations that have been shown to be protective of human health and the environment; consistent with the hydrogeologic setting, as discussed in SER Section 2.4.3; and consistent with the facility's stated disposal capacity, as discussed in SER Section 4.2.3. The staff will include a standard license condition on the maximum production throughput (see License Condition 10.2 in SER Section 3.1.4)

(d) Lixiviant Makeup

The applicant proposes to use a lixiviant that consists of native groundwater fortified with gaseous oxygen or a liquid oxidant as the oxidizer, and sodium carbonate, sodium bicarbonate, or carbon dioxide as the complexing agent (AUC, 2012). The complexing agent will be added to the injection stream (barren lixiviant) at the CPP, whereas the oxidant will be added to the injection stream at the individual header houses.

The applicant reports selected parameter concentrations in a typical lixiviant and expects its lixiviant to be within that range (AUC, 2012). The applicant estimates a maximum dissolved oxygen concentration of 400 mg/L for new wellfields but acknowledges that the concentration will depend on site conditions. The applicant further discusses the potential problems with the use of gaseous oxygen in the partially saturated portion of the PZA where the hydraulic head is low, thus resulting in the dissolved oxygen exsolving from groundwater, forming two phases: liquid and gaseous. The gaseous oxygen phase may coalesce and block the passages in the aquifer.

The applicant reports methods it will use to correct any blockage caused by gaseous oxygen exsolving from groundwater in the vicinity of an injection well. The applicant also states that it is considering use of a liquid oxidant such as sodium chlorate or hydrogen peroxide. The applicant reports that hydrogen peroxide was used successfully at the former research and development (R&D) operations that were conducted within the partially saturated portions of the PZA. The applicant committed to implementing proper safety procedures for storage and use of any liquid oxidant and states that it will use the Safety and Environmental Review Panel (SERP) to allow usage of an oxidant if not included in the application.

The staff reviewed the applicant’s information and finds the applicant’s lixiviant makeup descriptions consistent in part and not consistent in part with SRP Acceptance Criterion 3.1.3(5)(d). The applicant’s proposed lixiviant makeup is consistent with the criterion, because it is consistent with that used at existing facilities that demonstrate a reasonable prospect for achieving long-term groundwater restoration in a timely manner. The applicant’s proposed lixiviant makeup is not consistent with the criterion because of the increased possibility of difficulties in using gaseous oxygen at low pressures and the open-ended approach to defining which liquid oxidant may be used.

First, the exsolving of gaseous oxygen is a problem largely for the operation phase. During restoration, an oxidant is not added to the injection stream and thus not expected to be a concern. For example, although residual impacts of dissolved oxygen from operations may linger to the restoration phase, the residual impacts from any blockage by itself are not likely to appreciably affect the timely manner in which restoration may be achieved. On the other hand, the exsolving of gaseous oxygen during operations, along with other chemical changes, may affect the applicant’s ability to restore the aquifer if other reactions occur (e.g., as occurred in the Phase I of the R&D pilot, which used an acid lixiviant). The staff finds that the lixiviant makeup, along with the applicant’s commitment to evaluate any such condition that may arise, will ensure that future restorations are not impeded.

Second, except for hydrogen peroxide, the applicant does not provide a bounding analysis on the use of liquid oxidants on achieving the restoration goals, nor does the applicant provide information on the storage and use of the other liquid oxidants. The applicant states that use of the other liquid oxidants will be allowed through the SERP. However, this characterization of the SERP is inaccurate; the SERP determines whether or not an amendment to the NRC’s license is required for any change, but does not determine whether or not a change is “allowed.” Also, one criterion for evaluating whether or not an amendment is necessary is if the change falls within the boundaries of the staff’s evaluation of the approved application. The fact that the analysis was not performed in the application would not allow the applicant to use any unevaluated oxidant without an amendment. Therefore, the staff will limit use of a liquid oxidant to hydrogen peroxide and the use of a different oxidant would require the staff’s approval as part of the standard license condition on the lixiviant makeup (see License Condition 10.1 in SER Section 3.1.4).

Based on the above license condition, the applicant’s description of the general lixiviant makeup and the applicant’s commitment to review potential impacts attributed to the use of gaseous oxygen, the staff finds the applicant’s lixiviant makeup to be protective of human health and the environment.

(e) <u>Gaseous, Liquid, and Solid Wastes and Effluents</u>

The applicant identifies the gaseous, liquid, and solid waste and effluents that will be generated at the CPP in TR Section 4.0 (AUC, 2012). The staff provides an evaluation and review of the applicant’s description of those waste streams, proposed monitoring, and controls in SER Section 4.0.

(f) Control of Lixiviant Migration

In TR Sections 2.6 and 2.7 (AUC, 2012), the applicant presents its conceptual model of the geologic and hydrogeologic setting and supporting data that would provide a setting for the control for the migration of lixiviant. In SER Section 2.3.3, the staff evaluated the applicant's conceptual model and supporting data. With staff's verification of the conceptual model with an independent analysis as described in SER Section 2.3.4, staff has reasonable assurance that the hydrogeologic setting will provide a suitable setting for the licensee to control the migration of lixiviant with the appropriate operational controls.

The applicant anticipates that the production units will be a conventional 5-spot pattern, although more or fewer injection wells may be used, depending upon the ore body configuration (AUC, 2012). The typical spacing between injection wells will be between 23 and 37 m (75 and 120 ft). The staff finds that these typical production patterns are acceptable, as these patterns are currently being used at existing ISR operations and have been shown to adequately control the lixiviant migration at those facilities. However, the applicant did not make a bounding analysis on the non-typical production unit designs (e.g., fewer wells may include a single injection well per production well – a linear or staggered pattern). While such patterns have been used at existing ISR facilities, defining the impacted area geometries of those non-typical patterns, in particular the area for pore volume and flare factor calculations, require assumptions beyond those used for a typical 5-spot pattern. Furthermore, the geometry will be dependent upon the wellfield-specific setting. Therefore, should patterns other than the "typical 5-spot pattern" be used at a wellfield, staff will require the applicant to include an analysis of the impacts on restoration such that the appropriate pore volume and flare factor are calculated (see License Condition 10.12 in SER Section 5.7.8.4).

The applicant commits to maintaining an inward gradient at all production areas throughout the production and restoration phases. The staff will memorialize this commitment in a license condition (see License Condition 10.7 in SER Section 3.1.4).

The applicant proposes an excursion detection monitoring program for timely detection of lixiviant migration from the production area. The staff finds the proposed excursion detection monitoring program adequate to control the lixiviant migration. The staff documented its review and analysis of this program in SER Section 5.7.8.

During the license period, the applicant states it will: (1) perform effluent and leak detection monitoring programs; (2) properly install wells and perform routine MIT on those wells; and (3) provide an evaluation, reporting, and cleanup of spills (AUC, 2012). The staff finds the effluent and leak detection programs, along with the additional commitments, adequate to prevent lixiviant migration. The staff documented its review and analysis of the effluent monitoring program in SER Section 5.7.7.

In TR Section 6.1 (AUC, 2012), the applicant commits to restoring the groundwater quality in an aquifer subjected to ISR operations to the groundwater protection standards listed in Criterion 5B(5) in Appendix A of 10 CFR Part 40. The applicant provides an analysis of restoration success at the former Reno Creek R&D facility and existing Wyoming ISR facilities as analogs to the Proposed Project. The staff finds that the proposed restoration is adequate to control the lixiviant migration because the restorations that have been conducted have been shown to be protective of human health and the environment. The staff documented its review and analysis of the effluent monitoring program in SER Sections 5.7.8.3 and 5.7.9.3.

In TR Section 2.7 (AUC, 2012), the applicant acknowledges that improperly abandoned exploratory drill holes may provide preferential and unwanted pathways for fluid migration from the production aquifer to the surrounding aquifers (principally the overlying aquifer but also the underlying aquifer). The staff will impose a license condition that the applicant will abandon the abandoned drill holes in accordance with its SOP before conducting principal activities at a wellfield (see License Condition 10.11 in SER Section 2.3.4).

One current drinking water supply well is currently located within the Proposed Project area (AUC, 2012). In TR Sections 2.2.1 and 2.7.2.9 (AUC, 2012), and in response to requests for additional information (AUC, 2015a) the applicant commits to plugging and abandoning this well and not using it as a water supply well once construction begins. The applicant has subsequently acquired this property and abandoned this well, and submitted appropriate documentation to the State Engineer's Office (AUC, 2016a).

Based upon the above, the staff finds that the applicant's descriptions of the in situ leaching process meet Acceptance Criterion 3.1.3(5) (NRC, 2003), and with the license conditions described above, provides reasonable assurance that the applicant has (1) limited down hole pressures to those below the casing failure pressures and formation fracture pressures; (2) committed to maintaining an inward gradient with the overall production rates higher than injection rates; (3) described plant material mass balances and flow rates consistent with the proposed operations; (4) provided a description of the lixiviant chemical makeup; (5) identified the wastes and effluents to be generated; (6) analyzed the ability to control the migration of lixiviant. Therefore, staff finds that the applicant has demonstrated the ability to confine its possession and use of source and byproduct material to locations and purposes authorized by the license and that the applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property.

3.1.3.6 Operating Plans and Schedules

The applicant provides operating plans and schedules, including timetables for construction, wellfield operations, groundwater restoration, and surface reclamation. The periods overlap, as the applicant proposes a phased approach for initiation of operations at a specific wellfield. Based on TR Figure 1-3 (AUC, 2012), the applicant estimates that the construction phase will occur between years 0 and 1.0, wellfield operations between years 1.0 and 12.75, restoration between years 4.25 and 14.5, and surface reclamation (decommissioning) between years 6.25 and 16.0.

The applicant's plan for operation and restoration is based on a production unit basis (AUC, 2012). The applicant estimates that a total of 15 production units will be established for the Proposed Project. Based on Table 10, *Preliminary Production Schedule for Model Simulation, Proposed Maximum Extraction Rate of 11,000 GPM,* in TR Addendum 2.7-C (AUC, 2012), the applicant provides a schedule on a production unit basis. The schedule indicates that up to six production units are expected to be in operation during any calendar year and generally two to four production units will be in restoration in any calendar year after the 4th year of operation. This schedule is consistent with the narrative in the application and proposed schedule in TR Figure 1-3.

The applicant quantifies the impacts to the groundwater resources due to drawdown attributed to consumptive use of groundwater during the operation and restoration phases of the project (See SER Section 2.4.3).

The staff reviewed the proposed restoration schedule and stability monitoring program and finds the proposed schedule is consistent with SRP Acceptance Criterion 3.1.3(6), provided that the applicant updates the schedule as needed to comply with the requirements of 10 CFR 40.42. The staff reviewed and evaluated the water balance in SER Section 3.1.3.5(3) and the adequacy of liquid waste disposal in SER Section 4.2.3.

3.1.3.7 Flood and Flood Velocities

In SER Sections 2.4.3 and 2.4.4, the staff reviewed and verified the applicant's flood analysis. In summary, the applicant estimates, in the design criteria, that the maximum event during the life of the project would be flows resulting from the 24-hour, 100-year storm event. Based on that event, the applicant estimates minimal impacts from flooding due to the locations of the CPP, backup storage pond, and wellfield areas relative to the surrounding topography. The applicant states that portions of multiple production units are located within the 100-year floodplain and that, if necessary, mitigation measures may include fitting well-heads with water-tight seals, and any infrastructure that cannot be made flood resistant should be located beyond the flood plain.

The staff reviewed this information in SER Section 2.4.3. The staff will be imposing a license condition to ensure commitments from the applicant that wells completed in the flood plain will have proper mitigation methods and that infrastructure that cannot be made flood resistant will be constructed outside of the flood plain (see License Condition 10.12 in SER Section 5.7.8.4). Based on this license condition and the information supplied in the application, the staff finds that SRP Acceptance Criterion 3.1.3(7) is satisfied, because the applicant provided an adequate description that incorporated design assumptions and calculations that are reasonable and accurate and compare favorably with the staff's independent estimates.

3.1.3.8 Diversion Channel

In TR Section 2.7.1.5 (AUC, 2012), the applicant proposes to divert surface water flow in the area upstream of the proposed backup pond away from the pond. In SER Section 2.3.3, the staff verified the design criteria (storm event) for the diversion. The staff reviewed the diversion design for flood control in SER Section 4.2.3. The diversion channel will be subject to daily inspections (see SER Section 4.2.3). The applicant seeks no additional diversions.

The staff finds that the information submitted by the applicant and its commitment for daily inspections during operations meet SRP Acceptance Criterion 3.1.3(8), because the diversion channel design is sized to withstand flows and erosion during the probable maximum flooding event.

3.1.3.9 Construction Plans, Specifications, Inspection Programs, and Quality Assurance/Quality Control

In TR Section 1.9 (AUC, 2012), the applicant describes its construction plans and presents a Gant Chart graphically displaying its schedule. Construction of the CPP and ancillary facilities (pond, administrative building), development of the initial production unit, and construction of the supporting infrastructure (access roads, transmission lines, and fences) will occur during the first year after receipt of a license (and by license condition, all required permits from other agencies). The applicant proposes construction of the production units to extend through the first 9 years of operation; the construction of an individual production unit may take 1 to 2 years to complete (AUC, 2012).

In TR Section 2.6, the applicant discusses methods and material for construction of the production and monitoring wells (for the staff's evaluation, see SER Section 2.3.3). In TR Addendum 4.1-A, the applicant provides construction plans and design criteria for the CPP area, including the backup storage pond. In TR Section 2.6.6.4, the applicant discusses the Campbell County Wyoming seismological design criterion for the construction of buildings (see SER Section 2.3). In TR Section 3.2, the applicant provides details of the construction material for the CPP and ancillary equipment (see SER Section 3.2.3).

In TR Section 4.2, the applicant provides details on the design and construction of the deep wells for the deep well injection of byproduct material (see SER Section 4.2). In TR Section 5.3, the applicant presents details on the proposed plans and schedules for inspection of the ponds, diversion, and wellfields (see SER Section 5.3). In TR Section 5.7.8, the applicant discusses the environmental programs to be conducted during construction of the facility (see SER Section 5.7.8).

In TR Section 5.7.10, the applicant commits to establishing a quality assurance (QA) program that meets the regulatory guidelines and regulations (see SER Section 5.7.9). In addition, during review of the sampling procedures and analytical data presented in the application, the staff verified the accuracy and precision of the submitted data to ensure that the applicant performed proper QA/quality control (QA/QC). Proper QA/QC consists of procedures commonly employed by the industry and used as accepted engineering practices in the environmental field studies. The staff finds that the applicant adhered to proper QA/QC practices for the data presented in the application.

As documented in the referenced SER sections, the staff reviewed the construction plans, specifications, inspection programs, and QA/QC and finds that the applicant descriptions are clear and consistent with designs for an ISR facility used at other licensed facilities that have been shown to be protective of human health and the environment. The staff finds the applicant's proposed schedule for construction reasonable and consistent with other ISR facilities and consistent with SRP Acceptance Criterion 3.1.3(9).

3.1.3.10 Results from R&D Operations

In TR Section 2.6.2.7 (AUC, 2012), the applicant reports results of the former R&D facility operated within the Reno Creek area by Rocky Mountain Energy (RME) from the late 1970s through the early to mid-1980s. The applicant reports that RME operated two R&D operations. The first operation, Pilot Test Pattern 1, which began in 1978, used an acid lixiviant. The acid lixiviant reacted with the formation, resulting in a loss of injectivity and sealing off the formation.

The second operation, Pilot Test Pattern 2, which began in 1980, used a carbonate lixiviant (AUC, 2012). Pilot Test Pattern 2 consisted of six monitoring wells, four injection wells, and two production wells. The applicant reports that Pilot Test Pattern 2 confirmed the effectiveness of the carbonate lixiviant for potential commercial operations and restoration. The NRC approved the restoration of the Pilot Test Pattern 2 in 1983. In the approval letter, NRC noted that with the exception of uranium, the restoration objective of returning all parameters was achieved. The restored uranium concentrations exceeded the baseline levels but met the existing Wyoming Class of Use Standard and are thus acceptable. The letter noted that, if a commercial scale operation were pursued for the Reno Creek site, the staff expected the uranium to be restored to concentrations lower than those approved for the pilot program.

The applicant also reports a summary of a hydrogeologic integrity test report completed in 1982. The report investigated the self-plugging of a subset of abandoned drill holes (see SER Section 2.3).

AUC reports that an application was submitted for a commercial facility at this location by Energy Fuels Nuclear, Inc. and International Uranium Corporation in the early 1990s (EFN, 1993). The application was withdrawn before issuance of a license, due to economic conditions, in 1999.

The staff finds that the applicant's summary of the historic R&D facility and the prior commercial facility application are accurate. The application demonstrates the use and the results of the study, in particular, by not requesting the use of an acid-based lixiviant, to describe the proposed ISR operations. Therefore, the staff finds that the information and descriptions meet SRP Acceptance Criterion 3.1.3(10).

3.1.3.11 Solid Byproduct Waste Disposal Agreement

The applicant commits to acquiring a solid 11e.(2) byproduct material disposal agreement with a licensed facility before operations (AUC, 2012). The staff imposed a license condition that makes this commitment a requirement (see License Condition 12.5 in SER Section 4.2.4). The licensee shall submit the agreement prior to staff scheduling a pre-operational inspection.

3.1.4 Evaluation Findings

The staff reviewed the ISR process and equipment proposed for use at the Proposed Project in accordance with review procedures in Section 3.1.2 and acceptance criteria in SRP Section 3.1.3. The applicant adequately described the mine unit infrastructure, equipment, and ISR operations for the Proposed Project and, based on these descriptions, the staff finds the applicant has satisfactorily documented the ore body characteristics that are consistent with ore bodies that are undergoing safe operations at existing NRC-licensed ISR facilities. The staff finds that the applicant provided commitments to protect against unwanted vertical and horizontal migration of fluids, including materials used in construction of the infrastructure and routine monitoring at the surface and subsurface. The staff finds that the applicant's proposed ISR processes will meet the following safety criteria:

- 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 solid wastes and effluents are provided (used in evaluation of effluent monitoring and control measures in SRP Section 4.0).

Based on the staff's review of the applicant's components with respect to safety risk and current industry practice at existing NRC-licensed ISR facilities, the staff concludes that the applicant provided an acceptable description of the instrumentation and monitoring designed to prevent spills and/or excursions, as well as provided acceptable operating plans, schedules, and timetables for mine unit operation, surface reclamation, and groundwater restoration. Requirements for several aspects of the operations (in particular, lixiviant makeup, limitations on throughput capacity, groundwater monitoring, and spill reporting), will be enumerated in license conditions as follows:

- License Condition 10.1
- License Condition 10.2
- License Condition 10.5
- License Condition 10.7
- License Condition 12.9

The applicant has committed to performing and documenting results of daily inspections for leaks during routine field surveys and activities. The staff will include the following license condition to memorialize this commitment:

- License Condition 10.13

Based upon the review conducted by the staff as indicated in this section, the information provided in the application, as supplemented by the information to be collected and activities to be conducted in accordance with the noted license conditions, meets the applicable acceptance criteria of SRP Section 3.1.3 and thus meets the requirements of 10 CFR 40.32(c) and will meet the requirements of 10 CFR 40.41(c), if issued a license. The staff finds that the proposed ISR operations, with the license conditions described above, are consistent with those currently being used at existing NRC-licensed facilities and are NRC-accepted practices.

Based on commitments in the application and the license conditions identified above, the NRC staff concludes that the applicant has acceptably described the mineralized zone(s), demonstrated protection against vertical migration of water, proposed tests for well integrity, and demonstrated that the *in situ* leaching process will meet the following criteria: (i) down hole injection pressures are less than formation fracture pressures; (ii) overall production rates are higher than injection rates; (iii) plant material balances and flow rates are appropriate; (iv) lixiviant makeup is such that restoration goals can be achieved in a timely manner; (v) recovery efficiency is assessed through mass balance calculations; and (vi) reasonable estimates of gaseous, liquid, and solid wastes and effluents are provided. The applicant has used the results from research and development or other production operations to support the evaluation of the *in situ* leaching process. The applicant has provided acceptable operating plans, schedules, and timetables for well field operation, surface reclamation, and ground-water restoration.

Based on the information provided in the application and the detailed review conducted of the Reno Creek *in situ* leaching process and equipment for the Reno Creek *in situ* leach facility, described above, the staff concludes that the proposed *in situ* leaching process and equipment are acceptable and are in compliance with 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 or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR Part 40, Appendix A, Criteria 2 for non-proliferation of small disposal sites; 5(A) for ground-water protection; 5B for secondary ground-water protection; 5C for maximum values for ground-water protection; and 13 for hazardous constituents. The related reviews of the 10 CFR Part 20 radiological aspects of the *in situ* leaching process and equipment in accordance with SRP Sections 4.0, "Effluent Control Systems;" 5.0, "Operations;" and 7.0, "Environmental Effects;" are addressed elsewhere in this SER.

3.2 Processing Plant, Wellfields, and Chemical Storage Facilities

3.2.1 Regulatory Requirements

The staff determines if the application has demonstrated that equipment and processes used in the processing plant and other facilities at the Proposed Project during its operation meet the requirements of 10 CFR 40.32(c) and 10 CFR 40.41(c).

3.2.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria in SRP Section 3.2.3 (NRC, 2003).

3.2.3 Staff Review and Analysis

This section discusses the physical descriptions and operating characteristics of the major equipment that the applicant would use during processing. These descriptions pertain to the processing plant, the chemicals that the applicant would use on site, and the potential radiological and chemical hazards associated with the operations. Information in SER Section 3.2.3, unless stated otherwise, is from TR Section 3.2 (AUC, 2012).

3.2.3.1 Description of Processing Plant

The applicant describes the significant components to the CPP as the uranium processing equipment, drying and packaging equipment, water treatment equipment, and an onsite laboratory. The ancillary buildings and infrastructure consist of a warehouse and maintenance building, reagent and liquid materials storage tanks and hoppers, and designated areas for storing source or waste material, including petroleum products and hazardous waste.

The uranium processing equipment includes trunk lines into and out of the CPP, pressurized downflow ion exchange (IX) columns, resin transfer, chemical addition, filtration, elution, and precipitation. The drying and packaging equipment consists of filtering, dewatering (filter press), vacuum drying, and packaging of the slurry to dry yellowcake. The water treatment equipment consists of a two-stage reverse osmosis (RO) system that is primarily used to treat the restoration stream.

The reagent and liquid materials stored in and around the CPP consist of process-related chemicals (sodium chloride, acids, sodium hydroxide, hydrogen peroxide, oxygen, carbon dioxide, and possibly a chemical reductant). The nonprocess chemicals include liquid and gaseous propane products. In TR Section 7.5.1.2 (AUC, 2012), the applicant describes the safety procedures for storing a strong mineral acid (e.g., hydrochloric, sulfuric, nitric) that will be used in the elution process.

The applicant states that secondary containment of liquids will consist of concrete curbing (berms) within the CPP. The curbing will be designed for 110 percent of the capacity of a tank if a tank failure poses a major health risk. Curbing that would control limited volume spills will be employed in areas where it is unnecessary or impracticable to contain the total volume of a tank failure. The CPP foundation will also extend 30 cm (12 in) above the finished floor, and the floor will slope to sumps in which any liquid is either returned to the processing flow or disposed of as liquid 11e.(2) byproduct material.

On TR Figures 3-8 and 3-9, the applicant depicts the conceptual CPP building layout and process flow diagram, respectively.

The staff reviewed the applicant's description of the CPP design and finds it sufficient to meet SRP Acceptance Criterion 3.2.3(1) because the applicant provided diagrams showing the proposed plant layout in adequate detail for staff to perform an independent evaluation.

3.2.3.2 Identification of Dust, Fumes, or Gas Sources

The applicant states that sources of fumes at the CPP will be from the process-related chemicals: acids, sodium hydroxide, and hydrogen peroxide. The applicant expected minimal fumes or gases emanating from the piping and tanks used to convey or store the process water. However, the applicant identified radon as the predominant radionuclide expected to be released to unrestricted areas from nonpoint sources from pregnant lixiviant, including the wellfield infrastructure, and periodic tank ventilation and backwashing and normal venting in the CPP. Small amounts of radon are expected to off-gas from spills, filter changes, IX resin transfer, RO operations, and routine maintenance.

The applicant expects the generation of yellowcake dust to be minimal, as the proposed dryer will be a vacuum type, drum loading will be under a positive seal, and the entire drying chamber containing the yellowcake slurry is under vacuum or under negative pressures, or both.

The staff finds that the applicant's identification of the dust, fumes, or gas sources is acceptable in meeting SRP Acceptance Criterion 3.2.3(2) because the applicant provided figures identifying areas of the effluent sources and description of those sources in sufficient detail for staff to perform an independent evaluation. The radiological effluent is further evaluated in SER Section 4.2.3.

3.2.3.3 Description of Ventilation System

The applicant identifies the ventilation system as either natural ventilation or forced-air exhaust to the atmosphere. The ventilation system for the CPP is designed to move up to six air changes per hour. The ventilation is designed to control and capture releases from tanks or other point sources.

The staff finds that the applicant's identification of the dust, fumes, or gas sources is acceptable in meeting SRP Acceptance Criterion 3.2.3(3) because the applicant described the size, type and location of the dust collectors and radiation monitoring equipment in sufficient detail for staff to perform an independent evaluation. The radiological effluent is further evaluated in SER Section 5.3.1.

3.2.3.4 Availability of Safety Equipment

AUC describes the safety equipment available during operations. The equipment includes personal protection equipment (face shields, protective suits, gloves, and respirators), various eye wash/showers throughout the plant, monitoring equipment, alarms, and secondary containment structures.

3.2.3.5 Identifying Safe Operating Conditions

In TR Section 3.2.3 (AUC, 2012), the applicant discusses sources of nonradiological gases, including acid, sodium hydroxide, and hydrogen peroxide fumes, and routine and nonroutine safety procedures. The routine safety procedures included proper ventilation, construction of storage tanks and piping to established standards, inspections, Material Safety and Data Sheets, and use and training on safety equipment, including personal protection equipment. For nonroutine activities, the applicant commits to developing specific work permits, as well as providing adequate safety equipment, such as eye wash stations and monitoring equipment.

In TR Section 3.2.3 (AUC, 2012), the applicant discusses liquid containment within the CPP. The CPP will contain curbing that will contain 110 percent of the largest tank, drains that drain to a seal sump, and perimeter curbing extending at least 12 inches above the finish floor.

3.2.3.6 Applicable Regulations

In TR Section 3.2.2 (AUC, 2012), AUC stated that the design criteria for chemical storage and delivery systems include applicable regulations of the International Building Code, National Fire Protection Association, Compressed Gas Association, Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act, and the Department of Homeland Security.

In TR Section 5.2 (AUC, 2012), AUC states that radiation protection training will include applicable regulations, such as OSHA, Mine Safety and Health Administration, Wyoming regulations, and NRC regulations(10 CFR Parts 19 and 20).

3.2.3.7 Description of Controls for Eliminating or Mitigating Hazards

The applicant describes occupational and environmental safety controls in TR Sections 1.7, 3.2.3, 4.1, 4.2.1 and 5.7.1 (AUC, 2012). In TR Section 1.7, the applicant states that concurrent operational controls and environmental monitoring programs will ensure that any potential adverse impact on the environment and public health is minimal. Some of the control measures include physical (fences, gates, cattle guards, valves), monitoring (flow meters, alarms), audits, and redundant measures. The applicant in the CPP will be able to monitor operations at the header houses and be alerted to real-time upset conditions. Use of pressurized downward flow IX columns effectively minimizes and controls the release of radon to times of resin transfer or maintenance of the equipment. Radon and other possible gaseous daughter products that can be liberated in the IX and elution transfer process would be captured by ventilation systems and discharged outside of the CPP.

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 Proposed Project in accordance with the review procedures and the acceptance criteria in SRP Section 3.2.2 and Section 3.2.3, respectively. The applicant described the equipment, facilities, and procedures that would be used to protect health and minimize danger to life or property.

The NRC has completed its review of the equipment proposed for use and materials to be processed in the recovery plant, satellite processing facilities, well fields, and chemical storage facilities at the Proposed Project facility. This review included an evaluation using the review procedures in SRP Section 3.2.2 and the acceptance criteria outlined in SRP Section 3.2.3.

Based on the information provided in the application and the detailed review conducted of the equipment to be used and materials to be processed in the recovery plant, well fields and chemical storage facilities for the Proposed Project facility, as described above, the staff concludes that the proposed equipment to be used and materials to be processed in the recovery plant, well fields, and chemical storage facilities are acceptable and are in compliance with 10 CFR 40.32(c), which requires that applicant proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; and 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license. The related reviews of the 10 CFR Part 20 radiological aspects of the recovery plant equipment in accordance with standard review plan Sections 4.0, “Effluent Control Systems;” 5.0, “Operations;” and 7.0, “Environmental Effects” are addressed elsewhere in this SER.

3.3 Instrumentation and Control

3.3.1 Regulatory Requirements

The staff determines if the application has demonstrated that the instrumentation and controls for the Proposed Project meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.3.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 3.3.3 of the SRP (NRC, 2003).

3.3.3 Staff Review and Analysis

Information in SER Section 3.3.3, unless otherwise stated, is from TR Section 3.4 (AUC, 2012).

In TR Section 3.4 (AUC, 2012), the applicant describes the instrumentation and controls that would be used in the processing plant at the facility. The circulation of lixiviant between the wellfield and IX columns will be in a continuous state, and the applicant will monitor deviations from the normal operating conditions that would be indicative of an upset condition. The instruments in the CPP will measure flow rates and pressures on the main trunk lines. The instrumentation also includes an automated bypass and alarms to effectively isolate the CPP operations from the wellfield circulation, should operations in the CPP be shut down. The fluid levels and other parameters as appropriate (pressure, pH levels, and flow rates) in the tanks within the CPP will be monitored locally and displayed by instrumentation in the control room of the CPP.

Instrumentation and control of the yellowcake dryer would include parameters that are important to the efficient operation of the dryer and its safety features and would be sufficient to shut itself down in the event of malfunctions to the heating or vacuum systems (AUC, 2012). In the event of automatic instrumentation failure, manual or visual measurements of important parameters (e.g., differential pressure and vacuum) would be performed and recorded on an hourly basis in accordance with 10 CFR Part 40, Appendix A, Criterion 8.
Instrumentation in the header houses will be used to continuously monitor flow rates and pressures to individual wells and monitor pressures on the manifolds into and out of the header house. In addition, sensors in the header house will detect the presence of liquids and will be set to automatically trigger an alarm.

The staff reviewed the proposed instrumentation and finds that monitoring of these parameters, combined with alarm set points, would provide the operators with the ability to recognize and address problems that might arise. The staff concludes that the applicant has identified instrumentation; monitoring parameters and processes, including wellfield pressures; yellowcake dryer parameters; and backup systems that are consistent with the staff's observation of practices at operating ISR facilities. By providing this information, the applicant has met all of the SRP Acceptance Criteria 3.1.3 (1–5). Thus, these aspects of the facility and approaches to overall control are acceptable to the staff.

3.3.4 Evaluation Findings

The staff has completed its review of the instrumentation and control techniques proposed for use at the Proposed Project. This review included an evaluation using the review procedures in SRP Section 3.3.2 and the acceptance criteria in SRP Section 3.3.3. The instrumentation and control systems have been acceptably described for components, including the wellfields, wellfield header houses, trunk lines, and all plant systems. As discussed in SER Section 3.3.3, the instrumentation would allow for continuous monitoring and control of systems, including flow rates for total inflow to the plant, total waste flow exiting the plant, and liquid levels. Appropriate alarms and interlocks would be part of the instrumentation systems. Each control system would be equipped with an acceptable alternative that allows the system to be shut down in the event of an emergency or power failure.

Based on the information provided in the application and the staff's detailed review of the instrumentation and control for the Proposed Project, the staff concludes that, if the NRC issues a license, the proposed instrumentation is acceptable and is in compliance with 10 CFR 40.32(c) and 10 CFR 40.41(c).

SECTION 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 in situ recovery (ISR) facilities. Effluent control systems serve to (a) prevent and minimize the spread of gaseous and airborne particulate contamination to the atmosphere using emission controls and (b) ensure compliance for radiation dose limits to the public.

4.1.1 Regulatory Requirements

For gaseous and airborne particulates generated at the Proposed Project site, the staff determines whether the applicant has demonstrated compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, Appendix A, Criterion 8, which requires milling operations to be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable (ALARA). The applicant must also demonstrate that gaseous and airborne particulates comply with other relevant sections of 10 CFR Part 20, “Standards for Protection Against Radiation,” and 10 CFR Part 40, “Domestic Licensing of Source Material.”

4.1.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements in 10 CFR Parts 20 and 40 using the acceptance criteria in Standard Review Plan (SRP) Sections 4.1.3 and 5.7.1.3 (NRC, 2003) that apply to effluent controls. Effluent monitoring is addressed in Section 5.7.7 of this Safety Evaluation Report (SER).

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 the applicant will generate at the Proposed Project site, as well as the equipment and systems that the applicant proposes to use to control the release of these radioactive materials to the atmosphere. Review areas addressed in this section include identification of (a) major discharge release points; (b) ventilation, filtration, and confinement systems to be used to control the release of radioactive materials to the atmosphere; and (c) airborne radioactive effluents.

SRP Acceptance Criterion 4.1.3(1) states that monitoring and control systems for the facility are located to optimize their intended function. Monitors used to assess worker exposures are placed in locations of maximum anticipated concentration based upon determination of airflow patterns. SRP Acceptance Criterion 4.1.3(1) does not lend any further health and safety support that is not already discussed in SRP Acceptance Criterion 5.7.7.3(1).

The applicant addressed monitors used to assess worker exposures in locations of maximum anticipated concentration in technical report (TR) Section 5.7.3 (AUC, 2012). The staff reviewed this section and provided an analysis of this section in SER Section 5.7.7. The staff determines that SRP Acceptance Criterion 4.1.3(1) is adequately addressed in TR Section 5.7 and evaluated by the staff in SER Section 5.7.7, and no further review is warranted.

SRP Acceptance Criterion 4.1.3(2) requires that monitoring and control systems for the facility are appropriate for the types of effluents generated. The intended purposes of measurement devices are clearly stated, and criteria for monitoring are provided by the applicant in response to RAI-74 (AUC, 2015a) as discussed below. The acceptance criteria from SRP Section 5.7.7.3 is met by the applicant.

The applicant stated in TR Section 4.1 (AUC, 2012) that the primary radioactive airborne effluent at the Proposed Project facilities will be radon (Rn-222). Radon can be found in the pregnant lixiviant coming from the wellfields into the central processing plant (CPP) where processing of uranium takes place. Radon occurs naturally in the groundwater in the ore body and is brought to the CPP by pumping pregnant lixiviant out of the production zone aquifer to the CPP. Uranium will be recovered from the groundwater by passing the pregnant lixiviant through pressurized downflow ion exchanger (IX) columns and subsequent elution, precipitation, drying, and packaging (AUC, 2012).

