Safety Evaluation Report
License Amendment for the Ludeman Project to the Willow Creek In Situ Recovery Project
Converse County, Wyoming

Materials License No. SUA-1341

Docket No. 040-08502

URANIUM ONE USA CORPORATION

March 2018

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LIST OF ACRONYMS AND ABBREVIATIONS

11e.(2) byproduct material	Tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within this definition.
^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
AoR	Area of Review
ACL	Alternative Concentration Limit
ALARA	As Low As Is Reasonably Achievable
ALI	Annual Limit On Intake
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ASQC	American Society for Quality Control
bgs	below ground surface
BLM	Bureau of Land Management
BPT	Best Practicable Technology
CAP	Corrective Action Program
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CO_2	carbon dioxide
cpm	counts per minute
CPP	Central Processing Plant
C_r	concentration of radionuclide, r, in air
DAC	Derived Air Concentration
DC	Dose Coefficient
DCF	Dose Conversion Factor
DC_r	Dose Conversion
DDE	Deep Dose Equivalent
DDW	Deep Disposal Well
DOT	Department of Transportation
dpm	disintegrations per minute
DQO	Data Quality Objectives
EA	Environmental Assessment
Eh	oxidation-reduction potential
EHS	Environment, Health, and Safety
EHSM	Environment, Health, and Safety Manager
ELI	Energy Laboratories, Incorporated
EPA	U.S. Environmental Protection Agency
ER	Environmental Report

FONSI	Finding of No Significant Impact
ft	feet
ft/d	feet per day
ft/s	feet per second
g	acceleration of gravity
GAA	Gross Alpha Activity
g/cm^3	grams per cubic centimeter
gpm	gallons per minute
GPS	Global Positioning System
GWS	Ground Water Sweep
hrs	hours
H	number of hours of exposure
HPIC	High-Pressure Ionization Chamber
HPT	Health Physics Technician
HV	High Velocity
i	exposure period, i
IBC	International Building Code
ICRP	International Commission on Radiological Protection
in	inch
I_r	annual intake of radionuclide r by inhalation
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
m	meter
m^2	square meter
m^3	cubic meter
m^3/hr	cubic meter per hour
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
MDC	Minimum Detectable Contamination
mg	milligram
mg/l	milligram per liter

mi	mile
mi^2	square miles
mins	minutes
MIT	Mechanical Integrity Test
mm	millimeter
MOU	Memorandum of Understanding
mR/hr	milliRoengtens per hour
mrem	millirem
mrem/yr	millirem per year
msl	mean sea level
mSv	milliSievert
MT	metric ton
n	number of exposure periods n, in the year
NA	Not Applicable
$NaHCO_3$	sodium bicarbonate
NaI	sodium iodide
NELAC	National Environmental Laboratory Accreditation Conference
NEPA	National Environmental Protection Act
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NVLAP	National Voluntary Laboratory Accreditation
NWS	National Weather Service
OSHA	U.S. Occupational Safety and Health Administration
Pb-210	lead-210
pCi/l	picocuries per liter
person-rem/yr	person-rem per year
Po-210	polonium-210
PM_{10}	particulate matter less than ten micrometers
ppm	parts per million
PRB	Powder River Basin
psi	pounds per square inch
PV	Pore Volume
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
Ra-226	radiium-226
Ra-228	radium-228
RAI	Request For Additional Information
rem	Roentgen equivalent man
RG	Regulatory Guide
Rn-222	radon-222
RO	Reverse Osmosis
RTV	Restoration Target Value
RWP	Radiation Work Permit

SCS	Soil Conservation Service
SEIS	Supplemental Environmental Impact Assessment
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SHPO	State Historic Preservation Office
SM	Source Material
SOP	Standard Operating Procedure
Sv	Sievert
Sv/Bq	Sievert per Becquerel
TAC	Technical Assignment Control
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
UCL	Upper Control Limit
UIC	Underground Injection Control
µg	microgram
U-nat	natural uranium
U_3O_8	Uranium oxide
UPS	Uninterruptible power supply
Ur-E	Ur-Energy USA, Inc.
URPA	Ur-Energy Passive Air
US	United States
USDW	Underground Source of Drinking Water
USGS	United States Geological Survey
WDEQ	Wyoming Department of Environmental Quality
WPDES	Wyoming Pollution Discharge Elimination System
WQD	Water Quality Division
WSEO	Wyoming State Engineers Office
wt	weight
x	number of radionuclides of interest

INTRODUCTION

On December 3, 2011, Uranium One Americas submitted to the U.S. Nuclear Regulatory Commission (NRC) a request to amend its Willow Creek Project Source Material License SUA-1341 to authorize construction and operation of the Ludeman Project In Situ Recovery (ISR) expansion at a separate location in Converse County, Wyoming (Uranium One Americas 2011b). Uranium One Americas application for the Ludeman satellite facility consisted of a technical report and an environmental report (Uranium One Americas 2011b). The licensee provided information to supplement the technical report on March 16, 2012 (Uranium One Americas 2012a), March 20, 2012 (Uranium One Americas 2012b), March 30, 2012 (Uranium One Americas 2012c) and May 1, 2012 (Uranium One Americas 2012d). The licensee submitted a "change of design" request in April 2013 (Uranium One Americas 2013a). This "change of design" reduced the number of satellite facilities from three to one in addition to other substantive changes.

In the December 3, 2011, application, the licensee stated the technical report and environmental report for the Ludeman Project were prepared by Uranium One Americas, Inc., which is a Nevada corporation (Uranium One Americas 2011b). The licensee, however, requested the Ludeman Project be an amendment to their Uranium One USA Willow Creek Project License, SUA-1341. The NRC staff determined that Uranium One Americas, Inc. is owned by Uranium One Investments, Inc., which is a Canadian Corporation. Uranium One, Inc. is the parent company of Uranium One Investments, Inc. The NRC staff found, therefore, that the licensee did not demonstrate that the amendment request was being made by Uranium One USA, Inc. The NRC staff therefore requested the licensee demonstrate all assets related to the request were in the name of Uranium One USA, Inc. to enable the NRC staff to accept and issue the Ludeman amendment to the correct corporate entity. The licensee complied with this request in a letter dated March 13, 2014 (Uranium One USA 2014a). The NRC staff informed the licensee that it had satisfactorily addressed the issue in a letter dated April 8, 2014 (NRC 2014a).

The NRC staff issued its requests for additional information (RAI) on January 15, 2013, for the Ludeman Project safety review (NRC 2013a). The licensee provided two separate submissions to address the safety RAIs in June 2013 (Uranium One Americas 2013b) and November 2013 (Uranium One Americas 2013c). NRC staff review of the RAI responses submitted in June 2013 and November 2013 found missing responses and several deficiencies. The NRC staff therefore issued a second round of targeted RAIs (NRC 2014b). The licensee provided additional submittals to address these targeted RAIs in June 2015 (Uranium One USA 2015a, 2015b). The NRC and Uranium One USA held public meetings on February 8, 2016 (NRC 2016c) and February 22, 2017 (NRC 2017a) to discuss numerous unresolved open issues for the safety and environmental review. The licensee provided responses to the open issues raised in the February 8, 2016, meeting in several submissions (Uranium One USA 2016a; 2016b; 2016c; 2016d). The licensee provided responses to the open issues raised in the February 22, 2017, meeting in additional submissions (Uranium One USA 2017a; 2017b; 2017c).

The licensee submitted a revised technical report on June 28, 2017 (Uranium One USA 2017d) incorporating the major revisions to the original technical report based on the April 2013 "change of design" request April , and responses to RAIs and open issues. The licensee also submitted a revised environmental report on August 25, 2017 (Uranium One USA 2017e) incorporating the major revisions to the original technical report based on the April 2013 "change of design" request, and responses to RAIs and open issues. The revised technical and environmental reports and additional submissions provide the final basis for the staff's review.

The Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. The NRC must license facilities, including ISR operations, in accordance with NRC regulatory requirements to protect public health and safety from radiological hazards. In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) part 40.45, the Commission will apply the applicable criteria set forth in 10 CFR 40.32 in considering an application by a licensee to renew or amend his license. In accordance with 10 CFR 40.32, "General Requirements for Issuance of Specific Licenses," the NRC is required to make the following safety findings when amending an ISR license:

- The application is for a purpose authorized by the Atomic Energy Act.

- The licensee 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 licensee's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property.

- The issuance of the license amendment will not be inimical to the common defense and security or to the health and safety of the public.

This safety evaluation report (SER) documents the safety portion of the staff's evaluation of the Uranium One USA Ludeman Project amendment request, and includes an analysis to determine the licensee's compliance with these and other applicable 10 CFR Part 40 requirements, and applicable requirements set forth in 10 CFR Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content." This SER also evaluates the licensee's compliance with applicable requirements in 10 CFR Part 20, "Standards for Protection against Radiation."

The staff performed its safety evaluation of the proposed license amendment request to the existing Willow Creek Project Source Material License SUA-1341 (NRC 2016d) using NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications" (NRC 2003) (referred to hereafter as the SRP). As described in detail in Appendix A of this SER, the NRC staff concludes that the Willow Creek Project has been operated so as to protect health and safety and the environment and has identified no new safety-related concerns since the last license renewal (NRC 2013b). Therefore, the NRC staff has determined, in accordance with Appendix A, "Guidance for Reviewing Historical Aspects of Site Performance for License Renewals and Amendments," of the SRP, that only those parts of the Ludeman Project which are new, updated or changed, or introduce new safety-related concerns which were not reviewed in the previously-approved Willow Creek Project (NRC 2013b), should be reviewed using the appropriate sections of the standard review plan.

The review is a comprehensive assessment of the licensee's proposed license amendment request to include operations at the Ludeman Project in its Willow Creek Project. The regulations at 10 CFR Part 20 and Part 40, and those in Appendix A to 10 CFR Part 40, contain the technical requirements for licensing an ISR project. This SER is presented according to the organization of the SRP, except that sections addressing environmental aspects are not

included in the SER because they will be addressed in the Ludeman Project environmental assessment (EA) prepared for the Ludeman Project amendment request.

The staff's evaluation of the Ludeman Project amendment request, composed of the revised technical and environmental report and additional submissions, identified facility-specific issues that require either new or revised license conditions to ensure that the operation of the facility will be adequately protective of public health and safety. SER Table 1.1-1 includes the new or revised license conditions as well as the section of this SER where the need for the new or revised license condition is described. The staff concludes that the findings described in succeeding sections of this SER, including the necessary license conditions, support the issuance of an amended license authorizing licensed activities in the Ludeman Project. The staff supports the issuance of an amended license authorizing the construction and operation of the Ludeman Project facilities, provided that the new or revised conditions identified in SER Table 1.1-1 below are included in the license.

Table 1.1-1 New or Modified License Conditions, Source Material License SUA-1341 (NRC 2016a)
(new text in under-lined; removed text struck out)

License Condition Number	SER Section	License Condition
9.1	1.4	The authorized place of use shall be the licensee's Willow Creek Project comprised of the ~~both~~ Irigaray, ~~and~~ Christensen Ranch, and Ludeman Project, in Johnson, ~~and~~ Campbell, and Converse Counties, Wyoming.

9.3	1.4	The licensee shall conduct operations in accordance with the commitments, representations, and statements contained in the following: • License Renewal Application (LRA), May 30, 2008, NRC Agencywide Documents Access and Management System (ADAMS) Accession Package Number ML081850689 • LRA Revision, October 31, 2008, ADAMS Accession Number ML083110405 • LRA Revision, July 17, 2009, ADAMS Accession Package Number ML092110700 • LRA Revision, November 19, 2010, ADAMS Accession Number ML103280266. • LRA Revision, March 7, 2012, ADAMS Accession Package Number ML120820095. • LRA Revision, July 10, 2012, ADAMS Accession Number ML12206A436. • Response to Confirmatory Action Letter, September 21, 2012, ADAMS Accession Number ML12268A270. The redrying of dried Honeymoon, Australia yellowcake as documented in NRC Safety Evaluation Report (ADAMS Accession Number ML14212A154) is not subject to the 4.5 hour dryer retention time commitment by the licensee in Response to Confirmatory Action Letter, September 21, 2012, ADAMS Accession Number ML12268A270. • Amendment Request to Redry Dried Honeymoon, Australia yellowcake, February 28, 2014 (ML14066A112), March 27, 2014 (ML14113A421), June 28, 2014 (ML14192B247) August 26, 2014 (ML14240A045), September 9, 2014 (ML14253A026) and October 2, 2014 (ML14275A443). • Letters dated August 4, 2014 (ML14309A456) and January 11, 2018 (ML18016A578), regarding responses to License Conditions 9.8 and 9.12. • Letters dated September 25, 2013 (ML13273A017), January 20, 2015 (ML15040A077), June 5, 2015 (ML15181A357), and April 17, 2017 (ML17111A981) regarding responses to License Condition 11.3. • Letters dated May 30, 2014 (ML14153A103), April 17, 2017 (ML17111A945), and July 6, 2017 (ML17192A093), regarding responses to License Condition 11.9. • Ludeman Project License Amendment Request, December 3, 2011 (ML 12010A178, ML120120182), Ludeman Project Revised Technical Report, June 28, 2017 (ML17192A357); Ludeman Project Revised Environmental Report, August 25, 2017 (ML17261A460). The documents listed in this section are hereby incorporated by reference except where superseded by license conditions below. The land and structures will be decommissioned according to the Decommissioning Plan submitted December 19, 2000 (ADAMS Accession No. ML003781238), as revised by submittals dated June

License Condition Number	SER Section	License Condition
		15, 2001 (ADAMS Accession No. ML011700655), June 18, 2001 (ADAMS Accession No. ML011710035), and August 31, 2001 (ADAMS Accession No. ML012490112) and in accordance with 10 CFR 40.42. Whenever the word "will" or “shall” is used in the above referenced documents, it shall denote a requirement. [Applicable Amendments: 3, 6]
9.6		Written standard operating procedures (SOPs) shall be established and followed for all operational process activities involving radioactive materials that are handled, processed, stored, or transported by the licensee at or between the Irigaray, Christensen Ranch, and Ludeman Project. SOPs for operational activities shall enumerate pertinent radiation safety practices to be followed in accordance with 10 CFR Part 20. Additionally, written procedures shall be established and followed for non-operational activities to include in-plant and environmental monitoring, bioassay analyses, and instrument calibrations. An approved, up-to-date copy of each written procedure shall be kept in specified locations in the process area to which it applies. All written procedures for both operational and non-operational activities shall be reviewed and approved in writing by the RSO before implementation and whenever a change in a procedure is proposed to ensure that proper radiation protection principles are being applied. Additionally, the RSO shall perform a documented review of all operating procedures at least annually.

License Condition Number	SER Section	License Condition
9.7	4.2.4	The licensee shall dispose of Atomic Energy Act, as amended (AEA), Section 11e. (2) byproduct material, including evaporation pond residues, from the Willow Creek~~Irigaray and Christensen Ranch~~ and Ludeman Project ~~Satellite facilities~~ at a site licensed by the NRC or an NRC Agreement State to receive AEA 11e. (2) byproduct material. The licensee shall identify the disposal facility to the NRC in writing. The licensee's approved waste disposal agreement must be maintained onsite. In the event the agreement expires or is terminated, the licensee shall notify the NRC in writing, in accordance with License Condition 9.2, within 7 days after the date of expiration or termination. A new agreement shall be submitted for NRC approval within 90 days after expiration or termination, or the licensee will be prohibited from further lixiviant injection. If the licensee is not able to secure this agreement, then the licensee must increase the surety to include disposal at a commercial AEA 11e. (2) disposal facility.

9.8	5.7.6	Release of surface contaminated equipment, materials, or packages for unrestricted use ~~from restricted areas~~ shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993 (ADAMS Accession No. ML003745526) (the Guidelines) or suitable alternative procedures approved by NRC prior to any such release. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides shall apply independently. Personnel performing contamination surveys for items released for unrestricted use shall meet the qualifications as health physics technicians or radiation safety officer as defined in Regulatory Guide 8.31 (as revised). Personal effects (e.g., notebooks and flash lights) which are hand carried need not be subjected to the qualified individual survey or evaluation, but these items should be subjected to the same survey requirements as the individual possessing the items. Regulatory Guide 8.30 (as revised), Table 2, shall apply to the removal of equipment, materials, or packages that have the potential for accessible radiological surface contamination levels above background to unrestricted areas within the licensed boundary. ~~The licensee shall submit to the NRC for review and written verification a contamination control program within 90 days of license renewal. The program shall provide sufficient detail to demonstrate how the licensee will maintain control over the equipment, materials, or packages that have the potential for accessible radiological surface contamination levels above background, until they have been released for unrestricted use as specified in the Guidelines, and what methods will be used to limit the spread of contamination to unrestricted areas. The contamination control program shall demonstrate how the licensee will limit the spread of contamination when moving or transporting potentially contaminated equipment, materials, or packages (i.e. pumps, valves, piping, filters, etc.) from wellfield areas (restricted or controlled areas) through uncontrolled areas. The licensee shall receive written verification of the licensee's contamination control program prior to its implementation.~~ The licensee may identify a qualified designee(s) to perform surveys, as needed, associated with the licensee's contamination control program when moving or transporting potentially contaminated equipment, materials, or packages from restricted or controlled areas through uncontrolled areas and back into controlled or restricted areas. The qualified designee(s) shall have completed education, training, and experience, in addition to general radiation worker training, as specified by

License Condition Number	SER Section	License Condition
		the licensee. The education, training, and experience required by the licensee for qualified designees shall be submitted to the NRC for review and written verification. The licensee shall receive written verification of the licensees qualified designee(s) training program prior to its implementation.
9.10	App. B	~~The licensee shall maintain restricted area boundaries at the Irigaray and Christensen Ranch and Ludeman Project satellite facilities as described in Section 5.8.1 of the approved license application. Additionally, the Irigaray and Christensen Ranch well field buildings shall be restricted, if required, based on the results of radiological surveys.~~
9.11	5.0	The licensee is hereby exempted from the requirements of Section 20.1902(e) of 10 CFR 20 for licensed areas within the Willow Creek Project and Ludeman Project ~~Irigaray and Christensen Ranch and Ludeman Project satellite facilities~~, provided that all entrances to the facility are conspicuously posted in accordance with Section 20.1902(e) and with the words, **"ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."**

License Condition Number	SER Section	License Condition
9.12	5.7.2	The RSO shall have the health physics authorities, responsibilities, and technical qualifications identified in Regulatory Guide 8.31, as revised. Health Physics Technicians or Radiation Safety Technicians should have qualifications that are equal or equivalent to those specified in Regulatory Guide 8.31, as revised. The licensee shall follow the guidance set forth in Regulatory Guide 8.30, as revised, "Health Physics Surveys in Uranium Recovery Facilities," or NRC-approved equivalent with the following exception: ~~Within 90 days of license renewal, the licensee will develop an SOP and specific training for p~~Personnel that do not meet the qualifications of RSO or Health Physics Technician, as defined in Regulatory Guide 8.31, as revised, that are designated to survey resin trucks leaving a restricted area and traveling to another restricted area authorized by the license shall meet the qualification requirements described in correspondence dated August 4, 2014 (ML14309A456) and January 11, 2018 (ML18016A578). ~~The SOP and training shall be submitted to the NRC for review and verification.~~ The licensee shall follow the guidance set forth in Regulatory Guide 8.31, as revised, or NRC-approved equivalent with the following exception: Personnel that do not meet the qualifications of RSO or Health Physics Technician, as defined in Regulatory Guide 8.31, as revised, that are designated to perform daily visual inspections shall meet the qualification requirements described in correspondence dated August 4, 2014 (ML14309A456) and January 11, 2018 (ML18016A578) . ~~The licensee shall describe in an SOP the training provided and procedures used by the RSO designate to conduct daily inspections in the temporary absence of the RSO or Radiation Safety Technician. The SOP for the conduct of daily inspections and training requirements shall be submitted to the NRC for review and written verification. Weekly inspections shall be performed by the RSO and follow the recommendations of Regulatory Guide 8.31, as revised. The licensee shall describe in an SOP the procedures used to conduct weekly inspections in the temporary absence of the RSO. The SOP for the conduct of weekly inspections shall be submitted to the NRC for review and written verification.~~

License Condition Number	SER Section	License Condition
9.15	2.2.4	~~The licensee shall review and compare the data collected from a regional weather station during the same period as the onsite meteorological data collected to the long-term data collected from the same regional weather station. The licensee shall determine if the data collected onsite is representative of long-term conditions. Justification of the similarity or validity of the data will include analysis of the statistical data presented to illustrate confidence in the representativeness of the data. The meteorological data will include wind speed, wind direction, an annual wind rose, and a summary of the stability classification. The licensee shall submit this review and comparison to NRC within 6 months of license renewal for NRC review and written verification that the onsite meteorological parameters previously collected will allow the licensee to demonstrate compliance with regulatory requirements of 10 CFR Part 20.~~
10.1	3.1.4	For the Willow Creek and Ludeman Project, the licensee shall use a lixiviant composed of native ground water, with added sodium bicarbonate and/or CO2 gas and oxygen or hydrogen peroxide, as described in the approved license application and Section 3.1.4.1 of the Ludeman Project Revised Technical Report. The licensee shall maintain an inward hydraulic gradient by maintaining a bleed in each individual wellfield starting when lixiviant is first injected into the production zone and continuing until the ground water restoration stability monitoring has begun.

License Condition Number	SER Section	License Condition
10.2	3.1.4	The licensee shall construct all wells in accordance with methods described in Section 3.3.2 of the approved license application. The licensee shall perform well integrity tests on each injection and production well before the wells are utilized and on wells that have been serviced with equipment or procedures that could damage the well casing. Additionally, each well shall be retested at least once every five years. Integrity tests shall be performed in accordance with Section 3.3.2.2 of the approved license application for the Willow Creek Project and Section 3.1.3.4 of the Ludeman Project Revised Technical Report. Any failed well casing that cannot be repaired to pass the integrity test shall be appropriately plugged and abandoned, using procedures set out in Section 3.3.2 of the approved license application. Mechanical integrity testing is required prior to returning to service any injection well suspected of having subsurface damage due to unusual operating conditions or unusual natural phenomenon.

10.3	5.7.8.4	The licensee shall establish pre-operational baseline water quality data for all production units. Baseline water quality sampling shall provide representative pre-mining ground water quality data and restoration criteria as described in the approved license application and Ludeman Project Revised Technical Report. The data shall be from wells established in the mining zone, the mining zone perimeter, the upper aquifer and the lower aquifer where present, with spacing and locations as specified in the approved license application. The data shall, at a minimum, consist of the sample analyses shown in Table 5.24 of Section 5.8.2.2 of the approved LRA, and Section 5.7.7.2 of the Ludeman Project Revised Technical Report unless superseded by this license condition. The wells used for obtaining baseline ground water quality in current and future production areas shall be established at the following minimal density: Monitored Unit — Density Ore Zone Monitors — All Ore Zone Baseline (restoration) — 1 well per 3 acres of pattern area Shallow Zone Monitors — 1 well per 4 acres of pattern area Deep Zone Monitors (where zone present) — 1 well per 4 acres of pattern area Baseline ground water quality in previously approved production areas shall be the mean data values (well field average) from the following submittals: Christensen Ranch Unit 3 and Module 2 expansion — December 1, 1988 (Table 2) Unit 3 expansion and Module 4A expansion — August 8, 1991 (Table 6) Unit 2 south portion — November 27, 1992 (Table 2) Unit 2 north portion — April 16, 1992 (Table 2) Unit 4 — April 1, 1994 (Table 6) Unit 5 — February 28, 1995 (Table 7) Four samples shall be collected and analyzed for Assay Suite A from each monitor well to establish baseline water quality parameters including the ore zone perimeter, overlying and underlying monitor wells, and mine unit baseline wells. Consecutive sampling events shall be at least 14 calendar days apart. The third and fourth sample events may be analyzed for a reduced list of

License Condition Number	SER Section	License Condition
		parameters. The parameters that may be deleted from the third and fourth sampling events are those that are below the minimum analytical detection limits during the first and second sampling events.
10.4	5.7.8.4	Prior to mining in each production unit or Ludeman Project wellfield, the licensee shall collect ground water samples and establish Upper Control Limits (UCLs) in accordance with Section 5.8 of the approved license application or Section 5.7.7.2 of the Ludeman Project Revised Technical Report, respectively. UCLs shall be applied to all monitor wells (with the exception of the mine unit baseline wells) in conformance with the approved license application and appropriate SOPs. The UCL parameters shall be chloride, conductivity, and total alkalinity. UCLs for monitor wells established prior to the issuance of the Performance Based License Condition (PBLC) in December 1996, are provided in Table 5.26 for the Irigaray site and Table 5.27 for the Christensen Ranch site in Section 5.8 of the 1998 approved license application.
10.5	3.1.4	The licensee is authorized to conduct operations at the Willow Creek and Ludeman Project at a maximum flow rate of 9000 gallons per minute, each, exclusive of restoration flow. Annual dried yellow cake production shall not exceed 2.5 million pounds.

License Condition Number	SER Section	License Condition
10.7	4.2.4	All liquid effluents from process buildings and other process waste streams, with the exception of sanitary wastes, shall be returned to the process circuit, discharged to the solution evaporation ponds, or disposed of as allowed by NRC regulations. Additionally, the licensee is authorized to dispose of process solutions, injection bleed, and restoration brine in the following wells: Christensen Ranch DW No.1 Christensen Ranch 18-3 Christensen Ranch DW No. 2 Christensen Ranch DW No. 3 The licensee shall maintain a record of the volumes of solution disposed in these wells and submit this information in the annual monitoring report. <u>For the Ludeman Project, all liquid effluents from process buildings or other process waste circuits, with the exception of sanitary wastes, may be disposed of in the evaporation pond or deep disposal wells. Permeate from reverse osmosis of fluids from wellfields in restoration may be disposed of in the permeate pond.</u>

License Condition Number	SER Section	License Condition
10.15	6.1.4	The licensee shall conduct ground water restoration and post-restoration monitoring as described in Section 6.1 of the approved license application and Section 6.1 of the Ludeman Project Revised Technical Report**.** The primary goal of restoration shall be to return the ground water quality, on a production-unit average, to baseline concentrations on a parameter-by-parameter basis. If the primary goal cannot be achieved, the ground water will, at a minimum, be returned to an alternate standard approved by the NRC. In submitting any license amendment application requesting review of proposed alternate concentration limits pursuant to 10 CFR 40, Appendix A, Criterion 5(B)(6), the licensee must also show that it has first made practicable efforts to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater). For the Willow Creek Project and the Ludeman Project, the licensee shall conduct four rounds of sampling of all WDEQ-LQD Guideline 8, Assay Suite A constituents during stabilization monitoring, with each well sample being at least three months apart. The applicant shall continue the stability monitoring until the data show the most recent four consecutive samples indicate no statistically significant increasing trend for individual constituents which would lead to an exceedance above the approved target restoration values. Changes to ground water restoration or post-restoration monitoring plans shall be submitted to the NRC for review and approval at least 2 months prior to ground water restoration in a mining unit or Ludeman Project wellfield. The licensee shall conduct ground water restoration activities in accordance with the approved LRA application and Section 6.1 of the Ludeman Project Revised Technical Report for Ludeman Project wellfields. Permanent cessation of lixiviant injection in a production area would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of ground water restoration and decommissioning for any particular production area. If the licensee determines that these activities are expected to exceed 24 months for any particular production area, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42.
10.17	App. B	~~The licensee shall implement the respiratory protection program, as described in the approved LRA.~~

License Condition Number	SER Section	License Condition
10.22	3.1.4	The licensee will not construct or conduct uranium recovery operations within Wellfield 2 of the Ludeman Project.
10.23	3.1.4	The licensee will not install any wells or wellfield infrastructure in Ludeman Project Wellfield 5 within the boundary of the surface water impoundment located in Section 28 of T34N R73W as shown in Figure 2.7A-1 of Addendum 2.7-A of the Ludeman Project Revised Technical Report.
10.24	4.2.4	The licensee will install three downgradient and one upgradient ground water monitoring wells in the 110 sand aquifer at both the evaporation and permeate ponds shown in Figure 1 of Addendum 4-A of the Ludeman Project Revised Technical Report. The monitoring wells will be completed at a depth sufficient to obtain ground water adequate to monitor and to meet the requirements in License Conditions 10.4 and 11.2 with the exception that the licensee will monitor the wells at least quarterly. If an excursion is verified the licensee will not be required to implement immediate corrective actions, but will inform the NRC in 60 days of the actions it will take to determine if the excursion is associated with leaks from the evaporation or permeate ponds.
10.25	5.7.8.4	The licensee will install guard monitoring wells in Wellfield 1 as described in Addendum 4-B of the Ludeman Project Revised Environmental Report and meet the requirements in License Conditions 10.3, 10.4 and 11.2 for these wells.
10.26	5.7.8.4	The licensee will plug and abandon all private wells within production zone aquifer of a Ludeman Project wellfield within 500 feet of the perimeter excursion monitoring well ring before injection of lixiviant in that wellfield production zone aquifer.

License Condition Number	SER Section	License Condition
10.27	6.2.3	At least 12 months prior to initiation of any planned final site decommissioning, reclamation, or ground water restoration at the Ludeman Project, the licensee shall submit a detailed decommissioning plan for NRC staff review and approval. The plan shall represent as-built conditions at the Ludeman Project.
10.28	4.2.4	The licensee will not dispose of permeate pond water at the Ludeman Project as liquid effluent until it provides, for NRC review and approval, information to demonstrate that the dose limits for individual members of the public in 10 CFR 20.1301 will be met.

11.3	5.7.7	~~The licensee shall conduct effluent, personnel, and environmental monitoring programs in accordance with Sections 5.7 and 5.8 of the approved license application.~~ The licensee shall conduct airborne samples for natural uranium, Ra-226, Po-210, Th- 230 and Pb-210 at each in-plant air particulate sampling location at a frequency of once every 6 months for 2 years, and annually thereafter, to ensure compliance with 10 CFR 20.1204. The licensee shall also evaluate changes to plant operations to determine if more frequent radionuclide analyses are required to demonstrate compliance with 10 CFR 20.1204. ~~The licensee may demonstrate compliance or provide alternative procedures specific to in-plant air particulate sampling to show compliance with 10 CFR 20.1204 to the NRC for review and verification within 6 months of license renewal.~~ In its annual public dose calculations in accordance with 10 CFR 20.1302, the licensee shall evaluate public dose at the Ludeman Project using airborne sample results for natural uranium, radium-226, polonium-210, and lead-210 determined at the Irigaray location. ~~The licensee shall conduct airborne samples for natural uranium, Ra-226, Po-210, and Pb-210 at each Christensen Ranch environmental monitoring location at a frequency of once every 6 months for 2 years, and annually thereafter, to ensure compliance with 10 CFR 20.1301. The licensee shall also evaluate changes to plant operations to determine if more frequent radionuclide analyses are required to demonstrate compliance with 10 CFR Part 20.1301. The licensee may demonstrate compliance or provide alternative procedures specific to environmental monitoring for natural uranium, Ra-226, Po-210, and Pb-210 to show compliance with 10 CFR 20.1301 to the NRC for review and verification within 6 months of license renewal.~~ ~~The licensee shall describe how the environmental monitoring program demonstrates that 10 CFR Part 20 public dose limits in controlled and unrestricted areas are met. The documentation of the areas designated as restricted, controlled and unrestricted areas and the environmental monitoring station locations shall be updated periodically, as needed.~~ ~~The licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall develop written procedures, that shall be submitted to NRC for verification prior to implementation, to:~~ ~~a. Discuss, in accordance with 10 CFR 40.65, how the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.~~

License Condition Number	SER Section	License Condition
		~~b. Evaluate, consistent with 10 CFR 20.1301 and 10 CFR 20.1302, the highest exposures likely for member(s) of the public from licensee operations.~~ ~~c. Discuss how radon progeny (radon-222) will be factored into the determination of potential public dose from the licensee's operations consistent with 10 CFR Part 20, Appendix B, Table 2.~~ ~~d. Discuss, in accordance with 10 CFR Part 20.1501, how the occupational dose (gaseous and particulate) received throughout the entire license area from licensee operations will be accounted for, and verified by surveys and/or monitoring.~~
11.4	4.2.4	The licensee shall perform and document weekly visual inspections of the Irigaray and Christensen Ranch and Ludeman Project Satellite evaporation/permeate pond embankments, fences and liners, as well as measurements of pond freeboard and checks of the leak detection system. Any time 6 vertical inches or more of fluid is detected in the leak detection system standpipes, it shall be analyzed for chloride, conductivity, pH and uranium. If analyses indicate that the pond is leaking, the licensee shall lower the pond fluid level by transferring its contents to an alternate cell, and undertake repairs, as needed. If standpipe water exists, quality samples shall be analyzed for the above parameters weekly during the leak period and for at least 2 weeks following repairs. 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.

License Condition Number	SER Section	License Condition
11.7	App. B	~~The licensee shall monitor for external exposure in accordance with 10 CFR 20.1502(a) (1), and Section 5.7.2 of the approved license application. The licensee shall monitor for internal exposure in accordance with 10 CFR 20.1502(b) (1) and Section 5.7.3 of the approved license application.~~ The licensee shall conduct surveys in accordance with 10 CFR 20.1501 in header houses to evaluate the magnitude and extent of radiation levels and to determine potential radiological hazards present.
11.8	5.7.8.4	The licensee shall identify the location of any new ground water wells or new use of existing wells, where the information is publicly available and/or known to the licensee, that are located within the license area and within 2 kilometers of any Willow Creek production area or Ludeman Project wellfield monitoring ring wells. The licensee shall also report publicly available information such as well depth, screen depth and estimated pumping rate. The licensee shall evaluate the impact of ISR operations on ground water wells and recommend any additional monitoring or other measures to protect ground water users. The evaluation shall be submitted as part of the annual reporting to the NRC.
11.9	5.7.6	~~The licensee shall provide for NRC review the surface contamination detection capability (minimum detectable concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of disintegrations per minute per 100 cm_2.~~ ~~The licensee shall revise the applicable radiation safety training program to specify when alpha and beta contamination surveys are required to be conducted for personnel, equipment, and materials leaving a restricted area~~

1.0 PROPOSED ACTIVITIES

In this section, the NRC staff evaluates the licensee's description of the proposed activities for which it requested a license amendment for the Ludeman ISR Project. The purpose of the NRC staff's evaluation was to gain a basic understanding of those proposed activities and the likely consequences of any safety or environmental impact. In accordance with acceptance criteria in SRP Section 1.3 (NRC 2003), the staff reviewed the corporate entities involved; the location of the proposed activities; land ownership; ore-body locations and estimated uranium (U_3O_8) content; proposed solution extraction method and recovery processes; operating plans, design throughput and anticipated annual U_3O_8 production; estimated schedules for construction, startup, and duration of operations; plans for project liquid and solid waste management and disposal; plans for ground-water quality restoration, decommissioning, and land reclamation; and surety arrangements covering eventual facility decommissioning, ground-water quality restoration, and site reclamation.