In TR Section 4.2 (AUC, 2012), the applicant stated that a separate, independent ventilation system consisting of ducting and/or piping attached to the expected points of release will be installed for all indoor, atmospheric, process tanks and vessels where Rn-222 could be expected. These systems will use redundant exhaust fans to collect and exhaust gases to the outside atmosphere, controlling employee exposure if one of the fans is not operating properly. Ventilation exhaust points will be located on the leeward (downwind) side of the building at an elevation higher than the peak of the building to ensure prevailing winds will disperse the exhaust. Airflow through any openings in the vessels will be from the process area of the CPP, into the vessel and out through the ventilation system, controlling any releases that may occur inside the vessel. To ensure minimization of exposure for all process areas within the CPP, independent, point-source ventilation systems, such as over-the-resin screens, will be used as necessary (AUC, 2012).

In TR Section 4.2 (AUC, 2012), the applicant also stated that the work area will be ventilated with a combination of natural ventilation and a forced-air system that will draw air into the CPP and exhaust to the atmosphere outside of the building. During favorable weather conditions, open doorways and convection vents in the roof will provide sufficient work area ventilation. The forced air system will supplement this condition as required during the heating season (AUC, 2012).

In a request for additional information (RAI), the staff requested (through RAI-74) that the applicant identify all potential air and gaseous effluent release points (NRC, 2014a). The applicant responded to this request for additional information by identifying production units which included header houses and wellfields as potential air and gaseous effluent release points. The applicant also identified other potential air and gaseous effluent release points (AUC, 2015a).

The staff determines that there are several potential airborne source terms at the Proposed Project facility that are generated for potential effluents. These potential effluent source terms are Rn-222, Rn-222 progeny, natural uranium, and natural uranium progeny, and the applicant has identified the potential effluent sources in the application. The applicant recognized that the major source term is radon and, to a lesser extent, that there may be small quantities of air particulates released from the facility.

The staff determines that the applicant has identified all major gaseous effluent release points at the facility as requested in RAI-74 (NRC, 2014a). The staff determines that the identification of the major gaseous effluent release points at the facility provides an important foundation for the applicant to describe the monitoring and measurement process for each release point and the source terms. Thus, the applicant has satisfied SRP Acceptance Criterion 4.1.3(2) for the types of effluents generated. In response to RAI-74, the applicant provided a detailed discussion as follows of the monitoring and measurement process for each release point for both air radon and air particulate.

The applicant stated that radon releases resulting from the presence of radon within the overall CPP air volume (not within specific tanks) will be determined by measuring the average radon concentration within the building and multiplying that concentration by the building's average exhaust fan flow rate for the 6-month period of interest. The rate of CPP air release from the exhaust fans is determined on an air balance report to be developed by the system supplier and on final building design specifications. The total activity released can be calculated by multiplying the average concentration in picocuries per liter (pCi/L) by the total air volume exhausted during the 6-month period, in liters. AUC LLC will use Radtrak devices to monitor radon concentrations, since these devices integrate over the entire period of interest and provide a more accurate measure of released radon than can be provided by other methods, active scintillation cells (Lucas cells) for example, if used to take occasional radon concentration measurements. AUC would also perform Lucas cell measurements at extended intervals. The average of these radon concentration measurements performed at the specified location (illustrated in revised TR Figure 5-3 provided in response to RAI-45) over the 6-month period would then be used in place of the average concentration reported by the Radtrak device. Exhaust volumes are calculated using exhaust fan flow rates in liters per minute, multiplied by the number of minutes in a 6-month period, multiplied by the fraction of the period that the fans were operating. Recording devices will monitor the exhaust fans, providing a record of run time to be used to calculate that fraction. During times when the fans are not operating, an anemometer will be used to measure the exhaust flow. Volumes determined using these flow rates will be added to the release volume calculated for the exhaust fans. The total volume (exhaust fan plus anemometer-monitored volume) will be used to calculate the 6-month radon release, in curies (AUC, 2015a).

The applicant stated that the design basis of the AUC CPP facility includes systems that prevent particulate release. A combination of closed circuit vacuum dryer technology, and process wetting where the potential for exposed solid process material exists, will be used to ensure that airborne particulate radioactive materials will not be present within the plant or emitted from the facility. No vented tank particulate emissions are anticipated. AUC will monitor the CPP area for particulate airborne radioactive material and will report the results of that monitoring, converted to totals of released principal radionuclides, following 10 CFR 40.65, "Effluent Monitoring Reporting Requirements," requirements. Airborne particulate sampling will be continuous, using a pump drawing air through a 47 millimeter (mm) (1.85 inch [in.]) glass fiber filter located near the center of the CPP building (illustrated in revised TR Figure 5-3 provided in response to RAI-45). This will provide a representative measure of average airborne concentration in the plant. The laboratory-reported activity (uranium, Th-230, Ra-226, and Pb-210) for each radionuclide will be divided by the total airflow volume that passed through the filters. The results represent the average CPP air concentration for each radionuclide during the 6-month measurement period. The concentrations, in pCi/L, will be multiplied by the total facility flow rate in liters.

The result, picocuries (pCi) of each radionuclide released from the CPP during the 6-month period, will be divided by 10^{12} pCi/Ci to produce a 6-month release value, in curies, for each principal particulate radionuclide. The data will be reported to NRC in the 6-month 10 CFR 40.65 report (AUC, 2015a).

The applicant stated that releases of radon from vented tanks will be calculated by measuring the concentration of radon being emitted from the exhaust vent and determining the flow rate of gaseous effluent from the vent. The measured radon concentration in pCi/L, multiplied by the effluent flow rate in liters/minute, multiplied by the number of minutes during which venting takes place, divided by 10^{12} pCi/Ci, gives the total radon release in curies for the measured event. Total radon release in curies from vented tanks for the 6-month 10 CFR 40.65 reporting period is calculated by adding the event measurements totals over all measured events that occur during a 6-month period (AUC, 2015a).

The applicant stated that active scintillation cells (Lucas cells) will be used to measure the concentration of radon within each vent. For continuously vented tanks, concentration measurements will be taken quarterly. For intermittently vented tanks, concentration measurements will be taken at least once per quarter when venting occurs during that quarter and during the period determined by AUC to have the highest radon concentrations in effluent gas. For continuously vented tanks, the measured concentrations will be averaged over the 6-month reporting period to determine the total quantity of radon released from each vent during the period. For intermittently vented tanks, the measured concentration will be multiplied by the total gaseous effluent vented to the outside environment during the specific venting event. Total radon released over a 6-month period from that vent will be determined by assuming that other unmonitored venting events (records will be kept by AUC to identify each such event) released the same quantity of radon as the measured quantity for that quarter, or for another representative quarter (a quarter with similar operational status), if monitoring did not occur during the subject quarter. The total quantity of radon released from intermittently vented units is the sum of the radon release quantities, measured and assumed, for the 6-month period (AUC, 2015a).

The applicant stated that, to perform a measurement, the user must actively extract the effluent gas sample from the sampled vent into the Lucas cell. After sampling a vent and performing the Lucas cell analysis at the AUC facility, the radon activity measurement in pCi is divided by the Lucas cell volume, in liters, resulting in a measured radon concentration in pCi/L. This activity is divided by 10^{12} to convert to curies per liter, and the result is multiplied by the average flow rate for the quarter sampled, a flow rate determined by AUC for the specific sampled vent, to calculate the quantity of radon released for the quarter, in curies. Over the 6-month 10 CFR 40.65 period, the totals, all sampling events, all vents, are added together to determine the quantity of radon released, in curies, for the period. During the periods when certain vents are not open to the outdoor environment, AUC will assume that no radon is released from such vents (AUC, 2015a).

The applicant stated that, during the period that a production unit (containing header houses and wellfields) is operating or undergoing groundwater restoration, the potential exists for emissions of radon. No particulate principal radionuclides will be released from operations within the production units. Given the very large number of potential radon release points in these areas, most of which have no airflow systems allowing measurement of radon quantity released, AUC will monitor radon releases through a system employing sets of eight Radtrak high-sensitivity monitors uniformly located around the fenced boundaries. Updated measured radon background data, and the MILDOS code, will be applied to these radon concentration data to determine the radon quantity in curies released from the subject production unit (AUC, 2015a).

The staff determines that the applicant will monitor, measure, and quantify the radioactive materials released from all major gaseous effluent release points. The applicant has described the monitoring for all major gaseous effluent release points, and the methodology for converting the data into quantities that will meet the 10 CFR 40.65 reporting requirements is clearly described above. The staff determines that the intended purposes of measurement devices are clearly stated and criteria for monitoring are provided. Therefore, the staff has reasonable assurance that the applicant will monitor and measure major gaseous effluent release points from the facility and provide total quantities to meet 10 CFR Part 40.65 reporting requirements. This is consistent with SRP Acceptance Criterion 4.1.3(2) (NRC, 2003).

SRP Acceptance Criterion 4.1.3(3) states that the application provides a demonstration that adequate ventilation systems are planned for process buildings to avoid radon gas buildup. Ventilation systems should be consistent with the requirements of Regulatory Guide (RG) 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable" (NRC, 2002b). The acceptance criterion also states that the review should be on radon gas mobilization from (a) recovery solutions entering the plant, (b) the extraction process (where tanks are vented), and (c) uranium particulate emissions resulting from drying and packaging operations and spills. For facilities using an open-air design for processing (i.e., processing equipment is not enclosed by a building), ventilation will be less of a safety concern. Aspects of design that can significantly limit airborne releases include closed production systems (i.e., no venting) and the use of vacuum dryers that eliminate airborne uranium particulate releases from drying operations.

In response to RAI-37, the applicant stated that the heating, ventilation, and air conditioning (HVAC) system will provide air circulation to the facility's main process area, where process vessels, tanks, and other equipment are located, to reduce the potential concentration of radon gas. AUC anticipates a maximum of four air exchanges per hour. Based on the conceptual CPP building layout and a 6.1 meter (m) (20 feet [ft]) building height, the CPP ventilation system will need to provide 2,643 cubic meter per minute (93,333 actual cubic feet per minute [(ACFM]) to meet the maximum four air exchanges per hour to mitigate the production of radon gas within the CPP (AUC, 2015a).

The staff determines that the applicant has explained the four air exchanges per hour and how the four air exchanges per hour relate to the total flow rate, expressed in ACFM for the CPP facility. The staff also recognizes that this is a preliminary estimation of the flow rate and a more detailed flow rate will be provided upon the development of the final engineering plans for the facility. Therefore, the staff concludes that the applicant has demonstrated ventilation systems adequate to protect health and safety are planned for the process building to avoid radon gas buildup, and this is consistent with SRP Acceptance Criterion 4.1.3(3) (NRC, 2003) and RG 8.31 (NRC, 2002b).

SRP Acceptance Criterion 4.1.3(4) states that the application demonstrates that the effluent control systems will limit exposures under both normal and accident conditions. The application also provides information on the health and safety impacts of system failures and identifies contingencies for such occurrences. SRP Acceptance Criterion 4.1.3(5) is that that the application demonstrates that the operations will be conducted so that all airborne effluent releases are ALARA.

In TR Section 4.2.1 (AUC, 2012), the applicant stated that potential radiological air particulate effluents may consist of dried yellowcake from the drying and processing areas of the CPP, and Rn-222 progeny. The proposed CPP will use a vacuum dryer system to produce the final yellowcake product. The vacuum dryer technology provides an emission control approach to ALARA at the source, exceeding the 95- to 99-percent efficiency of multihearth dryers, and is designed to capture virtually all escaping particles. The vacuum drying system will include particulate controls potentially including high-efficiency filters on the vacuum line directly on the dryer, surface condensers, condensate tanks, vacuum pumps, and packaging hoods with filtration systems. The filter housing will be an air and vapor filtration unit, mounted directly onto the drying chamber. This will allow any dry solids that may be collected on the filter surfaces to be discharged back to the drying chamber, while the dryer remains under vacuum to maintain negative pressure in the drying chamber. The filter housing can be heated to control condensation of water vapor during the drying cycle if necessary. The filter housing will be kept under negative pressure by the vacuum system and the differential pressure across the filters being monitored to ensure adequate vapor recovery from the drying chamber. The condenser unit will be located downstream of the filter housing, and will be water cooled. This reduces the water vapor to a liquid and separates it from the noncondensable gases coming from the drying chamber. Gases will be moved through the condenser by the vacuum system. Any particulates passing through the filter housing will be wetted and entrained in the condensed moisture within this unit, then deposited in the condensate tank, where it will be recycled to the process (AUC, 2012).

The applicant stated that, once sufficiently dried, yellowcake will be discharged from the drying chamber through a bottom port into drums. A level gauge, weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture will be provided by a sealed hood between the drying chamber and the top of the drum. The vacuum will draw particles into a high-efficiency filter and draw the remaining gases to the vacuum system. To accomplish this, the packaging hood will be connected to the vacuum system before the condenser, to ensure entrainment of any particles that may pass the filter when the yellowcake is being transferred to drums (AUC, 2012).

The applicant stated that the drying system will have sufficient instrumentation to operate automatically and will be designed to shut down automatically if operating parameters including temperature or vacuum levels fall outside of limits. Automatic alarms will occur in the event the emission control system is not performing within operational limits. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition. In the event the emissions control system is not operating within normal parameters, and the dryer is full of product, the dryer will not be unloaded until the emission control system is returned to service within specified operational conditions. Additionally, the emission control system will be operated to ensure it is functioning properly before an empty dryer is loaded with product. To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed to use an audible and/or visual alarm if the vacuum level is outside operating specifications. The emission control system will be monitored continuously through the control system and automatically documented during drying operations. The control system will immediately initiate alarming to alert operators if operating parameters are approaching or past set limits. In the event the automatic control system is not functioning, but the operation of the system can be confirmed through manual or visual measurements, the operator will perform and document checks of the differential pressure, or vacuum, every hour in accordance with 10 CFR Part 40, Appendix A, Criterion 8, during dryer operations. These checks will be performed and documented by the control system during normal operations (AUC, 2012).

The applicant stated that air sampling will be routinely performed in the area to assess the concentration of Rn-222 progeny using the modified Kusnetz method. Measurements will be made throughout the plant on a monthly basis, and if concentrations exceed 25 percent of the derived air concentration (DAC) in 10 CFR Part 20, Appendix B (>0.08 working level), sampling will be increased to weekly and working level hours of exposure will be calculated and assigned to worker exposure records. If the concentrations reach greater than 25 percent of the DAC, the radiation safety officer (RSO) will investigate potential causes and execute corrective actions. In addition, a particulate air sampler will be operated continuously in the packaging area, with filters pulled and read immediately for gross alpha, then laboratory analyzed for uranium, during packaging operations (AUC, 2012).

In TR Section 4.1 (AUC, 2012), the applicant stated that the use of a pressurized, downflow IX system enables AUC to control Rn-222 releases during maintenance and resin transfer, allowing for a reduction in Rn-222 emissions relative to other available IX technologies. The use of this system also represents a specific emission control method which reduces emissions to levels that are ALARA and complies with the requirements of 10 CFR Part 40, Appendix A, Criterion 8 (AUC, 2012).

Venting of pressurized downflow IX columns occurs only when the columns are being dewatered, when they are refilled to be returned to a pressurized operating condition removing any trapped air, or during occasional upset conditions. Vents from the individual pressurized downflow IX columns will be directed to a manifold system which will be exhausted to the atmosphere outside and well above the CPP. An induced draft fan will be placed into this manifold system to force the exhausted air to the outside atmosphere. When it is necessary to vent a pressurized downflow IX column, venting any Rn-222 that may have been released from the lixiviant to the atmosphere outside the plant will minimize employee exposure. The pressurized downflow IX vessel vent outlet will be placed to minimize collection of Rn-222 by plant air intake vents. Small amounts of Rn-222 may be released via solution spills, filter exchanges, IX resin transfer, reverse osmosis (RO) system operation during groundwater restoration, and routine maintenance activities. The CPP ventilation system will minimize employee exposure to Rn-222. Air in the plant will be sampled for Rn-222 progeny to ensure that levels of Rn-222 and its progeny are maintained ALARA (AUC, 2012).

The staff determines that the applicant has demonstrated that the emission control system for the yellowcake dryer and packaging system and the pressurized downflow IX column process will limit exposures under normal and accident conditions and that operations will be conducted so that all airborne effluent releases are ALARA. The yellowcake drying and packaging system is designed to remove air particulates that may escape during the drying of the yellowcake, and the pressurized downflow IX columns will minimize the release of radon to the atmosphere during operations. Therefore, the staff has reasonable assurance that the yellowcake drying and packaging system and the pressurized downflow IX column process will control emissions and maintain radiation doses ALARA consistent with SRP Acceptance Criterion 4.1.3(4) and Acceptance Criterion 4.1.3(5) (NRC, 2003).

4.1.4 Evaluation Findings

The staff has completed its review of the effluent control systems for gaseous and airborne particulates proposed for the AUC facility. This review included an evaluation using the review procedures in SRP Section 4.1.2 and the acceptance criteria outlined in SRP Section 4.1.3.

The applicant adequately described the discharge points and the types, estimated composition, and flow rates of effluents released to the atmosphere. The applicant designated monitoring and control systems for the types of effluent generated. Also, the applicant specified acceptable monitoring criteria and located the facility monitoring and control systems for the required functions to optimally assess worker exposure in locations of likely maximum concentrations determined by the applicant's analysis of airflow patterns. The applicant demonstrated that ventilation systems are adequate to prevent radon gas buildup where (a) recovery solutions enter the plant, (b) tanks are vented during the extraction process, and (c) drying and packaging operations occur. By providing information on the health and safety impacts of system failures and identifying contingencies for such occurrences, the applicant adequately showed that effluent control systems will limit radiation exposures under normal and accident conditions. The applicant committed to occupational radiation doses and doses to the general public that meet dose limits and ALARA.

Based on the information provided in the application and the detailed review conducted of the effluent control systems for gaseous and airborne particulates for the Proposed Project facility, the staff concludes that the proposed effluent control systems for gaseous and airborne particulates are acceptable and are in compliance with 10 CFR 20.1101, "Radiation Protection Programs," which requires that a radiation protection program that achieves ALARA goals is in place and that a constraint on air emissions, excluding Rn-222 and its decay products, will be established to limit doses from these emissions; 10 CFR 20.1201, "Occupational Dose Limits for Adults," which defines the allowable occupational dose limits for adults; 10 CFR 20.1301, "Dose Limits for Individual Members of the Public," which defines dose limits allowable for individual members of the public; 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public," which requires compliance with dose limits for individual members of the public; 10 CFR Part 40, Appendix A, Criterion 5(G)(1), which requires that the chemical and radioactive characteristics of waste be defined; and 10 CFR Part 40, Appendix A, Criterion 8, which provides requirements for control of airborne effluent releases. The related reviews of the 10 CFR Part 20 radiological aspects of the effluent control systems for gaseous and airborne radionuclides in accordance with SRP Sections 5.0, "Operations," and 7.0, "Accidents," are addressed elsewhere in this report.

4.2 Liquids and Solids

In this section, the staff reviews the applicant's estimates of the quantities and composition of waste residuals expected during construction and operation, procedures for management of the waste residuals, design specifications for effluent control systems and plans to obtain necessary permits. The staff addresses radiological impacts from the effluent control systems for liquid and solid radiological waste in SER Section 5.0.

4.2.1 Regulatory Requirements

For liquid and solid waste generated at the applicant's facility, the staff determines whether the applicant has demonstrated compliance with 10 CFR Part 20 and 10 CFR Part 40, Appendix A. In addition to the aforementioned regulations, the staff determines whether the applicant has met RG 3.11, "Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities" (NRC, 2008).

4.2.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in SRP Section 4.2.3 (NRC, 2003), which incorporates guidance in RG 3.11. Additionally, the staff reviewed the application for compliance with the requirements of 10 CFR Part 20 using SRP Acceptance Criterion 6.1.3(13) (NRC, 2003).

4.2.3 Staff Review and Analysis

SRP Acceptance Criterion 4.2.3(1) states that common liquid effluents generated from the process bleed, process solutions, washdown water, well development water, pumping test water, and restoration waters are properly controlled. Acceptable control methods include diversion of liquid wastes to surface impoundments, deep well injection, and land application/irrigation. Solid effluents can be considered either as contaminated or as noncontaminated. For land application, the applicant should comply with 10 CFR Parts 20 and 40.

In TR Section 4.3 (AUC, 2012), the applicant classified liquid 11e.(2) byproduct material into three types: (1) brine, (2) permeate, and (3) other liquid 11e.(2) byproduct material. Brine that is generated through the use of the RO units will be sent to the CPP waste water tanks before disposal in a deep disposal well (DDW), and occasionally RO brine will be temporarily discharged to the lined backup storage pond if the DDW capacity is not sufficient due to maintenance or repair.

The applicant also stated that a high percentage of permeate generated through the use of the RO units will be injected either into the barren lixiviant stream or into the groundwater restoration circuit, and permeate which is not recycled back to operation or restoration activities will be used as plant makeup water. Other 11e.(2) liquid byproduct material includes spent eluate, resin transfer wash water, and plant washdown water. Fluids generated in the CPP will be discharged to the waste water disposal system or to the feed of the secondary RO unit. Liquid 11e.(2) byproduct material collected from the wellfields will be collected in dedicated portable tanks or tanker trucks and transported to the waste water disposal system or to the feed of the secondary RO unit. Also, any water captured from leaking pipelines or equipment will be transported to the waste water disposal system in dedicated portable tanks or tanker trucks. The staff determines that the applicant's excess liquids that are not used for the sole purpose of production fluids are either stored for future use, reprocessed for future production, or disposed to a DDW. The staff determines that the applicant will not discharge liquid effluents into an unrestricted area and the environment. The staff determines that the excess fluids disposed into DDWs are not a liquid "effluent" discharge as defined in RG 4.1, "Radiological Environmental Monitoring for Nuclear Power Plants" (NRC, 2009a) and RG 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste" (NRC, 2009b) because it is not discharged beyond the site-boundary. In addition the liquid is not discharged to an "unrestricted area," as defined in 10 CFR 20.1003, "Definitions." The staff determines that the liquid byproduct material is waste. The applicant showed the location of the DDWs in TR Figure 2.1-3 (AUC, 2012). The staff determines that the DDWs are within the Proposed Project boundary. The applicant stated in TR Section 4.3 (AUC, 2012) that the receiver interval consists of the Cretaceous Teapot and Parkman sandstones at depths of approximately 2,271 to 2,557 m (7,450 to 8,390 ft below ground surface [bgs]). The applicant stated in TR Section 4.3 (AUC, 2012) that liquid 11e.(2) byproduct material disposal at the site will be accomplished through deep well injection and permitted in accordance with Wyoming

Department of Environmental Quality (WDEQ) Water Quality Division (WQD) Class I Underground Injection Control (UIC) rules and regulations. The WDEQ/WQD has subsequently issued AUC, LLC a Class I UIC Permit for up to four DDWs (AUC, 2016b). The staff determines that the applicant will properly control all fluids and discharges to the DDWs and that members of the public do not have access to these wells or the contents within these wells. The staff determines that the applicant has met SRP Acceptance Criteria 4.2.3(1) and (8) for control of liquid 11e.(2) byproduct material disposal.

In response to RAI-38, the applicant stated that it will not incorporate land application as part of its waste water disposal system (AUC, 2014c).

The applicant stated in TR Section 3.1.8 and Section 4.3.5 that AUC will install a backup storage pond to temporarily store waste water which will provide excess waste water capacity during the time a DDW is offline (AUC, 2012). The applicant depicted a backup pond in TR Figure 3-1 (AUC, 2012). The pond will be installed to provide redundancy in the waste water management system and is not intended to be used to transfer waste water to the DDW on a daily basis. The applicant indicated in TR Section 3.1.8 that the backup storage pond is designed to have a capacity of approximately 1,987,341 liters (L) (525,000 gallons [gal]).

According to the applicant, the storage pond would have the following characteristics:

- dimensions of 53.3 m by 33.5 m (175 ft by 110 ft) at the crest
- double liner with a leak detection layer
- six perimeter sumps with a connection to the leak detection layer to allow staff personnel to check for the presence of liquids in the leak detection layer
- a maximum pond depth of approximately 2.4 m (8 ft) with 0.6 m (2 ft) of planned freeboard between the top of the water and the inside crest of the embankment slope
- a maximum embankment height of approximately 2.1 m (7 ft) above the existing ground surface on the east side of the storage pond
- four shallow leak detection wells to provide redundant detection of potential leaks

The staff's review included an assessment of (a) information from the subsurface investigation documenting soil conditions near the storage pond, (b) design and construction details of the storage pond, and (c) closure and decommissioning of the storage pond.

Storage Pond Site Characterization

The applicant completed a subsurface investigation to support construction of the storage pond (AUC, 2015a). The investigation included a series of four borings in the immediate vicinity of the storage pond and an additional 11 borings onsite. The borings were advanced to depths ranging from 3.5 to 6.5 m (11.5 to 21.5 ft). According to the applicant, groundwater was not encountered in any of the boreholes during drilling. The applicant obtained soil samples from a variety of depths and performed laboratory tests to determine the engineering properties of the soil. Engineering properties determined from the laboratory tests included gradation characteristics, liquid limit, plastic limit, plasticity index, moisture content, and consolidation characteristics.

The applicant stated in TR Section 2.7 and Section 4.3 (AUC, 2012) that the overlying aquifer is considered the uppermost aquifer within the site boundary. Based on the depth of the overlying aquifer, which ranges between approximately 21.3 to 47.2 m (70 to 155 ft) bgs, and the observed sequence of finer grained silt and shale that overlies this aquifer, the overlying aquifer is considered to be isolated from the surface water drainages present at the site, which would prevent the infiltration of fluids should a leak develop in the storage pond liner system. TR Section 4.3.5.2 (AUC, 2012) states that the applicant will not install leak detection wells in the overlying aquifer as part of the storage pond leak detection well network.

The staff finds that the soil properties were determined at various depths from borings in the vicinity of the storage pond. The staff observed that the engineering properties of the soils were determined using laboratory techniques that followed appropriate American Society for Testing and Materials (ASTM) standards. As the applicant determined soil properties near the storage pond using appropriate ASTM standards, the staff finds that the applicant has adequately characterized the subsurface conditions at the planned location of the storage pond. Therefore, the staff determines that the applicant's characterization of the storage pond site is sufficient to support engineering assessments related to the performance of the storage pond and related embankment.

Storage Pond Design

In response to RAI-39, the applicant presented drawings and plans documenting the engineering design and construction aspects of the planned storage pond (AUC, 2015a and AUC, 2015c). The pond will have a maximum capacity of approximately 2,971,548 L (785,000 gal) and an operating capacity of approximately 1,983,555 L (524,000 gal). The storage pond will have dimensions of 53.3 m by 33.5 m (175 ft by 110 ft) and a maximum exterior embankment height of approximately 2.1 m (7 ft) on the eastern side. The applicant plans to construct the pond with a double synthetic liner and leak detection system. The remainder of this section addresses specific storage pond design components.

Slope Stability

The applicant performed both static and pseudo-static slope stability analysis of the storage pond at the critical cross section (AUC, 2015c). The applicant identified the critical cross section running east to west through the middle of the storage pond; at this location, the top of the pond embankment is between 1.8 and 2.1 m (6 and 7 ft) above the surrounding ground surface. Based on its review of the pond configuration, the staff agrees that this location represents the highest embankment height and the critical cross section. The staff reviewed the material properties, critical cross section geometry, and loading cases for the slope stability analysis and finds them representative of the site. The applicant performed the slope stability analysis using Slope/W software package, which is a widely available computer program. The Morganstern-Price analysis method, a generally accepted analysis method, was used in the analysis. The applicant's results exceeds the 1.5 and 1.0 minimum factor of safety values for static and pseudo-static slope stability analysis used in standard practice. The staff concludes that the applicant has demonstrated that the storage pond will be stable under the anticipated loading conditions. By demonstrating stability of the storage pond, the staff finds that the applicant has shown that this approach is consistent with SRP Acceptance Criterion 4.2.3(4). This acceptance criterion states that the design of surface impoundments used in the management of byproduct material meets or exceeds the requirements in 10 CFR Part 40, Appendix A, Criterion 5A, and in RG 3.11, Section 2, (NRC, 2008), which outlines acceptable methods for slope stability and settlement analyses. Specifically, the staff finds that the applicant has not assumed that the double liner system will function without leakage when evaluating the slope stability and structural integrity of the embankment, as required by Criterion 5A(5) of Appendix A to 10 CFR Part 40. Additionally, the stability analysis follows the recommendations contained in Section 2.1.1.2 of RG 3.11.

Settlement

The applicant's engineering drawings for the storage pond call for placement of approximately 2.1 m (7 ft) of fill above the existing ground surface on the east side of the pond. The applicant analyzed settlement of the embankment based on the engineering properties of the soil and embankment height (AUC, 2015c). The applicant's analysis anticipates that approximately 0.11 m (0.35 ft) of settlement will occur at the crest of the embankment on the eastern side of the storage pond. The staff reviewed the applicant's settlement calculations and observed that the applicant's analysis was based on the anticipated loading conditions after embankment construction as well as the soil conditions identified during site characterization. For these reasons, the applicant's approach meets SRP Acceptance Criterion 4.2.3(4) (NRC, 2003) and is consistent with the settlement analysis guidance in Section 2 of RG 3.11.

Liquefaction Potential

The applicant addressed the potential for liquefaction to occur in the vicinity of the storage pond (AUC, 2015c). The applicant's subsurface investigation showed that soils in the area of the storage pond are generally cohesive in nature with greater than 50 percent fines in many samples. Additionally, the applicant determined that the liquid limit of the soils was typically less than 35 percent. The applicant also discussed the results of the standard penetration tests. These tests showed blow counts higher than those typically associated with liquefiable soils and an increasing blow count with depth. Based on these results, the applicant determined that the soils are not susceptible to liquefaction. The staff reviewed the results of the subsurface investigation and liquefaction potential analysis. The staff determines that the soils present at the pond location are not typically susceptible to liquefaction; therefore, no further analysis is warranted. Because the applicant submitted information documenting that liquefaction is not a concern, the staff finds this aspect of the storage pond design meets SRP Acceptance Criterion 4.2.3(3) (NRC, 2003). Therefore, this approach is acceptable to the staff.

Freeboard

The applicant evaluated the potential for overtopping of the storage pond to determine the required freeboard (AUC, 2015c). The applicant's engineering design and drawings for the pond depict a configuration where the pond has a perimeter embankment with no spillway. Additionally, the storage pond design will divert surface water runoff around the pond. The staff reviewed the applicant's design and determines that the only liquids entering the pond would be (a) water awaiting disposal via the deep disposal well or (b) precipitation that falls directly into the pond, as surface water will be diverted around the pond. The applicant used guidance developed by the U.S. Army Corps of Engineers to estimate the amount of wave runup and anticipates wave runup of 0.33 m (1.1 ft). The staff reviewed the proposed calculation method and determines that the method is acceptable. The applicant designed the pond to have 0.6 m (2 ft) of freeboard, which is greater than the amount of runup anticipated. Therefore, the staff finds that the applicant has met SRP Acceptance Criterion 4.2.3(2).

Liner and Leak Detection

The applicant proposed constructing the liner system for the storage pond with a double geosynthetic liner. A leak detection system will be located between the two geosynthetic layers. From top to bottom, the applicant's proposed liner system will consist of the following components (AUC, 2015c):

- a 0.09-cm (0.036-inch) thick (minimum) high density polyethylene or polypropylene primary geosynthetic liner

- a geotextile drainage layer to transmit any leakage to the perimeter monitoring sumps

- a 0.09-cm (0.036-inch) thick (minimum) secondary liner

- native soil

The staff observed that, in the applicant's design, the geotextile drainage layer will function as a leak detection layer. The geotextile drain is a highly permeable layer located between the two low permeability geosynthetic liners. Additionally, the grading plan for the pond shows the bottom of the pond sloped toward the leak detection sumps. Therefore, any liquid that leaks through the primary liner will be directed to one of the sumps, where it can be easily detected and collected. The staff finds that the proposed liner system meets the regulations in 10 CFR Part 40, Appendix A, which require that a synthetic liner have a leak detection system. The staff also finds that the storage pond has been designed to prevent migration of wastes to the subsurface, which is consistent with SRP Acceptance Criterion 4.2.3(2). Additionally, the applicant identified the anticipated chemical composition of the liquid byproduct material on TR Table 4-3. By providing this information, the staff finds that the applicant has satisfied SRP Acceptance Criterion 4.2.3(4).

In TR Section 4.3.5.3, the applicant proposed an operational inspection plan for the storage pond. The inspection plan includes daily, weekly, quarterly, and annual inspections. An overview of the inspection is as follows:

- Daily inspections will include visual inspections of the piping, berms, diversion ditches, freeboard, and leak detection systems.

- Weekly inspections will include visual inspection of the entire area, including perimeter fencing.

- Quarterly inspections will include sampling of the designated groundwater leak detection wells, and the results of the quarterly inspections will be included in the quarterly report submitted to the NRC.

- Annual inspections will include a review of the previous year's daily, weekly, and quarterly inspections, assessment of the hydraulic and hydrological capacities, and a survey of the embankment by qualified personnel.

The staff reviewed the applicant's proposed inspection plan and observed that it includes items related to integrity of the liner system, freeboard, integrity of the embankment slopes, and sampling of the leak detection sumps when they contain liquids. The staff determines that the applicant's inspection plan is consistent with SRP Acceptance Criterion 4.2.3(2). The staff will include the operational inspection plan in the license; this is further discussed in the evaluation findings below.

The applicant stated in TR Section 4.3 (AUC, 2012) that corrective actions for detected leaks include notifying the NRC Project Manager by telephone or email within 48 hours and lowering the water level in the storage pond sufficiently to eliminate the leak. TR Section 4.3.5.4 also states that the applicant commits to completing the corrective actions within 60 days, during which time the applicant will not use the pond to store byproduct material until qualified personnel inspect the repaired liner. The staff determines that the applicant has developed an adequate inspection and corrective action procedure to prevent migration of waste from the storage pond to the subsurface, which is consistent with the SRP Acceptance Criterion 4.2.3(2).

Groundwater Monitoring Program for the Backup Pond

In TR Section 4.3.5.2 (AUC, 2012), AUC states that it will install four shallow piezometer/leak detection wells as part of the leak detection program to provide redundant detection of potential pond leaks. The applicant also states that perched water table conditions do not exist to a depth of 6.1 m (20 ft) based on preliminary subsurface geotechnical borings conducted in the area of the proposed pond. Furthermore, AUC states that the Overlying Aquifer, which the applicant considers the uppermost aquifer, is found 21 to 47 m (70 to 155 ft) below grade and, due to the intervening fine grained horizons, is isolated from the surface and prevents the infiltration of a leak to the overlying aquifer. Therefore, AUC states that the completion intervals of the wells will be based on soil sampling and AUC will target the most permeable sediment layers that will provide a conduit of potentially leaked pond byproduct water. AUC will propose the location of the leak detection wells in the backup storage pond design plan.

AUC proposes to measure the water levels in the shallow piezometer/leak detection wells quarterly. If there is a water level increase in a pond leak detection well or water is present in a previously dry well, AUC will attempt to collect a water sample from the affected leak detection well. AUC will determine through statistical analysis of the water quality whether the groundwater collected form the leak detection well is from a storage pond leak or from surface waters. In response to RAI-19 (ML15002A077), AUC commits to installing a groundwater monitoring program compliant with Criterion 7A of Appendix A, 10 CFR Part 40.