1.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that its description of the proposed activities at the Ludeman Project is in compliance with the applicable requirements in 10 CFR 40.31 which provides the general requirements for issuance of a specific license.

1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR 40.31 using the acceptance criteria presented in SRP Section 1.3 (NRC 2003).

1.3 Staff Review and Analysis

The licensee submitted its original license amendment request including the Ludeman Project technical and environmental reports on December 3, 2011 (Uranium One Americas 2011b). The licensee submitted the Ludeman Project Revised Technical Report (Uranium One USA 2017d) on June 28, 2017, incorporating the major revisions to the original technical report based on an April 2013 "change of design" request (Uranium One USA 2013a), responses to RAIs and open issues. The licensee also submitted the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) on August 25, 2017, incorporating the major revisions to the original environmental report based on the April 2013 "change of design" request, and responses to RAIs and open issues.

The Ludeman Project amendment request (Uranium One Americas 2011b), Revised Technical Report (Uranium One USA 2017d) and Revised Environmental Report (Uranium One USA 2017e) and other submissions provide the final basis for the staff's review. The NRC will revise License Condition 9.3 of the Willow Creek Source Material License SUA-1341 as described in SER Section 1.4 and shown in SER Table 1.1-1 to include the license amendment request revised technical report, revised environmental report and other licensee documents that provide the tie-down to commitments, representations, and statements made by the licensee and upon which the NRC relies for this license amendment.

In this request, the licensee, Uranium One USA, proposes to amend its license for the Willow Creek facility, SUA-1341, to include the Ludeman Project satellite ISR facility in Converse County, Wyoming.

The licensee described the main features of the Ludeman Project in Section 1.0 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The satellite facility will consist of a satellite building with IX and ground water restoration circuit, onsite laboratory, office and maintenance building, chemical storage, and equipment storage. The primary option for 11 e.(2) byproduct liquid waste disposal will be in an evaporation pond and a permeate pond located at the satellite facility. In the first alternative for liquid waste disposal, up to six Class I deep disposal wells (DDW) may be installed if needed. In the second alternative for liquid waste disposal, only surge ponds will be installed with up to six DDWs. In situ recovery will be conducted in a series of sequentially developed wellfields with Class III injection and recovery wells. The wellfields will include horizontal and vertical excursion monitoring wells for the detection of excursions.

The licensee described the history of exploration for and evaluation of uranium deposits within the Ludeman Project license area in Section 1.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that regions within the license area were identified as having significant uranium resources as a result of investigations in the late 1970s through the early 1980s. The NRC staff review confirmed uranium exploration and research and development activities have been conducted within Ludeman Project proposed license area including widespread exploratory drilling and hydrologic pumping tests, and the licensing of three ISR pilot projects. The ISR pilot projects licensed by the NRC were the Teton, Inc. Leuenberger site (SUA-1373), Uranium Resources, Inc. North Platte site (SUA-1400) and Arizona Public Services, Inc. Peterson site (SUA-1386). The Leuenberger and North Platte pilot sites were operated, restored and decommissioned in the 1980s and 1990s (NRC 1986; NRC 1991). The Peterson pilot site license was terminated before operation (NRC 1998).

The licensee described the project location and surface and mineral ownership in Sections 1.4 and 1.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The Ludeman Project is located in the southern portion of the Powder River Basin (PRB) in Converse County, Wyoming, approximately 10 miles northeast of Glenrock, Wyoming. The location of Converse County in Wyoming and the boundary of the Ludeman Project is shown in SER Figure 1.3-1. Within the boundary, the Ludeman Project is composed of approximately 7,636 hectares [ha] (18,861 acres [ac]) of privately owned land. All federally owned lands within the boundary are specifically excluded. The licensee stated that access to the site is provided from State Highways 93 and 95. The NRC staff conducted a site visit of the Ludeman Project license area on August 6, 2012, and was able to confirm the project location.

The licensee provided a general description of the uranium ore to be targeted for production within the proposed wellfields in the license area in Section 1.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The report stated that the economic uranium deposits at the Ludeman project occur in roll fronts at different depths in medium to coarse-grained sands of the 70, 80, and 90 sands of the Lebo member of the Paleocene Fort Union Formation. The ore zones are variable in thickness, ranging from 0.3 to 9.1 m (1 to 30 ft) thick. The grade of uranium percent uranium oxide (U_3O_8) varies within each host sand from 0.074 to 0.130 percent.

The licensee stated that it plans to extract uranium at the Ludeman Project using the in-situ recovery (ISR) process described in Section 1.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). In general, ISR involves extracting uranium from underground ore bodies without bringing the ore itself to the surface. During the ISR process, a leaching solution is injected through wells into underground ore bodies to dissolve the uranium. The leaching solution consists of native ground water mixed with an oxidant, such as oxygen

gas or hydrogen peroxide, and a complexing agent, such as sodium carbonate. The solution, called lixiviant, is collected in a series of recovery wells, and then pumped to a processing plant where the uranium is separated from the pregnant lixiviant by chemical adsorption of the anionic (i.e. negative charged ions) uranium carbonate complexes onto an IX resin. The barren lixiviant is refortified with the oxidant and complexing agents and recirculated into the injection wells. The process is repeated until uranium recovery from the ore body is no longer economical.

The licensee stated in Section 1.7.2 of the Ludeman Project Revised Technical Report that the amenability to ISR of the uranium deposits in the Ludeman Project has been demonstrated through successful historical ISR pilot tests conducted in the license area, specifically at the Leuenberger and North Platte sites (Uranium One USA 2017d). The licensee added that existing nearby ISR projects in the PRB 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 licensee concluded 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. The NRC staff verified that the Leuenberger and North Platte ISR pilots were operated and satisfactorily restored, decommissioned and met NRC requirements for license termination and unrestricted release (NRC1986; NRC 1991).

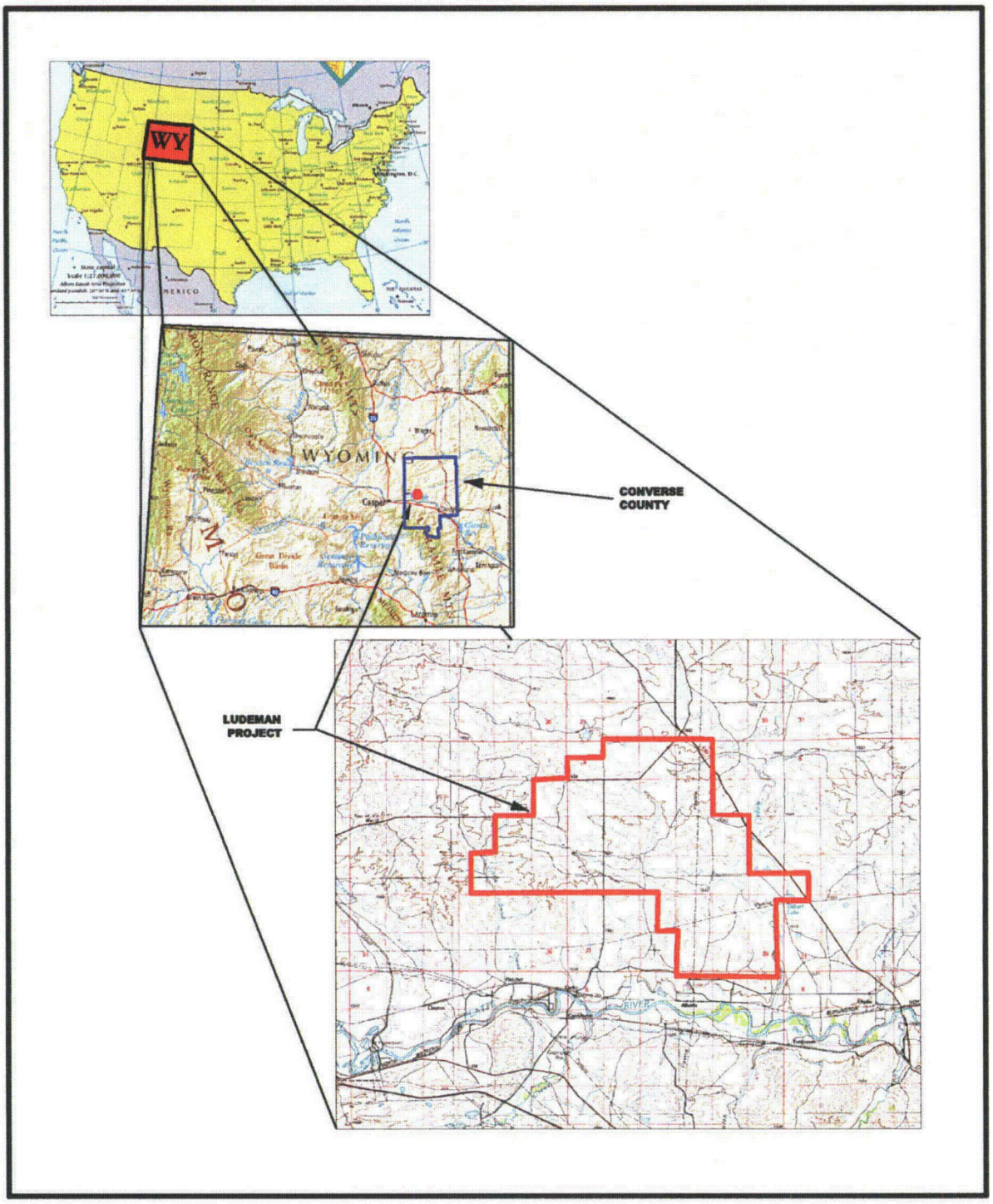

Figure 1.3-1 Location of Ludeman Project

The licensee stated that the ISR operations will take place in six distinct wellfields, named Wellfields 1-6, located in the northwest, central and southeast regions of the license area. The NRC staff determined and the licensee agreed, however, as presented in SER Sections 2.3.3.2, 2.4.3.2, and 3.1.3 that the ore zone in Wellfield 2 was incorrectly identified and the production zone aquifer was not sufficiently characterized for a safety review to be conducted at this time.

The NRC staff will therefore issue License Condition 10.22 for the Willow Creek Source Material License SUA-1341 as described in SER Section 3.1.4 and shown in SER Table 1.1-1 to exclude the construction and operation of Wellfield 2 in this license amendment.

The licensee stated it plans to operate the Ludeman Project as a satellite to the Willow Creek ISR facility in Section 1.8 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The satellite IX facility will be located in the northwestern section of the license area. The licensee is requesting to operate the satellite plant at approximately 34,068 liters per minute (9,000 gpm). The licensee intends to ship the uranium laden resin to its Willow Creek Central Processing Plant (CPP) for the final steps of yellowcake production. The licensee stated that approximately 6.3 million pounds of mineable uranium at an average grade of 0.097 percent are known to exist at the Ludeman Project. The licensee has not proposed an increase in the yellowcake production capacity for the Willow Creek CPP. The yellowcake production capacity will remain at 2.5 million pounds annually for Willow Creek Source Material license SUA-1341. The NRC staff will therefore revise License Condition 10.5 of the Willow Creek Source Material License SUA-1341 as described in SER Section 3.1.4 and shown in SER Table 1.1-1, to include the Ludeman Project maximum flow rate of 9000 gpm.

The licensee presented its schedule for construction, operation, restoration, and decommissioning of the satellite facility and wellfields for the Ludeman Project in Section 1.9 and Figure 1-3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee anticipates that construction of the satellite building, first wellfield and associated wellfield and waste disposal infrastructure will require approximately one year. Construction of additional wellfields would occur at approximately one year intervals for five years. The licensee expects recovery operations in each wellfield to occur over a two to three year period. The licensee anticipates wellfield ISR operations and ground water restoration will continue for approximately 13 years. After restoration of a wellfield is approved, decommissioning of each wellfield is expected to take about one year.

The licensee stated in Section 1.10 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that operation of the Ludeman Project will result in the generation of "byproduct material," as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended, and as codified in 10 CFR 40.4, "Definitions." Both liquid and solid forms of byproduct material will be generated during operations. The licensee stated that it will also generate non- "byproduct material" including domestic waste, solid waste, septic system waste, and a small amount of hazardous waste. The licensee plans to dispose of liquid byproduct material generated from the processing facility operations, wellfield production bleed and reverse osmosis (RO) brines at the Ludeman Project to an evaporation pond. The licensee will dispose of RO permeate from wellfields in restoration in a permeate pond. Both ponds will be located near the satellite facility. The primary alternative to this option if additional waste disposal capacity is needed will be to install up to six DDWs in addition to the evaporation and permeate ponds. In the second alternative for liquid waste disposal, only surge ponds will be installed with up to six DDWs. Solid byproduct material (e.g., spent IX resin, pumps, pipes, and building materials used during operations that cannot be decontaminated) will be disposed of at a licensed mill tailings facility or other licensed facility. The licensee stated in Section 1.10 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that it had an existing agreement for disposal of solid 11e.(2) byproduct material with the NRC licensed Pathfinder Mine Corporation Shirley Basin, Wyoming facility to accept shipment of any 11 e.(2) byproduct materials.

The licensee stated in Section 1.11 of the Ludeman Project Revised Technical Report that once recovery of uranium is completed in a wellfield, ground water restoration will begin (Uranium One USA 2017d). The licensee plans to restore ground water in each wellfield using ground water sweep (GWS), ground water treatment, and addition of chemical reductants. During restoration, GWS and restoration bleed will be treated by RO. The brine from the RO treatment will be sent an evaporation pond. The RO permeate from the wellfields in restoration will be sent to a permeate pond. The water in the permeate pond may then be discharged through a Wyoming Pollution Discharge Elimination System (WPDES) surface water discharge permit. The licensee plans to decommission the individual wellfields after ground water restoration is completed and approved by the NRC staff. The licensee stated in Section 1.12 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that decommissioning of the entire site will commence at the end of the project life after ground water restoration activities in all of the individual wellfields has been completed.

The licensee committed in Section 1.13 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) to have an approved financial assurance arrangement in place after issuance of a license, but prior to startup of operations. The licensee currently maintains an NRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities for Willow Creek License SUA-1341. Specifically, the licensee maintains an Irrevocable Standby Letter of Credit with a face value of $21,624,510 in favor of the State of Wyoming WDEQ (NRC 2016a).

To ensure that after operations the Ludeman Project site can be restored and returned to its preproduction use, a revised financial surety for Willow Creek Source Material license SUA-1341 will be required to be consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 9. The surety amount will be revised to reflect the estimated costs of reclamation activities for the Ludeman Project as development activities proceed. The licensee's financial assurance estimate will include costs for restoring ground water, reclaiming disturbed surfaces, and completion of decontamination and decommissioning activities of sites, structures, and equipment used during operation of the Ludeman Project. The financial surety arrangement must be in place before startup of operations and will be held by an approved State agency or the NRC. The surety amount will be revised annually in accordance with the requirements of SUA-1341.

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 Wyoming Department of Environmental Quality (WDEQ)
- Underground Injection Control (UIC) permits for the Class I DDWs & Class III injection wells from the WDEQ
- Installation permits for ISR monitoring and injection wells from Wyoming State Engineer's Office (WSEO)
- Aquifer exemptions from the U.S. Environmental Protection Agency (EPA)
- Permits to construct evaporation and permeate ponds (i.e., storage ponds) from WSEO
- Permit to construct a holding (storage) pond (40 CFR 61.07) from the EPA
- WPDES surface discharge permit
- National Emission Standards for Hazardous Air Pollutants (NESHAPS) permit from the EPA

1.4 Evaluation Findings

The NRC staff has completed its review of proposed activities at the Ludeman Project in accordance with review procedures in SRP Section 1.2 and acceptance criteria in SRP Section 1.3.

NRC staff finds the licensee has acceptably described the proposed activities at the Ludeman Project ISR satellite facility, including corporate entities involved; the location of the proposed activities; land ownership; ore-body locations and estimated uranium (U_3O_8) content; proposed solution extraction method and recovery processes; operating plans, design throughput and anticipated annual U_3O_8 production; estimated schedules of operations; plans for project liquid and solid waste management and disposal; plans for ground water quality restoration, decommissioning, and land reclamation; and surety arrangements covering eventual facility decommissioning, ground water quality restoration, and site reclamation.

Based on the information provided by the licensee, and the NRC staff's review conducted of the description of the proposed activities at the Ludeman Project, the NRC staff concludes that the information meets the applicable acceptance criteria of SRP Section 1.3. Staff also concludes the description meets the requirements of 10 CFR 40.31, which provides the general requirements for the issuance of a specific license. Therefore, the NRC staff will revise License Condition 9.1 of Source Materials License SUA-1341 to include the Ludeman Project as an authorized place of use for licensed material:

> License Condition 9.1
>
> The authorized place of use shall be the licensee's Willow Creek Project comprised of the ~~both~~ Irigaray, ~~and~~ Christensen Ranch, and Ludeman Project, in Johnson, ~~and~~ Campbell, and Converse Counties, Wyoming.

In addition, the NRC staff will revise License Condition 9.3 of Source Material License SUA-1341 to add the Ludeman Project license amendment request and revised technical and environmental reports and other licensee documents as tie-downs for the licensee commitments, representations, and statements upon which staff relied to make its findings:

> License Condition 9.3 additions:
>
> Letters dated August 4, 2014 (ML14309A456) and January 11, 2018 (ML18016A578), regarding responses to License Conditions 9.8 and 9.12.
>
> Letters dated September 25, 2013 (ML13273A017), January 20, 2015 (ML15040A077), June 5, 2015 (ML15181A357), and April 17, 2017 (ML17111A981), regarding responses to License Condition 11.3.
>
> Letters dated May 30, 2014 (ML14153A103), April 17, 2017 (ML17111A945), and July 6, 2017 (ML17192A093), regarding responses to License Condition 11.9.
>
> Ludeman Project License Amendment Request, December 3, 2011 (ML 12010A178, ML120120182), Ludeman Project Revised Technical Report, June 28, 2017 (ML17192A357); Ludeman Project Revised Environmental Report, August 25, 2017 (ML17261A460).

Whenever the word “will” or “shall” is used in the above referenced documents, it shall denote a requirement.

2.0 SITE CHARACTERIZATION

In this section, the NRC staff evaluates the licensee's description of the pre-operational site characterization including the Ludeman Project site location, layout and land use.

2.1 Site Layout and Location

This section describes the NRC staff's evaluation of the licensee's description of the Ludeman Project site location, layout and land use in the Ludeman Project Revised Technical Report. (Uranium One USA 2017d).

2.1.1 Regulatory Requirements

The staff determines if the licensee has adequately described the Ludeman Project site location, layout and land use in accordance with the requirements of 10 CFR 40.31(g)(2).

2.1.2 Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in SRP Section 2.1.3 (NRC 2003).

2.1.3 Staff Review and Analysis

The licensee showed the location of the Ludeman Project in relation to other significant regional population centers in Figure 1-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The Ludeman Project is approximately 17 km (10.3 mi) east of Rolling Hills, 20 km (12.1 mi) northeast of Glenrock, 25 km (15.1 mi) northwest of Douglas, and 65 km (39.3 mi) northeast of Casper. Figure 1-1 also displays the major transportation routes including roads and railroads displayed within a 30 mile radius. State Highway 95 provides access to the Ludeman Project from the towns of Rolling Hills and Glenrock and State Highway 93 provides access from the town of Douglas.

The licensee provided information on the site location, layout, and surface ownership of the Ludeman Project license in Section 2.1 and Figures 2.1-1 and 2.1-2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported the proposed Ludeman Project license area covers approximately 7633 hectares (18,861 acres) in Converse County, Wyoming. The license area includes excluded areas shown in Figure 2.1-2 which encompass all BLM land and the private land held by Chapman University. The remaining surface ownership of the Ludeman Project area primarily consists of private landowners, with small portions of State ownership. The licensee stated that it has obtained surface use agreements with all landowners with surface ownership located within the Ludeman Project license area.

The NRC staff presents the site layout of the Ludeman Project in SER Figure 2.1-1 based on information provided in Figure 2.1-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The Ludeman Project satellite facility processing building, evaporation and permeate ponds are located in the far northwestern corner of the license area. The six proposed wellfields, well patterns, monitoring ring wells, and DDWs are spread across the license area as shown. Restricted areas are located around the satellite facility. The satellite facility, proposed

wellfields and ponds will be located within fenced areas. The licensee estimated the total area to be fenced will be approximately 533 hectares (1317 acres).

The licensee described the land use within and near the Ludeman Project in Section 2.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated the predominant land used within the license area is grazing land (98 percent). The licensee reported that there are three active oil and gas well sites within the Ludeman Project license area and four more within the three-mile review area. The licensee also reported there is one NRC licensed uranium recovery facility, Cameco Resources Smith Ranch Highland Uranium Project (SUA-1548), within an 80 km (50 miles) mile radius of the Ludeman project. This facility is located approximately 12.8 km (8 miles) northwest of the proposed Ludeman Project. The licensee stated there are no current or historic coal mines within the license area or the 3 mile review area.

The licensee reported there is one private residence within, and several private residences near, the Ludeman Project license area in Section 2.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The locations of these residences are shown in SER Figure 2.1-1, based on information provided in Figure 2.1-1 of the Ludeman Project Revised Technical Report. The licensee identified one resident living within the proposed license boundary of the Ludeman Project. This resident is located approximately 1.61 km (1 mile) east of the satellite facility in the southeastern portion of Section 13 of T34N R74W. The licensee also stated that there are 13 residences within an unplatted rural neighborhood known as the Negley Subdivision just outside the northwest corner of the proposed license boundary in Section 11 of T34N R74W as shown in SER Figure 2.1-1. The closest residents in the Negley Subdivision are within 0.80 km (0.5 miles) of the proposed satellite facility. The farthest residence in this subdivision is located is 2.41 km (1.5 miles) north of the processing facility. The remainder of residences are scattered between these distances. A few residences are located outside the far northeastern and southeastern boundary of the license area. The NRC staff verified the presence of the one private residence east of the satellite facility within the license boundary and the Negley Subdivision residences immediately north and west of the proposed license boundary on a site visit in August 2012 (NRC 2017e).

2.1.4 Evaluation Findings

The staff has reviewed the site location, layout and land use of the Ludeman Project in accordance with the review procedures in SRP Section 2.1.2 and the acceptance criteria in SRP Section 2.1.3.

The NRC staff finds that the licensee has acceptably described the site location, layout and land use with appropriately scaled and labeled maps showing the site layout, principal facilities and structures, residences, and boundaries. The licensee provided a description and maps that identify the Ludeman Project site and its location relative to federal, state, county, and other political subdivisions; transportation links (roads, rails, airports, waterways); political subdivisions (counties, townships); population centers (cities, towns); and non-licensee property (farms, residences). The licensee has acceptably described the layout of the proposed Ludeman Project principal structures such as the satellite facility, evaporation and permeate ponds, deep disposal wells, wellfields and well patterns, monitoring wells, and exclusion area boundaries and fences associated with this infrastructure. Finally, the licensee acceptably described the land use within and near the license area.

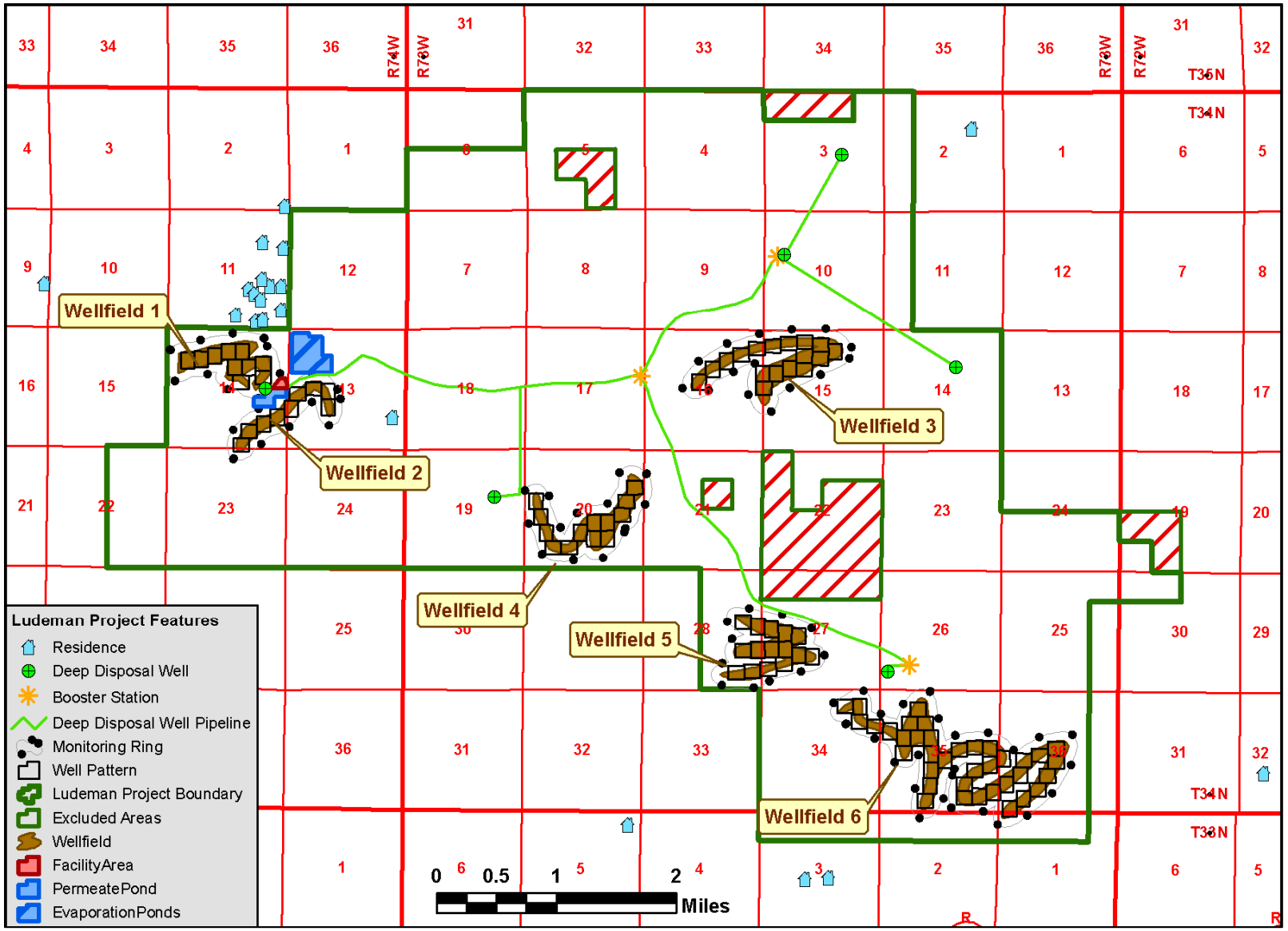

Figure 2.1-1 Ludeman Project Site Layout

Based on the information provided by the licensee, and the NRC staff's review conducted of the description of the Ludeman Project site location, layout and land use, the NRC staff concludes that information meets the applicable acceptance criteria of SRP Section 2.1.3. Staff also concludes the description meets the requirements of 10 CFR 40.31(g)(2).

2.2 Meteorology

This section describes the NRC staff's evaluation of the licensee's description of regional and site meteorology at the Ludeman Project. The licensee provided information on the Meteorology of the Ludeman Project in Section 2.5.3, "Site Specific Analysis," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Meteorological data are used for the selection of environmental monitoring locations, assessing the impact of operations on the environment, and performing radiological dose assessments.

2.2.1 Regulatory Requirements

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

2.2.2 Regulatory Acceptance Criteria

Staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7, using acceptance criteria in SRP Section 2.5.3 (NRC 2003).

2.2.3 Staff Review and Analysis

The following sections present the NRC staff's review and analysis of various aspects of the meteorological conditions and monitoring at the Ludeman Project. The aspects reviewed in the following sections include meteorological data acquisition, atmospheric dispersion, and meteorological data quality. The information reviewed in this section is from information, data, and maps contained in Section 2.5, "Meteorology," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Most of the regional and on-site meteorological data described in Section 2.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), such as information contained in Section 2.5.2, "Regional Overview," regarding regional and on-site temperatures, relative humidity, and precipitation, is not used for safety-related facility design or operation. Therefore, the NRC staff did not evaluate this information. However, the licensee did use on-site wind speed, wind direction, atmospheric stability, and mixing layer depth information to determine the locations of operational environmental air samplers in accordance with Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC 1980a). The licensee also developed an on-site joint frequency distribution from on-site meteorological data (i.e., a statistical summary of wind speed, wind direction and atmospheric stability class) in its use of the MILDOS-AREA code to estimate public dose in accordance with 10 CFR 20.1302. The NRC staff's evaluation of the public dose assessment for the Ludeman Project is addressed in Section 5.7.7.3 of this SER.

In Section 2.5.3, “Site Specific Analysis,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated the following regarding on-site meteorological data collection: (1) instruments were located at a height of 10 meters; (2) the period of record was at least 1 year (February 1, 2014, through January 31, 2015); and (3) the data recovery rate was greater than 99 percent for all monitored parameters. The NRC staff finds the licensee’s description of on-site meteorological data collection acceptable because the parameters meet the Acceptance Criterion (1) in SRP Section 2.5.3 (NRC 2003).

In Section 2.5.4, “Demonstration of Long-term Representativeness of On-Site Data,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee provided information to substantiate that its 1 year of on-site meteorological data is representative of long-term conditions at and near the site, as described in Regulatory Guide 3.63, “Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Report,” (NRC 1988b) and Acceptance Criterion (3) in SRP Section 2.5.3. The licensee performed numerous statistical tests to compare data from the Casper Airport, a National Weather Service site 40 miles west of the Ludeman Project site with 17 years of hourly data available in electronic form. The licensee described both qualitative comparisons using graphs and charts, and quantitative comparisons, using a number of quantitative statistical tests. The statistical tests used by the licensee to demonstrate representativeness include the Chi-Square (χ^2) test, the Student’s t test, and linear correlation. The licensee also explained why the Kolmogorov-Smirnov test is not an appropriate test for purposes of demonstrating representativeness. All of the methods used by the licensee demonstrated that the February 1, 2014, through January 31, 2015 period of on-site meteorological data was representative of on-site conditions. The NRC staff finds this acceptable because this information meets the Acceptance Criterion (3) in SRP Section 2.5.3 (NRC 2003).

Licensee’s Use of Irigaray Meteorological Data

In Section 2.2.3, “Staff Review and Analysis,” of the NRC staff’s SER for license renewal of the Willow Creek Uranium In Situ Recovery Project (NRC 2013b), the NRC staff evaluated the licensee’s description of on-site meteorological data collected over 33 years earlier from December 1980 to December 1981. The NRC staff concluded that

“...in order to continue to use the previously collected data in calculations to demonstrate compliance with 10 CFR Part 20 as low as is reasonably achievable (ALARA) requirements, and 10 CFR Part 20 dose and effluent release limits the licensee must demonstrate that the onsite data collected in 1980 and 1981 is representative of long-term conditions (see NRC Regulatory Guide 3.63, “Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting,” dated March 1988 (NRC, 1988d)).”

As a result of this deficiency, the NRC staff imposed License Condition 9.15 to the Willow Creek Project license, which states:

“The licensee shall review and compare the data collected from a regional weather station during the same period as the onsite meteorological data collected to the long-term data collected from the same regional weather station. The licensee shall determine if the data collected onsite is representative of long-term conditions. Justification of the similarity or validity of the data will include analysis of the statistical data presented to illustrate confidence in the representativeness of the data. The meteorological data will include wind speed, wind direction, an annual wind rose, and a summary of the stability classification. The licensee shall submit this review and comparison to NRC within 6 months of license renewal for NRC review and written

verification that the onsite meteorological parameters previously collected will allow the licensee to demonstrate compliance with regulatory requirements of 10 CFR Part 20."

By letter dated September 5, 2013 (Uranium One USA 2013), the licensee submitted its response to License Condition 9.15. In its 2013 submittal, Uranium One evaluated wind speed and wind direction data from the Casper Airport, which the NRC staff verified is located about 70 miles south-southwest of Irigaray, a site for which long-term weather data is available. The licensee compared the Casper Airport data for the same period it collected on-site meteorological data at Irigaray, calendar year 1981, to a 16-year long-term Casper Airport period of record, which comprised data from January 1997 through December 2012. The licensee completed several comparisons, including qualitative comparisons using wind roses, wind speed and wind direction frequency histograms, and statistical correlations. The licensee also evaluated whether 1981 was a representative year with regard to atmospheric stability class measurements. The licensee's stability class analysis involved a comparison of data collected in 1981 at the CX Ranch property, located about 96 miles north-northwest of the Willow Creek Project, to long-term data collected from 1990 through 2012 at the Spring Creek Mine, located about six miles north of CX Ranch. While the licensee observed that different methods were used to estimate atmospheric stability class at the two locations, the licensee stated the frequencies of stable, neutral, and unstable, stability classes were nevertheless similar.

The NRC staff evaluated the licensee's 2013 submittal and noted strong similarities between Figure 5, "Casper Wind Rose, 1981," and Figure 6, "Casper Wind Rose, 1997-2012." For example, predominant wind directions are from the southwest in both figures, and the least prevalent winds are from the east-southeast to south-southeast sectors. The NRC staff also observed that Figure 7, "Casper Wind Speed Comparison," shows similar wind speed distributions (e.g., in both 1981 and long-term data, the most frequent winds occur between 8-12 mph). Independent of the licensee's analysis, the NRC staff observed that Figure 2, "Irigaray Site Baseline Year Wind Rose," of the 2013 submittal (Uranium One USA 2013), bears strong similarity to the 5 years of wind roses collected at the nearby Nichols Ranch ISR Project (Uranerz 2017). In 2017, the NRC staff verified that the Nichols Ranch 5-year meteorological data set is representative of long-term conditions (NRC 2017c). The Nichols Ranch ISR Project meteorological tower is located about 14 miles south south-east of the Irigaray meteorological station location. Figure 6, "Year-to-Year Wind Rose Comparison," of Uranerz (2017), shows the minor changes which occur year-to-year in wind speed and direction. All the years at the Nichols Ranch site show prevalent wind directions from the southwest and north northwest, just like the Irigaray 1981 data. The most prevalent wind direction at Nichols Ranch is from the east, consistent with the east-west orientation of the Cottonwood Creek stream bed. Winds from the east at Nichols Ranch are most prevalent at night (see Figure 2, Uranerz (2017)), when drainage flows from higher elevations move over the land and across the site as they pass down the Cottonwood Creek stream bed at low wind speeds. Similarly, the most prevalent wind direction at Irigaray is a southeast wind, which is common at night, and follows the local terrain, including the ¼-mile to ½-mile wide Willow Creek valley that transects the site (Malapai 1988).