The staff reviewed the program subject to requirements for a groundwater detection monitoring program in 10 CFR Part 40, Appendix A Criterion 7A because the backup pond will be used to retain byproduct material. In essence, AUC proposes to monitor a shallow unsaturated or saturated sand for water level changes rather than the quality in the uppermost aquifer. The program as proposed by AUC may be considered as an "alternative detection monitoring program" subject to approval by the Commission in accordance with Criterion 5B(3). Similar programs have been approved at existing ISR facilities where it has been shown that, based on site conditions, monitoring the uppermost aquifer would not provide timely detection of a release.

AUC's language to describe the proposed program does not provide specific information needed for approval of an alternative program. The staff identified three issues with the applicant's description. First, the permeable sand layer should be that layer immediately overlying the shallow-most fine grained layer rather than referring to "the most permeable sediment layers that will provide a conduit of potentially leaked pond byproduct water." The applicant's description could refer to any layer in the stratigraphic column including those below uppermost fine grained horizon, which like the uppermost aquifer, would not provide timely detection of a leak. Second, if that layer is saturated prior to operations, the background water quality needs to be established prior to start of operations. Third, as discussed in SER Section 2.4.3.5, the staff considers the SM unit the uppermost aquifer where it exists. In the area of the pond, the SM unit exits. Furthermore, based on water level data from the existing monitoring well network, water levels in the SM unit are 14 to 20 m (45 to 67 ft) above those in the OM aquifer. Therefore, the uppermost aquifer may be found at a shallow depth such that an alternative program is not necessary.

The staff finds the proposed program and commitments by AUC acceptable subject to staff's verification that the program meets the requirements of 10 CFR Part 40, Appendix A Criterion 7A, or that AUC provides sufficient justification for approval of an alternative program based on site conditions. The staff verification will be performed during review of the Quality Assurance Program for the ponds (see License Condition 12.14).

<u>Construction Considerations</u>

The applicant provided a set of engineering drawings that provide details related to construction of the storage pond (AUC, 2013b) and (AUC, 2015c). The staff reviewed the drawings, which provide information on the location of the storage pond, liner system, details of the leak detection system, and associated pond infrastructure. With respect to engineering quality control for construction of the storage pond, the applicant committed to preparation of detailed specifications for material placement techniques as well as testing methods and frequencies. The applicant committed to developing a quality control program consistent with the guidance in NRC RG 3.11 and will notify the staff when this program is complete and available for NRC review. This approach is acceptable to the staff as the SRP states on page xviii that "[a] licensing review is not intended to be a detailed evaluation of all aspects of facility operations" and the construction of the pond has a nexus to health and safety and thus prohibited from being performed prior to issuance of the license. Submittal of a quality control document has not been a requirement for license issuance; however, the staff will include a requirement for notification of the quality control plan as a pre-operational license condition prior to the pond construction. This is further discussed in the evaluation findings below.

<u>Closure</u>

The applicant discussed the closure of the backup storage pond in TR Section 4.3.5 and Section 6.2, and TR Addendum 6-A, Section 1.2.4. The applicant anticipated that the storage pond will have the potential to be used over the entire life of the facility. After completion of license activities, including uranium recovery operations, and groundwater restoration, the applicant plans to close and decommission the pond. The applicant's closure activities would include removal of the liner material, removal of contaminated materials, and transport of these items to a facility licensed for byproduct material disposal. The applicant would conduct surveys to confirm that the area is suitable for release (AUC, 2012). The staff reviewed the applicant's plan for closure of the storage pond. By providing this information on decommissioning of the storage pond, the applicant has met SRP Acceptance Criterion 4.2.3(1).

SRP Acceptance Criterion 4.2.3(5) states that plans and procedures are provided for addressing contingencies for all reasonably expected system failures.

In TR Section 7.5.1, the applicant provided a description and evaluation of liquid waste and process fluid accidents, including a lined backup pond accident. The staff determines that the applicant has addressed likely consequences of any failures in process or wellfield equipment that could result in a release of material. In TR Sections 5.1 and 5.2, the applicant provided the corporate organization, responsibilities, and administrative procedures (AUC, 2012). This includes reporting procedures in the event of a spill or release. The staff determines that the applicant has identified appropriate plant and corporate personnel who must be notified in the event of specific types of failures. The applicant described in TR Section 4.3.5 (AUC, 2012) the pond liner and leak detection system. In addition to the pond liner and leak detection system, the applicant will install shallow leak detection wells to provide for redundant detection of potential leaks. The staff determines that the applicant has provided a detailed description of the pond liner and leak detection system for quickly containing and mitigating the impacts of released materials sufficient for staff's reasonable assurance determination that the pond construction includes suitable designs to identify potential leaks. The applicant provided in TR Section 5.2 (AUC, 2012) a description of the radiation work permit (RWP) and the conditions under which the RWP will be implemented. This includes cases when the RWP will be issued for nonroutine activities with a potential for exposure to radioactive materials for which no operating procedure exists in the CPP or the wellfields. The staff determines that the applicant has addressed the provisions for issuing RWPs for workers to mitigate impacts. The applicant provided in TR Section 5.2.6 (AUC, 2012) the reporting requirements for spills, leaks, or excursions and environmental monitoring reports consistent with 10 CFR Part 20, Subpart M; and 10 CFR 40.64, "Reports"; 10 CFR 40.65, "Effluent Monitoring Reporting Requirements"; and 10 CFR 40.66, "Requirements for Advance Notice of Export Shipments of Natural Uranium." This also includes a 48-hour notification followed by a submitted written report to the NRC headquarters' Project Manager, detailing the conditions leading to the spill or incident, corrective actions, and results achieved within 30 days of initial notification. The staff determines that the applicant has provided specific procedures for complying with notification requirements in the regulations. The staff determines that, consistent with SRP Acceptance Criterion 4.2.3(5), the applicant has provided plans and procedures for addressing contingencies for all reasonably expected system failures.

SRP Acceptance Criterion 4.2.3(6) states that the application contains a description of the methods to be used for disposing of contaminated solid wastes that are generated during operation of the facility.

The applicant divided solid waste into two groups—solid 11e.(2) byproduct material and solid non-11e.(2) byproduct material. The applicant stated in TR Section 4.3 (AUC, 2012) that all items contaminated during operations, groundwater restoration, and decommissioning, that cannot be decontaminated to meet release criteria, will be properly packaged, transported, and disposed offsite at a licensed solid 11e.(2) byproduct material disposal facility. Solid 11e.(2) byproduct material that may be contaminated, which was generated at the site, consists of items such as rags, trash, packing material, worn or replaced parts from equipment, piping, filters, protective clothing, solids removed from process pumps and vessels, and spent resin. The applicant estimated that the site will produce approximately 76.45 cubic meters (100 cubic yards) of solid 11e.(2) byproduct material per year during operation. The applicant stated in TR Section 4.3 (AUC, 2012) that solid 11e.(2) byproduct material will be collected and stored within a designated restricted area in appropriate containers approved by U.S. Department of Transportation and will be appropriately labeled and placarded for the class of material being shipped. The applicant stated in TR Section 4.3 (AUC, 2012) that, before beginning of operations, the applicant will have in place a signed contract for solid 11e.(2) byproduct material disposal at such a facility, and the applicant committed to acquiring a solid 11e.(2) byproduct material disposal agreement before commencement of licensed operations. The staff will include a license condition requiring that an agreement for disposal of byproduct material be in place before the preoperational inspection. This condition is further discussed in the evaluation findings below.

In TR Section 4.3 (AUC, 2012), the applicant estimated that the site will produce approximately 1,147 m^3 (1,500 yd^3) of uncontaminated solid waste material per year and the uncontaminated solid waste will be collected on the site on a regular basis and disposed of in the nearest approved sanitary landfill, compliant with the rules and regulations of WDEQ/Solid & Hazardous Waste Division (SHWD).

The staff determines that the applicant has provided a description of the methods to be used for disposing of both contaminated and noncontaminated solid waste and the annual estimated generation of waste during operation of the facility consistent with SRP Acceptance Criterion 4.2.3(6).

SRP Acceptance Criterion 4.2.3(7) states that water quality certification and discharge permits have been obtained or plans are in place to obtain them. The applicant indicated in TR Section 4.3 (AUC, 2012) that permits have been obtained for technologically enhanced naturally occurring radioactive material in conjunction with drilling fluids at drilling pads. Permits for storm water runoff around the site have been or will be obtained in accordance with the Wyoming Pollutant Discharge Elimination System issued by WDEQ/WQD. The applicant stated in TR Section 4.3 (AUC, 2012) that domestic waste from the restrooms, locker rooms, and lunchrooms will be disposed in a septic tank, and the storage of used oil onsite in a storage tank will be evaluated by the State of Wyoming and permits issued accordingly via WDEQ/WQD and WDEQ/SHWD. The staff determines that these waste streams are considered liquid non-11e.(2) byproducts, and the applicant has identified these waste streams for State review and permit. The staff determines that the applicant has obtained or will obtain the proper water quality certification and discharge permits consistent with SRP Acceptance Criterion 4.2.3(7).

SRP Acceptance Criterion 4.2.3(9) states that alternatives to liquid management activities have been considered and none were found to be obviously superior to the selected options. The staff determines that the applicant has described liquid waste management activities similar to liquid waste management activities at other uranium recovery facilities, and specifically in situ recovery facilities. The staff determines that the applicant has not provided alternatives to liquid management activities different from liquid waste management activities at other uranium recovery facilities, which is consistent with SRP Acceptance Criterion 4.2.3(9).

4.2.4 Evaluation Findings

The staff reviewed aspects of the solid and liquid effluents to be generated at the Proposed Project in accordance with the procedures in SRP Section 4.2.2 and acceptance criteria in SRP Section 4.2.3. The applicant described the common liquid effluents that will be generated at the facility. The applicant also described the methods used to dispose of solid and liquid effluents—deep well injection and a storage pond. To clarify certain aspects related to the authorized pond, operational inspection plan, and groundwater protection, the staff is imposing the following license conditions:

License Condition 10.9 (A, B, C, and D)

Before the construction of the retention pond, the licensee shall submit, for NRC review and verification, a groundwater detection monitoring program plan for the retention pond that is consistent with the applicant's conceptual model and commitments as described in the application. This commitment will be captured in the following license condition:

License Condition 10.17

On the basis of the information presented in the application, and the license conditions discussed above, the staff concludes that the characterization information provides an acceptable basis to enable the staff to make a finding on compliance with the applicable criteria in 10 CFR Part 40, Appendix A. The applicant described how embankments used to form the pond are designed, constructed, and maintained with sufficient structural integrity to prevent a massive failure. The design of the embankment to construct the storage pond is consistent with RG 3.11, Sections 2 and 3, and therefore meets the requirements of 10 CFR Part 40, Appendix A, Criterion 5A(5).

The applicant committed to securing an agreement for disposal of solid byproduct material; however, the applicant does not yet have an acceptable plan in place. Therefore, the staff is adding the following license condition to ensure that an agreement is in place before the startup of operations:

License Condition 12.5

Based upon the review conducted by the staff as indicated above, the staff concludes that the proposed control systems for liquid and solid effluents meet the applicable acceptance criteria in SRP Section 4.2.3 and the applicable requirements in 10 CFR Parts 20 and 40.

SECTION 5

OPERATIONS

5.1 Corporate Organization and Administrative Procedures

5.1.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed corporate organization and administrative procedures for the Proposed Project are consistent with requirements of Title 10 of the *Code of Federal Regulations* (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 staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, “Domestic Licensing of Source Material,” using the acceptance criteria outlined in Standard Review Plan (SRP) Section 5.1.3 (NRC, 2003).

5.1.3 Staff Review And Analysis

Information in this section, unless otherwise stated, is from Technical Report (TR) Section 5.1 (AUC, 2012). In this section, the applicant describes the management portion of the AUC, LLC (AUC), corporate organization including the President and Chief Executive Officer (CEO), General Manager, Plant Manager, Environmental Health and Safety Manager, and Radiation Safety Officer (RSO). The AUC organization chart in TR Figure 5-1 provides the part of the organization with responsibilities associated with the operation of the Proposed Project and represents the management levels that play a key part in the Radiation Protection Program (RPP). The management positions identified in this chart are responsible for the development, review, approval, implementation, and adherence to operating procedures, programs, environmental and groundwater monitoring programs as well as routine and nonroutine maintenance activities. TR Section 5.1 describes the roles and responsibilities of each part of the organization:

- The Board of Directors has the ultimate responsibility and authority for setting corporate policy and related procedural guidance but delegates (assigns) ultimate responsibility and authority for occupational and radiation safety, environmental protection, and compliance with all U.S. Nuclear Regulatory Commission (NRC) regulations, license condition and all state and local regulations and permit conditions to AUC’s management as described below.
- The President and CEO has the ultimate responsibility and authority for the radiation safety and environmental compliance programs at all AUC facilities. The President and CEO is directly responsible for ensuring that AUC personnel comply with industrial safety, radiation safety, and environmental protection programs as established in the AUC Program. The President and CEO has the responsibility and authority to

immediately terminate any activity that is determined to be a threat to employees or public health, the environment, or a potential violation of State or Federal regulations.

- The General Manager is responsible for management of all company operations at the Proposed Project. The General Manager has the responsibility and authority for the radiation safety and environmental compliance programs. The General Manager is responsible for ensuring that AUC personnel comply with industrial safety, radiation safety, and environmental protection programs as established in the AUC Program. The General Manager is also responsible for compliance with all regulatory license conditions/stipulations, regulations, and reporting requirements. The General Manager is responsible for all uranium production activity at the Proposed Project site. All site operations, maintenance, construction, environmental health and safety, and support groups report directly to the General Manager. In addition to production activities, the General Manager is also responsible for implementing the industrial and radiation safety and environmental protection programs associated with operations. The General Manager is authorized to immediately implement any action to correct or prevent hazards. The General Manager has the responsibility and the authority to suspend, postpone, or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of State or Federal regulations. In the event of a spill or release, it is the responsibility of the General Manager or designee to report the incident in accordance with license requirements, 10 CFR Part 20, Subpart M, and 10 CFR Part 40.60. The General Manager reports directly to the President and CEO.

- The Plant Manager is responsible for construction and vendor activities for the Proposed Project, and the Plant Manager reports to the General Manager (AUC, 2015c).

- The Manager of Environmental Health and Safety is responsible for all radiation protection, health and safety, and environmental programs as stated in the RPP and for ensuring that AUC complies with all applicable regulatory requirements. The Manager of Environmental Health and Safety reports directly to the General Manager and supervises the RSO to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The Manager of Environmental Health and Safety has no production-related responsibilities and has the responsibility to advise the President and CEO on matters involving radiation safety and to implement changes and corrective actions involving radiation safety authorized by the President and CEO. The Manager of Environmental Health and Safety is also the Quality Assurance (QA) Manager.

- The RSO is responsible for the development, administration, and enforcement of all radiation safety programs in accordance with the facility license, Regulatory Guide 8.31, Section 1.2 (NRC, 2002b), and all other applicable regulations and guidance. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and maintain regulatory compliance. The RSO is responsible for the implementation of all onsite environmental programs, including emergency procedures, training programs for both the staff and the radiation safety technicians (RSTs), and sampling and inspection processes. The RSO inspects facilities to confirm compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all 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 is also responsible for the collection and interpretation of employee exposure monitoring. The RSO makes recommendations to improve radiological safety-related controls, as well as to ensure appropriate QA/quality control (QC) for all health and environmental radiological monitoring programs. The RSO cannot be overruled by other members of the management team on any decision regarding radiation safety. The RSO has no production-related responsibilities and reports directly to the Manager of Environmental Health and Safety.

- The RST will assist the RSO with the implementation of the radiological and industrial safety programs. The RST is responsible for the orderly collection and interpretation of all monitoring data, including data from radiological safety and environmental programs. The qualifications of the RSO and RST are discussed further in Safety Evaluation Report (SER) Section 5.4.

The staff finds that the applicant has adequately described the corporate organization and management responsibilities and authority at each level, including the integration among groups that support the operation and maintenance of the Proposed Project in accordance with SRP Acceptance Criteria 5.1.3(1 and 2). The staff also finds the applicant's description of the as low as is reasonably achievable (ALARA) program in this section of the technical report demonstrates a strong commitment to support the development and implementation of the radiation safety and ALARA program as recommended in Regulatory Guide 8.31 (NRC, 2002b) to meet the regulatory requirements in 10 CFR Part 20, Subpart B, "Radiation Protection Programs."

In TR Section 5.2.5, the applicant commits to establish a Safety and Environmental Review Panel (SERP) in accordance with NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," and describes the organization, procedures, and responsibilities of the SERP. The SERP will review proposed changes, tests, or experiments at the facility to confirm that they do not conflict with any license requirements or NRC regulations, and that the commitments to safety and the environment are maintained. The applicant states that the SERP will consist of at least three individuals. One member will have expertise in management and will be responsible for managerial and financial approval for changes; a second member will have expertise in operations or construction or both and will have responsibility in implementing any operational changes; a third member will be the RSO, or equivalent, with the responsibility for ensuring that changes conform to radiation safety and environmental requirements. The applicant states that any additional member will be selected in accordance with SRP Section 5.1.3. AUC verifies that sufficient independence of the SERP is guaranteed to allow all significant issues to be raised to senior management, without fear of repercussion. The staff finds that the applicant's description and planned implementation of the SERP for the Proposed Project is in accordance with SRP Acceptance Criteria 5.1.3(3 and 5).

In TR Section 5.1, AUC commits, to the extent possible, to utilize administrative procedures that conform with Regulatory Guide 8.2, "Guide for Administrative Practices in Radiation Monitoring" (NRC, 1973), and Regulatory Guide 4.15, Revision 1, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) – Effluent Streams and the Environment" (NRC, 1979). The staff finds that this commitment is in accordance with SRP Acceptance Criterion 5.1.3(4).

5.1.4 Evaluation Findings

The staff completed its review of the corporate organization and administrative procedures proposed for use at the Reno Creek in situ recovery (ISR) facility. This review included an evaluation using the review procedures in SRP Section 5.1.2 and acceptance criteria in SRP Section 5.1.3.

The applicant has an acceptable corporate organization that defines management responsibilities and authority at each level. The applicant’s definition of the responsibilities and procedures with respect to development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, QA programs, routine or nonroutine maintenance activities, and changes to any of these is acceptable. Integration among groups that support operation and facility construction and plant management is demonstrated. The applicant has established a SERP with at least three individuals representing expertise in management or financial, operations or construction, and radiation safety matters. The applicant has demonstrated that specific technical issues will be dealt with by the SERP, with support from other qualified staff members or consultants, as appropriate. Staff included a preoperational license condition (License Condition 12.6) requiring the licensee to confirm that the written operating procedures, approved radiation safety and environmental monitoring programs, and written preoperational testing are completed prior to staff scheduling a preoperational inspection.

Based on the information provided in the application and the detailed review conducted by the staff as indicated above, the staff concludes that the proposed corporate organization and administrative procedures are acceptable and are in compliance with 10 CFR 20.1101, which defines RPP requirements. In addition, the requirements of 10 CFR 40.32(b), (c), and (d) are met as they relate to the proposed corporate organization and SERP functions.

5.2 Management Control Program

5.2.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the management control program for the Proposed Project is consistent with requirements of Subparts L, “Records,” and M, “Reports,” of 10 CFR Part 20, 10 CFR 40.61, and Criteria 8 and 8a of Appendix A to 10 CFR Part 40.

5.2.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in SRP Section 5.2.3 (NRC, 2003).

5.2.3 Staff Review and Analysis

Information in this section, unless otherwise stated, is from TR Section 5.2 (AUC, 2012). The applicant has committed to developing a management control program of written standard operating procedures (SOPs) for all routine activities that involve handling, processing, or storing radioactive materials, and SOPs will be developed and implemented before ISR operations. SOPs will be developed for emergency response, industrial and radiation safety protection, and environmental monitoring. All procedures involving radioactive material will be reviewed and approved by the RSO, or individual with equal qualifications, before implementation, and reviewed periodically by the RSO. The applicant states that AUC will conduct daily walkthrough inspections of all active plant areas, including storage areas, to ensure proper implementation of radiation safety procedures. Radiation work permits (RWPs) will be issued for activities of a nonroutine nature with potential for exposure to radioactive materials for which no operating procedure exists. The staff finds this approach acceptable because it is consistent with the Regulatory Guide 8.31 (NRC, 2002b) recommended practices for maintaining worker, members of the public, and environmental exposures ALARA to comply with 10 CFR Part 20, Subparts B, C, and D. The staff finds that this information satisfies SRP Acceptance Criteria 5.2.3(1-3).

In TR Section 5.2.3, the applicant stated that instructions for the proper maintenance, control, and retention of records will be developed and will be consistent with the requirements of 10 CFR Part 20, Subpart L, and 10 CFR Part 40.61(d) and (e). This TR section also lists specific AUC records that will be maintained until license termination. The applicant stated that records will be maintained in either hard-copy or electronic versions, and safeguards will be established to prevent against tampering, loss, or deterioration. The applicant also stated that records will be readily retrievable for NRC inspection. In TR Section 5.2.6, the applicant included a list of specific reporting requirements that will be implemented and identifies which reports will be submitted to the staff. The applicant stated that spills, leaks, or excursions and environmental monitoring reporting will be consistent with the requirements of 10 CFR Part 20 Subpart M, and 10 CFR 40.60. The applicant committed to submitting an annual report to NRC based on the guidance in NUREG-1569. This commitment is captured in License Condition 11.1. This report will include the ALARA audit report; land use survey; summary of monitoring data; corrective action program report; semiannual effluent and environmental monitoring report; and SERP information, and a license condition will be established to this effect. Additionally, the NRC project manager would be notified by telephone or email within 24 hours of discovery of a spill, excursion, or backup storage pond leak that is reportable to the Wyoming Department of Environmental Quality (WDEQ). Records retention will be memorialized by the license condition in SER Section 5.2.4. The staff finds the applicant’s proposed recordkeeping, supplemented with license condition, complies with 10 CFR Part 20, Subparts L and M. The staff finds that this information satisfies SRP Acceptance Criteria 5.2.3(7-13).

The applicant has committed to submitting semiannual effluent and environmental monitoring reports, SERP reviews, ALARA report, land use survey report, and corrective action program report to the staff. The applicant requested a performance-based license and has provided for the establishment of a SERP. The SERP makeup, responsibilities, and review procedures are appropriately described in detail in the application, and the applicant has identified the SERP records that will be maintained until license termination. The staff finds the applicant’s proposed recordkeeping and reporting comply with 10 CFR 40.60, 40.61, and 10 CFR Part 20, Subparts L and M, and as such, satisfy SRP Acceptance Criteria 5.2.3(7 and 8). Furthermore, the staff notes that all current NRC ISR licenses are performance-based licenses that operate with a SERP with similar duties as outlined in this paragraph. Decisions of the SERP are subject to NRC inspection and review, and have been found to be protective of public health, safety, and the environment. Therefore, the staff finds the applicant’s description of the SERP process acceptable to meet regulatory requirements in 10 CFR Part 20, Subparts B, C, and F, and as such, satisfies SRP Acceptance Criterion 5.2.3(4).

In TR Section 5.6, the applicant stated that all entrances to the proposed NRC-licensed facility and all controlled areas will be conspicuously posted with the words ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL, in order to be exempted from the requirements of 10 CFR 20.1902(e) for areas within the facility. This commitment is also captured in License Condition 9.11. The staff finds that this commitment satisfies SRP Acceptance Criterion 5.2.3(5).

The applicant performed archeological surveys in the license area and included the results of the surveys in the application. Surveys were performed over the Proposed Project area. The applicant committed to complying with the National Historic Preservation Act, the Archeological Resources Protection Act, and each law's implementing regulations. In addition, AUC committed to cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. These commitments are captured in License Condition 9.8. This license condition will require that, in the event of discovery of previously unknown artifacts, the applicant shall conduct an inventory and evaluation of the artifacts in accordance with 36 CFR Part 800, "Protection of Historic Properties." NRC authorization will be required before the applicant would be allowed to proceed with activities. The staff finds that this information coupled with the license condition noted above satisfies SRP Acceptance Criterion 5.2.3(6).

5.2.4 Evaluation Findings

The staff reviewed the management control program of the Proposed Project in accordance with SRP Section 5.2.3. The applicant proposed an acceptable recordkeeping and retention and reporting program that will be adequate to ensure that the applicant is able to track, control, and demonstrate control over the source and byproduct materials that are processed, produced, or stored at the facility during its operating life, through decommissioning, and until license termination. Recordkeeping and retention plans will assist in ensuring that both onsite and offsite exposures are kept within regulatory limits and in documenting compliance with NRC regulations. The applicant demonstrated an acceptable program to maintain records on spills, likely contamination events, and unusual occurrences for use in calculating annual surety amounts and to ensure acceptable decommissioning. The applicant will maintain records for decommissioning, onsite and offsite disposal, personnel exposure, and offsite releases of radioactivity as permanent records for the facility that will be transferred to any new owner or applicant, and ultimately to the staff, before license termination. Reports will be made to the staff as required by regulations. The staff notes that spills, excursions, and other contamination events at ISR facilities may not be captured by Part 20, "Standards for Protection against Radiation," 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, the staff is adding License Condition 11.6 to ensure that these activities are reported and documented during operation of the facility.

Based on the information provided in the application, the information required by the license conditions above, and the detailed review conducted of the management control program for the Proposed Project, the staff concludes that the management control program is acceptable and is in compliance with 10 CFR Part 20, Subpart L, and 10 CFR 40.62.

5.3 Management Audit and Inspection Program

5.3.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed management audit and inspection program for the applicant meets the requirements of 10 CFR 40.32(b) and (c).

5.3.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria outlined in SRP Section 5.3.3 (NRC, 2003).

5.3.3 Staff Review and Analysis

Information in this section, unless otherwise stated, is from TR Section 5.3 (AUC, 2012). Inspections and audits would be performed periodically at the proposed site to ensure compliance with radiological safety, operational, and environmental standards.

SRP Acceptance Criterion 5.3.3(1) states that the proposed frequencies, types, and scopes of reviews and inspections; action levels; and corrective action measures are acceptable to implement the proposed controls, and that management responsibilities for audit and inspection are adequately defined. Acceptable programs for inspection of embankment systems on a regular basis are described in Regulatory Guide 3.11 (NRC, 2008). An acceptable program for the annual ALARA audits is described in Regulatory Guide 8.31 (NRC, 2002b).

In TR Section 5.3 (AUC, 2012), the applicant stated that the RSO or a qualified designee will conduct daily and weekly walkthrough radiation safety inspections of all active plant areas, including storage areas. The inspection allows for a survey of procedure compliance, contamination control, and housekeeping efforts. An individual can qualify for daily walkthrough inspection if specific training is received from the RSO, and if the training is documented in the individual’s training records and is available for NRC inspection. The applicant stated in TR Section 5.3 (AUC, 2012) that a written summary of monthly radiological activities and monitoring data will be provided to management and the summary will also include information pertaining to personnel monitoring, radiation survey records, trends for ALARA consideration, and description of any area in the process or safety programs that could be improved, along with recommended corrective action.

The staff determines that the applicant’s inspection process, areas of consideration, and summary reports are consistent with Regulatory Guide 8.31 and meet the requirements of 10 CFR Part 20 Subparts B, F, and L.

In TR Section 5.3 (AUC, 2012), the applicant states that management will provide for annual audits of the radiation protection and ALARA program consistent with recommendations contained in Regulatory Guide 8.31, and will submit a written report to corporate management summarizing such audits. The annual ALARA audit report will include the following:

- employee exposure records
- bioassay results, inspection log entries, and summary reports of ISR and process inspections

- documented training program activities
- applicable safety meeting reports
- radiological survey and sampling data
- reports of any overexposure of workers
- operating procedures that were reviewed during this time period

In addition to the ALARA audit report, the applicant stated in TR Section 5.3 (AUC, 2012) that the report will specifically discuss the following:

- trends in personnel exposure
- proper use, maintenance, and inspection of equipment used for exposure control
- recommendations on reasonably achievable ways to reduce personnel radiation exposures

The staff determines that the applicant's annual ALARA audit program and report are consistent with Regulatory Guide 8.31.

In TR Section 4.3.5.3 (AUC, 2012), the applicant discussed the routine pond inspections. The routine pond inspections include daily, weekly, quarterly, and annual inspections. The staff determines that the applicant has identified and discussed an acceptable program for inspection of embankment systems on a regular basis. The staff determines that the applicant has described an acceptable program for inspection of embankment systems consistent with Regulatory Guide 3.11. The staff also determines that the applicant has adequately described the proposed frequencies, types, and scopes of reviews and inspections; action levels and corrective action measures are acceptable to implement the proposed controls; and management responsibilities for audits and inspections are adequately defined, including an annual ALARA audit, which meets SRP Acceptance Criterion 5.3.3(1).

5.3.4 Evaluation Findings

The staff completed its review of the management audit and inspection program for the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.3.2 and the acceptance criteria in SRP Section 5.3.3.

The applicant has an acceptable management audit and inspection program that provides frequencies, types, and scopes of reviews and inspections, action levels, and corrective action measures sufficient to implement the proposed action.

Based on the information provided in the application and the detailed review conducted of the management audit and inspection program for the Proposed Project, the staff concludes that the proposed programs are acceptable and are in compliance with 10 CFR 20.1702, which requires the use of process or other engineering measures to control the concentrations of radioactive material in the air, and 10 CFR 20.1101, which contains requirements for maintaining radiation exposure limits ALARA. In addition, the requirements of 10 CFR 40.32(b), (c), and (d) are met as they relate to the acceptability of management audits to ensure protection of health and minimize danger to life and property. The requirements of 10 CFR Part 40, Appendix A, Criteria 8 and 8A are met as they relate to yellowcake drying and packaging operations and inspection of waste retention systems.

5.4 Qualifications for Personnel Conducting the Radiation Safety Program

5.4.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the qualifications of the personnel conducting the radiation safety program satisfy 10 CFR 20.1101, which defines the RPP requirements, and 10 CFR 40.32(b), which provides requirements for applicant qualifications.

5.4.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in SRP Section 5.4.3 (NRC, 2003) and recommendations for technical qualifications of radiation safety in Regulatory Guide 8.31 (NRC, 2002b).

5.4.3 Staff Review and Analysis

SRP Acceptance Criterion 5.4.3(1) states that the personnel meet minimum qualifications and experience for radiation safety staff that are consistent with Regulatory Guide 8.31, Section 2.4 (NRC, 2002b). The emphasis of this guidance is for uranium recovery facilities; however, the training requirements apply equally to ISR facilities. The staff review and analysis includes the qualification of the RSO, RST, and the designee as identified in the application.

In TR Section 5.4 (AUC, 2012), the applicant stated that the minimum qualifications for the RSO include the following: (1) for education, a bachelor’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 radiation protection related to uranium recovery, and this includes that 2 years of relevant experience are generally considered equivalent to 1 year of academic study, (2) for experience, at least 1 year of work experience, relevant to uranium recovery operation, applied health physics, radiation protection, industrial hygiene, or similar and this experience must involve actual and significant work with radiation detection and measurement equipment, and not administrative work, (3) for specialized training, at least 4 weeks of specialized classroom training in health physics specifically applicable to uranium milling, and in addition, the radiation safety officer will attend refresher training on uranium mill health physics every 2 years, and (4) for specialized knowledge, a thorough knowledge of the proper application and use of all health physics equipment, chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the uranium recovery process and equipment used at the central processing plant (CPP) and how the hazards are generated and controlled during the uranium recovery process.

The staff finds that the RSO qualifications identified by the applicant are consistent with the guidance in Regulatory Guide 8.31 (NRC, 2002b) and SRP Acceptance Criterion 5.4.3(1), which includes education, training, and experience requirements for an RSO at existing facilities. These qualifications have been shown to demonstrate the protection of the health and safety of workers and members of the public and to minimize danger to life or property. Therefore, the information provided by the applicant is acceptable. Staff requires that licensees submit the qualifications for the initial RSO as a preoperational license condition (License Condition 12.4). The licensee shall submit the initial RSO qualifications prior to staff scheduling a pre-operational inspection.

In TR Section 5.4 (AUC, 2012), the applicant stated that the minimum qualification for the RST will have one of the following:

- an associate degree or 2 or more years of study in the physical sciences, engineering or a health-related field with at least 4 weeks of generalized training in radiation protection applicable to uranium recovery operations, and 1 year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety
- a high school diploma with a total of at least 3 months of specialized training in radiation protection relevant to uranium recovery and 2 years of relevant work experience in applied radiation protection

The applicant stated in TR Section 5.4 (AUC, 2012) that the RST will demonstrate a working knowledge of the proper operation of health physics instruments used in the facility, surveying and sampling techniques, and personnel dosimetry requirements.

The staff determines that the RST qualifications identified by the applicant are consistent with the training and experience recommended in Section 2.4 of Regulatory Guide 8.31 (NRC, 2002b) and acceptance criteria in SRP Section 5.4.3 (NRC, 2003), and are consistent with the education, training, and experience requirements for an RST at existing ISR facilities which have been shown to provide qualified personnel to protect the health of workers and public and minimize danger to life or property. Therefore, the information provided by the applicant is acceptable.

In response to RAI-42 (AUC, 2015a), AUC committed to using the following approach to qualify Designated Operators (DOs) to conduct certain daily walkthrough inspections of storage and work areas at the Proposed Project. The DOs will be responsible for the inspections only on weekends and holidays when the RSO and RST are not present. With the exception of the Thanksgiving holiday, the DO will not conduct the inspections for more than 2 days per week, or 3 days per week if a Federal holiday falls on Friday or Monday. For the Thanksgiving holiday, the DO may perform the inspections for up to 4 consecutive days. In all cases, either the RSO or RST will be available to the DO to provide support as needed. The applicant stated that any issues noted by the DO during the daily inspection will be recorded on the standard daily inspection form, signed and dated, and retained on file. The RSO and RST will review the inspection form as a top priority upon return to the site and will deal with noted problems. The RSO and RST will discuss and resolve any issues identified by the DO before the next weekend or holiday. Such discussions and their resolutions will be recorded in an RSO-RST-DO Performance logbook and made available to NRC inspectors upon request (AUC, 2015a).

In response to RAI-42, the applicant also stated that, at a minimum, the operator seeking designation must have the following combination of education, training, and experience:

- Education: A high school diploma or equivalent.

- Training:

    - New employee radiation safety training, including guidance concerning prenatal radiation exposure (Regulatory Guide 8.29);

    - Additional training relating to conducting daily inspections at the Reno Creek facility; and

    - Demonstration of proficiency, while accompanied by the RSO, in the performance of daily inspections.

  - Experience: A minimum of 3 months of work experience in operations or maintenance at a uranium recovery facility, including work with procedures that involve health physics, industrial safety or industrial hygiene (AUC, 2015a).

The applicant stated that AUC will conduct daily walkthrough inspections of all work and storage areas at the AUC facility to ensure proper implementation of radiation safety procedures. Such procedures include good housekeeping and practices that minimize unnecessary contamination. During the weekends, and on holidays when the RSO and RST are not onsite, the DO will observe the following activities through direct visual inspection:

- radiation safety practices
- housekeeping
- implementation of the radiation safety program, throughout the facility

Such duties include inspecting for compliance for the following:

- radiation safety postings
- contamination control
- control point procedures
- procedures for control of airborne radioactivity
- worker protection practices in the yellowcake drying and packaging area
- proper storage of byproduct material

A qualified DO may not develop or administer the RPP, other than conducting daily inspections. He may not approve equipment plans, process changes, or changes in SOPs with the potential to affect the RPP. He may not conduct radiation safety audits or make decisions concerning personnel dosimetry. He may not authorize work involving the potential for radiation exposure or radioactive contamination, for which there are no SOPs or a current RWP. The DO will not have authority to release materials for unrestricted use. In the event of an unusual situation or emergency, the DO will contact the RSO or RST, who will be responsible for radiation protection decisions. While acting as DO, the operator will not perform other than daily radiation protection inspection activities (AUC, 2015a).