In this SER for the Ludeman Project expansion, the NRC staff re-evaluated whether, in fact, the licensee uses its on-site meteorological data in its annual demonstrations of compliance with 10 CFR Part 20 public dose standards. In Section 5.7.7.4, "Staff Review and Analysis," of the NRC staff's SER for license renewal of the Willow Creek Uranium In Situ Recovery Project (NRC 2013b), the NRC staff found that the licensee had not demonstrated compliance with the NRC public dose limits in 10 CFR 20.1301 consistent with the requirements in 10 CFR 20.1302 relative to the restricted, controlled, and unrestricted areas. In the renewed license SUA-1341,

the NRC staff revised License Condition 11.3 to address this deficiency, which required the licensee to, among other things, evaluate the highest exposures likely to members of the public from licensee operations. The NRC staff have since approved the licensee's public dose assessment methodology (NRC 2017b). The licensee's revised methodology for demonstrating that public dose limits are met does not, in fact, rely on measurements or calculations based on the licensee's 1981 meteorological data. Therefore, the original safety concern that prompted the addition of License Condition 9.15 to the license in 2013, which was that the licensee would rely on invalid historical meteorological data to demonstrate compliance with 10 CFR Part 20, is now resolved because Irigaray meteorological data is not used for that purpose.

In conclusion, the licensee has provided the information required by License Condition 9.15. The NRC staff finds the licensee's analysis adequate for the reasons described above. In addition, the NRC staff's safety concern stated in the 2013 SER (NRC 2013b) that formed the basis for imposing License Condition 9.15 no longer exists – the licensee does not use meteorological data to demonstrate compliance with 10 CFR Part 20 public dose limits. For these reasons, the NRC staff will remove License Condition 9.15 as shown in SER Table 1.1-1

2.2.4 Evaluation Findings

The NRC has completed its review of the site characterization information concerned with meteorology at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 2.5.2 and SRP Section 2.5.3.

The licensee has acceptably described the site meteorology by providing data from an on-site meteorological tower, 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 licensee has provided acceptable on-site meteorological data, including (i) descriptions of instruments, and (ii) locations and heights of instruments. The joint-frequency data presented are for a minimum of 1 year, with a joint data recovery of 90 percent or more. The licensee has acceptably demonstrated that meteorological data used for assessing environmental impacts are representative of long-term meteorological conditions at the site.

Based on the information provided by the licensee, and the NRC staff's review conducted of the characterization of meteorology at the Ludeman Project, the staff concludes that the information is acceptable to allow evaluation of the dispersion of airborne contamination at the site and development of conceptual and numerical models. The characterization also meets the requirements of 10 CFR Part 40, Appendix A, Criterion 7, which requires pre-operational and operational monitoring programs.

2.3 Geology and Seismology

This section describes the NRC staff's evaluation of the licensee's description of site geology and seismology at the Ludeman Project. The licensee provided information on the site geology and seismology of the Ludeman Project in Sections 2.6, "Geology," Addendum 2.6-A "Geology Table and Figures," and Addendum 2.6-B, "Drill Hole Records and Drill Hole Index Map" of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee provided detailed geologic information to enable the NRC staff to assess the feasibility of conducting ISR operations at the proposed site as well as the likely ability of the geologic formations to isolate production fluids.

2.3.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the characterization of geology and seismology at the Ludeman Project is sufficient to document the licensee's ability to maintain control over production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c).

2.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the NRC staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in SRP Section 2.6.3 (NRC 2003).

2.3.3 Staff Review and Analysis

The following sections present the NRC staff's review and analysis of various aspects of the geology and seismology of the Ludeman Project. Aspects reviewed in the following sections include regional geology, site geology, stratigraphy, lithology, exploration boreholes, soils and seismology. The information reviewed in this section is from information, data, and maps submitted by the licensee in the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

2.3.3.1 Regional Geology

The licensee provided a description of the regional geology in Section 2.6.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated the Ludeman Project license area was located in the southwestern PRB. The PRB is an asymmetrical syncline filled with marine and non-marine and continental sediments that are approximately 4,573 m (15,000 ft) thick in the deepest part of the basin. The PRB covers approximately 56,980 square km (km^2) (22,000 square mi [mi^2]) in southeastern Wyoming.

The licensee displayed the location of the Ludeman Project within the regional geological setting of the PRB in Figure 2.6A-1 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The figure shows the Ludeman Project is located in the far southern portion of the PRB. The licensee stated the southern portion of the PRB contains the Lance, Fort Union, Wasatch and White River Formations. In the southwestern portion of the PRB where the Ludeman Project is located, the licensee stated the majority of the White River and Wasatch formations are absent. The NRC staff verified the regional shallow stratigraphy of the PRB is as shown in SER Figure 2.3-1 (DOE 2002).

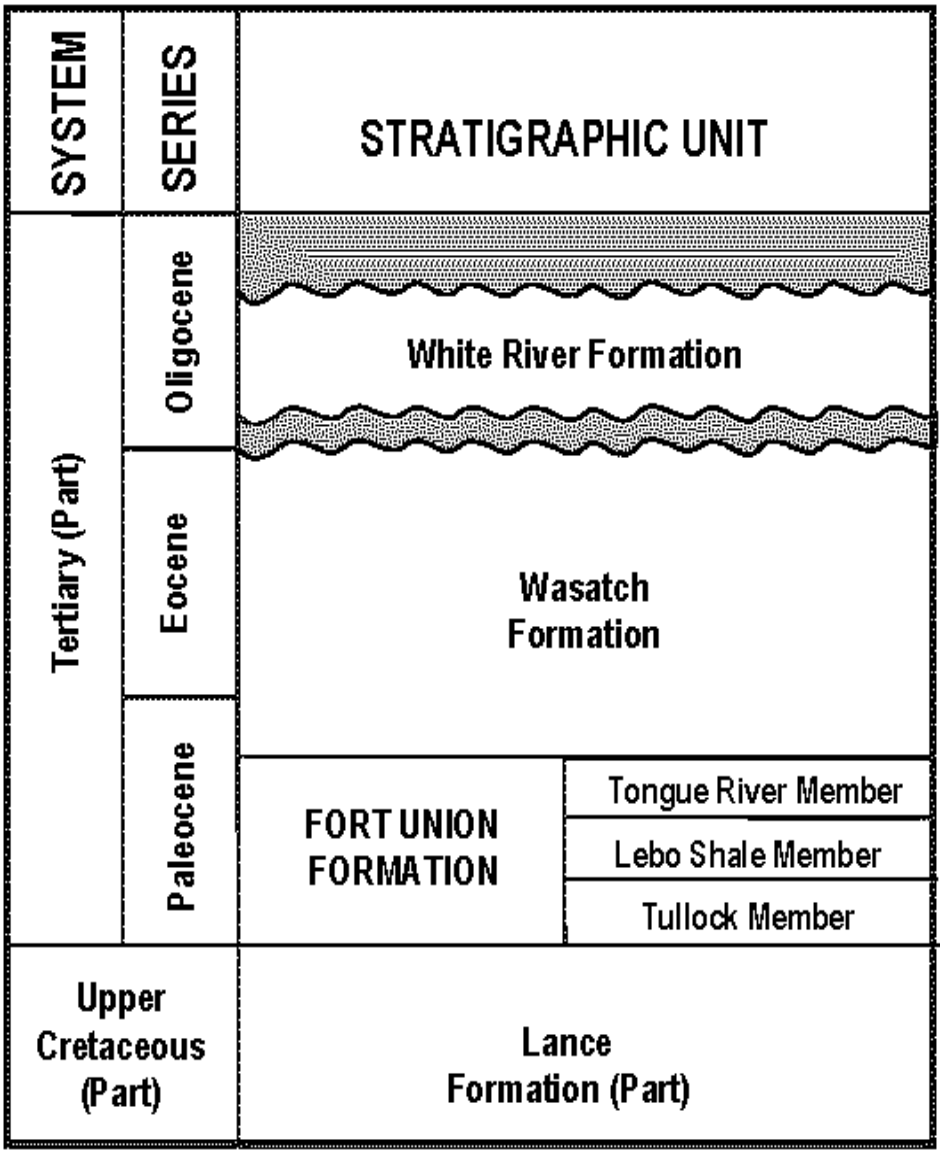

Figure 2.3-1 Powder River Basin Regional Shallow Stratigraphy

The licensee stated the Upper Cretaceous Lance Formation is composed of 1,000 to 3,000 ft of thinly bedded brown to gray sands and shales. The Paleocene Fort Union Formation uniformly overlies the Lance Formation. It consists of poorly consolidated continental shallow non- marine deposits. It has three distinct members: the Tongue River, the Lebo Shale and the Tullock. The total thickness of the Fort Union Formation varies between 2,000-3,500 ft. The early Eocene Wasatch Formation unconformably overlies the Fort Union Formation. The Wasatch Formation is similar in geology to the Fort Union Formation but contains thick lenses of course, cross bedded, arkosic sands deposited in a high energy fluvial environment. The Wasatch reaches a thickness of about 1600 ft in the PRB. The Oligocene White River Formation overlies the Wasatch Formation and has been removed by erosion from most of the basin. The youngest sediment in the basin consist of Quaternary alluvial sands and gravels present in larger valleys.

The licensee also described the deeper stratigraphy of the PRB not shown in SER Figure 2.3-1. The Fox Hills sandstone underlies the Lance Formation. It consists of fine to medium grain sandstone beds which were deposited in a marine environment. The Fox Hills sandstone lies

above the Lewis shale, which is a thick sequence of shale. The Teapot, Teckla and Parkman Formations are 8,500-9,000 feet below land surface and are a significant source of oil and gas in the PRB.

2.3.3.2 Site Geology

The licensee provided a description of the Ludeman Project site geology in Section 2.6.2 and Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee included a site generalized stratigraphic column in Figure 2.6A-2 that was based on a type log provided in Figure 2.6A-3. A portion of this type log is shown below in SER Figure 2.3-2. It shows the stratigraphy and describes the lithology in the license area from surface to depth as a sequence of sandstones and shale layers starting with the 120 sand and ending with the 60 sand.

The licensee stated the host rocks for the uranium mineralization within the Ludeman license area are located in the Fort Union Formation. Specifically, the production ore zone will be located in the sandstones of the Lebo member of the Paleocene Fort Union Formation. The Fort Union Formation was deposited in a fluvial paleo-drainage system which flowed in a north-northeasterly direction. It consists of a series of mudstones, siltstones and clays with minor coarse bedded sandstone channels and occasional thin limestone and lignite beds. As shown in the SER Figure 2.3-2 type log, the licensee described the Lebo member as being composed of gray to red arkosic sandstones. The sandstones are flat bedded, clay rich, cross bedded, cherty and poorly sorted with grain sizes ranging from fine to very coarse with coarse being the average. The sandstones contain minor to very abundant pyrite and carbonaceous materials. The finer grained rocks which make up the shale layers range from medium gray siltstones to dark gray carbonaceous claystones. The dominant clay is montmorillonite, which represents 50 percent of the total clay content. Illite and kaolinite represent 25 percent each of the total clay content. The licensee stated that all the mudstones, siltstones, claystones and clays will be collectively referred to as shales throughout the technical report, to reflect their behavior as confining layers.

The license stated the Ludeman Project targeted ore zones within the Lebo member are located in sandstones named from shallowest to deepest as the 90, 80 and 70 sands as shown in SER Figure 2.3-2. The uranium mineralization occurs as coatings on the surfaces of the sand grains in c-shaped roll front deposits within these sandstones. Individual roll fronts vary from 1.5 to 9.1 m (5 to 30 ft) in thickness. The ore grade mineralization is not typically present along the entire length of the roll fronts. The key uranium minerals present in the roll fronts are uraninite and coffinite. The licensee reported the mineralization in the 90 sand is located from 57.6 to 89 m (189 to 292 ft) deep. The thickness of the mineralization in the 90 sand is 2.54 m (8.35 ft) with an average grade of 0.09 percent U_3O_8. The mineralization in the 80 sand varies from 92.3 to 134 m (303 to 441 ft) deep. The thickness of the mineralization in the 80 sand averages 2.9 m (9.5 ft) with an average grade of 0.13 percent U_3O_8. The mineralization in the 70 sand is located about 465 to 690 ft below ground surface. The thickness of the mineralization in the 70 sand averages 10.6 ft with an average grade of 0.074 percent U3O8.

The licensee provided geological cross sections across the entire license area in in Figures 2.6A-5 to 2.6A-24 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The cross sections spanned the entire Ludeman Project license area from east to west and north to south over an area of approximately thirty square miles. The index map for these geological cross sections was provided in Figure 2.6A-4. The licensee also provided six cross sections to show the subsurface geology along the major axes of Wellfields

1-6 in Figures 2.6A-19 to 2.6A-24, respectively, of the of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). These cross sections clearly display the sandstones which contain the ore bodies in each of the proposed wellfields, as well as the overlying and underlying sandstones and shale sequences. The staff found these wellfield specific cross sections to be in compliance with the SRP, which states the licensee should provide detailed cross sections of the subsurface geology along the major and minor axis of each proposed wellfield in Acceptance Criterion (1) of SRP Section 2.6.3 (NRC 2003).

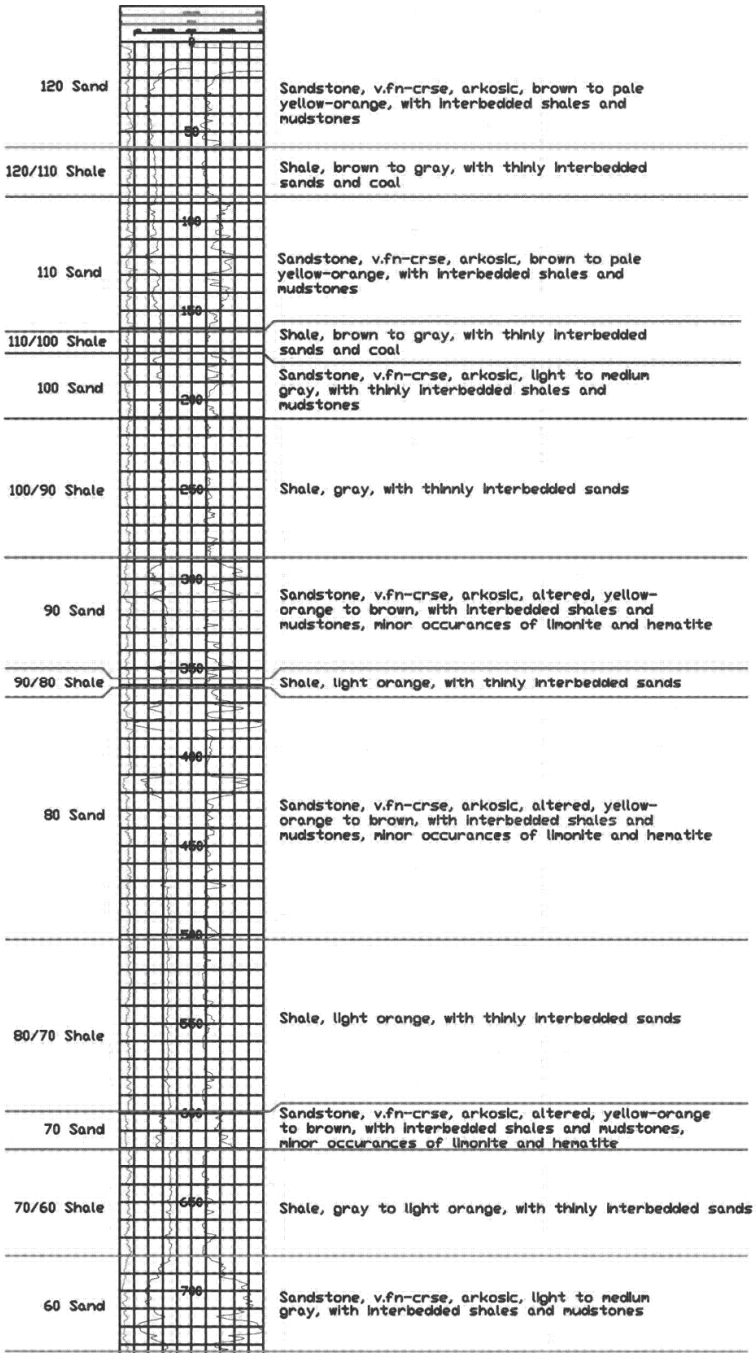

Figure 2.3-2 Type Log for Ludeman Project Stratigraphy

The licensee also provided isopachs for all sandstone and shale layers in Figures 2.6A- 25 to 2.6A-41 of Addendum 2.6-A of the Revised Technical Report (Uranium One USA 2017d). The isopachs display the thickness and extent of the formations of interest across the entire license area as defined using formation picks from 392 drilling logs.

The licensee proposed to install six wellfields in the Ludeman Project license area. NRC staff found the subsurface geology changes significantly between the Ludeman Project wellfields; therefore, a separate evaluation of the geology of each wellfield was conducted.

Wellfield 1

Wellfield 1 is located in the northwest portion of the proposed license area in T34N R74W Section 13 as shown in SER Figure 2.1-1. The licensee stated it intends to recover uranium from the 80 and 90 sands in Wellfield 1. The licensee reported the depth to the mineralization in Wellfield 1 in the 90 sand ranges from 195-345 ft bgs and in the 80 sand ranges from 295-450 ft bgs in Table 2.7B1-a of Addendum 2.7-B of the Revised Technical Report (Uranium One USA 2017d).

Cross Section O-O', provided in the Figure 2.6A-19, shows the subsurface geology along the major axis of Wellfield 1. The NRC staff conducted an evaluation of this cross section and the isopachs to verify the licensee had provided sufficient information to characterize the location and thickness of the targeted ore zone sandstones and overlying and underlying confining layers and sandstones in Wellfield 1 to determine compliance with applicable portions of SRP Acceptance Criteria 2.6.3 (NRC 2003).The results are shown in SER Table 2.3-1.

Layer (Shallow to Deep)	**Wellfield 1**	
	Approximate Thickness (ft)	**Description**
110 sand	10-80	Surficial sandstone
110/100 shale	10-25	Confining layer
100 sand	0-50	Ore zone overlying sandstone (discontinuous)
100/90 shale	60-120	Ore zone overlying confining layer
90 sand	25-50	Ore zone
90/80 shale	50-75	Confining layer between ore zones
80 sand	40-75	Ore zone
80/70 shale	50-75	Ore zone underlying confining layer
70 sand	50-80	Ore zone underlying sandstone (multilayer)

Table 2.3-1 Stratigraphy of Wellfield 1

NRC staff finds the Wellfield 1 subsurface geology has been characterized in sufficient detail to demonstrate that the targeted 80 and 90 ore zone sandstones are located between the 100/90, 90/80, and 80/70 shale confining layers which possess thicknesses of at least 50 feet. NRC staff finds the presence of shale confining layers with thickness of 10 feet or more above and below the targeted production zones provides evidence that the production ore zone is physically isolated. This physical isolation is necessary to demonstrate that the licensee will be able to control the movement of fluids to within the ore zones.

Wellfield 2

Wellfield 2 is located in the northwest portion of the proposed license area in T34N R74W Sections 14 as shown in SER Figure 2.1-1. Cross Section P-P', provided in Figure 2.6A-20 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) shows the subsurface geology along the major axis of Wellfield 2. The targeted ore zone is clearly located in the 60 sand in this cross section. The licensee, however, incorrectly reported the ore is located in the 70 sand in Wellfield 2 in Table 2.7B1-a of Addendum 2.7-B. The licensee agreed in an RAI response that it had made this error and that the production ore zone in Wellfield 2 is located in the 60 sand (Uranium One Americas 2013c). The licensee was also informed of this finding in two public meetings (NRC 2016c, NRC 2017a)

The 60 sand is not characterized in the Ludeman Project Revised Technical Report (Uranium One USA 2017d), and the licensee has not submitted a separate characterization of this layer. The NRC staff has therefore determined that the licensee has not provided a satisfactory characterization of the ore zone and its stratigraphic setting in Wellfield 2 to enable its inclusion in this licensing action. The licensee has agreed with this finding and has indicated it will request a license amendment to approve operation of Wellfield 2 at a later date. NRC will therefore include a new License Condition 10.22 in Willow Creek Source Material License SUA-1341 as described in SER Section 3.1.4 and Table1.1-1 prohibiting any construction of or uranium recovery operations within Wellfield 2 in this license amendment.

Wellfield 3

Wellfield 3 is located in the northeast portion of the proposed license area. As shown in SER Figure 2.1-1, the ore body is located in T34N 73W Sections 15 and 16. The licensee reported that mineralization in this part of the license area is contained within the 50, 60 and 70 sands. However, the licensee stated it only intends to recover uranium from the 70 sand. The licensee reported the depth to the mineralization in Wellfield 3 in the 70 sand ranges from 470 -690 ft bgs in Table 2.7B1-a of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Cross Section Q-Q', provided in Figure 2.6A-21 of Addendum 2.6 -A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), shows the subsurface geology along the major axis of Wellfield 3. The NRC staff conducted an evaluation of this cross section and the isopachs to verify the licensee had provided sufficient information to characterize the location and thickness of the targeted ore zone sandstones and overlying and underlying shale confining layers and sandstones in Wellfield 3 to determine compliance with applicable portions of SRP Acceptance Criteria 2.6.3 (NRC 2003).The results are shown in SER Table 2.3-2.

NRC staff finds the Wellfield 3 geology has been characterized in sufficient detail to demonstrate that the targeted 70 ore zone sandstone is located between the 80/70 and 70/60 shale confining layers which have thicknesses of 25 ft or more. NRC staff finds the presence of confining layers of shale of thickness greater than 10 ft above and below the targeted 70 sand production zone offers evidence that the zone is sufficiently physically isolated to enable to the licensee to maintain hydraulic control of fluids within the targeted ore zone.

Layer (Shallow to Deep)	Wellfield 3	
	Approximate Thickness (ft)	Description
110 sand	20-50	Surficial sandstone
110/100 shale	10-75	Confining layer
100 sand	80-160	Sandstone (multilayer)
100/90 shale	40-120	Confining layer
90 sand	5-25	Sandstone (multilayer)
90/80 shale	75-100	Confining layer
80 sand	0-5	Ore zone overlying sandstone (multilayer, discontinuous)
80/70 shale	50-80	Ore zone overlying confining layer
70 sand	25-75	Ore zone sandstone
70/60 shale	25-70	Ore zone underlying confining layer
60 sand	25-50	Ore zone underlying sandstone

Table 2.3-2 Stratigraphy of Wellfield 3

Wellfield 4

Wellfield 4 is located in the central portion of the proposed license area in T34N 73W Section 20 as shown in SER Figure 2.1-1. The licensee reported that mineralization in the central part of the license area is contained within the 50, 60 and 70 sands. However, the licensee stated it only intends to recover uranium from the 70 sand In Wellfield 4. The licensee reported the depth to the mineralization in the 70 sand in Wellfield 4 ranges from 480-590 ft bgs in Table 2.7B1-a of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Cross Section R-R', provided in Figure 2.6A-22 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) shows the subsurface geology along the major axis of Wellfield 4. The NRC staff conducted an evaluation of this cross section and the isopachs to verify the licensee had provided sufficient information to characterize the stratigraphy in Wellfield 4 to assess the location and thickness of the targeted ore zone sandstones and overlying and underlying confining layers and sandstones to determine compliance with applicable portions of SRP Acceptance Criteria 2.6.3 (NRC 2003).The results are shown in SER Table 2.3-3.

NRC staff finds the Wellfield 4 geology has been characterized in sufficient detail to demonstrate that the targeted 70 sand ore zone is located between the 80/70 shale and 70/60 shale confining layers which have thicknesses of 20 ft or more. NRC staff finds the presence of competent confining shale layers of thickness greater than 10 ft above and below the targeted 70 sand production zone is evidence that it is physically isolated to prevent the movement of production fluids to overlying and underlying formations.

Layer (Shallow to Deep)	Wellfield 4	
	Approximate Thickness (ft)	Description
110 sand	0-10	Surficial sandstone (discontinuous)
110/100 shale	25-125	Confining layer
100 sand	0-25	Sandstone (multilayer, discontinuous)
100/90 shale	50-75	Confining layer
90 sand	0-80	Sandstone (multilayer, discontinuous)
90/80 shale	125-200	Confining layer
80 sand	0-25	Ore zone overlying sandstone (multilayer, discontinuous)
80/70 shale	20-100	Ore zone overlying confining layer
70 sand	75-150	Ore zone sandstone
70/60 shale	25-75	Ore zone underlying confining layer
60 sand	0-25	Ore zone underlying sandstone (multilayer, discontinuous)

Table 2.3-3 Stratigraphy of Wellfield 4

Wellfield 5

Wellfield 5 is located in the southwestern portion of the Ludeman Project license area in Sections 27 and 28 of T34N R73W as shown in SER Figure 2.1-1. The licensee reported that mineralization in the area is contained within the 70, 80, and 90 sands. However, the licensee stated it only intends to recover uranium from the 70 and 80 sands in Wellfield 5. The licensee reported the depth to the mineralization in the 80 sand in Wellfield 5 ranges from 224-383 ft bgs and the depth to the mineralization in the 70 sand ranges from 303-550 ft bgs in Table 2.7B1-a of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Cross Section S-S', provided in Figure 2.6A- 23 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), shows the subsurface geology along the major axis of Wellfield 5. The NRC staff conducted an evaluation of this cross section and the isopachs provided to verify the licensee had provided sufficient information to characterize the stratigraphy in Wellfield 5 and assess the location and thickness of the targeted ore zone sandstones and overlying and underlying confining layers and sandstones to determine compliance with applicable portions of SRP Acceptance Criteria 2.6.3 (NRC 2003).The results are shown in SER Table 2.3-4.

NRC staff finds the Wellfield 5 geology has been characterized in sufficient detail to demonstrate that the targeted 70 ore zone sandstone is located between the 80/70 and 70 /60 shale confining layers with thicknesses of 10 ft or more. NRC staff finds the presence of competent confining shale layers of thickness greater than 10 ft above and below the targeted production 70 sand and below the 80 sand supports the a finding of physical isolation to prevent the movement of production fluids to overlying and underlying formations. The 80 sand, however, is overlain in the most northern portion of the ore body by approximately 5 ft of 90/80 shale confining layer, which is marginal for establishing sufficient confining layer thickness. Other evidence will be required to establish that the licensee can maintain hydraulic control of fluids for operations in the 80 sand in Wellfield 5 as discussed in SER Section 2.4.3.2.

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Layer (Shallow to Deep)	Wellfield 5	
	Approximate Thickness (ft)	Description
110 sand	0-25	Surficial sandstone (discontinuous)
110/100 shale	10-20	Confining layer
100 sand	0-50	Sandstone (multilayer, discontinuous)
100/90 shale	5-75	Confining layer
90 sand	0-50	Ore zone overlying sandstone (multilayer, discontinuous)
90/80 shale	5-50	Ore zone overlying confining layer
80 sand	0-50	Ore zone sandstone (multilayer, discontinuous)
80/70 shale	10-50	Confining layer between ore zones
70 sand	0-100	Ore zone sandstone (multilayer, discontinuous)
70/60 shale	25-75	Ore zone underlying confining layer
60 sand	10-25	Ore zone underlying sandstone

Table 2.3-4 Stratigraphy of Wellfield 5

Wellfield 6

Wellfield 6 is located in the southwestern portion of the license in Sections 34, 35 and 36 of T34N R73W as shown SER Figure 2.1-1. The licensee reported that mineralization in the area is contained within the 70, 80, and 90 sands. However, the licensee stated it only intends to recover uranium from the 90 sand in Wellfield 6. The licensee reported the depth to the mineralization in Wellfield 6 ranges from 53 to 271 ft bgs in Table 2.7B1-a of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Cross Section T-T', provided in Figure 2.6A- 23 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), shows the subsurface geology along the major axis of Wellfield 6. The NRC staff conducted an evaluation of this cross section and the isopachs provided to verify the licensee had provided sufficient information to characterize the stratigraphy in Wellfield 6 and assess the location and thickness of the targeted ore zone sandstone and overlying and underlying confining layers and sandstones to determine compliance with applicable portions of SRP Acceptance Criteria 2.6.3 (NRC 2003).The results are shown in SER Table 2.3-5.

Layer (Shallow to Deep)	Wellfield 6	
	Approximate Thickness (ft)	Description
110/100 shale	0-20	Confining layer
100 sand	0-25	Ore zone overlying sandstone (discontinuous)
100/90 shale	20-75	Ore zone overlying confining layer
90 sand	50-150	Ore zone sandstone (multilayer)
90/80 shale	10-100	Ore zone underlying confining layer
80 sand	0-70	Ore zone underlying sandstone (multilayer, discontinuous)

Table 2.3-5 Stratigraphy of Wellfield 6

NRC staff finds the Wellfield 6 geology has been characterized in sufficient detail to demonstrate that the targeted 90 ore zone sandstone, is located between the 100/90 and 90/80 shale layers with thicknesses of 10 ft or more. NRC staff finds the presence of competent confining layers of thickness greater than 10 ft provides evidence that the production sand is physically isolated to prevent the movement of production fluids outside the targeted 90 sand production ore zone.

2.3.3.3 Exploration Boreholes

The licensee reported in Section 2.6.4 and Addendum 2.6-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that the Ludeman Project license area had been extensively explored for uranium by several companies from the 1970s to the 1990s. From 1967 to the 2000, the licensee reported approximately 4,574 drill holes and approximately 66 core holes were completed by other exploration companies. In addition, the licensee reported it had drilled approximately 1,107 rotary drill holes, 1 core hole and 42 monitoring wells in 2007 and 2008.

The licensee provided the description and location of all known drill holes in Table 2.6B-1 and Figure 2.6B-1, respectively, in Addendum 2.6-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Within Table 2.6B-1, the licensee also assigned a number to designate the abandonment procedures which were used to plug these boreholes as follows:

1. Holes drilled by Uranium One USA, which were plugged according to Wyoming Department of Environmental Quality- Land Quality Division (WDEQ-LQD) Rules & Regulations (Chapter 8).
2. Holes typically drilled prior to 1979, which were sealed with drill and natural muds defined as drill muds commonly used to drill, plug, and core holes. No additional materials added to increase viscosity; holes were surface sealed with backfill and cement caps.
3. Holes drilled from 1979 to 2000, which were sealed with fortified drill muds defined as T.D. or abandonment muds as required by W.S. 35-11-404. Holes were surface sealed with backfill and cement caps.
4. Holes with no description of drilling or abandonment.

According to Table 2.6B-1, the majority of wells drilled by previous exploration companies were plugged and abandoned per WDEQ requirements at the time; however, the abandonment procedure was reported as unknown for 780 wells.

The licensee therefore committed in Addendum 2.6-C of the Ludeman Project Revised Technical Report to properly plug and abandon any open or improperly plugged drill holes within the Ludeman Project wellfields. Specifically, the licensee committed to take the following actions:

1. Conduct a search for historic holes while working within the area of each proposed wellfield based on the most current data available regarding the location of historic drill holes.
2. Plug and abandon any historic drill hole discovered in accordance with WDEQ procedures prior to hydrogeologic testing in each wellfield.
3. Document the location and plugging of each drill hole discovered.

The NRC staff finds the assessment of the location and plugging of boreholes and the commitment to take corrective action if any improperly plugged holes are located meets the applicable acceptance criteria in SRP Section 2.6.3 (NRC 2003) and regulatory requirement in 40.41(c) to control production fluids.

2.3.3.4 Seismology

The licensee characterized the seismology within and around the Ludeman Project in Section 2.6.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for the area using an analysis of the available literature and record of historical seismicity. The licensee reported the magnitude, date, and location of all known seismic events for Converse, Albany, Campbell, Carbon, Natrona and Johnson Counties. The licensee also provided the location, where available, of all recorded earthquakes and mapped faults in relation to the Ludeman Project license area on Figure 2.6A-42 of Addendum 2.6-A. This figure shows that most of the historic earthquakes have occurred in the west-northwestern portion of Wyoming. The east-central portion of Wyoming, where the Ludeman Project is located in Converse County, has had a low to moderate level of earthquakes. Specifically, the licensee reported that twelve magnitude 3 or greater earthquakes have been recorded in Converse County since 1947. The largest was a magnitude 3.8 earthquake which occurred on August 29, 2004, approximately 10 miles north-northwest of Douglas, WY. No damage was reported. For all of the counties, the largest earthquake in the past 100 years which occurred in this region was a magnitude 5.1 in Johnson County on September 7, 1984.

The licensee reported there were no capable faults with surface expression mapped within or near where the Ludeman Project is located; therefore, no fault-specific analysis was possible. The licensee did provide a floating or random earthquake analysis, and reported the largest floating earthquake for the province where Converse County is located would have an average magnitude of 6.25. If this earthquake were placed within 15 km (9.32 mi) of any structure in Converse 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 (Uranium One USA 2017d).

The licensee reported that the most recent USGS probabilistic acceleration maps for Wyoming were published in 2008 . These maps, which were provided in Addendum 2.6-A Figures 2.6A-43, 2.6 A-44 and 2.6A -45, display the 500-year, 1,000-year, and 2,500-year probabilistic

accelerations for Wyoming near the Ludeman Project. The licensee estimated the peak horizontal acceleration for Converse County ranges from: 3 to 6 percent of gravity on the 500 –year map; 5 to 9 percent of gravity for the 1000-year map; and 9 to 19 percent of gravity for the 1000-year map. As shown in Table 2.6A-1, these accelerations are equivalent to Level IV, V, VI and VII earthquakes. The damage that would be expected at these levels through Converse County are shown Table 2.6A-2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Because the existing building codes are based on the 2,500-year probability, the licensee concluded the damage to buildings constructed in compliance with those codes and their contents would be moderate.