The applicant stated that additional radiation safety training provided to operators seeking designation involves 4 hours of training followed by an examination, with an 80-percent passing grade covering the topics below:

- employee personal protective equipment (PPE) usage
- contamination control
- entrance and exit station procedures

- radiation area boundaries
- required signs
- required labels
- leak detection and prevention
- yellowcake spill prevention
- ventilation
- housekeeping
- active monitors
- when and how to contact the RSO or RST
- completion and control of the Daily Inspection Form

The applicant stated that, upon completion of training and before designation, an operator will be required to demonstrate, to the RSO, proficiency in conducting the daily inspections. Before assuming responsibility for an inspection, the operator seeking designation will perform a minimum of four daily inspections under the supervision of the RSO or RST. The supervised inspections will include coverage of the topics listed above and will be documented via signatures on the inspection form. An operator who fails to demonstrate proficiency will be re-evaluated, after performing additional supervised inspections, until the RSO is satisfied with the operator's proficiency. An operator designation form will be signed by the DO and the RSO when the RSO is satisfied that the operator meets all requirements. The applicant stated that, to remain qualified, the DO must complete annual refresher training to address the same topics covered in the additional training described above. An examination will be required with a passing grade of 80 percent. In addition, the DO must have completed two RSO or RST-supervised inspections during the past year, including one within the past 6 months (AUC, 2015a).

The staff determines that the DO training will demonstrate that the DO has been adequately trained to perform limited radiation safety duties as described above. The staff determines that the training is acceptable because it meets the standards described in Regulatory Guide 8.31, which the staff has previously determined to be sufficient to ensure that inspections are performed by qualified individuals.

5.4.4 Evaluation Findings

The staff completed its review of the radiation safety training program at the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.5.2 and the acceptance criteria in SRP Section 5.5.3. The radiation safety training program for the Proposed Project is consistent with the guidance contained in NRC Regulatory Guides 8.13, 8.29, and 8.31. Therefore, the staff concludes that the content of the training material, testing, on-the-job training, and the extent and frequency of retraining are acceptable.

Based on the information provided in the application and the detailed review conducted of the radiation safety training program for the Proposed Project, the staff concludes that the radiation safety training program is acceptable and is in compliance with 10 CFR 20.1101, which defines RPP requirements, and 10 CFR 40.32(b), as it relates to applicant qualifications through training.

5.5 Radiation Safety Training

5.5.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed radiation safety training program complies with 10 CFR 19.12, which provides requirements for instructions to workers; 10 CFR 20.1101, which defines radiation protection program requirements; 10 CFR 19.11, which requires posting of notices to workers; 10 CFR 19.12, which addresses requirements for instructions to workers; 10 CFR 19.13, which addresses requirements for notifications and reports to individuals; 10 CFR 19.15, which addresses consultation with workers during inspections; 10 CFR 19.16, which addresses requests by workers for inspections; and 10 CFR 40.32(b), as it relates to applicant qualification through training.

5.5.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with applicable requirements of 10 CFR Parts 19, 20, and 40 using the acceptance criteria in SRP Section 5.5.3 (NRC, 2003) and guidance on (1) protecting the fetus, (2) a basis for training employees on the risks from radiation exposure in the workplace, and (3) the fundamentals of protection against exposure to uranium and its progeny as provided in Regulatory Guide 8.13 (NRC, 1999b), Regulatory Guide 8.29 (NRC, 1996), and Regulatory Guide 8.31 (NRC, 2002b), respectively.

5.5.3 Staff Review and Analysis

SRP Acceptance Criterion 5.5.3(1) states that the radiation safety training program is consistent with the approach described in Regulatory Guide 8.31, Section 2.5, which recommends that before beginning their jobs, all new employees should be instructed, by means of an established course, in the inherent risks of exposure to radiation and the fundamentals of protection against exposure to uranium and its daughters.

In TR Section 5.5 (AUC, 2012), the applicant stated that all site employees and contractor personnel will be instructed in a training program covering the risks of exposure to uranium and its daughters before commencing work, and all visitors who have not received documented training will be escorted by AUC staff properly trained and knowledgeable about the hazards of the facility. The applicant stated that, at a minimum, visitors will be instructed specifically on what is expected of them to avoid possible hazards in the areas of the facilities that they are visiting. In TR Section 5.5 (AUC, 2012), the applicant indicated that the radiation safety training will incorporate the following topics consistent with Regulatory Guide 8.31:

- fundamentals of health protection
- personal hygiene at uranium facilities
- facility-provided protection
- health protection measurements
- radiation protection regulations
- emergency procedures

The applicant stated in TR Section 5.5 (AUC, 2012) that a written or oral test with questions directly relevant to the principals of radiation safety and health protection will be given to each worker, the instructor will discuss any incorrect answers to test questions with the worker until the worker understands the correct answer, and workers who fail the exam will be retested after receiving additional training. All test results will be maintained on file. The applicant also stated that, following initial radiation safety training, all permanent employees and long-term contractors will receive ongoing radiation safety training as part of the annual refresher training program, and in addition, the RSO may include more training during periodic safety meetings. The applicant stated that the RSO will receive a minimum of 40 hours of refresher training (total) biannually in health physics and related subjects. The applicant added that records of training will be kept until license termination for all employees trained as radiation workers (AUC, 2012). The staff reviewed the radiation safety training topics identified in Regulatory Guide 8.31 and compared them to the applicant's suggested topics and determines that the applicant's topics are consistent with Regulatory Guide 8.31. The staff determines that the applicant provides adequate training to workers (employees and contractors) and addresses escort of visitors with employees who have received radiation safety training. The staff determines that the applicant will allow 40 hours of refresher training for the RSO and will maintain records of training until license termination. The staff determines that the applicant's radiation safety training program is consistent with Regulatory Guide 8.31 and meets SRP Acceptance Criterion 5.5.3(1).

SRP Acceptance Criterion 5.5.3(2) states that the radiation safety training program is consistent with Regulatory Guide 8.13, which provides guidance for protection of the fetus.

The applicant stated in TR Section 5.5 (AUC, 2012) that female workers who require training under 10 CFR 19.12 will be provided with training that meets the guidance in Regulatory Guide 8.13, and in addition, they will receive a copy of Regulatory Guide 8.13, and supervisors who are responsible for providing supervision of female workers will also receive training on Regulatory Guide 8.13. The staff determines that the applicant's radiation safety training program will include training to female workers and their supervisors on the protection of the fetus and this is consistent with Regulatory Guide 8.13 and SRP Acceptance Criterion 5.5.3(2). Therefore, the instruction concerning prenatal radiation exposure and the protection of the fetus in the applicant's radiation safety training program is acceptable.

SRP Acceptance Criterion 5.5.3(3) states that the radiation safety training program is consistent with Regulatory Guide 8.29 and this guide provides a basis for training employees on the risks from radiation exposure in the workplace.

In TR Section 5.5 (AUC 2012) and in the response to RAI-43 (AUC, 2015a), the applicant stated that the training program will be administered in keeping with standard radiological protection guidelines and the guidance provided by Regulatory Guides 8.13, 8.29, and 8.31. The staff determines that the applicant has adequately discussed the radiation safety training program, including health risks from occupational exposure, and the instructions for prenatal radiation exposure as identified in Regulatory Guides 8.13, 8.29, and 8.31. The staff determines that the applicant's radiation safety training program will include the health risk associated from occupational exposure to workers and this is consistent with Regulatory Guide 8.29 and SRP Acceptance Criterion 5.5.3(3). Therefore, the health risk to workers from radiation exposure is covered in the applicant's radiation safety training program and is acceptable.

5.5.4 Evaluation Findings

The staff completed its review of the radiation safety training program at the AUC facility. This review included an evaluation using the review procedures in SRP Section 5.5.2 and acceptance criteria in SRP Section 5.5.3.

The radiation safety training program for the Proposed Project is consistent with the guidance contained in NRC Regulatory Guides 8.13, 8.29, and 8.31. The content of the training material, testing, on-the-job training, and the extent and frequency of retraining is acceptable.

Based on the information provided in the application and the detailed review conducted of the radiation safety training program for the AUC facility, the staff concludes that the radiation safety training program is acceptable and is in compliance with 10 CFR 20.1101, which defines RPP requirements, and 10 CFR 40.32(b), as it relates to applicant qualification through training.

5.6 Security

5.6.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed security measures for the Proposed Project meet the requirements of 10 CFR Part 20, Subpart I, “Storage and Control of Licensed Material.”

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 in SRP Section 5.6 (NRC, 2003).

5.6.3 Staff Review and Analysis

Information in this section, unless otherwise stated, is from TR Section 5.6 (AUC, 2012). The applicant committed to providing a security program to prevent unauthorized entry to all controlled and restricted areas in accordance with 10 CFR Part 20, Subpart I. Controlled areas will be fenced to limit access. Anticipated controlled areas include all fenced areas around the CPP, wellfields, backup storage pond, and DDWs. AUC restricted areas will lie within controlled areas (AUC, 2015a). Restricted areas will control access to protect individuals from exposure to radiation and byproduct materials in selected areas within the CPP building, byproduct storage areas, backup pond, DDW buildings, and areas exceeding 2 mrem/hr. AUC’s security will include active and passive measures: (1) all restricted areas will be fenced and structures locked, (2) all gates and doors for areas containing licensed material will have appropriate signage and be locked when AUC staff are not within the area, (3) all visitors and contractors will be required to sign in and receive appropriate safety training and have an AUC escort before being allowed entry into any controlled areas, and (4) pertinent SOPs and related information will be shared with local first responders (police, fire, emergency medical technicians, etc.) before the initiation of operations. AUC will conduct daily inspections to ensure all licensed material is properly labeled and stored and that locks are in place for all restricted plant and storage facilities. Access to the processing plant will be controlled with a fence and locked gate and AUC staff will monitor all Proposed Project access 24 hours a day, 7 days per week.

In TR Section 5.6.2, AUC committed to store and ship hazardous materials as defined by the U.S. Department of Transportation (DOT) and 10 CFR 71.5, “Transportation of Licensed Material.” The applicant states that AUC will strictly adhere to the packaging, shipping, and training requirements contained in the DOT Hazardous Materials Regulations. AUC plans to use an outside contractor for all yellowcake shipments. AUC will require the contractor to be compliant with hazardous material transportation regulations and will follow requirements in 49 CFR Part 172, Subpart I, “Safety and Security Plans.” All access to containers and vehicles where licensed material is located when not in storage will be locked, if possible, and under surveillance. The staff finds that the applicant's transportation and security procedures are acceptable because the transportation procedures comply with the requirements in 49 CFR Parts 172 and 173 and 10 CFR 71.5(a)(1), and security procedures comply with 10 CFR Part 20, Subpart I, "Storage and Control of Licensed Material."

5.6.4 Evaluation Findings

The applicant described the security measures that will be used for stored material and control measures for material not in storage. The security measures for the Proposed Project demonstrate that the applicant has acceptable active and passive constraints on entry to the licensed and restricted areas. The applicant identified acceptable passive controls; for example, fencing, locked gates, and warning signage for site control and active security systems for buildings.

Based on the information provided in the application and the review conducted of the security measures for the Proposed Project, the staff concludes that the security measures are acceptable and in compliance with 10 CFR Part 20, Subpart I, which provides requirements for the security of stored material and control of material not in storage.

5.7 Radiation Safety Controls and Monitoring

This section discusses radiation safety controls and monitoring techniques used to ensure the applicant maintains radiation exposures and releases of radioactive materials in effluents to unrestricted areas ALARA.

Standards

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 SER Section 5.7. These standards are as follows:

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 Dose 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 8.30, "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", Revision 1, 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.
- Regulatory Guide 8.37, “ALARA Levels for Effluents from Materials Facilities,” July 1993.

Regulations

- 10 CFR 20, Subpart B—Radiation Protection Programs, § 20.1101
- 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, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage,” Table 1—DAC Natural Uranium Class W: 3.0 E−10 μCi/ml, DAC Natural Uranium Class D: 5.0 E−10 μCi/ml.
- 10 CFR 20.1201(a)(1)—total effective dose equivalent (TEDE): 5 rem, or the sum of the deep dose equivalent (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(a)(2)(I)—annual limit to the eye lens: 15 rem
- 10 CFR 20.1201(a)(2)(II)—annual limit to the skin of the whole body and extremities: 50 rem
- 10 CFR 20.1201(e)—weekly limit on intake of soluble uranium: 10 mg

5.7.1 Effluent Control Techniques

The areas of review and acceptance criteria present in SRP Section 5.7.1 (NRC, 2003), which address effluent control techniques, are covered in other sections of this SER. The staff’s review of the applicant’s proposed effluent control techniques can be found in SER Section 4.1 and Section 5.7.9 and are therefore not discussed here.

5.7.2 External Radiation Exposure Monitoring Program

5.7.2.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed external radiation exposure monitoring program for the Proposed Project meets the requirements of 10 CFR Part 20 and 10 CFR Part 40.

5.7.2.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in SRP Section 5.7.2.3 (NRC, 2003).

Regulatory Guides 4.14 (NRC, 1980), 8.7 (NRC, 2005), 8.30 (NRC 2002a), 8.31 (NRC, 2002b), and 8.34 (NRC, 1992a) provide guidance on how compliance with the regulations can be demonstrated.

5.7.2.3 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 Proposed Project. Review areas addressed in this section included radiation surveys, personnel monitoring, records, and reporting.

In TR Section 5.7.2 (AUC, 2012), the applicant stated that general area surveys (i.e., air radon, air particulate, and gamma surveys) are identified in TR Figure 5-2 (AUC, 2012). The applicant also stated in TR Section 5.7.3.1 that, due to the nature of the ISR process and the design of the drying system, the primary source for airborne uranium particulates will occur during packaging operations. In TR Section 5.7.2.1 (AUC, 2012), the applicant stated that surveys will be performed in accordance with the guidance contained in Regulatory Guide 8.30 (NRC, 2002a) and will be documented in accordance with Regulatory Guide 8.7 (NRC, 2005). The staff reviewed TR Figure 5-2 (AUC, 2012) and determined that the general survey areas identified by the applicant will include 9 radon survey locations, 45 gamma survey locations, and 4 air particulate sampling locations in the facility. The staff further determines that the identification of these general area surveys indicate that the applicant has developed a monitoring program that will allow the protection of workers from hazards of beta radiation resulting from the decay products of uranium, detection and control of gamma radiation from uranium decay products in areas where large volumes of uranium may be present, and determination of doses from external exposure, as well as maintain radiation dose levels ALARA. In Response to RAI-45, the applicant revised and renumbered TR Figure 5-2 (Radiological Survey Locations) to TR Figure 5-3 (AUC, 2014a). The staff reviewed this response and determines that the applicant will conduct air particulate and gamma surveys in the dryer area and air radon and gamma surveys in the yellowcake storage area, as shown in the TR Figure 5-3. The staff also determines that the other general survey areas in the plant, including air particulate sampling locations, are consistent with SRP Acceptance Criterion 5.7.2.3(1) and Acceptance Criteria 5.7.2.3(5-10) (NRC, 2003), and the general area surveys are found acceptable.

SRP Acceptance Criterion 5.7.2.3(2) (NRC, 2003) states that the application provides criteria to be used in establishing which employees are to receive external exposure monitoring. In TR Section 5.7.2.3 (NRC, 2003), the applicant stated that, based on operating experience at similar facilities, it is not anticipated that process plant employees will exceed the 10-percent regulatory limit, but to minimize the potential for error, the applicant will provide dosimetry badges to all employees with significant potential for exposures. The staff determines that the applicant has adequately evaluated similar facilities and the applicant acknowledges the regulatory standard of 10 percent of the regulatory limit. The staff determines that the applicant has established criteria for which employees are to receive external exposure monitoring, and these criteria are found acceptable.

SRP Acceptance Criterion 5.7.2.3(3) (NRC, 2003) states that monitoring equipment is identified by type, sensitivity, calibration methods and frequency, availability, and planned use to protect health and safety. The applicant identified the radiation detectors in TR Table 5-1 (AUC, 2012). TR Figure 5-1 shows the detector model, radiation detected, type, and characterization. The applicant stated in TR Section 5.7.9 that it will ensure that proper maintenance, calibration, and use of equipment and instruments are implemented to ensure the quality of all collected data, which will include the use of calibration standards or sources traceable to the National Institute of Standards and Technology. In Section 5.7.2 (AUC, 2012), the applicant stated that fixed location dosimeters will be exchanged quarterly and process area gamma surveys using hand-held detectors will be performed at least monthly. The applicant stated in TR Section 5.7.2.1 that surveys will be performed in accordance with Regulatory Guide 8.30 (NRC, 2002a) and will be documented in accordance with Regulatory Guide 8.7 (NRC, 2005). In TR Section 5.7.2.3 (AUC, 2012), the applicant stated that dosimeters will have a lower limit of detection (LLD) of 1 mrem and an upper limit of 1,000 rem. The staff reviewed the summary of survey frequencies in Regulatory Guide 8.30, Table 3, and finds them acceptable. The staff reviewed the list of radiation detectors in TR Table 5-1 and noted that the radiation detectors are capable of detecting alpha, beta, and gamma emissions under different types of survey conditions and these detectors will be maintained and calibrated to ensure the quality of data. The staff determines that the applicant has satisfied SRP Acceptance Criterion 5.7.2.3(3) (NRC, 2003). The staff therefore finds the monitoring equipment acceptable.

SRP Acceptance Criterion 5.7.2.3(4) (NRC, 2003) states that all monitoring equipment has a lower limit of detection (LLD) that allows measurement of 10 percent of the applicable limits. In TR Table 5-1 (AUC, 2012), the applicant noted that detector LLD may be calculated per Regulatory Guide 8.30 (NRC, 2002a). The LLD is an important method when measuring activity or concentrations of surface contamination or volumetric concentrations that are small. The applicant provided, in TR Table 5-1 and TR Table 5-2 (AUC, 2015a), the list of proposed radiation instrumentation and the minimum detectable activity (MDA). The applicant indicated that it will use the equation identified in NUREG-1507 (NRC, 1995) to determine the MDA for both alpha and beta activity. AUC stated that this equation was initially applied to determine whether beta contamination regulatory requirements for release of personnel and equipment can be met in areas with gamma backgrounds. AUC stated that it anticipates a gamma exposure rate, based on other operating ISR facilities, of 25 μR/hr, and plans to use a conservative efficiency of 20 percent. The applicant stated that the equipment manufacturer (Ludlum) indicated that the 43-93 beta detector's gamma sensitivity is 15-20 counts per minute (cpm) per μR/hr. The applicant stated that, by applying the equation (from NUREG-1507) at a background count rate of 500 cpm (20 cpm/μR/hr × 25 μR/hr = 500 cpm), the estimated MDA for beta will be 575 disintegrations per minute (dpm)/100 cm^2 (AUC, 2015a). The staff determines that the applicant has provided sufficient information in TR Table 5-1 that indicates that the applicant has adequate radiation instrumentation to detect alpha and beta contamination and the MDA for several detectors that can meet the MDA for alpha measurements with the exception of the Ludlum 43-93. The staff determines that, although the beta MDA is not within 10 percent of the 1,000 dpm/100 cm^2 contamination limit, the staff has reasonable assurance that the applicant can detect 1,000 dpm/100 cm^2 beta contamination limit. It is important to note that the staff determines that the MDA is an a priori (before the fact) calculation. The parameters (background count rate, efficiency, etc.) used to compute the MDA are based on best available information before the construction and operation of the facility. When the facility becomes operational, the radiation safety staff at the facility should re-assess and upgrade any parameter used to compute the MDA consistent with NRC guidance (RG 8.30). The staff determines that the applicant has met SRP Acceptance Criterion 5.7.2.3(4). Therefore, the monitoring equipment and equations used to detect the MDA are acceptable.

5.7.2.4 Evaluation Findings

The staff completed its review of the external radiation exposure monitoring program for the proposed AUC facility. This review included an evaluation using the review procedures in SRP Section 5.7.2.2 and the acceptance criteria in SRP Section 5.7.2.3.

The applicant proposed an acceptable external radiation exposure monitoring program for the Proposed Project. The applicant provided acceptable drawing(s) that depict the facility layout and the location of external radiation monitors. The external radiation monitors are acceptably placed. The applicant established appropriate criteria to determine which employees should receive external radiation monitoring. The applicant demonstrated that the range, sensitivity, and calibration of external radiation monitors will protect health and safety of employees during the full scope of facility operations. Planned radiation surveys are adequate and the planned documentation of radiation exposures is acceptable. The applicant's monitoring program is acceptable to protect workers from beta and gamma radiation.

Based on the information provided in the application and the detailed review conducted of the external radiation exposure monitoring program for the Proposed Project, the staff concludes that the external radiation exposure monitoring program is acceptable and is in compliance with 10 CFR 20.1101, which defines a radiation protection program and as low as is reasonably achievable requirements; 10 CFR Part 20, Subpart B, which defines occupational dose limits; 10 CFR 20.1501, which provides requirements of surveying and radiation monitoring; 10 CFR 20.1502, which defines conditions requiring individual monitoring of external dose; 10 CFR Part 20, Subpart L, which specifies recordkeeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting requirements.

5.7.3 In-Plant Airborne Radiation Monitoring Program

5.7.3.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed in-plant radiation monitoring program for the Proposed Project meets the requirements of 10 CFR Part 20, Subparts B and C, 10 CFR 20.1501, and 10 CFR 20.1702.

5.7.3.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in SRP Section 5.7.3.3 (NRC, 2003). Regulatory Guide 8.30 (NRC, 2002a) provides guidance on how the applicant can demonstrate compliance with the regulations.

5.7.3.3 Staff Review and Analysis

This section describes the in-plant airborne radiation monitoring program. In-plant airborne radiation monitoring includes the airborne uranium particulate monitoring, radon progeny concentration monitoring, and the respiratory protection program. In-plant airborne radiation monitoring measures airborne concentrations at various locations at the site to determine necessary posting requirements, respiratory protection needs, and dose assessments. In demonstrating compliance with these requirements, the applicant must provide acceptable methods for determining internal radiation dose including accounting for the presence of mixtures of contaminants as described in 10 CFR Part 20, Subpart C. Table 1 in Appendix B to 10 CFR Part 20 specifies the DACs for each contaminant. Each DAC identifies the concentration for that radionuclide that, if breathed over a course of 2,000 hours by a worker, would result in an ALI, which equates to the annual occupational dose limit.

5.7.3.3.1 General Program Description

The staff acknowledges that, while the primary operations at the Proposed Project will be wet operations and the lixiviant will be contained within its primary boundary, airborne radioactivity could result from spills, leaks, and maintenance activities. The in-plant airborne radiation monitoring program is designed to detect these contaminants if they escape the primary boundary and become airborne.

5.7.3.3.2 Airborne Particulate Uranium Monitoring

SRP Acceptance Criterion 5.7.3.3(1) (NRC, 2003) states that the applicant provides one or more drawings that depict the facility layout and the location of samplers for airborne radiation. Locations are based, in part, on a determination of airflow patterns in areas where monitoring is needed, and determination of monitoring locations is consistent with Regulatory Guide 8.30 (NRC, 2002a). The applicant stated in TR Section 5.7 that airborne particulate sampling locations for the CPP are shown in TR Figure 5-2 (AUC, 2012). The applicant stated in TR Section 5.7.3 (AUC, 2012) that the primary source for airborne uranium particulates will occur during packaging operations and these operations will be confined to the enclosed drying room which will be under negative pressure during operation. In TR Section 5.7, the applicant stated that the sampling locations are selected to characterize various locations in the process (e.g., lixiviant, precipitation, and drying and packaging areas). The staff reviewed TR Figure 5-2 and determines that the applicant has placed four air particulate and nine air radon monitoring locations within the CPP. The applicant revised and renumbered TR Figure 5-2 to TR Figure 5-3 (Radiological Survey Locations) in response to NRC RAI-45 (AUC, 2014a), and the staff determines that the applicant will conduct air particulate and gamma surveys in the dryer area and air radon and gamma surveys in the yellowcake storage area, as shown in the TR Figure 5-3. The staff reviewed TR Figure 5-3 and determines that the air particulate and air radon sampling locations are consistent with SRP Acceptance Criterion 5.7.3.3(1).

SRP Acceptance Criterion 5.7.3.3(2) (NRC, 2003) states that monitoring equipment is identified by type, sensitivity, calibration methods and frequency, availability, and planned use to accurately measure concentrations of airborne radioactive species. The applicant identified the type of monitoring equipment in TR Table 5-1 (AUC, 2012). For air sampling, the applicant identified the Eberline RAS-1 air sampler and the SKC Model PCXR4 air pump. The applicant also identified several other instruments for alpha and alpha/beta counting. In addition to the general area surveys for air particulate and air radon sampling, the applicant stated in TR Section 5.7 that breathing zone sampling will be performed to determine individual exposure to airborne uranium during certain operations. The staff reviewed the instrumentation in TR Table 5-1 and determines that the applicant has identified the type of monitoring equipment to collect and count air particulate and air radon samples.

In TR Section 5.7.3 (AUC, 2012), the applicant stated that airborne uranium particulate samples will be analyzed on a monthly frequency and, for airborne radioactivity areas as defined in 10 CFR 20.1003, airborne uranium particulate samples will be analyzed on a weekly frequency if workers are potentially exposed. The applicant stated in TR Section 5.7 that, as specified in Regulatory Guide 8.30 (NRC, 2002a), the radon progeny concentrations will be measured on a quarterly basis at the locations shown in TR Figure 5-2, and if the radon progeny concentration at a given location exceeds 10 percent of the DAC, monitoring will be done on a monthly basis and the RSO will initiate a review to identify possible corrective actions. If radon progeny concentrations exceed 25 percent of the DAC for a location, weekly monitoring will be done until measured levels drop below 0.08 WL for 4 consecutive weeks. The staff reviewed the applicant's frequency for air particulate and air radon and compared them to the frequency identified in Table 3 of Regulatory Guide 8.30 (NRC, 2002a) and determines that the applicant's survey frequency is consistent with Regulatory Guide 8.30 (NRC, 2002a).

In TR Section 5.7.3, the applicant stated that samplers for both air particulate and air radon will be calibrated in accordance with the manufacturer's recommended frequency or suggested interval (at least annually) and after repairs. The staff determines that the applicant has established an adequate airborne monitoring program that is consistent with the conditions identified in SRP Acceptance Criterion 5.7.3.3(2).

SRP Acceptance Criterion 5.7.3.3(3) states that planned surveys of airborne radiation are consistent with the guidance in Regulatory Guide 8.30 (NRC, 2002a). In addition, SRP Acceptance Criterion 5.7.3.3(4) states that the proposed monitoring program is sufficient to adequately protect workers from radon gas releases from venting of processing tanks and from yellowcake dust from drying operations, spills, and maintenance activities and is consistent with Regulatory Guide 4.14 (NRC, 1980a), Sections 1.1, and 2.1, and the air sampling program is consistent with Regulatory Guide 8.30 (NRC, 2002a). In TR Section 5.7.3, the applicant stated that it plans to estimate radionuclide air concentrations with the initial air particulate samples obtained following plant startup. The sample will be composited according to the sampler location as shown on TR Figure 5-2. Samples submitted to a contract laboratory for radioisotope analysis will be analyzed for natural uranium, thorium-230, and radium-226, and the results will be used in the sum of fractions rule to ensure the appropriate use of the DAC from 10 CFR 20, Appendix B, Table 1. This includes the DAC for Class W natural uranium, which is 3.0 E−10 μCi/ml. The applicant stated that, assuming that the laboratory results of the initial radioisotopic analysis confirm that natural uranium is the primary radionuclide of concern in the air particulate samples and that other uranium decay products may be disregarded, measurement of airborne uranium will be performed by gross alpha counting of the air filters using an alpha particle detector system, such as the Ludlum Model 43-1 or similar detector coupled to an appropriate scaler (AUC, 2012).

In addition to the estimation of the radionuclide air concentration, the applicant stated that the applicant will assume Class W (or International Commission on Radiological Protection 66 Class M) for purposes of establishing the initial DAC upon plant startup and should in vitro solubility studies indicate that Class D or a mixed DAC (i.e., a combination of the Class D and Class W DACs) is appropriate, the DAC will be adjusted accordingly using the sum of fractions rule (AUC, 2012). The applicant stated that, following the initial sampling event, the applicant will conduct isotopic analyses of concentrations of radionuclides in air semiannually for the first year, and annually thereafter, to ensure that the mixture of radionuclides in air is in compliance with 10 CFR 20.1204(g). The staff agrees with the applicant's commitment and finds that this sampling and analysis is consistent with SRP Acceptance Criteria 5.7.3.3(3 and 4).

SRP Acceptance Criterion 5.7.3.3(5) states that plans for documentation of radiation exposures are consistent with the requirements in 10 CFR 20.2102, 20.2103, 20.2106, and 20.2110. In TR Section 5.7.4 (AUC, 2012), the applicant stated that employee exposure to radiation will be monitored and recorded in accordance with 10 CFR 20.1502 and 10 CFR 20.1201, and Regulatory Guide 8.30 (NRC, 2002a) and Regulatory Guide 8.34 (NRC, 1992a). The applicant further stated in TR Section 5.7.4 that routine employee exposures will be determined and recorded for those employees with the potential to receive more than 10 percent of the allowable occupational dose limit (i.e., 0.5 rem). The staff determines that the applicant's plan for documentation of radiation exposures is in accordance with 10 CFR 20.1202, 10 CFR 20.2103, 10 CFR 20.2106, and 10 CFR 20.2110 and this is consistent with SRP Acceptance Criterion 5.7.3.3(5) and found acceptable.

SRP Acceptance Criterion 5.7.3.3(6) states that the applicant demonstrates that respirators will routinely be used for operations within drying and packaging areas and identifies the criteria for determining when respirators will be required for special jobs or emergency situations, and the respiratory protection program should be consistent with guidance in Regulatory Guide 8.15, (NRC, 1999c). The applicant stated in TR Section 5.7.3 that process and engineering controls will be the primary means for control of airborne radioactive material, and in cases where significant potential exposure exists and all feasible process and engineering controls have been evaluated, the applicant will utilize respiratory protective equipment under a fully qualified program in accordance with 10 CFR 20.1703, Regulatory Guide 8.15 (NRC, 1999c), and Regulatory Guide 8.31 (NRC, 2002b). The program will be implemented under applicable SOPs and will include appropriate training and equipment/personnel testing and maintenance programs (AUC, 2012). The staff determines that the applicant has committed to developing a respiratory protection program consistent with 10 CFR 20.1703, Regulatory Guide 8.15 (NRC, 1999c), and Regulatory Guide 8.31 (NRC, 2002b). The staff determines that the applicant has identified the use of the respiratory program in accordance with SRP Acceptance Criterion 5.7.3.3(6) and found this acceptable.

5.7.3.4 Evaluation Findings

The staff completed its review of the in-plant airborne radiation monitoring program for the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.7.3.2 and the acceptance criteria in SRP Section 5.7.3.3.

The applicant has an acceptable in-plant airborne radiation monitoring program for the Proposed Project. The applicant has provided acceptable drawing(s) that depicts the facility layout and the locations of airborne radiation monitors. The airborne radiation monitors are acceptably placed. The applicant demonstrated that the range, sensitivity, and calibration of monitors of airborne radiation will enable accurate determinations of the concentrations of airborne radioactive material so as to protect the health and safety of releases from venting of processing tanks and from yellowcake dust from drying operations, spills, and maintenance activities. Planned radiation surveys are acceptable. Planned documentation of radiation exposures is consistent with the requirements. The applicant’s respiratory protection program is acceptable. The applicant program for monitoring uranium and sampling of radon or its daughters is acceptable. Employee internal exposure calculations will be performed in accordance with 10 CFR 20.1204(a).

Based on the information provided in the application and the detailed review conducted of the airborne radiation monitoring program for the Proposed Project, the staff concludes that the airborne radiation monitoring program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program and as low as is reasonably achievable requirements; 10 CFR Part 20, Subpart C, which defines occupational dose limits; 10 CFR Part 20, Subpart L, which specifies recordkeeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting requirements.

5.7.4 Exposure Calculations

5.7.4.1 Regulatory Requirements

The staff determines if the applicant demonstrated that the proposed exposure calculation for the Proposed Project meets 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.

5.7.4.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using acceptance criteria in SRP Section 5.7.4.3 (NRC, 2003). Regulatory Guides 8.13 and 8.36 (NRC, 1999b, 1992b) provide guidance on how compliance with the regulations can be demonstrated.

5.7.4.3 Staff Review and Analysis

This section discusses the exposure calculations to be performed by the applicant, which include internal and external occupational radiation dose, as well as radiation doses to the embryo or fetus. Occupational workers can be exposed externally and internally to radioactive material in a number of ways. These could include radioactive material in the air, loose surface contamination, or radioactive material that might be stored or processed inside equipment or components.

SRP Acceptance Criterion 5.7.4.3(1) states that the methodologies proposed to determine the intake of radioactive materials by personnel in work areas where airborne radioactive materials could exist are in accordance with 10 CFR 20.1204 and 20.1201. The applicant stated in TR Section 5.7.4 that it will monitor worker exposures using internal, external, and total (internal and external) methods, as well as prenatal and fetal exposure for declared pregnant occupational female workers. The applicant's methodologies for determining intake of radioactive materials are described below in this SER. The staff determines that the applicant has addressed all appropriate methods used to determine the intake of radioactive materials by workers and the occupational dose delivered externally to workers (expressed as the deep-dose equivalent or DDE), including the sum of all the dose methods. The prenatal and fetal exposure for declared pregnant occupational female workers is computed separately for prenatal and fetal. This is consistent with the methodologies proposed in SRP Acceptance Criterion 5.7.4.3(1) and found acceptable. These methodologies are discussed in more detail in the other SRP Acceptance Criteria in this section.

SRP Acceptance Criterion 5.7.4.3(2) and Acceptance Criterion 5.7.4.3(3) state that calculations for natural uranium exposure and for airborne radon daughter exposure are consistent with Regulatory Guide 8.30. In TR Section 5.7.4 (AUC, 2012), the applicant stated that the exposure (internal dose) calculations for airborne natural uranium and airborne radon progeny will be performed using the intake method from Regulatory Guide 8.30 (NRC, 2002a). The equations are as follows:

For natural uranium,

$$I_u = b \sum_{i=1}^{n} \frac{X_i \, x \, t_i}{PF}$$

Where:

I_u	=	uranium intake, expressed in µg or µCi
t_i	=	time that the worker is exposed to concentration X_i, expressed in hours
X_i	=	average concentration of uranium in breathing zone, µg/cm^3, µCi/m^3
b	=	breathing rate, 1.2 m^3/hr
PF	=	the respirator protection factor (unitless)
n	=	number of exposure periods during the week or quarter

For radon progeny,

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

Where:

I_r	=	radon progeny intake, expressed in working-level months (WLMs)
t_i	=	time that the worker is exposed to concentrations W_i, expressed in hours
W_i	=	average number of working levels in the air near the worker's breathing zone during t_i
170	=	number of hours in a working month
PF	=	the respirator protection factor (unitless)
n	=	the number of exposure periods during the year

In TR Section 5.7.4 (AUC, 2012), the applicant uses the intake levels from the equations above for the following equations to compute the committed effective dose equivalent (CEDE) for natural uranium and radon progeny:

For natural uranium,

$$CEDE_u = \frac{I_u \, x \, 5000}{ALI}$$

Where:

$CEDE_u$	=	committed effective dose equivalent, expressed in mrem from uranium
I_u	=	uranium intake, expressed in µCi
5000	=	radiation dose, expressed in mrem from the intake of 1 ALI
ALI	=	annual limit on intake for uranium presented in 10 CFR 20, Appendix B, Table 2 (assuming Class W solubility)

For radon progeny,

$$CEDE_r = \frac{4 x 5000}{ALI}$$

Where:

$CEDE_r$ = committed effective dose equivalent, expressed in mrem from Rn-222 and progeny
I_r = radon intake, expressed in working level months
5000 = radiation dose, expressed in mrem from the intake of 1 ALI and this assumes that is equivalent to 4 WLM/yr
ALI = annual limit on intake for Rn-222 and Rn-222 progeny in WLM

The applicant shows in TR Section 5.7.4 (AUC, 2012) that the total effective dose equivalent (TEDE) is computed as follows:

$$TEDE = CEDE_u + CEDE_r + DDE$$

Where:

TEDE = total effective dose equivalent in mrem = total radiation dose
$CEDE_u$ = committed effective dose equivalent in mrem from uranium
$CEDE_r$ = committed effective dose equivalent in mrem from Rn-222 and Rn-222 progeny
DDE = the external deep dose equivalent

The applicant stated in TR Section 5.7.4 that, in general, 100-percent occupancy time will be initially used to determine exposures. Using this method to determine time of exposure, each worker is assumed to have spent the entire work shift in the survey area(s). The occupancy time determinations for each worker will be based on the actual time worked during the monitoring period, and this approach generally results in a conservative (i.e., higher than actual) estimate of internal exposure to airborne natural uranium and radon progeny as it does not account for time the worker may have spent outside the work area (AUC, 2012). The staff concurs that using the assumption of 100-percent occupancy and assigning the concentration as described in the above equations as the potential intake will result in a conservative estimate of the deposition and internal dose or CEDE. The staff determines that the applicant has provided methods for determining the intake and internal dose and these methods meet SRP Acceptance Criterion 5.7.4.3(2) and Acceptance Criterion 5.7.4.3(3) and therefore are acceptable.

SRP Acceptance Criterion 5.7.4.3(4) states that the calculations and guidance for prenatal and fetal radiation exposure are consistent with Regulatory Guide 8.36 (NRC, 1992b) and Regulatory Guide 8.13 (NRC, 1999b). In TR Section 5.7.4 (AUC, 2012), the applicant stated that the dose equivalent to the embryo or fetus is determined by monitoring the declared pregnant woman. The applicant committed in TR Section 5.7.4 to using the DDE of the declared pregnant female during the gestation period, and the applicant will apply the DDE to the embryo or fetus for external dose. For internal dose, the applicant will perform exposure calculations in accordance with Regulatory Guide 8.36. In TR Section 5.5.1.4 (AUC, 2012), the applicant stated that female workers (and supervisors who oversee female workers), who require training under 10 CFR Part 19, will be provided with training that meets the guidance contained in Regulatory Guide 8.13 and will receive a copy of this guidance. The staff finds the methodologies for calculating and limiting the dose of the prenatal or fetus and training consistent with SRP Acceptance Criterion 5.7.4.3(4) and found to be acceptable.

SRP Acceptance Criterion 5.7.4.3(5) states exposure calculations are presented for routine operations, nonroutine operations, maintenance, and cleanup activities and are consistent with Regulatory Guide 8.30 (NRC, 2002a) and Regulatory Guide 8.34 (NRC, 1992a). In TR Section 5.7 (AUC, 2012), the applicant described an RPP for routine radiation safety operations, and this includes exposure calculations for routine operations. In TR Section 5.2.2 (AUC, 2012), the applicant discussed the use of the RWP which is issued for nonroutine activities with a potential for exposure to radioactive materials for which no operating procedure exists at the site. The staff has reasonable assurance, based on the methodologies discussed in TR Section 5.7.4 (AUC, 2012), that the applicant has developed exposure calculations for routine and nonroutine operations, as well as for maintenance and cleanup activities that would allow the applicant to reasonably assess the exposure calculations and the total effective dose equivalent consistent with SRP Acceptance Criterion 5.7.4.3(5) and this is acceptable.

SRP Acceptance Criterion 5.7.4.3(6) states that the parameters used in exposure calculations are representative of conditions at the site and include the time-weighted exposure that incorporates occupancy time and average airborne concentrations. In TR Section 5.7 (AUC, 2012), the applicant described in-plant field measurements, such as radiation exposure surveys and air particulate and air radon sampling locations, that are located within the central processing facility for routine operations, as well as the use of the RWP as discussed above for nonroutine operations. The applicant also provided the parameters used in exposure calculations in previous paragraphs in this section of the SER that are consistent with Regulatory Guide 8.30 (NRC, 2002a). The staff determines that the applicant is using parameters used in exposure calculations and field measurements that are representative of the conditions at the site, including time-weighted exposure that incorporates occupancy time and average airborne concentrations that are consistent with SRP Acceptance Criterion 5.7.4.3(6) and this is acceptable.

SRP Acceptance Criterion 5.7.4.3(7) states that the estimation of airborne uranium concentrations takes into account the maximum production capacity requested in the application and the anticipated efficiencies of airborne particulate control systems reviewed using SRP Section 4.1 and Section 5.7.1. The staff determines that the estimation of airborne uranium concentration and the anticipated efficiencies of airborne particulate control systems is adequately discussed in SER Section 4.1 and will not be reviewed again in this section of the SER.

SRP Acceptance Criterion 5.7.4.3(8) states that all reporting and recordkeeping of worker doses is done in conformance with Regulatory Guide 8.7 (NRC, 2005) and 10 CFR 20.2103. In TR Section 5.7.4 (AUC, 2012), the applicant stated that all dose records will be kept and reported in accordance with Regulatory Guide 8.7 and 10 CFR 20.2103 and records of prior dose history and exposure monitoring results will be maintained as required for each monitored individual on an NRC Form 5 or equivalent. In TR Section 5.7.4.5, the applicant also stated that, in accordance with 10 CFR 19.13(b), monitored employees will be advised in writing on an annual basis of their calculated TEDE and employees may request a written report of their individual exposure history at any time. These reports will be provided within 30 days of the request. The applicant will also report and identify any exposure of an identified occupationally exposed individual or an identified member of the public to radiation or radioactive material under 10 CFR 20.2203, “Reports of Exposures, Radiation Levels, and Concentrations of Radioactive Material Exceeding the Constraints or Limits,” or 10 CFR 20.2204, “Reports of

Planned Special Exposures.” The staff determines that the applicant will report and keep records of worker doses in conformance with Regulatory Guide 8.7. The applicant’s commitment for reporting and recordkeeping of worker doses is consistent with SRP Acceptance Criterion 5.7.4.3(8) and this is acceptable.

5.7.4.4 Evaluation Findings

The staff completed its review of the exposure calculations program for the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.7.4.2 and acceptance criteria in SRP Section 5.7.4.3.

The applicant provided acceptable calculational methods for exposure calculations for the Proposed Project. The applicant has calculational methods to determine intake of radioactive materials by personnel in work areas. The applicant exposure calculations for natural uranium and airborne radon daughter exposure are acceptable and are in conformance with the guidance in Regulatory Guide 8.30 and Regulatory Guide 8.34. The applicant has acceptable methods to calculate prenatal and fetal radiation exposure, and calculation methods for routine operations, nonroutine operations, maintenance, and cleanup activities are acceptable and are consistent with Regulatory Guide 8.30 and Regulatory Guide 8.34. The applicant used parameters that are representative of the site, such as using both full- and part-time workers in exposure calculations. The applicant considered maximum production capacity and anticipated efficiencies of airborne particulate control systems in exposure calculations. All reporting and recordkeeping is in conformance with Regulatory Guide 8.7.

Based on the information provided in the application and the detailed review conducted of the exposure calculation program for the Proposed Project, the staff concludes that the exposure calculation program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program and as low as is reasonably achievable requirements; 10 CFR Part 20, Subpart C, which defines occupational dose limits; 10 CFR Part 20, Subpart L, which specifies recordkeeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting requirements.

5.7.5 Bioassay Program

5.7.5.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed bioassay program for the Proposed Project meets the requirements of Subparts C, L, and M of 10 CFR Part 20.

5.7.5.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in SRP Section 5.7.5.3 (NRC, 2003). Regulatory Guides 8.9, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program” (NRC, 1993a), 8.22, “Bioassay at Uranium Mills” (NRC, 1988b), 8.30 (NRC, 2002a), and 8.34 (NRC, 1992a) provide guidance on meeting the applicable regulations.

5.7.5.3 Staff Review and Analysis

This section discusses 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.

SRP Acceptance Criterion 5.7.5.3(1) states that it is consistent with applicable sections of Regulatory Guide 8.22 (NRC, 1988b) and Regulatory Guide 8.31 (NRC, 2002b) including as low as is reasonably achievable requirements, and that the bioassay program is adequate to confirm results determined from the airborne radiation monitoring program and the exposure calculations. In TR Section 5.7.5, the applicant committed to implement a urinalysis bioassay program consistent with applicable sections of Regulatory Guide 8.22 (NRC, 1988b) and Regulatory Guide 8.31 (NRC, 2002b), including the ALARA requirements. In TR Section 5.1.7.1 (AUC, 2012), the applicant stated that management is responsible for the following:

- the development of a strong commitment to and continuing support of the implementation and operations of the ALARA program
- an annual audit program which reviews radiation monitoring results, procedures, and operational methods
- a continuing evaluation of the program including adequate staffing and support
- proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors

In TR Section 5.1.7.1 (AUC, 2012), the applicant addressed the ALARA responsibilities of the radiation safety officer, supervisors, and workers. The staff determines that the applicant has established an adequate airborne radiation monitoring program and exposure calculations, as described in the previous sections of this SER, and the results will support applicable sections of Regulatory Guide 8.22 and Regulatory 8.31 consistent with SRP Acceptance Criterion 5.7.5.3(1), and this is found to be acceptable.

SRP Acceptance Criterion 5.7.5.3(2) and Acceptance Criterion 5.7.5.3(3) state that the determination of which workers will be monitored in the bioassay program is consistent with Regulatory Guide 8.22 (NRC, 1988b), and sampling and analysis frequencies include baseline for all new employees and exit bioassays on termination of employment. The applicant stated in TR Section 5.7.5 (AUC, 2012) that, in general, bioassay results will be collected monthly for those who are involved with the uranium extraction process from the ion exchange process to the final packaging and any employees who perform routine maintenance on filtration equipment will also be tested monthly. The applicant also stated in TR Section 5.7.5 that the determination of which workers are to be monitored will be in accordance with Regulatory Guide 8.22, Section 2, including the sampling and analysis frequencies for new and terminated employees. The staff determines that the collection of monthly urine samples for analysis for workers as well as new and exit employees is consistent with the SRP Acceptance Criterion 5.7.5.3(2) and Acceptance Criterion 5.7.5.3(3) and this is acceptable.

SRP Acceptance Criterion 5.7.5.3(4) and Acceptance Criterion 5.7.5.3(5) state that action levels for bioassay monitoring are set in accordance with Regulatory Guide 8.22 and that all reporting and recordkeeping are done in conformance with the requirements of 10 CFR Part 20, Subpart L and Subpart M. In TR Section 5.7.5 (AUC, 2012), the applicant stated that, in the event that a bioassay result is above a specified action level in Table 1 of Regulatory

Guide 8.22 (NRC, 1988b), corrective actions will be in accordance with Table 1 and all recording and reporting will be done in accordance with the requirements of 10 CFR Part 20, Subparts L and M. The staff determines that the guidelines and corrective action in Regulatory Guide 8.22, Table 1, are the proper guidelines and corrective action for urinalysis of employees working at the site. These guidelines and corrective actions are designed to provide proper health and safety features to workers. The staff determines that the action levels for bioassay monitoring and the reporting and recordkeeping are consistent with SRP Acceptance Criterion 5.7.5.3(4) and Acceptance Criterion 5.7.5.3(5) and this is acceptable.

5.7.5.4 Evaluation Findings

The staff has completed its review of the bioassay program for the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.7.5.2 and the acceptance criteria in SRP Section 5.7.5.3.

The applicant has established an acceptable bioassay program for the Proposed Project that is consistent with Regulatory Guide 8.22. An acceptable program for baseline urinalysis and exit bioassay is in place. Individuals routinely exposed to yellowcake dust are a part of the bioassay program. An acceptable action program to curtail uranium intake is established, and appropriate action levels are set. The applicant has established reporting and recordkeeping protocols in conformance with the requirements of 10 CFR Part 20, Subpart L.

Based on the information provided in the application and the detailed review conducted of the bioassay program for the Proposed Project, the staff concludes that the bioassay program is acceptable and is in compliance with 10 CFR 20, Subpart C, which provides requirements for the determination of internal exposure, and 10 CFR Part 20, Subpart L, which establishes recordkeeping requirements.

5.7.6 Contamination Control Program

5.7.6.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the contamination control program for the Proposed Project meets the requirements of Subparts B, C, and F of 10 CFR Part 20.

5.7.6.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in SRP Section 5.7.6.3 (NRC, 2003). Regulatory Guide 8.30 provides guidance on how compliance with the applicable regulations can be demonstrated.

5.7.6.3 Staff Review and Analysis

This section discusses 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. This contamination can take the form of loose surface contamination that resides 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 not spread to areas outside of the restricted area(s) and into unrestricted areas.

SRP Acceptance Criterion 5.7.6.3(1) states that radiation surveys will be conducted to prevent contaminated employees from entering clean areas or from leaving the site in conformance with guidance in Regulatory Guide 8.30 (NRC, 2002a). In TR Section 5.7.6 (AUC, 2012), the applicant stated that surveys will be conducted for surface contamination throughout all plant areas on at least a weekly basis and surveys will be conducted using hand-held instrumentation (e.g., portable rate meters with pancake-type Geiger-Müller (GM) or large area scintillation detectors) to assess surface contamination, and smear surveys of surfaces to assess removable contamination. The applicant stated in TR Section 5.7.6 that TR Figure 5-2 depicts typical surface contamination sampling locations at which both hand-held instrument surveys and swipe tests will be performed. The applicant stated in TR Section 5.7.6 that the policies and methods that will be applied for the conduct of contamination surveys in restricted areas (process areas as well as general plant areas), for assessment of contamination of skin and clothing of workers, and for the release of equipment to unrestricted areas, and contamination assessments will also be conducted in unrestricted areas to ensure program effectiveness. In addition to these contamination control programs, the applicant stated in TR Section 5.7.6 that, in yellowcake areas, daily inspections will be made by the RSO or RST for locating yellowcake contamination on surfaces and visible yellowcake will be cleaned up promptly, especially where contamination could be disturbed and resuspended from walkways, railings, other high-traffic areas, tools, and similar surfaces. The applicant stated in TR Section 5.7.6 that, in areas where work with uranium is not performed, such as eating rooms, change rooms, control rooms, and offices, a lower level of surface contamination is possible and these areas will be spot-checked weekly by the RSO or RST for removable contamination using filter paper smear test. The applicant stated in TR Section 5.7.6 (AUC, 2012) that areas will be immediately cleaned by trained radiation workers, if surface contamination levels exceed the values of Regulatory Guide 8.30, Table 2 (NRC, 2002a), but to help maintain doses ALARA, any detectable activity above background in these areas will be cleaned and removed as soon as possible. Maintenance of equipment and systems will be controlled by SOPs and the RWP. The staff determines that the applicant has adequately described the contamination control program in TR Section 5.7.6. The applicant will control contamination within the restricted area by daily inspections and within unrestricted areas (i.e., eating area, etc.) by weekly smear surveys; personnel leaving the restricted area will be monitored by alpha surveys and equipment leaving the restricted area will be surveyed by the RSO or RST or both. The staff reviewed the external radiation exposure monitoring program in SER Section 5.7.2 and noted that the applicant has identified areas within the plant to conduct radiation surveys. The staff determines that the applicant will conduct radiation surveys to prevent contaminated employees from entering clean areas or from leaving the site consistent with Regulatory Guide 8.30 (NRC, 2002a) and SRP Acceptance Criteria 5.7.6.3(1) and this is acceptable.

SRP Acceptance Criterion 5.7.6.3(2) states that the requirements for a contamination control program (e.g., maintaining change areas and personal alpha radiation monitoring before leaving radiation areas) are included in SOPs or are discussed in the application. In TR Section 5.7.6 (AUC, 2012), the applicant stated that the contamination surveys will be conducted in accordance with the applicable SOPs and that, before leaving the restricted area, all individuals must perform and document an alpha survey at scanning areas. In TR Section 5.7.6, the applicant stated that individuals who have been in the wellfields, byproducts storage area, or near the deep disposal well or backup pond will perform and document an alpha survey immediately upon returning to the plant before entering office areas, before eating, or before leaving the site. The staff has reasonable assurance that the applicant will establish SOPs for monitoring contamination control and the use of alpha radiation monitoring before leaving a restricted area. The applicant has discussed, in the application in more detail, surveys for skin contamination and personal clothing and surveys for release of equipment to unrestricted areas, including routine daily inspections and qualifications of personnel performing contamination surveys. The staff determines that the applicant has adequately discussed the requirements for a contamination control program (e.g., maintaining change areas and personal alpha radiation monitoring before leaving radiation areas) consistent with SRP Acceptance Criterion 5.7.6.3(2) and this is acceptable.

SRP Acceptance Criterion 5.7.6.3(3), Acceptance Criterion 5.7.6.3(8), and Acceptance Criterion 5.7.6.3(9), in general, state that the action levels for surface contamination are set in accordance with Regulatory Guide 8.30 (NRC, 2002a) and SRP Table 5.7.6.3-1 (NRC, 2003). In TR Section 5.7.6 (AUC, 2012), the applicant stated that, for surveying skin and personal clothing, a typical alarm setting for this type of equipment (Ludlum Model 43 series with background at 3 cpm and an efficiency of 17-35 percent for plutonium-239 (Pu-239)) is 20 cpm. The applicant stated in TR Section 5.7.6 (AUC, 2012) that the goal is to ensure no personal contamination significantly above background levels. The applicant further stated in TR Section 5.7.6 that, upon determination by any employee that contamination on his or her person, clothing, or other personal effects exceeds background, the affected area(s) will be washed with water and soap and resurveyed, and a second washing using modest abrasive methods may be required (soft brush and soap). In TR Section 5.7.6.3.3, "Contamination Limits To Be Applied for Release of Equipment and Materials from Restricted Areas" the applicant defines the limits in Table 2 of Regulatory Guide 8.30 (NRC, 2002a), its history (i.e., Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," (NRC, 1974)), and other policies associated with Regulatory Guide 1.86. In this section, the applicant stated that the applicable recommendations provided in Regulatory Guide 8.30 will be integrated into the contamination assessment and control elements of the project's RPP. The staff determines that the applicant will integrate the recommendations provided in Regulatory Guide 8.30 including Table 5.7.6.3-1 into the project's RPP. The staff determines that the application is consistent with SRP Acceptance Criterion 5.7.6.3(3) and this is acceptable.

In TR Section 5.7.6.2.1 (AUC, 2012), the applicant stated that, since any beta-gamma contamination at an ISR (or uranium mill) should be associated with alpha emitting nuclides, no special monitoring or survey for beta-gamma emitters is required and the lack of detectable alpha contamination ensures no beta-gamma contamination. The applicant's description of personnel contamination surveys is acceptable to staff, except with respect to beta-gamma contamination surveys. The applicant justified its statement in the first line of this paragraph by concluding that in-growth of beta-gamma contamination from fresh yellowcake product will require approximately 4 months and that fresh yellowcake will not remain at the facility long enough for such in-growth to occur (AUC, 2012). Additionally, the applicant stated that the radionuclide composition of material in an ISR facility would be almost exclusively natural uranium or Ra-226 or both and near background, and that there is a very small amount of in-growth of other progeny during the brief life cycle of the material through the plant.

The staff determines that, although it may take approximately 4 months for uranium daughter products to reach equilibrium (the activity of uranium daughter products equals the activity of uranium-238 (U-238)), uranium daughter products are produced immediately from fresh uranium. Given large quantities of fresh uranium, uranium daughter products may become detectable immediately by the beta-gamma emissions from these uranium daughter products. Aged yellowcake can remain in some areas of the facility from spills or maintenance activities. The principal decay scheme of the uranium series can be found in Figure 3.1 of National Council on Radiation Protection and Measurements (NCRP) Report No. 97 (NCRP, 1988). Further, radon-222 (Rn-222) is also a radioactive constituent of the uranium series and can be found in groundwater and ISR lixiviant and is produced from the decay of Ra-226. Radon-222, a radioactive gas with a 3.8-day half-life, decays to several solid particles that tend to be electrically charged and can deposit on surfaces or attach to dust particles. The short-lived radon progeny decay to lead-210 (Pb-210), which is a beta-emitter with no alpha emissions, that can build up in buildings if the ventilation is not adequate to ensure complete air exchange or a contamination control program is inadequate and allows potential contaminants to migrate. Therefore, the staff determines that beta-gamma activity in the form of surface contamination can be transferred to equipment or personnel or both during normal operations and must be detected before leaving a restricted area within the facility. In response to RAI-49 (AUC, 2014a), the applicant committed to developing and implementing a survey program for beta-gamma contamination for personnel exiting from restricted areas, which will meet the requirements of 10 CFR Part 20, Subpart F. NRC staff determined that the contamination control program as described in the original application was not sufficient. The staff determined that a survey program for beta-gamma contamination for personnel (and equipment) exiting from restricted areas that meets the contamination limits as described in NRC "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, and Special Nuclear Material (NRC, 1993c) and the methodologies described in NUREG-1507 and NUREG-1575 will satisfactorily comply with NRC requirements. Based on the staff's review of RAI-49, the staff determined that the applicant will provide a written overview of a program meeting this criteria before the pre-operational inspection. The program overview may be deemed acceptable if it is consistent with the "Beta-Gamma Contamination Control Program" found in a Strata Energy letter to the NRC dated October 28, 2015 (Strata, 2015). This commitment is captured in License Condition 12.7. Therefore, the staff has reasonable assurance that the applicant will implement a contamination control program that will include both alpha surveys and beta-gamma surveys for surface contamination for personnel and equipment leaving a restricted area. The staff determines that the applicant's contamination program is consistent with SRP Acceptance Criteria 5.7.6.3(3), 5.7.6.3(8), and 5.7.6.3(9) and therefore the contamination control program is acceptable.

SRP Acceptance Criterion 5.7.6.3(4) states that monitoring equipment by type, specification of the range, sensitivity, calibration, methods and frequency, availability, and planned use are adequately described. The application demonstrated that the ranges of sensitivity for monitoring equipment will be appropriate for expected facility operation. In TR Section 5.7.6 (AUC, 2012), the applicant stated that survey equipment will be calibrated annually or at the manufacturer's recommended schedule, which is more frequent, and after repair, and verification of instrument operation will be performed using check sources, and in accordance with the applicable SOP before each daily use. The applicant stated in TR Section 5.7.6 that surface activity will be measured with an appropriate alpha survey meter (e.g., Ludlum Model 2241 scaler or Ludlum Model 177 ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe or equivalent) and, additionally, a portable pancake GM survey meter with a beta/gamma probe and/or a Ludlum Model 3 survey meter with a Ludlum 44 series GM probe or equivalent may be utilized. The applicant also identified radiation detectors, the type of radiation detected, and use, including the characteristics of each detector in TR Table 5-1 (AUC, 2012). The staff determines that the applicant has identified a sufficient suite of radiation detectors to measure both alpha and beta/gamma radiation and the characterization of the detectors in TR Table 5-1 provides general information about background and efficiency capabilities. The staff does note that this is general information and that the applicant will have to develop background measurements, efficiencies, and LLD using actual field measurements after construction but before operations. The staff determines that the applicant has described general calibrations and methods in the application and SOPs should be reviewed by inspection before operations. The staff determines that the applicant has met the SRP Acceptance Criterion 5.7.6.3(4) and this is acceptable.

SRP Acceptance Criterion 5.7.6.3(5) states that all reporting and recordkeeping is done in conformance with the requirements of 10 CFR Part 20, Subpart L and Subpart M. The staff understands this Acceptance Criterion to be referring to the contamination and control program. In TR Section 5.7.6 (AUC, 2012), the applicant stated that, before leaving the restricted area, all individuals must perform and document an alpha survey. In TR Section 5.7.6 (AUC, 2012), the applicant stated that all instrument documentation will be maintained onsite. The staff determines that the applicant will document the contamination control program consistent with SRP Acceptance Criterion 5.7.6.3(5). There are no reporting requirements under Subpart M for the contamination control program.

SRP Acceptance Criterion 5.7.6.3(6) and Acceptance Criterion 5.7.6.3(7) state that the applicant will ensure that radioactivity on equipment or surfaces is not covered by paint, plating, or other covering material unless contamination levels, as determined by survey and documented, are below the limits specified in SRP Table 5.7.6.3-1 (NRC, 2003), and that the radioactivity of the interior surfaces of pipes, drain lines, or duct work will be determined by taking measurements at all traps and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or duct work, respectively. In TR Section 5.7.6 (AUC, 2012), the applicant stated that equipment and surfaces shall not be painted over or plated for the purpose of meeting release criteria, but if painting over an area with contamination that cannot reasonably be removed is determined by the RSO to be ALARA, it may be allowed as long as the contamination on the article or object is characterized and documented with the item or area being visibly labeled as contaminated. The applicant also stated that the radioactivity of pipes, drain lines, pumps, or duct work where access can be difficult will be determined by taking measurements at a trap or similar access point, and adequate records will be maintained to ensure that the article or object is not inadvertently released for unrestricted use. The applicant also stated that items that cannot be representatively surveyed due to geometry or any other reason may not be released for unrestricted use and a Ludlum Model 2224 scaler and Model 44-9 or equivalent will be used for release surveys. The staff determines that the applicant's contamination control program makes a reasonable effort to detect difficult contamination on equipment or surfaces not covered by paint, plating, or other covering material, as well as radioactivity on the interior surfaces of pipes, drain lines, or duct work where access can be difficult. The staff determines that the applicant's contamination control program will make a reasonable effort to detect difficult contamination and this is consistent with SRP Acceptance Criterion 5.7.6.3(6) and Acceptance Criterion 5.7.6.3(7) and found to be acceptable.

5.7.6.4 Evaluation Findings

The staff completed its review of the contamination control program for the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.7.6.2 and acceptance criteria in SRP Section 5.7.6.3.

The applicant established an acceptable contamination control program for the Proposed Project. Acceptable controls are in place to prevent contaminated employees from entering clean areas or from leaving the site. The SOPs will include provisions for contamination control, such as maintaining changing areas and personal alpha radiation (and beta/gamma) monitoring before leaving radiation areas. Acceptable action levels have been set in accordance with Regulatory Guide 8.30 and plans for surveys are in place for skin and personal clothing contamination. The applicant established that all items removed from the restricted area are surveyed by the radiation safety staff and meet release limits. All reporting and recordkeeping is done in conformance with protocols established in Regulatory Guide 8.7. The applicant demonstrated that the range, sensitivity, and calibration of monitoring equipment will protect the health and safety of employees during facility operations. The applicant demonstrated that contaminated surfaces will not be covered unless, before covering, a survey documents that the contamination level is below the limits specified in SRP Table 5.7.6.3-1 before unrestricted release. The applicant will determine the radioactivity on the interior surfaces of pipes, drain lines, or duct work by taking measurements at appropriate access points that have been shown to be representative of the interior contamination. The applicant committed to establishing that contamination on equipment or scrap will be within the limits in SRP Table 5.7.6.3-1 before unrestricted release. To relinquish possession or control of equipment or scrap with material in excess of the limits specified in SRP Table 5.7.6.3-1, the applicant will provide detailed information on the contaminated material, provide a detailed health and safety analysis that shows that the release of the contaminated material will not result in an unreasonable risk to the health and safety of the public, and obtain the staff's approval.

Based on the information provided in the application and the detailed review conducted of the contamination control program for the Proposed Project, the staff concludes that the contamination control program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program and as low as is reasonably achievable requirements; 10 CFR Part 20, Subpart F, which provides survey and monitoring requirements; and 10 CFR Part 20, Subpart L, which establishes recordkeeping requirements.

5.7.7 Airborne Effluent and Environmental Monitoring Program

During the course of the evaluation, the staff found that there was overlap among the areas of review and acceptance criteria in SRP Section 4.1, "Gaseous and Airborne Particulates," Section 5.7.1, "Effluent Control Techniques," and Section 5.7.7, "Airborne Effluent and Environmental Monitoring Program" (NRC, 2003). As discussed in SER Section 5.7.2, the staff reduced the overlap in the SER by limiting the discussion of the staff's review of the effluent control techniques to SER Section 4.1 and effluent monitoring to SER Section 5.7.8.

5.7.7.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the airborne effluent and environmental monitoring program for the Proposed Project meets the requirements of 10 CFR 20.1003, 20.1301, 20.1302, 20.1101(d), 20.1501, 10 CFR 40.65, and Criteria 7 and Criteria 8 of 10 CFR Part 40, Appendix A.

5.7.7.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in SRP Section 5.7.7.3 (NRC, 2003). Regulatory Guides 4.14 and 8.37 provide guidance on how the applicant can comply with the applicable regulations.

5.7.7.3 Staff Review and Analysis

This section discusses the applicant's proposed airborne effluent and environmental monitoring program. This includes radiation monitoring outside of the plant area during operations and monitoring environmental media at the boundary of the Proposed Project and at a background or control location.

The applicant is required to demonstrate how it will comply with 10 CFR Part 40, Appendix A, Criterion 7, which states, "Throughout the construction and operating phases of the mill, an operational monitoring program must be conducted to measure or evaluate compliance with applicable standards and regulations; to evaluate performance of control systems and effects." The applicant is also required to demonstrate how it will comply with 10 CFR Part 40, Appendix A, Criterion 8, which states:

> Milling operations must be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable. The primary means of accomplishing this must be by means of emission controls. Notwithstanding the existence of individual dose standards, strict control of emissions is necessary to ensure that population exposures are reduced to the maximum extent reasonably achievable and to avoid site contamination.

The applicant is also required to demonstrate compliance with 10 CFR 40.65. Specifically, it must report "…the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents…."

SRP Acceptance Criteria 5.7.7.3(1) states that the proposed airborne effluent and environmental monitoring program is consistent with Regulatory Guide 4.14, Sections 1.1 and 2.1 (NRC, 1980a), and as low as is reasonably achievable requirements as described in Regulatory Guide 8.37, Section 3 (NRC, 1993b). The staff determines that the applicant has discussed the environmental monitoring program for air particulate, radon, surface soil, sediment, subsurface soil, vegetation, and direct radiation in accordance with Regulatory Guide 4.14, Sections 1.1 and 2.1 (NRC, 1980a).

Aside from the reporting requirements in 10 CFR 40.65, an applicant must provide details on how it will perform surveys sufficient to demonstrate compliance with 10 CFR 20.1301 and 10 CFR 20.1302, which requires compliance with dose limits for individual members of the public. An applicant must also demonstrate compliance with 10 CFR 20.1501, which requires surveys that are reasonable under the circumstances to evaluate concentrations or quantities of radioactive materials and the potential radiological hazards.

To comply with 10 CFR 20.1302(a), applicants must demonstrate that they will conduct appropriate surveys of radioactive materials in effluents released to unrestricted and controlled areas. For point sources (e.g., a defined stack, pipe, or vent), the release point will generally be the effluent discharge point (i.e., where the uncontrolled effluent is released to the air). Regulatory Guide 4.1, "Radiological Environmental Monitoring for Nuclear Power Plants" (NRC, 2009a), and Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste" (NRC, 2009b), define effluent as liquid or gaseous waste containing plant-related, licensed radioactive material, emitted at the boundary of the facility (e.g., building, end-of-pipe, stack, or container) as described in the final safety analysis report. If the effluent is discharged to a restricted area, the applicant may propose measuring or calculating the effluent quantities or concentrations: (1) at the effluent discharge point or (2) at the unrestricted/controlled area boundary. If the effluent is measured or calculated at the discharge point, the applicant may use: (1) this undiluted value or (2) an appropriate model to estimate the concentrations to which people are exposed. For dose calculations, the applicant may also propose taking direct measurements at the unrestricted area boundary. Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities" (NRC, 1993b), provides additional guidance on airborne radioactive effluent monitoring. In response to RAI-74, the applicant discussed and identified the potential release points at the facility and methods for monitoring the release points (AUC, 2015a), and SRP Acceptance Criterion 5.7.7.3(1) is addressed in SER Section 4.1. The staff has reasonable assurance that the applicant has identified potential release points and will monitor these release points with appropriate instrumentation to obtain data to compute quantities of radioactive material discharged from these gaseous effluent release points. The staff determines that the application is consistent with SRP Acceptance Criterion 5.7.7.3(1) and Regulatory Guide 4.14.

SRP Acceptance Criteria 5.7.7.3(2-4) state that the proposed locations of the airborne effluent monitoring stations are consistent with guidance in Regulatory Guide 4.14, Sections 1.1.1 and 2.1.2 (NRC, 1980a), and that the proposed airborne effluent and environmental monitoring program should sample radon, air particulates, surface soils, subsurface soils, vegetation, direct radiation, and sediment, and use sampling methods consistent with Regulatory Guide 4.14, Section 3 (NRC, 1980a). In TR Section 5.7.7 (AUC, 2012), the applicant stated that air particulate sampling locations will be located at a minimum of three air monitoring stations at or near the site boundaries, one station at or close to the nearest occupiable structure within 10 km (6 mi) of the site, and one station at a control or background location, and these air particulate monitoring stations have been operated during the preoperational phase to establish background concentrations of airborne particulate radionuclides. In TR Section 5.7.7 (AUC, 2012), the applicant also stated that radon monitoring will be performed at locations recommended by Regulatory Guide 4.14 (the same locations selected for air particulate monitoring) using the same types of detectors and frequency of analysis employed during preoperational monitoring. The staff reviewed the site selection of air particulate and air radon sampling stations in SER Section 2.6 and determines that the applicant needs to provide an adequate technical justification for the current air particulate and air radon monitoring stations. To address this issue, the applicant corrected the sampling locations and is collecting air sample data at new additional locations to satisfy Regulatory Guide 4.14 before operations (AUC, 2015c). This is addressed as a license condition in SER Section 2.6. This commitment is captured in License Condition 12.13. The staff also reviewed the type of collection devices, frequency of collection, and analysis in SER Section 2.6 and determines them to be consistent with the acceptance criteria in SRP Section 2.9.3.