The staff review of the licensee's seismic characterization of the Ludeman Project finds it acceptable, because it provides a satisfactory analysis of seismic setting and hazard based on seismological characterization data from reliable sources including recent publications from the United States Geological Survey (USGS) and the Wyoming State Geological Survey.

2.3.3.5 Soils

The licensee described and mapped the soils within the Ludeman Project area based on a soil survey conducted in 2008. The licensee provided a description of the soil survey methodology in Section 2.6.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). A map of soils was provided for the area in the Ludeman Project Revised Environmental Report Addendum 3.3-A (Uranium One USA 2017e).

The licensee reported the soils in the Ludeman Project area are typical for semiarid grasslands and shrublands in the Western United States. Most soils were taxonomically classified as Ustic Torriorthents, Ustic Haplargids and Ustic Torrifluents. The licensee found marginal material for a plant-growth medium at 37 of 56 sampling locations studied and unsuitable material at 3 of the 56 sites. No prime farmland was identified in the Natural Resources Conservation Service (NRCS) letter in Addendum 3.3-F of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e). The soils within the Ludeman Project area exhibited a negligible to severe wind and water erosion hazard; the soils are more susceptible to erosion from wind than water.

Based on the information provided, the staff finds that the licensee adequately described the soils within the Ludeman 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.

2.3.4 Evaluation Findings

The NRC staff evaluated the licensee's site characterization information addressing geology and seismology at the Ludeman Project in accordance with the review procedures in SRP Section 2.6.2 and the acceptance criteria in SRP Section 2.6.3.

The NRC staff finds the licensee has acceptably characterized the geology and seismology by providing: a description of the local and regional geologic structure; a description of the local and regional stratigraphy; a site stratigraphic column that includes the thickness of rock units and description of lithologies; a geologic description of the mineralized zone ; geologic cross sections and isopach maps at acceptable scales showing surface and subsurface features and locations of all wells and logs used in defining site stratigraphy; a discussion of exploration

boreholes and their plugging and abandonment; a discussion of the seismic history and hazard of the region; and a description and map of the soils.

Based on the information provided by the licensee, and the NRC staff's review conducted of the characterization of the geology and seismology at the Ludeman Project, the NRC staff concludes, that with one exception in Wellfield 2, the information is sufficient as it meets the applicable acceptance criteria of SRP Section 2.6.3. As described in SER Section 2.3.3.2, the licensee incorrectly identified the 70 sand as the ore zone aquifer in Wellfield 2 when it is located in the 60 sand. In addition, the licensee did not characterize the 60 sand to enable the staff to make findings regarding the hydraulic control of production fluids in Wellfield 2. As discussed by the NRC staff in SER Section 2.3.3.2, the licensee acknowledges this error (Uranium One Americas 2013c; NRC 2016c, 2017a) and has agreed to a license condition which prohibits any construction of or operation to recover uranium in Wellfield 2 as part of this license amendment. Therefore, the NRC staff will add a new License Condition 10.22 to the Willow Creek Source Material License SUA-1341 as described in SER Section 3.1.4 and shown in SER Table 1.1-1.

Otherwise, staff finds the information is sufficient for staff to conclude as described in SER Section 2.3.3 that the geologic setting within the wellfields and the licensee commitment to plug and abandon any exploratory boreholes that the licensee will have the ability to maintain control over production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c).

2.4 Hydrology

This section describes the NRC staff's evaluation of the licensee's description of site hydrology at the Ludeman Project. The licensee provided information on the hydrology of the Ludeman Project in Section 2.7 and Addendum 2.7-A, B, and C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). This information is needed to establish the potential effects of ISR operations on the surface water and ground water resources and the potential effects of surface water flooding on the in situ recovery facility. The following sections present the NRC staff's review and analysis of various aspects of the surface water and ground water hydrology and ground water use for the Ludeman Project. Unless otherwise stated, the information reviewed in this section is from information, data and maps submitted by the licensee in its Ludeman Project Revised Technical Report (Uranium One USA 2017d).

2.4.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the characterization of surface water, ground water hydrology and ground water use at the Ludeman Project is sufficient to document the licensee's ability to maintain control over production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the NRC staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in SRP Section 2.7.3 (NRC 2003).

2.4.3 Staff Review and Analysis

The following sections present the NRC staff's review and analysis of various aspects of the surface water and ground water hydrology for the Ludeman Project.

2.4.3.1 Surface Water

The licensee characterized the surface water hydrology for the proposed Ludeman Project in Section 2.7 and Addendum 2.7-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee provided a map of the major watersheds, surface water features, surface water rights, sampling sites and FEMA 100-year flood hazard zones for the license area and 2 mile buffer in Figure 2.7A-1 of Addendum 2.7-A of the Revised Technical Report.

The licensee reported that the Ludeman Project license area and 2 mile review buffer falls within the north-eastern portion of the Middle North Platte – Casper Basin. The major 12 digit Hydrologic Unit Code watersheds that are located within the 2 mile buffer are shown in SER Figure 2.4-1 which was adapted from Figure 2.7A-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). All of the watersheds discharge directly into the North Platte River just south of the Ludeman Project southern boundary. The North Platte River flows to the east to the city of Douglas. Farther downstream it flows southeast into the Glendo Reservoir and on to the Guernsey Reservoir. Past this reservoir, the North Platte River flows into Nebraska where it joins the South Platte River to form the Platte River which enters the Missouri River.

The licensee defined eight sub-watersheds within the Ludeman Project license area as shown in SER Figure 2.4-2 which was adapted from Figure 2.7.A-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). These sub-watersheds were named as Sand -10, Sand-20, Sage-10, Sage-11, Sage-12, Sage-13, Sage-14, Sage-20 and RD-10. The licensee reported the Sand -10 drainage had an area of 0.8 square miles and channel length of 1.36 miles with an average slope of 0.94 percent. The Sand -20 drainage was reported to have a total drainage area of 5.16 miles and a length of 2.81 miles with an average slope of 0.94 percent. The licensee stated the Sage -10 drainage had an area of 3.75 square miles and channel length of 4.25 miles with an average slope of 0.53 percent. The Sage -11 drainage was reported to have a total drainage area of 1.96 square miles and a length of 2.72 miles with an average slope of 1.46 percent. The Sage -12 drainage was reported to have a total drainage area of 3.33 square miles and a length of 3.17 miles with an average slope of 1.14 percent. The Sage -13 drainage was reported to have a total drainage area of 2.34 miles and a length of 2.60 miles with an average slope of 1.31 percent. The licensee stated the RD -10 drainage had an area of 3.33 square miles and channel length of 1.90 miles with an average slope of 1.2 percent.

The licensee identified approximately 195 individual water bodies ranging from 28 square ft to 5.1 acres in the Ludeman Project license area and two mile buffer. The largest of these surface water impoundments are shown in SER Figure 2.4-2. Most of these water body features are located on drainages which were impounded for livestock while others are stock ponds supplied by windmills. The licensee reported the largest pond was Gilbert Lake in the eastern portion of the license area. Gilbert Lake was described as 16 acres and 6 inches deep when surveyed in 2008.

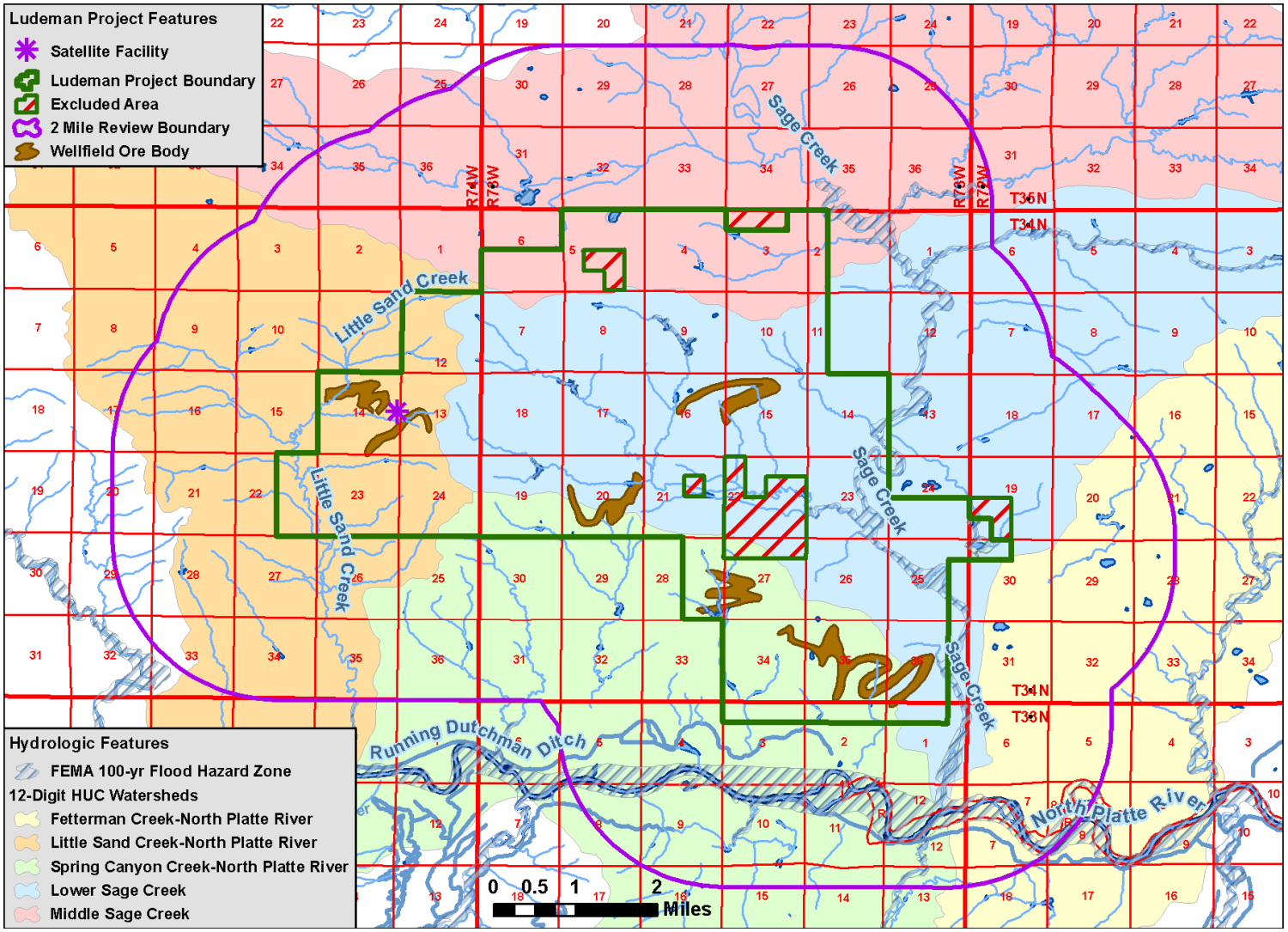

Figure 2.4-1 Watersheds and Surface Water Features in the Ludeman Project and 2 Mile Review Buffer

The licensee reported that there were no USGS stream gauges in the license area. Historical stream discharge data were available from USGS stream gauges at (1) Running Dutchman Ditch (RDD), (2) Sand Creek and (3) the North Platte River near the license area and two mile buffer. The location of these stream gauges is shown in Figure 2.7A-2 of Addendum 2.7-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For RDD, an irrigation channel, a gauge was located just south of the Ludeman Project license area in the two mile buffer and was active from 1935-1950. The daily mean discharge of water from the North Platte River into the RDD was 8.2 cfs. The Sand Creek gauge, located just up gradient from the license area near the city of Glenrock, received drainage from the western portion of the license area. Flow measured at this gauge from 1977-1981 demonstrated an average of 0.64 cfs (cubic ft per second) with a maximum peak flow of 546 cfs. The North Platte River gauge was located downstream of the proposed license area at the city of Douglas and was active from 1919 to 1959. It measured an average flow of 1563 cfs and max peak flow of 16,700 cfs. The licensee reported that since this time many dams and reservoirs have been constructed on the North Platte River and flows and diversions are closely controlled.

The licensee reported that no perennial or intermittent streams exist within the drainage channels of the eight sub-watersheds in the license area. The licensee also reported that the drainage channels are dry for the majority of the year. The licensee stated it was therefore not able to measure the flow within these ephemeral drainage channels. On a field visit in August 2012, the NRC staff verified the lack of flow in several drainages within the license area. Staff noted that many drainages were typically flat and wide with no well-defined channel. The drainages observed by staff were typically vegetated with dry grasses, sagebrush, and small trees.

The licensee evaluated the potential for flooding from runoff in the license area in Section 2.7.1.9 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported that the runoff in the license area will consist of primarily overland sheet flow. The licensee estimated the surface runoff for peak storm rates for the license area using the HEC-HMS software program developed by the US Army Corp of Engineers. The HEC-HMS software is a well-established and accepted method and is listed in both NUREG-1623 and WDEQ guidelines. The licensee stated the HEC-HMS program uses the Soil Conservation Service (SCS) Unit Hydrograph Runoff Method which is suitable for the watersheds in the license area.

The licensee applied the HEC-HMS software to determine the peak runoff flow rates in drainage channels in two major watersheds in the license area, the Little Sand Creek watershed on the west side and Sage Creek watershed on the east side. As shown in SER Figure 2.4-2, the satellite facility and Wellfields 1 and 2 are located in the Little Sand Creek watershed. The Little Sand Creek drainage channel runs through Wellfield 1. The Sage Creek watershed covers the middle and eastern portion of the license area. The Sage Creek drainage channel is located very near to the east side of Wellfield 6.The licensee described the model input parameter selection and features for the HEC /HMS software simulation in Section 2.7.1.9.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee used the model to determine peak runoff rates for a 50-yr and 100-yr 24–hour SCS Type II storm. The NRC staff found the HEC-HMS simulation approach to be acceptable as it focused on large watersheds which have or are near critical infrastructure and used a realistic peak runoff scenario.

The licensee reported the HEC-HMS simulated peak flow rates for the drainage channels in the Little Sand Creek and Sage Creek watersheds for 50-yr and 100- yr recurrence intervals in

Table 2.7A-1 of Addendum 2.7-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For the Sand Creek drainage channel, at its confluence with the North Platte River, the peak runoff flow rate was 4276 cfs for a 100-yr event and 3694 cfs for the 50–yr event. For Sage Creek, at the confluence with the North Platte River, the peak flow was 5,794 cfs for the 100- yr event and 4,591 cfs for the 50-yr event.

The NRC staff finds that these estimated flow rates, although downstream from the license area, could indicate flow rates within the Little Sand Creek or Sage Creek which may potentially impact infrastructure in the wellfields which are placed near these drainage channels. The licensee stated the satellite plant and associated infrastructure are located on high flat ground that is unlikely to be impacted by runoff. The licensee also committed to facility planning that will ensure that runoff will be directed away from the satellite plant and associated infrastructure such as ponds in Section 2.7.1.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also stated in Section 2.7.1.7 that if flooding occurs, it will undertake operational changes such as shut down of production flow to and from the wellfield until the inundation is eliminated.

The NRC staff reviewed the FEMA 100-year flood hazards, surface water rights and sampling locations on a wellfield by wellfield basis. The surface water features near the Ludeman satellite facility and Wellfields 1 and 2 are shown in SER Figure 2.4-3. The satellite facility and both wellfields are located in the Sand -20 drainage of the Little Sand Creek sub-watershed. The southern tip of Wellfield 2 is located in the Sand -10 drainage. No FEMA 100-year flood hazard zones are present within or near the satellite facility or these wellfields.

The licensee reported there were five surface water rights within 2 km of Wellfield 1 and 2 as shown in SER Figure 2.4-3. The NRC staff reviewed the status of these surface water rights using the Wyoming State Engineers Office (WSEO) water rights database. The NRC staff found two of the surface water rights, P8065R and P8066R, were for two evaporation ponds used for liquid waste disposal at the historical Teton Pilot ISL. The historical location of the two ponds has been noted by the NRC staff on SER Figure 2.4-3 based on drawings from original 1983 Leuenberger Final Environmental Impact Statement (FEIS) (NRC 1983). The NRC staff determined that both of these ponds were decommissioned before the Teton Pilot ISL license was terminated (NRC 1986). In addition, the WSEO permits have been cancelled. Two other permits for impoundments, P8533.0R and P8532.0R, were also issued for the historical Teton ISL facility. The NRC staff determined these impoundments were never built and the WSEO permits were cancelled. The remaining surface water permit, P20858.OD, was issued in 1951 for storage of irrigation water and has expired. The NRC staff therefore finds there are no current surface water rights within 2 km of Wellfields 1 and 2.

The licensee reported it had located three surface water sampling points (SW-1, SW-24 and SW-25) near Wellfields 1 and 2. These locations were sampled to evaluate surface water quality before operations. A discussion of pre-operational water quality measured at these locations is provided separately in SER Section 2.5.3.1.