In TR Section 5.7.7 (AUC, 2012), the applicant stated that surface soil sampling during operations will be conducted on an annual basis at the locations near the air particulate sampling sites as identified in TR Section 2.9.6 (AUC, 2012) at a depth of 5 cm (2 in) and analyzed in accordance with Regulatory Guide 4.14 (NRC, 1980a) by a certified laboratory. The applicant further stated in TR Section 5.7.7 that the applicant is not required to collect subsurface soil sampling consistent with Regulatory Guide 4.14 (NRC, 1980a), post-operational subsurface soil samples will be taken following conclusion of operations, and the results will be compared to the results of the preoperational monitoring program. The staff reviewed the surface and subsurface soil sampling preoperational environmental monitoring program in SER Section 2.6. The staff determines that the applicant has not provided adequate justification for the site selection of the surface soil samples (which must be the same location as the air particulate sampling stations). The applicant corrected the sampling locations and is collecting soil sample data at new additional locations to satisfy Regulatory Guide 4.14 before operations (AUC, 2015c). This is addressed as a license condition in SER Section 2.6. The staff also reviewed the frequency of collection and analysis in SER Section 2.6 and determines the frequency of collection and analysis to be consistent with the acceptance criteria in SRP Section 2.9.3.

In TR Section 5.7.7 (AUC, 2012), the applicant stated that, during operations, AUC will conduct sediment sampling on an annual basis and discrete grab samples of sediment will be collected at the same baseline surface water sampling location as discussed in Section 3.4.1 of the Environmental Report. All sediment samples will be collected to a depth of 5 cm (2 in) for consistency with the baseline sediment sampling surveys and analyzed for natural uranium, Ra-226, Pb-210, and gross alpha. In response to RAI-51, the applicant will analyze for Th-230 (AUC, 2015a). The staff determines that the applicant has provided adequate justification for the sediment sampling locations in SER Section 2.6 and the sediment sampling locations were consistent with the acceptance criteria in SRP Section 2.9.3, and this was found to be acceptable. The staff also determines that the frequency and analysis are consistent with Regulatory Guide 4.14, Table 2, for sediment and this is consistent with SRP Acceptance Criteria 5.7.7.3(2-4).

In TR Section 5.7.7 (AUC, 2012), the applicant stated that ambient environmental gamma radiation levels will be monitored continuously at the air monitoring station locations selected per Regulatory Guide 4.14 recommendations. The applicant further stated in TR Section 5.7.7 that gamma radiation has been monitored during the prelicensing period using Landauer X9 optically stimulated luminescence environmental dosimeters obtained from Landauer or another National Voluntary Laboratory Accreditation Program-certified vendor, meeting the specifications noted in Regulatory Guide 4.14, and the dosimeters will continue to be exchanged on a quarterly basis. The staff reviewed the direct radiation sampling locations in SER Section 2.6. The staff determines that the applicant had not provided adequate justification for the site selection of the direct radiation sampling locations (which must be the same location as the air particulate sampling stations). The applicant corrected the sampling locations and is collecting direct radiation sample data at new additional locations to satisfy Regulatory Guide 4.14 before operations (AUC, 2015c). This is addressed as a license condition in SER Section 2.6. The staff also reviewed the frequency of collection and analysis in SER Section 2.6 and determines the frequency of collection and analysis to be consistent with the acceptance criteria in SRP Section 2.9.3.

In TR Section 5.7.7 (AUC, 2012), the applicant stated that during operations, the results of operational vegetation sampling will be reviewed immediately and a determination made as to whether the potential for "…significant pathway to man…" exists. If such potential is determined to exist (i.e., if significant radionuclide concentrations are found in forage vegetation), meat sampling will be initiated in accordance with Regulatory Guide 4.14 and "[a]t least three samples should be collected at the time of harvest or slaughter or removal of animals from grazing for each type of crop (including vegetable gardens) or livestock raised within three-kilometers of the mill site." The staff reviewed vegetation, food, and fish sampling in SER Section 2.6. The staff identified several issues regarding to the site selection of vegetation samples and frequency of sample collections in SER Section 2.6. The applicant corrected the sampling locations and is collecting direct vegetation sample data at new additional locations to satisfy Regulatory Guide 4.14 before operations (AUC, 2015c). This is addressed as a license condition in SER Section 2.6.

The staff also reviewed fish sampling in SER Section 2.6 and determines that fish sampling can be omitted from the environmental monitoring program because the applicant has demonstrated that the lack of water for the habitat for fish and the ephemeral nature of the local streams cannot sustain a fish population. Therefore, the staff determines that the applicant is not required to perform fish sampling.

SRP Acceptance Criterion 5.7.7.3(5) states that, for license renewal applications, the historical airborne effluent and environmental monitoring program results are included through the most recent reporting period preceding the submittal of the application. The effectiveness of the historical program is discussed with regard to all applicable regulatory requirements. Long-term trends are discussed, and any short-term deviations from the long-term trend are explained. This application is not a license renewal or an amendment. Therefore, the staff determines that SRP Acceptance Criterion 5.7.7.3(5) is not applicable.

SRP Acceptance Criterion 5.7.7.3(6) states that the applicant commits to semiannual airborne effluent and environmental monitoring reporting. These reports will be submitted to the appropriate NRC Regional Office with copies to the Chief, Fuel Cycle Facilities Branch, and the project manager. The reports will specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous 6 months, injection rates, recovery rates, injection manifold pressures, and injection trunk line pressures for each satellite facility. The process rate and pressure data are to be reported as monthly averages. A license condition will be imposed to specify these reporting requirements.

The applicant addressed SRP Acceptance Criterion 5.7.7(6) in TR Section 4 (AUC, 2012) and therefore the staff will refer to SER Section 4 for the evaluation of this acceptance criterion and will not evaluate it in SER Section 5.7.

5.7.7.4 Evaluation Findings

The staff has completed its review of the airborne effluent and environmental monitoring programs for the Proposed Project. This review included an evaluation using the review procedures in SRP Section 5.7.7.2 and the acceptance criteria in SRP Section 5.7.7.3.

The applicant has established acceptable airborne effluent and environmental monitoring programs for the Proposed Project. The programs are consistent with Regulatory Guide 4.14. The applicant will sample air radon, air particulates, soils, vegetation, direct radiation, foods, and sediment. Locations of monitoring are consistent with Regulatory Guide 4.14, with the exception of the license condition as identified in Section 2.6 of this SER.

Based on the information provided in the application and the detailed review conducted of the airborne effluent and environmental monitoring programs for the Proposed Project, the staff concludes that the airborne effluent and environmental monitoring programs are acceptable, with the exception of the open issue identified in SER Section 2.6, and in compliance with 10 CFR Part 20, Subpart D, “Radiation Dose Limits for Individual Members of the Public,” which requires effluent monitoring to determine dose to individual members of the public; 10 CFR Part 20, Subpart F, which specifies survey and monitoring requirements; 10 CFR Part 20, Subpart L, which establishes recordkeeping requirements; and 10 CFR 40.65, which specifies effluent and environmental monitoring requirements.

5.7.8 Operational Groundwater and Surface Water Monitoring Programs

5.7.8.1 Regulatory Requirements

General requirements for the contents of an application for a specific license issued under 10 CFR Part 40 are listed in 10 CFR 40.31. Section 10 CFR 40.31(h) specifies that an application must clearly demonstrate how requirements and objectives set forth in 10 CFR Part 40, Appendix A, are addressed. Technical Criterion 7 of 10 CFR Part 40,

Appendix A, sets forth requirements and objectives for preoperational and operational groundwater monitoring programs at a uranium recovery facility. A preoperational monitoring program must be conducted to provide complete baseline data on a milling site and its environs, and an operational monitoring program must be conducted to measure or evaluate compliance with applicable standards and regulations, performance of control systems and procedures, and environmental impacts of the operations, and to detect potential long-term effects.[17] Technical Criterion 7A of 10 CFR Part 40, Appendix A, sets forth requirements and objectives for a groundwater detection monitoring program that are needed to establish the site-specific groundwater protection standards (GWPS) in Criterion 5 of 10 CFR Part 40, Appendix A.

Section 5.7.8 of the SRP (NRC, 2003) provides guidance on reviewing a groundwater detection monitoring program to meet requirements in Criteria 5 and 7(a) of 10 CFR Part 40, Appendix A. The purpose of a groundwater detection monitoring program is to establish GWPS and ensure that any hazardous constituents that may have entered the groundwater regime comply with those standards. To establish the GWPS, the applicant defines procedures for determining the baseline data for each wellfield before its operation. The baseline data will then be used to set standards for operations (excursion monitoring program) and closure (restoration).

5.7.8.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the review procedures in SRP Section 5.7.8.2, acceptance criteria in SRP Section 5.7.8.3 (NRC, 2003), and guidance on effluent monitoring programs for groundwater and surface water media in Regulatory Guide 4.14 (NRC, 1980a).

5.7.8.3 Staff Review and Analysis

In SER Section 5.7.8.3, unless specifically stated otherwise, the reported information is from TR Section 5.7.8 (AUC, 2012). In this SER section, the staff reviews the groundwater and surface water monitoring programs to be implemented at the Proposed Project. Preoperational groundwater and surface water monitoring is addressed in SER Section 2.6.3, and restoration monitoring is addressed in SER Section 6.1.3.

5.7.8.3.1 Groundwater Monitoring

The applicant discusses various groundwater monitoring programs to be conducted during operation and restoration phases until the groundwater restoration for a wellfield has been approved (AUC, 2012). The groundwater monitoring programs consist of evaluation of groundwater on a regional basis, groundwater within the Proposed Project area, and surface water on a regional and site-specific basis.

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[17] Criteria in 10 CFR Part 40, Appendix A are written for a conventional mill setting. The conventional mill setting differs from an ISR setting in that: (1) at a conventional mill, all activities conducted under the license are performed above ground, whereas, at ISR settings, the uranium extraction from the ore is performed in situ (or in the subsurface) and (2) at a conventional mill, a solid byproduct material, the mill tailings, is stored above ground in a tailing pile, whereas, at ISR settings, no mill tailings are generated. The staff is applying these criteria to ISR facilities because 10CFR 40.31(h) specifies that the application must clearly demonstrate how both the requirements and objectives set forth in Appendix A are met.

Private Water Supply Wells (Regional Groundwater Monitoring Program). The applicant states that all private wells used for drinking water, livestock watering, or crop irrigation within 2 kilometers (km) (1 mi) of a wellfield boundary will be sampled on a quarterly basis given the owner's consent (AUC, 2012). The samples will be analyzed for parameters identified in Regulatory Guide 4.14, Table 2. The applicant summarizes the major elements of the operational environmental monitoring programs in TR Table 5-4. The parameters to be analyzed consist of dissolved and suspended uranium, Ra-226, Th-230, Pb-210, and polonium-210 (Po-210). For the preoperational monitoring program, in response to staff's RAIs, the applicant stated that all wells within 2 km (1 mi) of the proposed license area have been sampled except for three wells (AUC, 2015a). The three wells are assigned designations of GW18, GW19 and GW20. The applicant commits to sampling these three wells in the operational monitoring program. Staff will include a license condition (License Condition 12.12) requiring the applicant to obtain preoperational water quality for the three wells prior to staff scheduling the preoperational inspection.

The staff finds that the proposed sampling of the nearby water supply wells is consistent with guidance in Regulatory Guide 4.14 (NRC, 1980a) and, in general, effluent monitoring programs currently being conducted at existing ISR facilities. Those programs have been shown to effectively measure and evaluate compliance with applicable standards and regulations, performance of control systems and procedures and environmental impacts of the operations, and to detect potential long-term effects.

The staff will impose a preoperational license condition that the applicant identify and sample all water supply wells within 2 km (1 mi) of the Proposed Project area as part of the preoperational monitoring program. During the operational monitoring program, the applicant is required to sample existing water supply wells within 2 km (1 mi) of the boundary of active production units. For clarification, active production units means those in operation and restoration (i.e., from the start of principal activities to the start of the stabilization monitoring period), and the boundary of a production unit is the perimeter well ring.

Discrepancies between the applicant's proposed operational groundwater sampling program and the regulatory requirements (or SRP Guidance):

- The applicant fails to state that the results of the regional groundwater monitoring program will be reported to the staff semiannually in accordance with 10 CFR 40.65.
- The applicant fails to include all wells in the program (specifically, if a well is classified as industrial, it may be used as a water supply well for other purposes).
- The applicant fails to state that a survey of existing water supply wells will be performed annually as part of the annual land use survey.

In accordance with 10 CFR Part 40, Appendix A Criterion 7, the preoperational monitoring program is to be completed prior to any major site construction and not necessarily before the license is issued. Furthermore, the applicant committed to address the above discrepancies through appropriate license conditions (AUC, 2015c), which satisfies the deficiencies. The staff will include License Conditions 11.1 and 12.3 that documents the applicant's proposed program with the staff's discrepancies listed above (see SER Section 5.7.8.4). The licensee shall submit information on any potential new wells as required by License Condition 12.3 prior to staff scheduling a pre-operational inspection.

Production Unit Baseline Monitoring (Site-Specific Monitoring). The applicant commits to sampling selected recovery and injection wells four times, at least 2 weeks apart to establish the production unit baseline data. The selected wells will be on a density of one well per 2 hectare (ha) (4 acres [ac]) of ISR unit. The constituents to be analyzed as proposed by the applicant are listed in TR Addendum 2.7-B, Table 2.7B-22 (AUC, 2012). If a constituent concentration level was below the minimum analytical detection level for the first two sampling events, then the constituent will not be analyzed for the latter two sampling events.

AUC will adopt statistical principles of U.S. Environmental Protection Agency's (EPA's) Unified Guidance (EPA, 2009) to evaluate baseline data and establish Restoration Target Values (RTVs) for each production unit. The analysis will consist of evaluation of the data distributions as well as spatial and temporal dependencies for each constituent (AUC, 2012). The applicant proposes to subdivide the data to ensure representativeness of the data population, if appropriate. The applicant proposes to apply statistically sound treatment of outliers and nondetectable concentrations in determining the RTV for each constituent.

In response to RAI-54 (AUC, 2015a), the applicant commits to restoring the production unit aquifer subject-to-operations to standards listed in 10 CFR Part 40, Appendix A, Criterion 5(B)(5). However, in response to RAI-54, the applicant discusses the statistical testing to ensure "compliance" with a standard, "whether it is a previously determined background value or some defined groundwater protection standard (GWPS)." The applicant then performs an example statistical analysis of two "pseudo" datasets for which outliers had been removed, and both datasets are normally distributed. The applicant performed the statistical analyses using guidance from EPA's Unified Guidance document and the computer software ProUCL. The applicant performed t-tests between datasets and calculated the 95-percent upper confidence limit (UCL95%) for each dataset. The applicant stated that the statistical analyses demonstrate that the pseudo datasets are statistically distinct.

The staff reviewed the applicant's description of the baseline data acquisition and analyses and finds it meets SRP Acceptance Criterion 5.7.8.1(1) for the primary restoration goal of returning each wellfield to its preoperational water quality conditions with three clarifications. First, the applicant proposes a density of one well per 4 ac, but that should be a minimum density rather than a specific density (similar to the applicant's proposed spacing for the overlying aquifer). The staff will state that this is a minimum density in the license condition. Second, the applicant did not include silver in its list of parameters to be monitored and initially gave no rationale or justification for excluding it. In response to staff's clarification request, the applicant provided its justification consisting of: (1) the extremely low concentrations of similar heavy metal elements such as copper, which was analyzed in each of the regional baseline and non-baseline wells with levels below the minimum analytical detection levels for more the 50 samples; (2) low potential that silver exists in the Tertiary fluvial systems that have not been impacted by hydrothermal fluids; (3) silver is excluded by WDEQ in its Guideline 8 analytes for ISR facilities; most other ISR facilities are not required to analyze silver because of the above (AUC, 2016c). Staff finds this justification reasonable and agrees that silver can be removed from the list of baseline parameters. Third, the staff is clarifying that the applicant will have to define the GWPS as required by 10 CFR Part 40, Appendix A, Criterion 5B(5), in the wellfield data package.

Excursion Detection Monitoring Program During Operations. The applicant states that wells to be used for the excursion monitoring program consist of wells in the overlying aquifer within the footprint of a production unit and in the production aquifer in a ring surrounding the production unit (AUC, 2012). The applicant does not propose sampling of an underlying aquifer because the underlying unit, which the applicant defines as the "first significant sandstone in closest proximity (subjacent) to the Production Zone," does not meet the definition of an aquifer due to its low yields and the next underlying sandstone is 15 to 47.5 m (49 to 156 ft) below that (AUC, 2012, 2014a). The applicant commits to distance of 122 m (400 ft) to the perimeter well ring from a production unit and spacing of 122 m (400 ft) between wells on the perimeter ring (AUC, 2015a). The applicant proposes that the perimeter wells be completed as partially penetrating wells (i.e., screened over the ore zone only) (AUC, 2015a). The wells in the overlying aquifer will be installed at a minimum density of one well per every 2 ha (4 ac) of production area (AUC, 2012). The applicant commits to completing the wells in the overlying aquifer as partially penetrating wells screened in the lowermost portion of the aquifer if the thickness of the overlying aquifer exceeds 6 m (20 ft) (AUC, 2015a).

The baseline sampling for the wells in the excursion monitoring program is similar to the baseline sampling proposed for the production unit (AUC, 2012). The applicant proposes the indicator parameters of chloride, conductivity, and alkalinity for the excursion monitoring program and provides its justification in TR Section 5.7.8.1.5. The applicant discusses upper control limits (UCLs) for the excursion parameters based on recommendations in WDEQ Guideline 4 (WDEQ, 2013), which is the mean value plus five standard deviations (AUC, 2014a). The applicant discusses additional statistical analyses to be performed that test whether or not the underlying distribution of data is normal (e.g., goodness-of-fit tests), and the possibility of subdividing the data into separate groups or using nonparametric methods (AUC, 2014a).

The applicant states that the excursion detection monitoring program will consist of sampling all wells in the program twice a month at least 10 days apart for the designated excursion parameters (AUC, 2012). The applicant reports that due to emergencies or similar unusual circumstances, sampling at a well may have to be delayed beyond the maximum of 5 days. In TR Section 6.1, the applicant proposes to reduce the frequency of sampling for the excursion detection monitoring program from biweekly to once every 60 days quarterly for a wellfield in restoration and once every 180 days "while the staff and WDEQ evaluate the groundwater restoration report" (AUC, 2012). Although not directly stated, the staff assumes that the applicant will continue excursion monitoring once every 60 days during the stability monitoring period before the report is submitted. The applicant reports that water levels will be recorded during each sampling event and low-flow purging may be performed in certain instances (AUC, 2012).

The applicant states that if, during the excursion detection monitoring program, the levels of two of the three indicator parameters exceed their respective UCLs at a well, the applicant will perform additional sampling – first for verification of the excursion and then under an excursion status, if warranted (AUC, 2012). Verification monitoring consists of a second resampling (within 48 hours) and a third resampling, if needed (within 48 hours of the second sampling) of the well at which the excursion parameters levels exceeded the UCLs. If the verification sampling confirms the initial results (i.e., two of the three sampling results exceed the triggering threshold), then the well will be placed on excursion status. If the verification sampling does not confirm the initial results (i.e., the second and third sampling results are equal to or below the triggering threshold), then the initial result is deemed a "false positive" and the well is returned to the excursion detection monitoring program.

For a well on excursion status, the applicant proposes to notify the NRC project manager by email or telephone within 24 hours of verifying the excursion status and with a followup written report, which documents the corrective actions taken, to the NRC project manager within

60 days (AUC, 2012). While on excursion status, the applicant proposes weekly sampling of the affected well(s) until the excursion status for the well is terminated. If an excursion status is not corrected within 30 days, the applicant proposes sampling for a complete set of parameters per WDEQ requirements. If a well is on excursion status in excess of 60 days, in TR Sections 5.7.8 and 6.1.3, the applicant states that NUREG-1569, Criterion (5), requires applicants to terminate lixiviant injection or provide additional reclamation surety that is agreeable to the staff. In response to RAIs (AUC, 2014a), the applicant commits to following Criterion (5).

In responses to RAIs (AUC, 2014a), the applicant committed to providing a quarterly report on the status of wells on excursion status and clarified the termination of excursion status for a well. The excursion status is terminated if the weekly sampling for 3 consecutive weeks shows excursion parameter levels below the respective triggering threshold or if only one excursion indicator exceeds its respective UCL by less than 20 percent.

The staff reviewed the applicant's proposed excursion monitoring program and finds it acceptable because the program will provide reasonable assurance that the production fluids are confined to the wellfield, thus meeting requirements in 10 CFR 40.41(c) for a licensee to confine his possession and use of source and byproduct material to the locations and purposes authorized by a license. The proposed program is consistent with Acceptance Criterion (5) of SRP Section 5.7.8.3 because it adequately defines the excursion detection monitoring program. The staff is reasonably assured that the proposed monitoring program, in combination with the operational program of maintaining an inward gradient, will prevent an unwanted migration of fluids from the wellfield.

The excursion monitoring program as proposed by the applicant will be included as a standard license condition. The staff will also include in the standard license condition that the quarterly report will include termination of an excursion status.

Monitoring of the trend wells or water levels or both is a voluntary program proposed by the applicant. The staff encourages such programs but does not have any such regulatory requirements that an applicant must meet.

<u>Backup Pond—Leak Detection and Groundwater Monitoring Programs</u>. The applicant proposes a leak detection monitoring program and a groundwater detection monitoring program for detection of a release from the retention pond. The leak detection monitoring program is described and evaluated by the staff in SER Section 4.2.3. The staff will include a license condition that requires the applicant to submit a program for the staff's review and verification (see SER Section 5.7.8.4). Per License Condition 12.10, the licensee shall submit, and receive staff's written verification of the groundwater detection monitoring plan prior to construction of the storage pond.

<u>Production Unit Hydrogeologic Data Package</u>. In TR Section 5.7.8.1.4 (AUC, 2012), the applicant lists information to be included in a production unit hydrogeologic data package. The information includes location maps, isopach maps, geologic cross-sections, discussion of the pumping test results including a demonstration that the perimeter wells are properly located, baseline water quality and establishment of the GWPSs, and any other pertinent information. In responses to RAIs (AUC, 2014a), the applicant committed to submitting the first production unit hydrogeologic data package to the staff for review and verification and submitting subsequent packages to the staff for review.

In responses to RAIs (AUC, 2014a), the applicant states that, if the production unit is located along a highway or country road, the data package will include discussion on containment of any spill.

In a response to Open Items (AUC, 2015c), the applicant agreed to a license condition which requires the abandonment and plugging of drill holes before the hydrogeologic testing for the production unit data package.

The staff finds that the proposed information to be included in the wellfield data package will provide reasonable assurance that operations at a specific wellfield will be controlled and monitored by means that are protective of human health and safety and the environment. Furthermore, based on the preoperational pumping tests and results of the staff's revised numeric groundwater flow modeling (described in SER Section 2.4), the staff is reasonably assured that the applicant can operate the Proposed Project in a manner that will confine the source and byproduct materials to the authorized locations. These reasonable assurance determinations, that the applicant's operations will be performed in accordance with 10 CFR 40.41(c), are contingent on the fulfillment of a license condition requiring the submittal of the initial production unit hydrogeologic data package to the staff for review and verification and submitting subsequent packages to the staff for review.

The proposed monitoring program for the overlying aquifer meets the requirements in 10 CFR 40.41(c) for a licensee to confine its possession and use of source and byproduct material to the locations and purposes authorized by the license and is consistent with SRP Acceptance Criterion 5.7.8.3(3).

5.7.8.3.2 Surface Water Monitoring

The applicant states that surface water from all preoperational surface water locations will be monitored quarterly when water is present. The parameters to be analyzed for the operational surface water monitoring program are dissolved and suspended uranium, Th-230, Ra-226, Po-210, and Pb-210. The surface water monitoring results will be submitted within the semiannual environmental and effluent monitoring reports.

The staff finds that the proposed construction and operational surface water monitoring programs are adequate by providing defense-in-depth monitoring for a potential release. Due to the ephemeral nature of the streams, the staff acknowledges that stream water quality sampling is not a regulatory requirement but a good best practices technique and that quarterly sampling will not be available throughout the year. Therefore, the staff finds that the applicant has met SRP Acceptance Criterion 5.7.8.3(6) and will include a standard license condition to memorialize the applicant's commitment to the surface water monitoring program.

5.7.8.4 Evaluation Findings

The staff completed its review of the surface water and groundwater monitoring programs at the Proposed Project. This review included an evaluation of the review procedures in SRP Section 5.7.8.2 and the acceptance criteria outlined in SRP Section 5.7.8.3. The applicant has defined acceptable groundwater and surface water sampling programs that are consistent with those used at existing ISR facilities, which have been shown to provide data that the operations at those facilities are protective of human health and safety and the environment. As noted above, the staff will include the following license conditions to define aspects of the monitoring program that the staff identified as needing clarification, document commitments made by the applicant, or as standard license conditions:

- License Condition 10.14
- License Condition 12.1
- License Condition 11.1
- License Condition 11.3
- License Condition 11.4
- License Condition 11.5
- License Condition 12.3
- License Condition 12.12

License conditions for effluent and monitoring programs and NRC notification are presented in SER Section 5.7.7. The license conditions for reports to be submitted to the staff are presented in SER Section 3.1.4.

Based on the information provided in the application and on the detailed review conducted by the staff of the groundwater and surface water monitoring programs at the Proposed Project, and contingent upon the license conditions noted above, the staff concludes that the groundwater and surface water monitoring programs are acceptable and comply 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 provides concentration limits for contaminants
- 10 CFR Part 40, Appendix A, Criterion 5D, which requires a groundwater corrective action program
- 10 CFR Part 40, Appendix A, Criterion 7, which requires a detection and compliance groundwater monitoring program

5.7.9 Quality Assurance (QA)

5.7.9.1 Regulatory Requirements

The staff's analysis will determine if AUC has demonstrated that the proposed QA program for the Proposed Project meets the requirements of 10 CFR 20.1101, 10 CFR Part 20, Subpart L, and Subpart M.

5.7.9.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with applicable requirements of 10 CFR Part 40 using acceptance criteria in SRP Section 5.7.9.3 (NRC, 2003). Regulatory Guide 4.15 provides guidance on demonstrating compliance with the applicable regulations.

5.7.9.3 Staff Review and Analysis

Unless otherwise stated, the information in this SER section was from TR Section 5.7.9 (AUC, 2012). This section discusses the proposed QA programs for radiological and nonradiological monitoring activities. QA is a methodical program of procedures and controls required to provide sufficient confidence in the evaluation of monitoring results (NRC, 2007). Quality control is the methodology, such as tests, audits, and analyses, used within the QA program to verify that established standards are met. The QA/QC program includes all radiological and nonradiological measurements that support the radiological, effluent, and environmental monitoring programs. The QA/QC program is essential to ensure that data collected and recorded to demonstrate compliance with 10 CFR Parts 20 and 40 and 40 CFR Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operations,” are reasonably valid and of a defined quality.

5.7.9.3.1 Radiological and Nonradiological Monitoring Programs

Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills” (NRC, 1980a), Sections 3 and 6, describe guidance to ensure that representative effluent and environmental monitoring data are collected by implementing sampling and analytical procedures, collecting samples at appropriate locations, using correct and calibrated equipment, and minimizing random and systemic errors. Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)—Effluent Streams and the Environment” (NRC, 2007), and Regulatory Guide 4.14 state that analytical processes should be tested with periodic cross-check analyses with independent laboratories. Further, Regulatory Guide 4.15 suggests that any contractor performing monitoring activities should provide a QA program and program data summaries consistent with the guidance established in the guide.

The applicant will document the QA and QC attributes in a QA program developed for the Proposed Project (AUC, 2012). The applicant indicates that its proposed QA program will include the following items:

- delineation of organizational structure and responsibilities of management, which will include responsibilities for both review and approval of written procedures and monitoring data and reports
- minimum personnel qualifications and training for individuals performing radiological monitoring, to include job descriptions, training program, and continuing training and education requirements
- written operating procedures and instructions for general laboratory and internal QC that includes instrument calibration, external performance evaluation, and data verification and validation
- procedures covering statistical data evaluation, instrument calibration, duplicate sample programs, and spike sample programs

- audits and qualifications of personnel conducting the audits
- preventive and corrective actions to ensure continuous improvements in the program, which include evaluating performance levels and deficiencies, corrective actions, and efficacy evaluations

5.7.9.4 Evaluation Findings

The purpose of a QA program is to ensure that procedures and practices for any operational or decommissioning monitoring program are based on sound radiation protection principles to achieve doses to the workers and public ALARA and that the data acquired to make the ALARA determinations are precise and accurate. The underlying regulatory requirement for the QA program is 10 CFR 20.1101. That regulation requires licensees to develop, document, and implement the QA program. The applicant states that it will provide a QA program to the staff as a part of the preoperational inspection (AUC, 2013a). The staff included the License Condition 12.9 to ensure this commitment is met prior to scheduling a pre-operational inspection.

SECTION 6

GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 Plans and Schedules for Groundwater Restoration

6.1.1 Regulatory Requirements

General requirements for contents of an application for a specific license issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material," are listed in 10 CFR 40.31, "Application for Specific Licenses." Regulations in 10 CFR 40.31(h) specify that an application must clearly demonstrate how requirements and objectives set forth in 10 CFR Part 40, Appendix A, "Criteria Related to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content," are addressed. Technical Criterion 7A of 10 CFR Part 40, Appendix A, sets forth requirements and objectives for a groundwater detection monitoring program needed to establish the site-specific groundwater protection standards in Criterion 5 of 10 CFR Part 40, Appendix A. Technical Criterion 5B(5) of 10 CFR Part 40, Appendix A, sets forth requirements and objectives for the maximum concentration of hazardous constituents at the point of compliance.

Paragraph 10 CFR 40.32(c) requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property. Paragraph 10 CFR 40.41(c) requires a licensee to confine the possession and use of source or byproduct material to the locations and purposes authorized in the license. Paragraph 10 CFR 40.32(d) requires that issuance of a license will not be inimical to the common defense and security or to the health and safety of the public.

Standard Review Plan (SRP) Section 6.1.3 (U.S. Nuclear Regulatory Commission (NRC), 2003) provides guidance for reviewing groundwater restoration plans and schedules to meet requirements in Criteria 5 and 7(A) of 10 CFR Part 40, Appendix A, and 10 CFR 40.32(c), 10 CFR 40.32(d), and 10 CFR 40.41(c). The purpose of groundwater restoration is to demonstrate compliance with established groundwater protection standards and ensure that any hazardous constituents that may have entered the groundwater regime comply with those standards. The methods used to establish groundwater protection standards are described and evaluated in the safety evaluation review (SER) Section 5.7.8. In this SER section, the staff reviews and evaluates the proposed plans and schedules for compliance with the standards.

The staff is required to determine that the proposed plans and schedules for groundwater restoration at the Proposed Project meet the requirements of 10 CFR 40.32(c), 10 CFR 40.32(d), 10 CFR 40.41(c), and 10 CFR Part 40, Appendix A, Criteria 5 and 7.

6.1.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the review procedures in SRP Section 6.1.2 and acceptance criteria in SRP Section 6.1.3 (NRC, 2003).

6.1.3 Staff Review and Analysis

Information in this SER section, unless stated otherwise, is from Technical Review (TR) Section 6.1 (AUC, 2012). In this SER section, the staff reviews the applicant's proposed plans for restoration activities at the Proposed Project. This review includes proposed restoration standards, restoration methods, restoration effectiveness, estimates of the number of pore volumes needed to complete restoration, restoration and stability monitoring, wastewater disposal, well plugging and abandonment, and the preliminary restoration schedule.

6.1.3.1 Restoration Standards

The applicant commits to restoring groundwater in the ore zone on a constituent-by-constituent basis using the groundwater protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) (AUC, 2012). The groundwater protection standards are either the Commission-approved background values (Criterion 5B(5)(a)), values listed in the table in paragraph 5C of 10 CFR Part 40, Appendix A (Criterion 5B(5)(b)), or an alternate concentration limit (ACL) established by the NRC in accordance with Criterion 5B(6) (Criterion 5B(5)(c)).

If restoration of a wellfield cannot achieve the Commission-approved background or values listed in paragraph 5C, the applicant commits to submitting a license amendment for the NRC's approval of an ACL. The applicant states that an ACL request would occur after AUC has demonstrated that it has made practicable efforts to restore the specified constituent for which the ACL request is sought.

The staff finds that the applicant's commitments satisfy the regulatory requirements and will include a standard license condition memorializing the applicant's commitments. In reaching this determination, the staff evaluated the applicant's procedures to determine Commission-approved background values as discussed in SER Section 5.7.8.3. The staff acknowledges that the applicant uses terms not defined in NRC implementing regulations, such as "restoration target values (RTVs)," "best management practices (BMP)," and "best practicable technology (BPT)." These terms are common practice in the industry and likely derived from requirements from other regulatory agencies. However, the introduction to Appendix A of 10 CFR Part 40 states that the Commission will consider "practicable" and "reasonably achievable" as equivalent terms, and decisions involving these terms will take into account the state of technology and the economics of improvements in relation to benefits to the public health and safety. In addition, Criterion 5B(6) of 10 CFR Part 40, Appendix A, states that for consideration of an ACL, the licensee must provide a basis for the proposed limits, including consideration of practicable corrective actions, that the limits are as low as reasonably achievable (ALARA), and information on the factors that the Commission must consider. Therefore, the staff finds the applicant's commitment to BPT meets, in part, the ALARA requirements of Criterion 5B(6); however, the staff has reasonable assurance that, if an ACL was requested, the applicant would meet the requirements in Criterion 5B(6) in full based on the applicant's commitments to using the groundwater protection standards. In addition, the staff finds that the applicant's commitments are consistent with SRP Acceptance Criterion 6.1.3(4).

6.1.3.2 Restoration Methods

The applicant states that the groundwater restoration program consists of two phases: (1) active groundwater restoration, and (2) stabilization monitoring (AUC, 2012). The proposed active restoration methods consist of:

- groundwater transfer
- groundwater sweep
- groundwater treatment (reverse osmosis (RO) treatment)

Groundwater transfer consists of pumping fluids from one production unit in active restoration and re-injecting the fluids into another production unit entering production, or moving fluids between two areas that are in different stages of restoration within a single production unit (AUC, 2012). The applicant states that groundwater transfer will tend to lower the total dissolved solids levels in the production unit being restored and not create wastewater. Before re-injection, the applicant states that fluids recovered from one production unit may be passed through the ion exchange (IX) columns or filters for additional uranium recovery. The applicant states it will decide when use of groundwater transfer is appropriate.

Groundwater sweep is a process in which groundwater is pumped from a production unit without injecting water back into the production unit, creating an influx of native groundwater surrounding the production unit (AUC, 2012). The primary goal of groundwater sweep is to recover flared lixiviant outside of the production area. The main drawback for this method is the consumptive use of groundwater. Because of the excessive consumptive use of groundwater, the applicant reports that the Wyoming Department of Environmental Quality (WDEQ) Land Quality Division (LQD) considers groundwater sweep not a BPT.

The applicant proposes treating the fluids pumped during groundwater sweep through the IX columns and groundwater treatment (e.g., RO). Permeate generated by the treatment of groundwater sweep fluids will be re-injected into another wellfield undergoing restoration by groundwater treatment but not back into the same wellfield. The applicant states that groundwater sweep may be a stand-alone process or performed in conjunction with the other restoration methods at any time during restoration.

Groundwater treatment consists of pumping fluids from one or more production units to the central processing plant (CPP) for treatment (AUC, 2012). The treatment consists of uranium removal through the IX columns and then treatment through the RO system to reduce the dissolved constituents. The permeate from the groundwater treatment will be reinjected into the production unit and brine disposed of in the deep disposal well (DDW). The treatment system was described and evaluated by the staff in SER Section 3.2.

The applicant states that chemical reductants will be added to the RO permeate before re-injection to lower the oxidation-reduction potential of the production aquifer. The applicant commits to implement procedures for the safe handling and use of the chemical reductant, such as sodium sulfide.

The applicant discusses bio-remediation as an alternate groundwater restoration method; however, the applicant states it does not have essential site-specific information at this time to determine if this method would be successful at the Proposed Project. The applicant proposes to investigate bio-remediation through experimentation and bench-scale testing and to employ the Safety and Environmental Review Panel (SERP) process before beginning any field testing (AUC, 2012).

The staff finds that the restoration methods, excluding the use of reductant, are acceptable because they reflect historical in situ recovery (ISR) industry restoration practices that have achieved the groundwater protection standards of 10 CFR Part 40, Appendix A, Criterion 5B(5), and are included as acceptable methods in SRP Acceptance Criterion 6.1.3(3) (NRC, 2003). The staff finds that such practices have provided NRC-approved restorations that ensure a high degree of certainty that water quality in the surrounding aquifers, which might be an underground source of drinking water, will have a negligible potential to be impacted in the future.

Based on the history at existing ISR facilities, the staff finds that historical use of selected biological and chemical reductants has the potential to accelerate the restoration process but also has proven to be ineffective in some cases. Historic reductant use and onsite storage have not adversely affected workers' or the public's health and safety or the environment. However, the applicant did not provide any information for the staff to review on the impacts on the site-specific use and storage of chemical reductants or biological reductants, except for sodium sulfate (AUC, 2012; NRC, 2015b). Therefore, the staff will include a license condition that the applicant will submit for NRC review and approval any proposed equipment, processes and procedures for onsite use, storage, handling, and transport of chemical or biological reductants other than sodium sulfate for the restoration activities (see SER Section 6.1.4, License Condition 10.10).

The staff finds that the applicant's phased approach to restoration is consistent with SRP Acceptance Criterion 6.1.3(3) (NRC, 2003), which allows flexibility and innovation in approaches to restoration, and that applicants are not limited to using one restoration method for all wellfields. Therefore, the staff finds that the applicant's restoration plans are acceptable because the applicant adequately described the sequential phases of restoration that it could use and the most likely restoration scenario based on similar restorations successfully used for the Pattern 2 area at the former research and development (R&D) site at the Proposed Project area and existing commercial ISR facilities.

Should restoration of a mine unit not achieve the groundwater protection standards in 10 CFR Part 40, Appendix A, Criteria 5B(5)(a) or (b), then the staff will expect the applicant to demonstrate with any ACL application that the levels of constituents in the ore zone aquifer after restoration are ALARA. The staff will include a standard license condition for an ACL application (see SER Section 6.1.4, License Condition 10.6).

6.1.3.3 Effectiveness of Groundwater Restoration Methods

The applicant states that ISR operations that have used the restoration methods proposed by the applicant have obtained regulatory approval for the groundwater restoration (AUC, 2012). Several of the facilities are located near the Proposed Project, and one—the former R&D facility—was located on the Proposed Project area.

The former R&D ISR project consisted of two tests, Pattern 1 and Pattern 2. An acid lixiviant was used in Pattern 1, which led to severe injectivity problems. The applicant states that the Proposed Project does not intend to use an acid lixiviant and, thus, Pattern 1 is not an analogue for the Proposed Project. Pattern 2 used a carbonate lixiviant and serves as an analogue for the Proposed Project.

Pattern 2 was performed in the partially saturated portion of the production aquifer (AUC, 2012). The groundwater restoration methods consisted of groundwater recirculation with minor treatment (passing through an IX column with a weak acid resin to remove divalent cations) followed by groundwater sweep. The total volume of fluids used for restoration was 6.6 pore volumes. All measured constituents, except uranium, were restored to baseline conditions. The uranium levels were reduced to 5 parts per million, which was the Wyoming standard for drinking water at that time. Wyoming concluded that the restoration met the class-of-use standard. The NRC and Wyoming both approved restoration of the R&D project and concluded that the R&D project demonstrated that a commercial operation was viable (AUC, 2012).

The applicant also reports on two analogous commercial ISR projects (i.e., Irrigaray Uranium Project and Smith Ranch–Highland Uranium Project) that occurred in other areas of the Powder River Basin, in support of the effectiveness of its groundwater restoration methods. The applicant reports that at the Irrigaray Uranium Project, the NRC and WDEQ approved the groundwater restoration at Wellfields 1 through 9 after 27 of 29 constituents were restored to their RTVs. The two constituents that did not meet the RTVs did meet the State's preoperational class-of-use standard.

At the Smith Ranch–Highland Uranium Project, the applicant reports that restoration at an R&D and a commercial wellfield (the A-Wellfield) had been approved by the NRC and WDEQ. The applicant reports that not all constituents were returned to baseline following restoration at the A-Wellfield but that the groundwater quality was consistent with Wyoming's preoperational class-of-use standard. The restoration methods undertaken at the A-Wellfield consisted of groundwater sweep, groundwater treatment (RO) and use of a chemical reductant (hydrogen sulfide). These are some of the same methods proposed for the Reno Creek Project.

The staff finds that the proposed analogs are appropriate because of the similarities in hydrogeologic and geochemical settings and proposed restoration methodologies. Analyzing analogous restoration programs provides the staff with reasonable assurance that the same restoration program can achieve the NRC's groundwater protection standards at the Proposed Project because the applicant's proposed methods are consistent with those used to achieve restoration of wellfields at existing commercial ISR projects and former R&D facilities. They also have been shown to be protective of human health and safety and the environment. In addition, the applicant commits to performing restoration in the most efficient manner to achieve its restoration goals as soon as possible, consistent with the ALARA approach.

The staff finds that the applicant's evaluation of effectiveness of the restoration is consistent with SRP Acceptance Criterion 6.1.3(3) (NRC, 2003), which allows flexibility in the approach as long as restoration success is reasonably assured.

6.1.3.4 Pore Volume Estimates

In TR Section 6.6 (AUC, 2012), the applicant presents its method to determine pore volume (PV) as the thickness of the ore sand multiplied by the production unit pattern area, effective porosity, flare, and conversion factor. The applicant states that this method of calculation is consistent with those used at existing licensed ISR facilities. The thickness of the ore sand is the average completion thickness of the production wells. Based on the delineation drilling by the applicant during exploration for the proposed Production Unit 1, the average screen thickness is 3.7 meters (12.1 feet) (AUC, 2012). The applicant estimates the production unit pattern area or affected ore zone area to be 1.4 million square meters (1.5 million square feet).

The effective porosity is determined from the laboratory analysis of the core samples. For the ore zone, the applicant's estimate of the effective porosity is 24 percent.

Flare is an adjustment used to estimate the volume of the aquifer water outside of the wellfield area that may have been affected by lixiviant during operations (AUC, 2012). Flare consists of two factors: one describing flare in the horizontal dimension and the other describing flare in the vertical dimension. In describing flare, the factors are expressed as a percentage of the horizontal or vertical dimensions. In TR Section 6.6 (AUC, 2012), the applicant states it is using a flare of 1.44 (i.e., 20 percent in the horizontal direction and 20 percent in the vertical direction) for the financial assurance calculations, which is consistent with that used at other ISR facilities and supported by the numeric groundwater model developed by the applicant (AUC, 2012). The conversion factor depends on the units for the various inputs used to estimate the PV. The applicant uses a conversion factor of 7.48 to convert cubic feet to gallons. Based upon the above, the calculated PV for Production Unit 1 is 176 million liters (46.5 million gallons).

The applicant estimates that a minimum of seven PVs is required for active restoration (groundwater sweep and groundwater treatment phases) of a production unit (AUC, 2012). The applicant acknowledges that its estimate is low compared to the number of PVs for wellfield restorations that have been approved. The applicant suggests that the number of PVs at the wellfield restorations that have been approved can be attributed to a lack of infrastructure and poor management and execution of restoration operations (AUC, 2012). AUC commits to minimize the PVs for its proposed operations by having RO units operational before the start of restoration and by monitoring progress of RO treatment on a pattern-by-pattern basis. In addition, the applicant states that seven PVs is consistent with the number approved by the NRC for the Nichols Ranch ISR Project.

The staff reviewed the applicant's estimated PVs and finds that this information is adequate because it meets SRP Acceptance Criteria 6.1.3(1, 2, and 3) (NRC, 2003) by including descriptions of the PVs, flare factors, and the level of effort needed for restoration. The staff also finds the applicant's estimate to be acceptable because of the following:

- The estimate is within the range currently used by industry.
- The applicant commits to minimize inefficiencies and to adjust the estimate based on future experience.

Similar restoration methodologies have been used successfully at previous ISR facilities and have been shown to be protective of human health and the environment. Pursuant to 10 CFR Part 40, Appendix A, Criterion 5D, the applicant will provide "data from the ground-water monitoring program and other information" for the staff to make a determination that the groundwater restoration program achieved the NRC's groundwater protection standards. This information will be in the form of a report submitted to the staff for its approval, and such approval is required before any wellfield reclamation and decommissioning activities. The staff also notes that if the applicant submits an application for an ACL, the staff will at that time examine whether the applicant was faithful to its commitments. The staff will not approve an ACL unless and until the applicant adequately proves that its restoration was ALARA, regardless of whether seven PVs or more of restoration activities were performed at the Proposed Project.

6.1.3.5 Groundwater Restoration Monitoring

In TR Section 6.1.3 (AUC, 2012), the applicant commits to conducting monthly sampling of the production unit baseline wells to evaluate the effectiveness and efficiency of the restoration activities. The constituents analyzed at the beginning of the restoration will be the complete list of baseline constituents, and then “all or some” of the constituents will be analyzed during subsequent sampling events as restoration progresses. In addition, the applicant commits to sampling individual patterns within a production unit undergoing active restoration every 2 weeks for a limited set of constituents.

The applicant proposes to decrease the sampling frequency of the monitoring wells in the excursion monitoring program from semi-monthly (twice per month) to once every 60 days (AUC, 2012). The rationale is that lixiviant is no longer being injected and a greater bleed volume is taken during restoration, both of which decrease the potential for an excursion to occur.

The staff reviewed the applicant’s proposed restoration monitoring and finds it acceptable because similar programs have been conducted at existing ISR facilities and have provided sufficient data to demonstrate that these operations were operated safely. These operations also safely restored groundwater to levels that are protective of the environment and provided early detection of unwanted contaminant migration to apply appropriate and timely corrective actions. The staff finds the applicant’s proposed monitoring is consistent with SRP Acceptance Criterion 6.1.3(3) by including a description of monitored constituents, sampling frequency, and sampling density.

6.1.3.6 Wellfield Bleed during Restoration Stage

In TR Section 3.1.7 (AUC, 2012), the applicant states that the bleed for production units in restoration will be less than 10 percent. Based on TR Figures 3-6 and 3-7, the applicant estimates a bleed of approximately 3 percent for a production unit in restoration (provided the project has production units in both production and restoration) and a bleed of approximately 9 percent for a production unit in restoration if the project only has production units in restoration.

In TR Section 3.1.5 (AUC, 2012), the applicant commits to maintaining an inward hydraulic gradient to control the migration of process or restoration solutions for each production unit from its initial production until the initiation of the groundwater stability monitoring.

The staff finds this commitment acceptable because it meets the requirements of 10 CFR 40.41(c) that licensees confine source and byproduct materials to authorized locations. A standard license condition will memorialize this commitment (see SER Section 3.1.4, License Condition 10.7). The staff finds that the applicant’s commitments in the license application, along with the proposed license condition, are consistent with SRP Acceptance Criteria 6.1.3(6 and 8), which require discussions on the control of likely external effects of groundwater restoration on the outside of the production area and on the consumptive impacts estimated by bleed. (For a full discussion of bleed and consumptive use (water balance), see SER Sections 3.1 and 4.2.)

6.1.3.7 Restoration Waste Water Disposal

SER Sections 3.1.3 and 4.2.3 describe the applicant's disposal of restoration wastewater. The staff finds that the anticipated wastewater production can be adequately met by the estimates of the waste disposal capacity for the four Class I deep disposal wells, as permitted by Wyoming. Therefore, the staff finds that the applicant's plans for disposing of restoration wastewater are acceptable and consistent with SRP Acceptance Criteria 6.1.3(8 and 13).

6.1.3.8 Restoration Stability Monitoring

In TR Section 6.1.5 (AUC, 2012), the applicant commits to performing a groundwater stability monitoring program on a production unit basis. This monitoring program will begin upon completion of active restoration and will consist of collecting four rounds of samples over a 9-month stability monitoring period, yielding four quarters of data. The constituents and wells sampled are those used to establish baseline water quality for the production unit.

The applicant commits to evaluating temporal trends in each parameter for the production zone monitoring wells using established statistical methods to determine the significance of any trend or hot spot (AUC, 2012). If an increasing concentration trend is evident, the applicant proposes additional actions that it would take, such as resuming active or passive (recirculation) restoration or extending the stabilization-monitoring period. If the analytical results meet the appropriate standards and do not exhibit significant increasing trends, the applicant commits to submitting a restoration report with the supporting documentation to the NRC for its review and approval (AUC, 2012). If hot spots are identified, the applicant commits to either evaluate the potential impacts, by methods including additional monitoring and fate and transport modeling, to predict impacts to the surrounding aquifers, or resume active restoration.

The applicant proposes to continue the excursion monitoring program at the perimeter ring wells on a 60-day frequency for the excursion monitoring parameters during restoration stability monitoring.

The staff reviewed the restoration stabilization monitoring information provided by the applicant and finds it acceptable because it is consistent with SRP Acceptance Criteria 6.1.3(3 and 5) (NRC, 2003). The applicant described (a) wellfield restoration plans that included stabilization monitoring schedules and constituents, and (b) the post-restoration stability monitoring program. The proposed stabilization-monitoring program is consistent with NRC-approved monitoring programs that licensees currently use or have used at existing ISR facilities that have been shown to be protective of human health and safety and the environment.

6.1.3.9 Well Plugging and Abandonment

In TR Section 6.1.9 (AUC, 2012), the applicant states that plugging and abandonment of wells in a production unit will be initiated once the regulatory agencies concur that groundwater in a wellfield has been adequately restored and is stable. The applicant commits to plugging and abandonment of all wells in accordance with State of Wyoming requirements unless a well for future use has been requested and approved. In TR Addendum 2.6-B (AUC, 2012), the applicant provides its methodology for abandoning and plugging wells.

The staff reviewed the applicant's proposed plugging and abandonment procedures and finds them to be acceptable because they meet SRP Acceptance Criterion 6.1.3(7) (NRC, 2003), which states that plugging and abandonment procedures that are "codified in State regulations or rules are considered acceptable." Furthermore, proper abandonment of the wells meets, in part, requirements of Criterion 6(7) of Appendix A, 10 CFR Part 40, which states:

> *To the extent necessary to prevent threats to human health and the environment, the licensee should control, minimize or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to the ground or surface waters or to the atmosphere.*

Although this regulation was written for mill tailings, specifically the tailing disposal area, the criterion is also applicable to ISR facilities. After termination of the license (post-closure), any existing well will potentially provide a conduit to the subsurface for contaminated rainwater. Because properly plugging and abandoning wells will control the movement of such contaminants, the applicant's commitment to plug and abandon wells pursuant to the State of Wyoming regulations is acceptable to the staff.

6.1.3.10 Restoration Schedule

In TR Figure 1-3 (AUC, 2012), the applicant presents a general production, restoration and stability monitoring schedule for the Proposed Project. In general, the applicant depicts a 1- to 1.75-year duration of restoration/stability monitoring period for each production unit with the start of each staggered over an 8-year period.

In TR Section 6.1.6 (AUC, 2012), the applicant commits to begin restoration immediately following uranium recovery operations at a production unit. In addition, the applicant expects that the restoration can be efficient by having the infrastructure in place and adequate waste water disposal capacity. The applicant commits to revising the number of PVs in the financial surety based on performance.

The applicant states that the combined active restoration, stability monitoring, and surface reclamation and decommissioning of all wellfields may exceed 24 months. The applicant requests that staff approve the proposed schedule in the application as an alternate schedule pursuant to 10 CFR 40.42, "Expiration and Termination of Licenses and Decommissioning of Sites and Separate Buildings or Outdoor Areas."

The staff reviewed the proposed restoration schedule and stability monitoring program and finds the proposed schedule meets SRP Acceptance Criteria 6.1.3(3 and 6) (NRC, 2003), provided that the applicant updates the schedule, as needed, to comply with the requirements of 10 CFR 40.42. The staff notes that any change to the schedule that requires more than 24 months to complete decommissioning activities will require NRC approval of an alternate schedule pursuant to 10 CFR 40.42, which requires that decommissioning activities be completed within 24 months of initiation of decommissioning. Regulations in 10 CFR 40.42(g)(2) permit the NRC to approve a request for an alternate schedule for completion of decommissioning under certain circumstances. The staff finds that permanent cessation of lixiviant injection in a wellfield would signify intent to shift from the principal activity of uranium production to the initiation of groundwater restoration. The requirement for the applicant to submit a request for an alternate schedule will be included in a standard license condition (see SER Section 6.1.4, License Condition 10.6).

6.1.4 Evaluation Findings

The staff has completed its review of the plans and schedules for groundwater quality restoration for the Proposed Project. This review included an evaluation of the methods that the applicant proposed to use to develop the groundwater restoration program and schedules using the review procedures in the SRP Section 6.1.2 and the acceptance criteria in the SRP Section 6.1.3.

The applicant's plans and schedules for groundwater restoration are acceptable to the staff, except that the applicant did not include analysis of use, storage, and handling of a reductant other than sodium sulfate during restoration. The staff will include the following license condition to obtain approval by the NRC before the use, storage, handling, or transport of a specific reductant other than sodium sulfate:

- License Condition 10.10

The staff includes standard license conditions regarding aspects of groundwater restoration activities as presented in other SER sections:

- SER Section 5.7.8.4, License Condition 11.3, presents procedures for determining baseline or the Commission-approved background values, which constitute part of the groundwater protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5).

- SER Section 3.1.4, License Condition 10.7, presents a requirement to maintain an inward hydrologic gradient during operations and production, which will meet the requirements of 10 CFR 40.41(c) to confine the possession and use of source and byproduct material to locations and purposes authorized by a license.

The staff will also include the following standard license condition to memorialize the applicant's commitment to the restoration schedule and ACL application:

- License Condition 10.6

Based on its review of the information provided in the application, and the license conditions noted above, the staff is reasonably assured that the applicant will restore groundwater to the groundwater protection standards of 10 CFR Part 40, Appendix A, Criterion 5B(5), and will provide the information for the NRC's determination required per 10 CFR Part 40, Appendix A, Criterion 5D. The staff also finds these procedures acceptable because they meet the applicable acceptance criteria in SRP Section 6.1.3 (NRC, 2003) and requirements of 10 CFR 40.32(c), 10 CFR 40.42, and Criteria 5B(5) and 6(7) of Appendix A to 10 CFR Part 40 by:

- Committing to adopt wellfield groundwater restoration standards that are representative of background conditions.

- Committing to maintaining an inward hydrologic gradient during restoration.

- Committing to perform restoration using methods consistent with the ALARA approach.

- Providing estimates of PVs based on appropriate measured or estimated parameter values.

- Providing an acceptable list of indicator constituents and procedures to be used to establish statistically valid data sets to measure restoration success and stabilization.

- Documenting standards to be used to plug and abandon wells properly after the ISR operations are complete.

- Establishing an acceptable schedule for restoration.

6.2 Plans for Reclaiming Disturbed Lands

6.2.1 Regulatory Requirements

The staff determines if the application has demonstrated that the proposed plans for reclaiming disturbed lands for the AUC Reno Creek project meet the requirements of 10 CFR 40.42 and Criteria 6(6) and 6(7) of Appendix A to 10 CFR Part 40.

6.2.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in SRP Section 6.2.3 (NRC, 2003).

6.2.3 Staff Review and Analysis

The applicant discusses various aspects for reclamation of disturbed lands in TR Section 6.2 (Reclamation of Disturbed Land), TR Section 6.3 (Removal and Disposal of Structures, Waste Material, and Equipment), and TR Section 6.4 (Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys) (AUC, 2012). The staff based its review on information from these sections of the application.

SRP Acceptance Criterion 6.2.3(1) states that the appropriate cleanup criteria will be used in conducting the pre-reclamation surveys and planned activities. Acceptable cleanup criteria are discussed in SRP Sections 6.3 and 6.4.

The applicant described its proposed cleanup criteria in TR Section 6.4 (AUC, 2012). The staff reviewed and evaluated the cleanup criteria in SER Section 6.4. The staff has determined that the applicant has provided appropriate cleanup criteria, and the cleanup criteria will be used in conducting the pre-reclamation surveys and planned activities. The staff has reasonable assurance that the appropriate cleanup criteria will be used in conducting the pre-reclamation surveys and planned activities consistent with SRP Acceptance Criterion 6.2.3(1).

SRP Acceptance Criterion 6.2.3(2) states that the pre-reclamation radiological survey program for buildings and soils identifies instruments and techniques similar to those used in the pre-operational survey program to determine baseline site conditions (e.g., background radioactivity), but also takes into account current technology (acceptable sensitivity), results from operational monitoring, and other information that provides insights to areas of expected contamination.

In TR Section 6.2 (AUC, 2012), the applicant stated that pre-reclamation radiological surveys, as discussed in TR Section 2.9, will be conducted in a manner consistent with SRP Acceptance Criterion 6.2.3(2) for comparison to the baseline radiological surveys, and this will allow the data to be compared for identification of potentially contaminated areas and to identify candidate areas for cleanup operations, as stated in SRP Acceptance Criterion 6.2.3(3). The staff reviewed the pre-operational radiological survey in TR Section 2.9 and evaluated the pre-operational radiological survey in SER Section 2.6. The staff found the pre-operational radiological survey, as described in TR Section 2.9, acceptable for pre-reclamation radiological surveys. The staff determined that the pre-reclamation radiological surveys will be conducted in a manner consistent with SRP Acceptance Criterion 6.2.3(2).

SRP Acceptance Criterion 6.2.3(3) states that the licensee provides the procedures for interpretation of the pre-reclamation survey results and describes how they will be used to identify candidate areas for cleanup operations. Acceptable survey methods are discussed in SRP Section 6.4.

In TR Section 6.3 (AUC, 2012), the applicant stated that before CPP decommissioning, a preliminary radiological survey will be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The applicant further stated that the survey will support the development of procedures for dealing with such hazards before commencement of decommissioning activities and, in general, the contamination control program used during ISR operations will be appropriate for use during the decommissioning of structures. In TR Section 6.3, the applicant stated that, based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed.

The staff has determined that the applicant will conduct post-reclamation and decommissioning radiological surveys as described in TR Section 6.4. The staff has determined that preliminary radiological surveys to characterize the levels of contamination on structures and equipment to identify any potential hazards is acceptable for scoping, characterization, or remedial action support surveys, and the preliminary survey can provide valuable information for planning a final status survey provided it is of sufficient quality. The applicant stated, within the decommissioning plan, that a separate final status survey plan will be provided that includes the planning, implementation, and evaluation of radiological surveys that demonstrate how AUC will meet compliance during the final status survey (AUC, 2015a). The staff has further determined that the final status survey will provide data to demonstrate that all radiological parameters satisfy the established guideline values and conditions. The applicant has committed to provide a final status survey plan that will describe how they will be used to identify candidate areas for cleanup operations and acceptable survey methods consistent with the SRP Acceptance Criterion 6.2.3(3).

SRP Acceptance Criterion 6.2.3(4) states that the discussion of surface restoration includes a pre-construction surface contour map, a description of any significant disruptions to surface features during facility construction and operation, and a description of planned activities for surface restoration that identifies any important features that cannot be restored to the pre-operations condition.

In TR Section 6.2, the applicant stated that it intends to restore topography and vegetation to a state that is comparable to pre-operational conditions. The applicant provided descriptions in TR Section 6.2 of topsoil handling and replacement, final contouring, and re-vegetation practices. The staff determined that these practices are regulated by WDEQ and are not regulated by the NRC. The applicant provided a pre-construction contour map in TR Figure 3-1 and stated in TR Section 6.2 that due to the fact that there will be no significant changes to the topography of the land during operations, a final contour map will not be necessary. The staff determined that the applicant provided a discussion of surface restoration, and this is consistent with SRP Acceptance Criterion 6.2.3(4). WDEQ regulates the final site restoration and NRC will not consider final restoration in granting the license.

SRP Acceptance Criterion 6.2.3(5) states that any changes to the existing NRC-approved radiation safety program that are needed for decommissioning and reclamation work are identified with appropriate justification to ensure continued safety for workers and the public. Acceptable approaches for the radiation safety program are evaluated in accordance with SRP Section 5.7.

The applicant described the radiation safety program in TR Section 5.7 (AUC, 2012).
In addition to the radiation safety program, the applicant provided a discussion of the SERP in TR Section 5.2 (AUC, 2012). The purpose of the SERP is to review and approve minor and administrative changes without the need for a license amendment. The staff has determined that any changes to the existing NRC-approved radiation safety program are covered under the applicant's SERP process. The staff determined that the applicant will review any changes to the existing NRC-approved radiation safety program that are needed for decommissioning and reclamation work identified with appropriate justification to ensure continued safety for workers and the public consistent with SRP Acceptance Criterion 6.2.3(5).

SRP Acceptance Criterion 6.2.3(6) states that the applicant has an approved waste disposal agreement for 11e.(2) byproduct material disposal at an NRC or NRC Agreement State licensed disposal facility. This agreement is maintained on site. The applicant has committed to notify the NRC in writing within 7 days if this agreement expires or is terminated and to submit a new agreement for NRC approval within 90 days of the expiration or termination. The staff will include a license condition to memorialize the applicant's commitment (see SER Appendix A, License Condition 9.9).

In TR Section 4.3 (AUC, 2012), the applicant discussed having a contract for an approved waste disposal agreement for 11e.(2) byproduct material before operations. The staff reviewed this commitment in SER Section 4.2 and found it consistent with SRP Acceptance Criterion 4.2.3(6). The applicant has committed to having a contract for an approved waste disposal agreement for 11e.(2) byproduct material before operations, which meets SRP Acceptance Criterion 6.2.3(6) (see SER Appendix A, License Condition 12.5).

SRP Acceptance Criterion 6.2.3(7) states that the applicant commits to providing final (detailed) reclamation plans for land (soil) to the NRC for review and approval at least 12 months before the planned commencement of reclamation of a wellfield or licensed area. The final decommissioning plan includes a description of the areas to be reclaimed, a description of planned reclamation activities, and a description of methods to be used to ensure protection of workers and the environment against radiation hazards.

In TR Section 6.2 (AUC, 2012), the applicant stated that it will submit a standard production unit decommissioning plan specific to Production Unit 1 for approval at least 12 months before the completion of groundwater restoration, in accordance with NRC requirements. The applicant further stated that decommissioning will not begin in a production unit until final approval of groundwater restoration has been received from the NRC and WDEQ. The applicant also stated that it commits to providing detailed reclamation plans for land (soil) to the NRC for review and approval at least 12 months before the planned commencement of final site reclamation. To further explain the relationship between the reclamation plan and the decommissioning plan, the applicant stated that upon completion of licensed ISR operations at the proposed project, all lands disturbed by ISR production activities will be reclaimed, to the extent necessary, so that they can be released for unrestricted use. AUC commits to providing a final detailed decommissioning plan for each production unit to the NRC. In accordance with SRP Acceptance Criterion 6.2.3(7), AUC commits to including a final (detailed) reclamation plan for land (soil) to the NRC for review and approval at least 12 months before the planned commencement of reclamation of a production unit or licensed area. The reclamation plan will be submitted as part of the decommissioning plan, which will include a description of the areas to be reclaimed, a description of planned reclamation activities (e.g., replacing excavated soils, re-contouring affected areas, re-establishing original drainages and re-vegetation), and a description of methods to be used to ensure protection of workers and the environment against radiation hazards (AUC, 2014a). The applicant also stated that, once operations permanently end for the entire site, AUC commits to providing a final site decommissioning plan for the CPP and any remaining pipelines and other infrastructure at least 12 months before commencement of final decommissioning for NRC approval. The final decommissioning plan will also include a final site reclamation plan for land (soil) (AUC, 2014a). The staff determined that this is consistent with SRP Acceptance Criterion 6.2.3(7).

SRP Acceptance Criterion 6.2.3(8) states that the decommissioning plan addresses the nonradiological hazardous constituents associated with the wastes according to 10 CFR Part 40, Appendix A, Criterion 6(7). Any unusual or extenuating circumstances related to such constituents should be discussed in the reclamation plan or decommissioning plan in relation to protection of public health and the environment and should be evaluated by the staff.

In TR Section 6.2 (AUC, 2012), the applicant stated that, before reclamation, it will identify the disposition of all nonradiological components and hazardous materials, including all structures and equipment. Those that may be decontaminated to regulatory standards will be demolished and disposed of at a permitted nonhazardous materials disposal facility (e.g., a local landfill). Contaminated structures and equipment will be dismantled and transported offsite to a licensed facility for disposal as solid 11e.(2) byproduct material, in accordance with 10 CFR Part 40, Appendix A, Criterion 2. The applicant also stated that salvaged equipment may be transferred to another applicant project or NRC licensee, and non-11e.(2)–regulated material, including uncontaminated materials and equipment, and septic system materials will be disposed of in an approved sanitary landfill, compliant with the rules and regulations of WDEQ/Solid and Hazardous Waste Division (SHWD). The applicant stated that it will commit to decommissioning nonradiological components and hazardous materials in accordance with 10 CFR Part 40, Appendix A, Criterion 6(7) (AUC, 2014a).

The applicant stated that before reclamation, AUC will identify the disposition of all nonradiological components and hazardous materials, including all structures and equipment and those that may be decontaminated, to WDEQ/SHWD, Hazardous Waste Management Rules and Regulations (Wyoming Environmental Quality Act, W.S. 35-11-101, et seq.) (AUC, 2014a), consistent with SRP Acceptance Criterion 6.2.3(8). The staff determined that this meets SRP Acceptance Criterion 6.2.3(8).

SRP Acceptance Criterion 6.2.3(9) states that the quality assurance and quality control programs address all aspects of decommissioning. The programs should indicate a confidence interval or that one will be specified before the collection of samples. The data to be used to demonstrate compliance and the quality assurance procedures should confirm that compliance data are precise and accurate. Management will ensure that approved procedures are followed.

In TR Section 5.7.9 (AUC, 2012), the applicant stated that it will implement a quality assurance (QA) program at the site for all relevant operational monitoring and analytical procedures. The applicant stated that the objective of the program will be to identify any deficiencies in the sampling techniques and measurement processes so that appropriate corrective actions can be implemented to obtain a level of confidence in monitoring program results, and that the proposed QA program will cover radiological and nonradiological monitoring activities and will help ensure that all measurements and monitoring programs reasonably validate a defined quality. The applicant further stated that it will address all aspects of decommissioning, including a confidence interval (or one to be specified) before collecting decommission samples, and the data will be used to demonstrate compliance. The QA procedures will verify that compliance data are precise and accurate. The staff has determined that the applicant adequately discussed the QA Program in TR Section 5.7.9, and the staff evaluated the QA program in this SER. AUC commits to developing a QA program that will be consistent with RG 4.15 as identified in response to RAI-62. AUC will provide the NRC staff a completed QA program at least 60 days prior to the preoperational inspection. The staff determined that the applicant addressed all aspects of decommissioning in the QA and quality control programs consistent with SRP Acceptance Criterion 6.2.3(9).

6.2.4 Evaluation Findings

The staff has completed its review of the applicant's commitment to decommission the disturbed lands for the Proposed Project. The review included an evaluation of the methods that will be used to develop the decommissioning and reclamation of disturbed lands program using the acceptance criteria in the SRP (NRC, 2003).

Based on the information provided in the application and the detailed review conducted of the plans for reclaiming disturbed lands for the Proposed Project, the staff concludes that the proposed decommissioning plans are acceptable and are in compliance with the following:

- 10 CFR 40.32(c), which requires applicant-proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property

- 10 CFR 40.42(g)(4), which provides requirements for final decommissioning plans

- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license

- 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide objective evidence of an agreement for disposal of 11e.(2) byproduct material, either in a licensed waste disposal site or a licensed mill tailings facility to demonstrate nonproliferation of waste disposal sites

- 10 CFR Part 40, Appendix A, Criterion 6(6), which identifies cleanup criteria requirements

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

6.3.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed plans for removal and disposal of structures, waste material, and equipment for the Proposed Project meet the requirements of 10 CFR 40.42.

6.3.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in SRP Section 6.3.3 (NRC, 2003).

6.3.3 Staff Review and Analysis

The applicant stated in TR Section 6.3 (AUC, 2012) that it will assume that most of the process equipment within the CPP will be reusable, including the building itself, and that all potentially contaminated materials and equipment will be inventoried and designated either for removal to a new location or other licensed facility, permanent disposal, or decontamination for unrestricted use. The applicant also stated that, if the buildings cannot be decontaminated successfully, they will be treated as solid 11e.(2) byproduct material and disposed of offsite at a licensed facility. The applicant further stated that salvageable building materials, equipment, pipe, and other materials will be surveyed for alpha and beta/gamma contamination to establish that residual contamination is within the limits, as specified in TR Section 5.7.6, "Contamination Control Program," before release for unrestricted use. Nonsalvageable contaminated equipment, materials, and dismantled structural sections will be sent to a licensed facility for disposal. The staff has determined that the applicant has provided a program to control residual contamination on structures and equipment consistent with SRP Acceptance Criterion 6.3.3(1).

In TR Section 6.3 (AUC, 2012), the applicant stated that all openings on contaminated equipment will be plugged or covered before moving from the plant facility within covered transport vehicles in preparation for disposal at a licensed facility. Smaller contaminated items can be placed in roll-off containers, barrels, or dump trucks for delivery to a licensed facility, and all contaminated buried process lines and drain lines will be excavated and removed for shipment to a licensed facility. The applicant also indicated that an agreement for disposal of solid 11 e.(2) byproduct material will be in place before operation of the Proposed Project commences, consistent with SRP Acceptance Criteria 6.3.3(5).

In TR Section 6.3 (AUC, 2012), the applicant also stated that the decontamination of surfaces will be guided by the ALARA principle to reduce surface contamination to levels as far below the limits as practicable. Interior surfaces on which radiological materials could accumulate, such as piping, drain lines, duct work, etc., will be sampled and monitored for contamination at accessible locations. Inaccessible surfaces of equipment and scrap with a reasonable likelihood of contamination will be presumed contaminated in excess of the release limits and will be disposed of accordingly. The staff has determined that the applicant will presume surfaces of premises, equipment, or scrap that are likely to be contaminated but inaccessible for purposes of measurement to be contaminated in excess of the limits consistent with SRP Acceptance Criterion 6.3.3(3).

The applicant stated in TR Section 6.2 (AUC, 2012) that, as previously noted in the application, at least 12 months before the planned commencement of reclamation and final decommissioning, the applicant will submit a detailed decommissioning plan to the NRC for review and approval. The applicant indicated in its RAI response that the decommissioning plan will include a separate final status survey plan that will describe how the applicant will demonstrate compliance during the final status survey (AUC, 2014). The staff has determined that the applicant will provide a final (detailed) decommissioning plan, which will provide a comprehensive final status survey plan within the decommissioning plan consistent with SRP Acceptance Criteria 6.3.3(4) and 6.3.3(6).

The staff has reasonable assurance that the applicant has identified the important elements for removing and disposing of structures, waste materials, and equipment consistent with the acceptance criteria, as described in SRP 6.3.3 (NRC, 2003). The staff has reasonable assurance that the applicant has provided reasonable measurements to protect the health and minimize danger to life or property. Therefore, the staff finds the applicant's methods for the removal and disposal of structures, waste materials, and equipment acceptable.

6.3.4 Evaluation Findings

The staff has completed its review of the methodologies for removal and disposal of structures and equipment used at the Proposed Project. This review included an evaluation of the methods that will be used to develop the procedures for removal and disposal of structures, waste materials, and equipment using the acceptance criteria in SRP Section 6.3.3.

The applicant has established an acceptable program for the measurement and control of residual contamination on structures and equipment. The applicant has made acceptable plans for measurements of radioactivity on the interior surfaces of pipes, drain lines, and ductwork by making appropriate measurements at all traps and other access points where contamination is likely to be representative of system wide contamination. For all premises, equipment, or scrap likely to be contaminated in excess of specified limits, the applicant will provide detailed, specific information describing the premises, equipment, or scrap in terms of extent and degree of radiological contamination. The applicant plans to conduct a comprehensive radiation survey to establish that any contamination is within limits specified before the release of the premises, equipment, or scrap. A contract will exist between the licensee and a licensed waste disposal site operator to dispose of 11e.(2) byproduct material.

Based on the information provided in the application and detailed review conducted of the methodologies for removal and disposal of structures, waste materials, and equipment for the Proposed Project, the staff concludes that the methodologies are acceptable and are in compliance with the following:

- 10 CFR 40.32(c), which provides requirements for final decommissioning plans

- 10 CFR 40.42(g)(4), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property

- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license

- 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide objective evidence of an agreement for disposal of 11e.(2) byproduct materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate nonproliferation of waste disposal sites

6.4 Post Reclamation and Decommissioning Radiological Surveys

6.4.1 Regulatory Requirements

The staff determines if AUC has demonstrated that the applicant's proposed methodologies for conducting post reclamation and decommissioning radiological surveys for the Proposed Project meet the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.4.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria in SRP Section 6.4.3 (NRC, 2003).

6.4.3 Staff Review and Analysis

The purpose of the "radium benchmark approach" is for applicants and licensees to develop a site-specific dose model from the existing radium (Ra)-226 standard (i.e., 5 picocuries per gram (pCi/g)) and then use that dose developed from the Ra-226 standard to determine the allowable quantity of any other radionuclides that would result in a similar dose to the average member of the critical group. The sum of the unity of the other radionuclides and Ra-226 must be less than one. This includes the impact of the uranium chemical toxicity. These values are used for site cleanup.

6.4.3.1 Cleanup Methodology and Criteria

In TR Section 6.4 (AUC, 2012), the applicant commits to meet the soil cleanup criteria established in 10 CFR Part 40, Appendix A, Criterion 6(6). The applicant stated in TR Section 6.4 that RESRAD Version 6.3 was used to model the Proposed Project site and calculate the annual dose from the current Ra-226 cleanup standard (5 pCi/g), and the applicant provided the RESRAD data input basis and a full printout of the final RESRAD result in TR Addendum 6-B (AUC, 2012). In TR Section 6.4 (AUC, 2012), the applicant stated that it selected the resident farmer scenario and calculated a maximum dose over a 1,000-year time period and provided a breakdown of the fraction of dose due to each pathway. The maximum dose from the resident farmer scenario was 39.5 millirem (mrem) per year.

The applicant also stated that the two major pathways were external exposure and plant ingestion. Under the resident farmer scenario, the applicant stated that the assumptions that went into the calculation were the diet—which consisted of 25 percent of meat, fruits, and vegetables grown at the site—and no intake of contaminated food through the aquatic or milk pathways. The scenario also assumed that the contamination would not affect groundwater quality. When compared to other scenarios (i.e., industrial, recreational, etc.), the residential farmer scenario is subject to more pathways than other scenarios. Therefore, the staff determined that the applicant's dose approach using the residential farmer scenario is expected to result in a dose that is protective of public health and safety. The staff has determined that the applicant used the cleanup criteria for radium in soils consistent with 10 CFR Part 40, Appendix A, Criterion 6(6) and SRP Acceptance Criterion 6.4.3(1).

In TR Section 6.4 (AUC, 2012), the applicant stated that the RESRAD computer code was used to determine the concentration of natural uranium in soil that can be differentiated from background, which would result in a maximum dose of 39.5 mrem per year. It also stated that this dose was compared to the Ra-226 benchmark dose, then scaled to arrive at the maximum allowable natural uranium concentration in soil. The applicant stated that natural uranium consists of three isotopes, which included 48.9 percent for U-238, 48.9 percent for U-234, and 2.2 percent for U-235. The distribution coefficients selected for each radionuclide were primarily RESRAD default values. The applicant calculated a natural uranium soil concentration at 526 pCi/g. The applicant commits to using the unity (sum of fractions) rule for Ra-226 and natural uranium concentrations in soil when both constituents are present (AUC, 2012).

In TR Section 6.2 (AUC, 2012), the applicant stated that pre-reclamation radiological surveys, as discussed in TR Section 2.9, will be conducted in a manner consistent with SRP Acceptance Criterion 6.2.3(2) for comparison to the baseline radiological surveys, and this will allow the data to be compared for identification of potentially contaminated areas and to identify candidate areas for cleanup operations as stated in SRP Acceptance Criterion 6.2.3(3). The staff determined that this meets SRP Acceptance Criterion 6.2.3(3).

6.4.3.2 Uranium Chemical Toxicity Assessment

The applicant extended the assessment of level of natural uranium concentration in soil for uranium chemical toxicity, and this was discussed further in TR Section 6.4 (AUC, 2012). In TR Section 6.4, the applicant stated that the method and parameters for estimating the human intake of uranium from ingestion are taken from NUREG/CR-5512, Vol. 17. The applicant took into consideration the annual intakes from leafy vegetables and other vegetables and fruit with the assumption that 25 percent of the foods are grown on the site and that the uranium concentration in the garden or orchard was 526 pCi/g (AUC, 2012).

The applicant then computed an annual uranium intake from all food sources from the site as 51 mg/yr or 0.14 mg/day (AUC, 2012). Using equations and parameters identified in International Commission on Radiological Protection Publication 69, "Age-Dependent Doses to Members of the Public from Intake of Radionuclides—Part 3 Ingestion Dose Coefficients," the applicant computed a concentration of 0.03 micrograms (ug) in the kidney. The applicant indicated in TR Section 6.4 (AUC, 2012) that U.S. Environmental Protection Agency (EPA) arrived at a 30 ug/liter limit for use as a National Primary Drinking Water Standard (*Federal Register*, December 7, 2000) and determined that this is equivalent to an intake of 0.06 mg/day for the average individual. Thus, taking the ratio of 0.06 mg/day and 0.14 mg/day and multiplying this ratio by 526 pCi/g, the applicant determined a soil limit of 225 pCi/g; this would correspond to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day. In TR Table 6-5 (AUC, 2012), the applicant proposed an ALARA goal of 150 pCi/g for natural uranium in the top 15-centimeter (cm) (6-inch (in.)) soil layer and a limit of 225 pCi/g for natural uranium in soils below the top 15-cm (6-in) soil layer, taking into consideration the chemical toxicity of natural uranium in soils.

In TR Section 6.4 (AUC, 2012), the applicant stated that cleanup of surface soils will be restricted to a few areas where there are known spills or leaks and, potentially, small spills or leaks near wellheads and the spill and leak locations. The size (cleanup area) will be documented to ensure cleanup criteria are met before final decommissioning. The applicant also stated that final Global Positioning System-based gamma surveys will be conducted in potentially contaminated areas. The applicant further stated that areas will be divided into 100 square-meters (1,076 square-foot) grid blocks and soil samples will be obtained from grid blocks with gamma count rates exceeding the gamma action level. Samples will be multipoint composites analyzed by an offsite laboratory for Ra-226 and natural uranium.

The staff reviewed the RESRAD input parameters and RESRAD results in TR Addendum 6-B and found them to be applicable for the dose assessment. The staff looked at the radium benchmark dose in the application and found it acceptable in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6). The staff also compared the projected dose estimate from the radium benchmark dose and the projected uranium concentrations in soils with those projected for the Strata ISR facility (Strata, 2011) and found them to be consistent. The staff determined that this meets the acceptance criteria in SRP Section 6.4.3.

6.4.4 Evaluation Finding

The staff has completed its review of the methodologies for conducting post-reclamation and decommissioning radiological surveys for the Proposed Project. This review included an evaluation of the methods that will be used for the post-reclamation and decommissioning radiological surveys using the acceptance criteria in SRP Section 6.4.3.

The applicant has developed acceptable methodologies for verification of cleanup (final status survey plan) that demonstrate that the radium concentration in the upper 15 cm (6 in.) of soil will not exceed 5 pCi/g, and in subsequent 15 cm (6 in) layers will not exceed 15 pCi/g. Also, the cleanup of other residual radionuclides in soil will meet the criteria developed with the radium benchmark dose approach, including a demonstration of ALARA and application of the unity test of 10 CFR Part 40, Appendix A, Criterion 6(6), where applicable.

Based on the information provided in the application and the detailed review conducted of the methodologies for conducting post-reclamation and decommissioning radiological surveys for the Proposed Project, the staff concludes that the methodologies are acceptable and are in compliance with the following:

- 10 CFR 40.32(c), which requires the applicant’s proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger of life or property
- 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public
- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license
- 10 CFR Part 40, Appendix A, Criterion 6(6), which provides standards for cleanup of radium.

6.5 Financial Assurance

6.5.1 Regulatory Requirements

The staff determines if the proposed financial assurance for the Proposed Project meets the requirements of 10 CFR Part 40, Appendix A, Criterion 9.

6.5.2 Regulatory Acceptance Criteria

The staff reviewed the application for consistency with applicable regulations of 10 CFR Part 40 using the acceptance criteria outlined in Section 6.5.3 of the SRP (NRC, 2003).

6.5.3 Staff Review and Analysis

Information in this section, unless otherwise stated, is from TR Section 6.6 and the Restoration Action Plan in TR Addendum 6-A (AUC, 2012). The applicant has provided a financial assurance estimate of $7,004,586 that includes costs for all decommissioning, groundwater restoration, and reclamation activities required for the CPP, the first five wellfields (Production Unit 1) and offsite disposal of all wastes, including byproduct material, to allow their release for unrestricted use. AUC has developed its cost estimates to address items in Appendix C of the NRC's SRP (NRC, 2003).

The cost estimate includes the costs for an independent contractor to complete facility decommissioning and waste disposal, groundwater restoration and well plugging, radiological survey, and environmental monitoring to allow the site to be released for unrestricted use. A discussion of the costs associated with these activities is included in TR Section 6.6 and Addendum 6-A of the application. AUC commits to providing an appropriate financial mechanism for the approved financial estimate in accordance with the conditions as set forth in 10 CFR Part 40, Appendix A, Criterion 9, before the commencement of uranium recovery operations. These costs have been provided in current dollars and can be adjusted to account for inflation, as necessary. The financial assurance cost estimate includes operational costs, such as environmental sampling, that would be needed during groundwater restoration and surface reclamation. The initial license will have a condition requiring submittal of an updated financial assurance estimate before the commencement of operations, as described in SER Section 6.5.4.

Financial assurance documentation includes a breakdown of costs, the basis for cost estimates, and a 15-percent contingency. The applicant has committed to perform the following administrative issues related to financial assurance:

- Provide an annual adjustment of the financial assurance value and to providing an updated estimate at least 90 days before major construction that has not been previously addressed in the estimate.

- Automatically extend the financial assurance instrument if the NRC has not approved the proposed revision 30 days prior to the expiration date.

- Revise the financial assurance arrangement within 3 months of NRC approval of a revised closure (decommissioning) plan if estimated costs exceed the amount of the existing arrangement.

- Update the financial assurance in the event that an excursion of ISR production solutions is not recovered within 60 days.

- Provide the NRC with a copy of WDEQ's review and final financial assurance arrangement.

In Section 1.2.2 of TR Addendum 1-A, AUC estimated that seven PVs of active groundwater restoration will be required to reach the restoration goal discussed in TR Section 6.1.1. The applicant expects that six PVs of RO treatment with permeate injection and one PV of combined groundwater transfer and groundwater sweep will be required to complete active groundwater restoration for a production unit. As discussed in SER Section 6.1, the applicant has provided adequate technical information regarding this PV estimate for groundwater restoration. The technical information provided by the applicant includes an analog study comparing restoration efforts at other ISR facilities, as well as a commitment to follow timely and efficient restoration practices. Activities that are included in the reclamation cost estimate are consistent with what is planned for and what is known about the site.

As discussed in SER Section 4.2, the applicant has adequately described the quantities of liquid byproduct material that will be disposed of through deep well injection. The applicant anticipates installing four deep disposal wells to handle the expected volumes of liquid byproduct material at the facility. The staff reviewed the proposed water balance and agrees that adequate liquid disposal capacity is available at the site.

In Section 1.2.2 of TR Addendum 1-A, the applicant states that the duration of active groundwater restoration phase is based on the processing and circulation of seven PVs of groundwater at the flow rates specified in the calculations worksheets for each stage in the Groundwater Restoration section of Attachment 1. The financial assurance will be maintained at this level until the number of PVs required to complete each phase has been demonstrated. AUC will adjust the financial assurance budget for groundwater restoration during each annual update review to reflect experience gained from actual restoration processes and any changes in ISR operations, industry standards, or economic conditions that require or potentially affect financial assurance.

The financial assurance estimate does not identify specific costs related to the cleanup of spills in the wellfields. The applicant has committed to the cleanup of spills at the time of detection. The cleanup area will include the spill area itself, as well as the surrounding affected area. As the financial assurance amount will be reviewed on an annual basis, the staff will have the ability to review and revise this portion of the amount to reflect the performance of the facility as it relates to spill prevention and cleanup.

Based on the above discussion, the applicant has established an acceptable financial assurance cost estimate based on the requirements in 10 CFR Part 40, Appendix A, Criterion 9. In TR Addendum 6-A, the applicant provided a cost estimate that follows the outline in Appendix C of NRC's SRP (NRC, 2003) and includes groundwater restoration and well plugging, decommissioning, radiological surveys and environmental monitoring, and reclamation work to be performed at the site. For each of these areas, the applicant included a breakdown of costs and the basis for the cost estimates. Financial assurance assumptions are based on analyses of onsite conditions, including experiences with generally accepted industry practices, and R&D activities at the site. The values used in the financial assurance analysis are based on current dollars, and reasonable costs for the required reclamation activities are described. The applicant has not proposed a financial assurance instrument at this time. The applicable regulations in 10 CFR Part 40, Appendix A, require that the financial assurance arrangement be established before commencement of operations. Therefore, the staff will include a license condition that the financial assurance arrangement be established before commencement of operation (see SER Appendix A, License Condition 9.5). With the addition of this license condition, the staff finds that the applicant has adequately addressed the acceptance criteria in SRP Section 6.5.3.

6.5.4 Evaluation Findings

The staff has completed its review of the financial assurance cost estimate for the Proposed Project. This review included an evaluation of the methods that will be used to develop the procedures using the review procedures in SRP Section 6.5.2 and the acceptance criteria in SRP Section 6.5.3.

Based on the information provided in the application and the staff's detailed review of the decommissioning cost estimate for the Proposed Project, the staff concludes that the amount of the applicant's proposed financial assurance and its methods of estimation are acceptable and consistent with 10 CFR Part 40, Appendix A, Criterion 9, which requires that financial assurance arrangements be established by each operator. As maintaining adequate financial assurance is an important aspect of the facility, compliance with the applicable regulations would be required through License Condition 9.5.

SECTION 7

ACCIDENTS

7.1 Regulatory Requirements

General requirements for issuance of a Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material," specific license are listed in 10 CFR 40.32. Section 10 CFR 40.32(c) requires that an applicant's proposed procedures be adequate to protect public health and minimize danger to life or property. In 10 CFR 20.1101, the U.S. Nuclear Regulatory Commission (NRC) requires that a licensee develop, document, and implement a radiation protection program commensurate with the scope and extent of the licensed activities and sufficient to ensure compliance with 10 CFR Part 20, which establishes standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC. In 10 CFR 20.2202 "Notification of Incidents" and 20.2203 "Reports of Exposures, Radiation Levels, and Concentrations of Radioactive Material Exceeding the Constraints or Limits," the NRC specifies notification and reporting requirements for a loss, incident, or accident that may affect public health and safety and the environment. Finally, for unrestricted release of the area upon license termination, Criteria 6(6) and 6(7) of 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 Concentration of Source Material from Ores Processed Primarily from Their Source Material Content," provide standards for residual radiation levels in soil and closure to prevent threats to human health and the environment from nonradiological hazards.

Standard Review Plan (SRP) Section 7.5.1 (NRC, 2003) states that the NRC has evaluated the effects of accidents at in situ recovery (ISR) and conventional milling facilities and has determined that the consequences are minor for most credible potential accidents and an applicant need not conduct an independent accident analysis, provided that:

- Effective emergency procedures and properly trained personnel are used.
- The proposed facility is consistent with the operating assumptions, site features, and designs examined in the prior NRC analyses.

Guidance in the SRP (NRC, 2003) indicates that staff should pay particular attention to procedures related to monitoring, identification, and response to accidents related to the following:

- radon releases from process streams
- yellowcake dryer explosions
- lixiviant leaks in buried piping between the wellfields and the processing facility
- chemical accidents

The staff determines if the applicant has addressed potential accidents at the Proposed Project and has demonstrated 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; the response program requirements of 10 CFR 20.2202 and 20.2203; and closure requirements of Criteria 6(6) and 6(7) of Appendix A of 10 CFR Part 40.

7.2 Regulatory Acceptance Criteria

The staff reviewed the application for consistency with applicable regulations of 10 CFR Part 40 and Part 20 using review procedures in SRP Section 7.5.2 and acceptance criteria in SRP Section 7.5.3 (NRC, 2003).

7.3 Staff Review and Analysis

Unless otherwise stated, information reported in this safety evaluation report (SER) section is from Technical Report (TR) Section 7.5 (AUC, 2012). This SER section describes the effects of potential accidents that could occur at the Proposed Project and the accident reporting and cleanup criteria that the applicant would follow in the event of an accident. The staff's review included an evaluation using the areas of review, review procedures, and acceptance criteria as described in SRP Sections 7.5.1, 7.5.2, and 7.5.3 (NRC, 2003), respectively. If, after the staff's detailed review of information supplied by the applicant in an application, the staff is reasonably assured that the applicant, by training, experience and expertise, is capable of developing, documenting, and implementing an adequate program, the staff may, by a preoperational license condition, accept the documentation immediately prior to its implementation.

In accordance with SRP Section 7.5.1, where the applicant's operating assumptions, site features and designs are consistent with those evaluated in NUREG-0706, "Final Generic Environmental Impact Statement on Uranium Milling" (NRC, 1980b), and NUREG/CR-6733, "A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees" (Mackin et al., 2001), the staff review focused on the accident response procedures and personnel training.

The applicant described what it considered to be credible accidents following guidance provided in NUREG/CR-6733 (Mackin et al., 2001). The applicant stated that all of the accident scenarios described will require reporting to various regulatory agencies and might require immediate notification depending on the severity of the accident. In TR Section 7.5 (AUC, 2012), the applicant committed to preparing an emergency response standard operating procedure (SOP) as part of its emergency response program. The staff's review of the applicant's program for emergency responses to chemical accidents, radiological release accidents, groundwater contamination, wellfield spills, transportation accidents, fire and explosions, and natural events is discussed below.

7.3.1 Chemical Accidents

In TR Section 3.2.2 (AUC, 2012), the applicant discussed use and storage of process and nonprocess chemicals. The process chemicals are as follows:

- strong mineral acid (hydrochloric, sulfuric, nitric)
- oxygen
- carbon dioxide
- sodium sulfide
- sodium hydroxide
- hydrogen peroxide

- sodium carbonate
- salt (sodium chloride)

The nonprocess chemicals are as follows:

- diesel
- propane

In SER Section 3.2, the staff reviewed and evaluated the applicant's use and storage of process and nonprocess chemicals. In TR Section 6.1.4.3 (AUC, 2012), the applicant suggested it may use a reductant addition (e.g., sulfide or sulfite compounds or both) during aquifer restoration (groundwater treatment). In Environmental Report (ER) Section 4.12.1 and TR Section 7.5.1.2 (AUC, 2012), the applicant discussed the health-based risks for sodium sulfide and committed to having a SOP for the use, storage, handling, and disposal of this compound. The applicant did not provide a description of any additional reductant to be used or hazard analyses of its storage, use, and handling.

In TR Section 7.5, the applicant provided a comprehensive evaluation of the potential accidents, including those involved in transportation, for the following process chemicals:

- mineral acid
- oxygen
- carbon dioxide
- sodium hydroxide
- hydrogen peroxide
- sodium carbonate
- salt (sodium chloride)

For the above chemicals, the applicant acknowledged the associated hazards and provided plans to minimize the potential for an accident to occur, as well as mitigative measures should an accident occur (AUC, 2012). The applicant's proposed emergency response program includes discussions on the compatibility of the chemicals, ventilation requirements, monitoring, inspections, training, and secondary containment. For several chemicals (e.g., hydrogen peroxide, sulfuric acid), the applicant acknowledged that the volumes to be stored may trigger compliance with additional regulations (e.g., 40 CFR Part 355, "Emergency Planning and Notification," 40 CFR Part 302, "Designation, Reportable Quantities, and Notification").

The applicant provided an evaluation of accidents involving the nonprocess chemicals (AUC, 2012). The nonprocess chemicals will be stored in aboveground tanks. The applicant's proposed emergency response program includes discussions on the compatibility of the nonprocess chemicals, ventilation requirements, monitoring, inspections, training, and secondary containment. The applicant acknowledged that the volumes to be stored may trigger compliance with additional regulations (e.g., 40 CFR Part 112, "Oil Pollution Prevention").

In TR Section 5.3.2 (AUC, 2012), the applicant stated that the annual as low as is reasonably achievable (ALARA) audit report will include reporting of overexposures of workers. In TR Section 7.5.2 (AUC, 2012), the applicant stated the emergency response plan will include descriptions of the following provisions:

- notification and evacuation procedures
- personnel protective equipment
- general firefighting safety rules
- reporting procedures
- electrical and gas emergencies

The staff reviewed the applicant's proposed emergency response program related to chemical accidents and finds that the program adequately addresses the program requirements for an emergency response to a chemical accident for the process and nonprocess chemicals, except those noted, because the applicant's designs and measures to prevent the occurrence of an accident, and the proposed emergency response procedures in the event of an accident, are similar to and based on those in NUREG/CR–6733 (Mackin et al., 2001) and NUREG-0706 (NRC, 1980a). The noted exceptions are the accidents associated with a chemical reductant, other than sodium sulfide, for aquifer restoration. The staff will include a license condition that requires the applicant to prepare its SOPs, including the emergency response program, prior to operations and maintain those SOPs during operations. The license condition will specify that the emergency response program include a hazard assessment of all chemicals used at the facility, including an accident analysis (this information is in SER Section 3.1.4). A copy of the current written procedures will be required to be kept in area(s) of the production facility where the chemicals are utilized.

For chemical reductants other than sodium sulfide, because the application lacked discussions on which chemicals the applicant plans to use, the staff will include a license condition prohibiting the use and storage of chemicals associated with reductant addition (with the exception of sodium sulfide) for groundwater restoration until the applicant submits to the staff, for review and approval, a chemical hazard assessment on the use, storage, and transport of chemicals to be used as the chemical reductant (this information is in License Condition 10.10 as presented in SER Section 6.1.4).

7.3.2 Radiological Release Accidents

The applicant identified tank and plant pipe failures as potential accidents that could pose a radiological risk (AUC, 2012). The applicant stated that the central processing plant (CPP) building structure and concrete curb will contain spills from tanks and leaks from pipes. The floor sump system will direct liquids to other tanks or to a lined storage pond. TR Section 3.1 provides information on the operation and shutdown mechanisms that will be used if a piping failure occurs. The applicant stated that leak detection sensors will be located in the header house building sumps and the valve manholes that will activate audible and visual alarms at that location and at the CPP if fluid is detected. Additionally, the applicant committed to developing an emergency response plan that will define under what circumstances reporting is required and to which agency(ies) and will comply with all notification requirements put forth in 10 CFR 20.2202 and 20.2203 (AUC, 2012).

The staff reviewed the potential radiological release accident scenarios and commitments made by the applicant and finds the information is acceptable because it is consistent with requirements of 10 CFR Part 20, current industry standard practices, and historical release accidents at existing facilities. The number of accidents historically at ISR facilities has been low and often not related to radiological materials. Practices at existing ISR facilities demonstrate that historical monitoring programs for the workers' health and safety, and for the effluent and environmental monitoring, have been shown to be protective of workers' and public safety and the environment. The applicant has committed to similar practices as those that have been used at the existing ISR facilities.

The staff has reasonable assurance that the applicant will meet its commitments for preparing SOPs to address any release, and specifically any radiological release accident, prior to and during operations. The staff will review the applicant's SOPs as part of the required preoperational inspection to ensure compliance with its commitments. During operations, the staff will continue to review the SOPs through routine inspections as the applicant will be required to update the SOPs to reflect future conditions.

7.3.3 Groundwater Contamination

The applicant described plans for the prevention and mitigation of excursions using systems that include monitoring injection and production rates, maintaining the appropriate bleed rate, measuring water levels, and monitoring ground water quality by sampling for specific parameters (AUC, 2012). The applicant presented information on its operational controls in TR Sections 3.1, 3.2, and 3.3 and on its groundwater monitoring programs in TR Section 5.7.8 (AUC, 2012). SER Section 3.0 discusses the control systems in detail and the staff's analyses. SER Sections 2.4.3, 4.2.3, and 5.7.8.3 discuss the groundwater monitoring programs, control of excursions, and the staff's analyses.

In brief, the applicant will be required to maintain controls on fluid migration and several monitoring programs for the early detection of a release. The monitoring programs consist of a leak detection system for the onsite pond designed to detect a loss of integrity of the primary liner system before the integrity of the secondary liner is compromised. Another groundwater detection monitoring program will be performed at shallow monitoring wells surrounding the pond. This program will ensure that a release from the retention pond does not impact the environment or potentially affect the health and safety of workers or the public. Finally, the primary groundwater detection monitoring program is the excursion monitoring program, which requires semimonthly sampling of the groundwater quality at designated wells surrounding a wellfield. This program provides early detection of a potential release by measuring for the more highly mobile constituents in close proximity to a wellfield.

The staff has reviewed the applicant's proposed control systems and monitoring programs and finds them to be protective of the health and safety of workers and the public and protective of the environment because they are consistent with those used at existing facilities that have been shown to provide early detection of a release.

7.3.4 Wellfield Spills

The applicant stated that pond failure or rupture of an injection or recovery line in a wellfield or between a wellfield and the plant could contaminate the ground in the area of the break (AUC, 2012). SER Sections 3.1 and 4.2 discuss the applicant's designs of the wellfield infrastructure proposed to minimize the likelihood of this type of accident and the methodologies to detect leaks. The applicant stated that it will develop a response plan for wellfield spills that will include procedures for notification, spill containment and recovery, post-spill sampling and cleanup, and reporting.

The staff reviewed the commitments by the applicant to prepare a response plan, and finds that the information is adequate because it meets the requirements of 10 CFR Part 20 as it is consistent with current industry standard practices. Requirements of 10 CFR Part 20 include establishment of an adequate radiation safety protection program for the protection of public and worker's safety. The programs currently employed by existing ISR facilities have been shown to be protective of workers' and public health and safety and also promotes the ALARA principle and provides protection of the environment in the event of loss of integrity of nearsurface equipment.

The staff has reasonable assurance that the applicant will meet its commitments for preparing SOPs to address any release, and specifically any wellfield spills or releases, prior to and during operations. The staff will review the applicant's SOPs as part of the required preoperational inspection to ensure compliance with its commitments. During operations, the staff will continue to review the SOPs through routine inspections as the applicant will be required to update the SOPs to reflect future conditions.

As discussed in SER Section 3.1, the applicant will be required to document that environmental impacts resulting from wellfield spills meet the requirements of Criteria 6(6) and 6(7) of Appendix A in 10 CFR Part 40 prior to license termination.

7.3.5 Transportation Accidents

In TR Section 7.5.3 (AUC, 2012), the applicant considered the potential for transportation accidents involving shipments of ion exchange resins, yellowcake, chemicals, and radioactive wastes. The applicant identified several procedures and actions to prevent transportation accidents, including maintaining vehicles in good operating condition, using properly trained and licensed drivers, inspecting vehicles prior to shipment, and following the NRC and U.S. Department of Transportation hazardous materials shipping requirements (10 CFR Part 71, "Packaging and Transportation of Radioactive Material," and 49 CFR Part 173, "Shippers—General Requirements for Shipments and Packagings"). AUC committed to providing continuing training for local emergency personnel to include firefighters, police, and emergency medical technicians in the emergency response procedures. Moreover, AUC committed to implementing specific mitigation measures for shipment of yellowcake, uranium-loaded ion exchange resin, and radioactive wastes. AUC committed to perform all notifications, to prepare and submit incident and examination reports, and to assist with investigations and special studies following an incident or accident. AUC will perform a post-cleanup radiological survey of the affected area following an accident that results in a release of any hazardous materials to the environment, to ensure that any spill has been properly addressed (AUC, 2012).

The staff finds that the applicant's commitments to (1) follow transportation regulations pursuant to 49 CFR Parts 173 and NRC regulations in 10 CFR Part 71, (2) develop procedures that minimize and mitigate traffic accident consequences, and (3) adhere to response reporting requirements of 10 CFR 20.2202 and 20.2203 are consistent with the analyses conducted in NUREG-0706 and NUREG/CR-6733 and that the applicant has provided acceptable descriptions of accident response procedures and personnel training. Therefore, the staff finds the applicant's transportation program acceptable.

7.3.6 Fires and Explosions

The applicant discussed the potential for fires and explosions at the Proposed Project in TR Section 7.5.2 (AUC, 2012). The applicant stated that the hazard of fire or explosion is minimal, but committed to taking precautions to further reduce the risk. The applicant stated it will take preventative measures to ensure that chemicals do not inadvertently come into contact with each other. The applicant stated that it will locate the oxygen storage facility at a safe distance from the CPP and header house buildings to avoid damage to those buildings and operations. As stated earlier, the applicant stated that buildings will be adequately ventilated to reduce the opportunity for buildup of explosive gases in the buildings. AUC committed to ensuring that all employees will be trained on the proper procedures and evacuation plans in the event of a fire or explosion.

The staff reviewed the information provided by the applicant and finds it acceptable because the proposed handling and storage of the propane and oxygen on the Proposed Project follow the best management practices for an industrial setting at which similar materials are used.

7.3.7 Natural Events

In TR Section 7.5.3.8, the applicant concluded that the most significant risk from natural events at the Proposed Project is a tornado or earthquake that disperses yellowcake or causes failure of the chemical storage facilities (AUC, 2012). The probability of a tornado occurring at the site is low (in the range of about one per 10,000 to one in 1,000,000 years). AUC stated the peak acceleration would equate to a Level IV earthquake. A Level IV earthquake would be felt by almost everyone in the vicinity but would not cause significant damage (AUC, 2012). The applicant stated that the primary hazard associated with an earthquake at an ISR facility is from the rupture of hazardous chemical tanks and mixing of incompatible fluids. The applicant stated that it will have separate containment berms around storage tanks to reduce the risk of mixing incompatible chemicals in the event of a spill. Also, the applicant committed to locate tanks such that there is a low risk of a chemical reaction during an accident that follows a tank rupture (AUC, 2012). The applicant stated that SOPs, training, and personal protective equipment will be provided to personnel for response and mitigation of hazardous chemical spills.

The staff reviewed the information provided by the applicant and finds it acceptable because it is risk informed and reflects best management practices for such industrial facilities. The training for emergency responses includes procedures for situations that may arise, based on the facility design and planned operations, resulting from a natural event. Any release or spill involving radiological exposures will have to be reported and evaluated by the applicant pursuant to requirements in 10 CFR Part 20, regardless of whether the spill or release resulted from a manmade incident or natural events.

The applicant stated that it will develop emergency procedures to include notification of personnel of potential severe weather, evacuation procedures, damage inspection, and reporting. Notification of personnel of potential severe weather is not a requirement to meet an NRC regulation but a good management practice in order to be compliant with other regulations (e.g., regulations promulgated for the Emergency Planning and Community Right-to-Know Act of 1986, Title III. Pub. L. 99–499). In ER Section 3.10.3.6 (AUC, 2012), the applicant committed to developing the communication and emergency response plan cooperatively with local and State agency staff who will be responding to potential environmental, safety, and health emergencies at the Proposed Project. The staff included a license condition in SER Section 7.4 to memorialize this commitment.

7.4 Evaluation Findings

The staff reviewed potential accidents that could occur at the Proposed Project in accordance with the areas of review in SRP Section 7.5.1, review procedures in SRP Section 7.5.2, and acceptance criteria in SRP Section 7.5.3 (NRC, 2003). The applicant cited information in NUREG-0706 and NUREG/CR-6733 as the bases for its assessment of accident consequences at the Proposed Project. The staff concludes that these accident consequence analyses are applicable to the Proposed Project.

Based on its review of information provided in the application, the staff finds that the applicant's designs, plans, and training are acceptable because the applicant's emergency response program will:

- Address the hazards of chemicals to be used at the facility.
- Minimize the potential for accidents to happen.
- Provide procedures to mitigate the hazards that are protective of workers' and the public health and safety and the environment.
- Include training for the workers.
- Document the hazard analysis of the emergency.
- Provide proper notification to the Federal and State agencies.

The staff findings are based on the applicant's commitments to prepare such an emergency response program and license conditions requiring that the applicant prepare adequate SOPs for the emergency response program. The license conditions consist of those presented in SER Sections 3.1.4 and 5.2.4 and License Condition 12.2 was added memorializing the applicant's commitment to develop communication and emergency response plans cooperatively with local and State agencies responding to potential hazards at the Proposed Project. The licensee shall confirm that the coordination activity are completed prior to staff scheduling a pre-operational inspection.

Based upon the staff's review and the requirements of the license conditions, the staff finds that the applicant's emergency response program is in compliance with 10 CFR 40.32(c), which requires that the applicant's proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; Criteria 6(6) and 6(7) of Appendix A of 10 CFR Part 40, which specify standards for residual radiation and nonradiation hazards in the environmental media at license termination; 10 CFR 20.2202 and 10 CFR 20.2203, which specify NRC notification of an incident; and 10 CFR 20.1101, which specifies that a radiation protection program commensurate with the scope and extent of the licensed activities and sufficient to ensure compliance with 10 CFR Part 20 be developed, documented, and implemented.

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