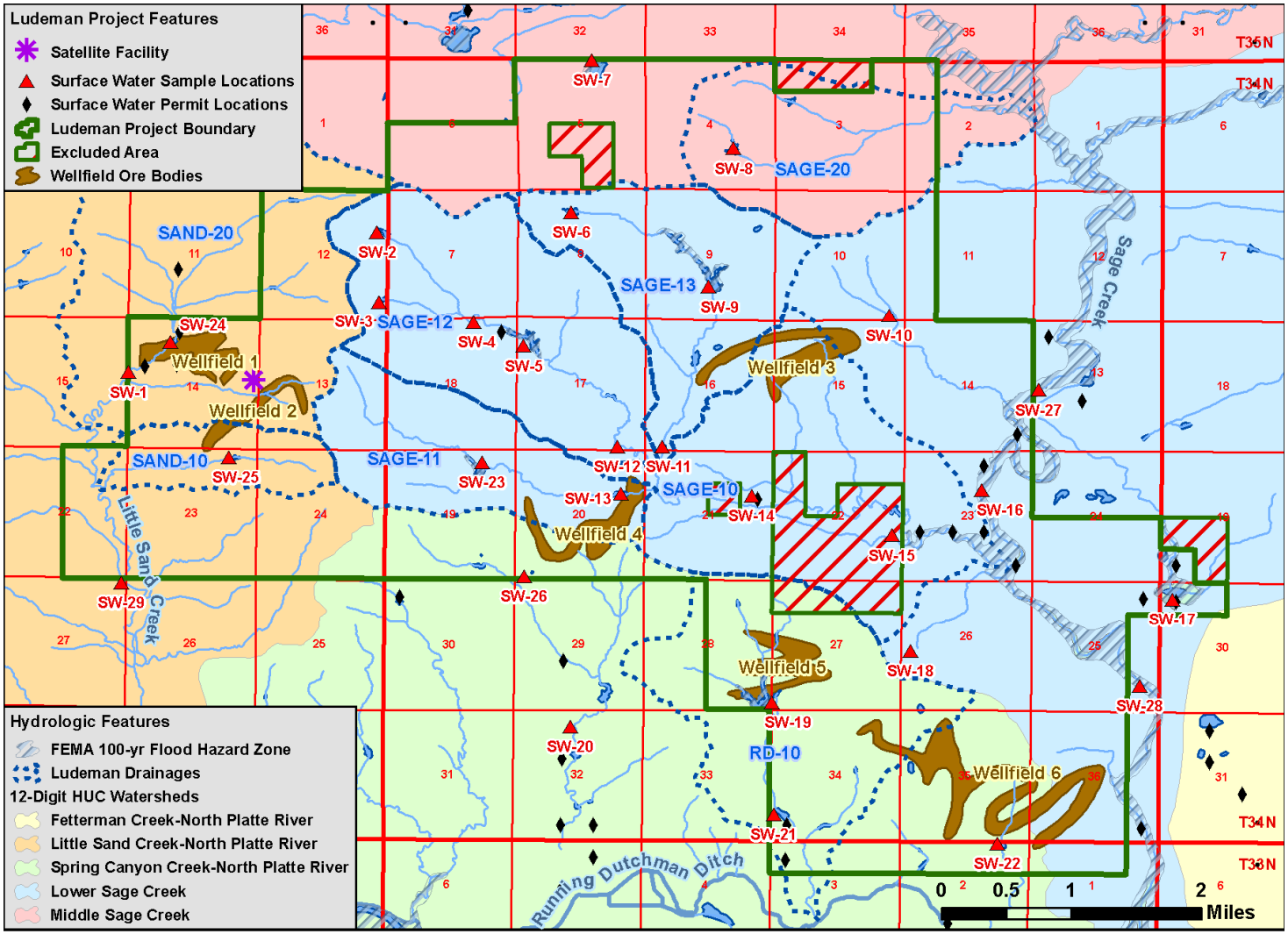

Figure 2.4-2 Ludeman Project Sub-Watersheds, Surface Water Features and Rights

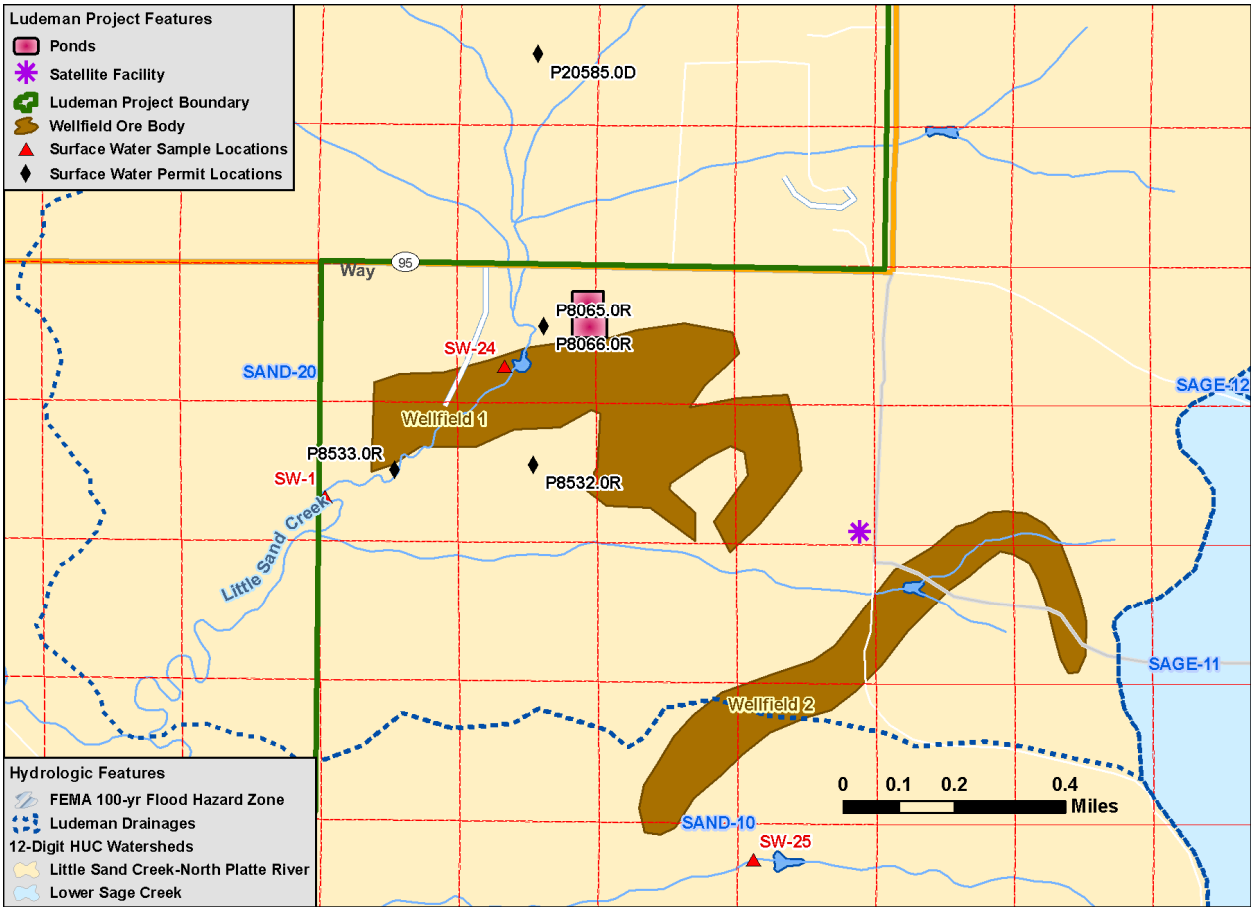

Figure 2.4-3 Surface Water Features and Rights near Wellfields 1 and 2

The surface water features near Wellfields 3 and 4 are shown in SER Figure 2.4-4. Wellfield 3 crosses the Sage -10 and Sage -13 subwatersheds and also lies within a small portion of unconcentrated flow within the larger Sage Creek watershed. Wellfield 4 lies mainly within the Sage-11 subwatershed and a portion of the RDD watershed. There are three water bodies designated as FEMA 100- year flood hazard zones near but not within these wellfields. NRC staff finds these 100- year flood hazard zones are located sufficiently distant from Wellfield 3 and 4 to not represent a significant source of flooding for these wellfields.

The licensee reported one surface water right within 2 km of these wellfields in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). NRC staff found this surface water right, P3275.0R, was issued in 1916 for an irrigation impoundment. The permit shows an expiration notice was issued in 1922. The WSEO database currently reports the status of this water right as incomplete. NRC staff therefore finds there are no current surface water rights within 2 km of Wellfields 3 and 4.

The licensee reported ten surface water sampling points, SW-5, 9, 10, 11, 12, 13, 14, 15, 23 and 26, are located near Wellfields 3 and 4 as shown in SER Figure 2.4-4 (Uranium One USA 2017d). These surface water locations were sampled to evaluate surface water quality before

operations. A discussion of pre-operational surface water quality measured at these locations is provided separately in SER Section 2.5.3.1.

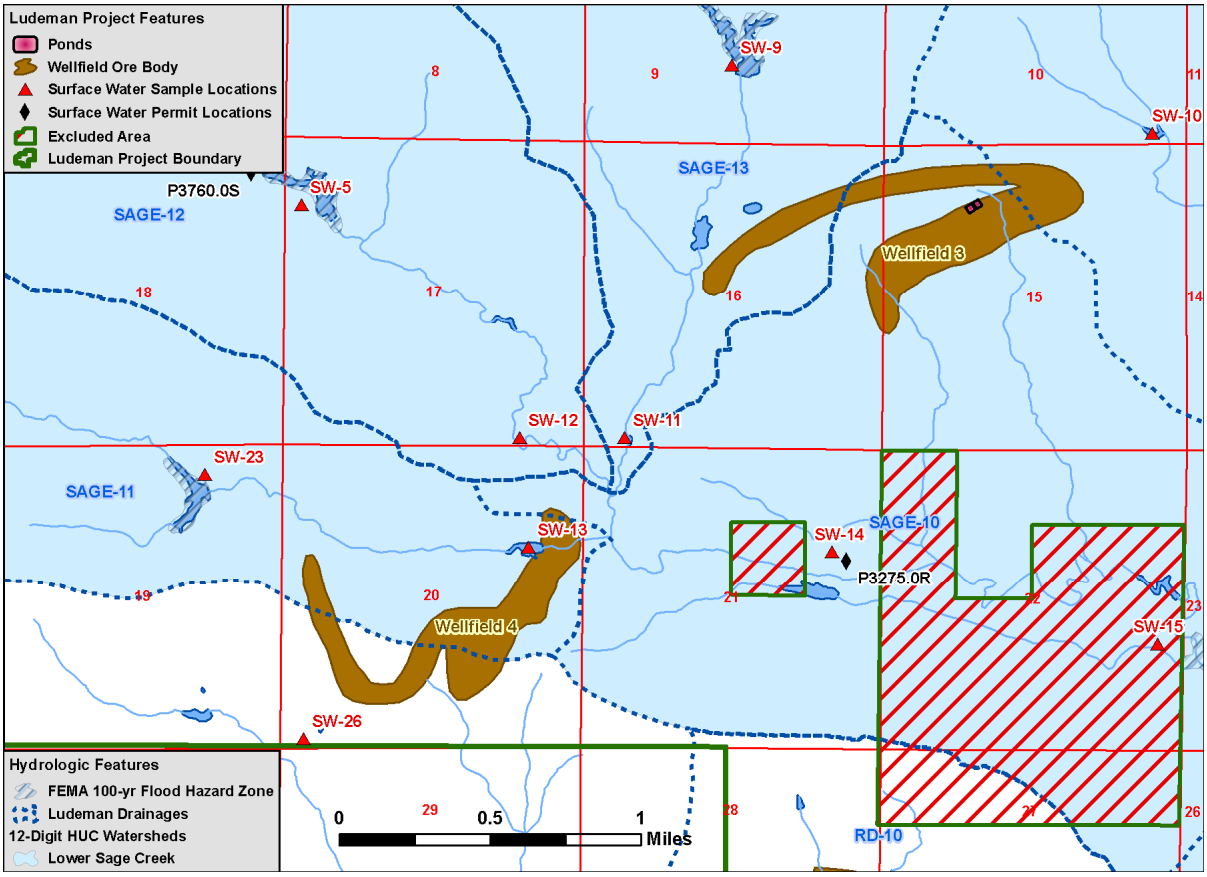

Figure 2.4-4 Surface Water Features and Rights near Wellfields 3 and 4

The surface water features for Wellfield 5 and 6 are shown in SER Figure 2.4-5. Wellfield 5 is located in RD -10 sub-watershed. Wellfield 6 is located in far eastern portion of RD-10 and the Lower Sage Creek watershed. Sage Creek to the east and the North Platte River to the south display FEMA- 100 year flood hazard zones all along their length. One impoundment to the east, known as Gilbert Lake, is shown as a 100- year flood hazard zone. The NRC staff finds these 100- year flood hazard zones are located sufficiently distant from Wellfield 5 and 6 and are unlikely to be a significant source of flooding.

Another large impoundment, located in Wellfield 5 in Section 28 of T34N R73W, is marked as a FEMA 100- year flood hazard zone in SER Figure 2.4-5. The licensee identified this impoundment as WB-43 in Photo 23 of Addendum 3.5- K of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e). The photo shows that WB-43 was inundated in August 2008. The licensee reported that WB-43 was a diked drainage, 5.09 acres in size, in the wetland summary table in Addendum 3.5-I of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e). The NRC staff reviewed this information and recent satellite images of this impoundment in Wellfield 5 from 2009-2015. The NRC staff found the area of surface water feature was variable but it was inundated in different seasons over this time period.

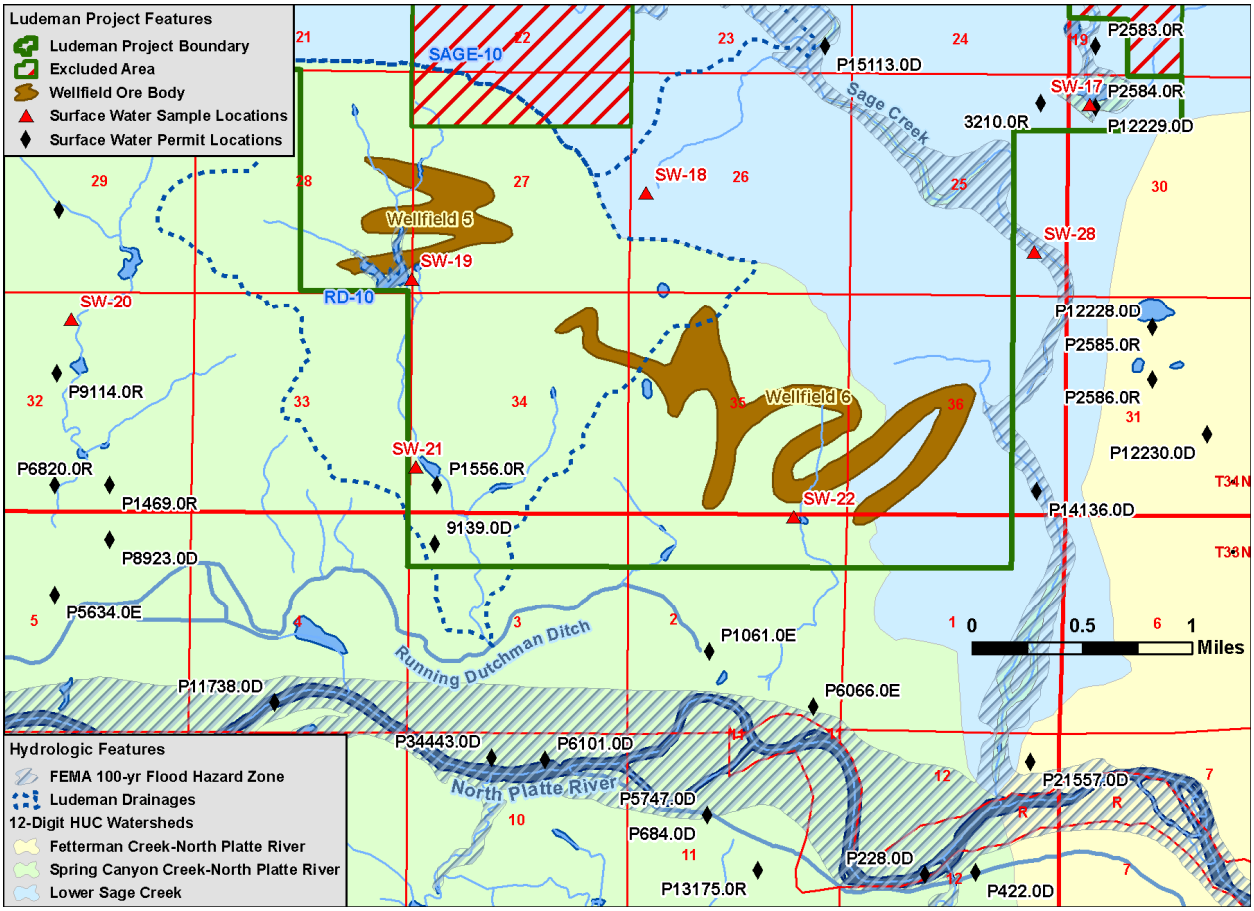

Figure 2.4-5 Surface Water Features and Rights near Wellfields 5 and 6

The NRC staff concludes that any wellfield infrastructure located in the footprint of this apparently perennial but variable surface water feature in Wellfield 5 would be subject to damage from periods of standing water and flooding. The NRC staff addresses the safety issues involved with this surface water feature in SER Section 3.1.3.8. Because of the safety concerns with this feature in Wellfield 5, the NRC staff will require new License Condition 10.23 to be added to the Willow Creek Source Materials License as described in SER Section 3.1.4 and shown in SER Table 1.1-1.

The licensee reported numerous surface water rights near Wellfields 5 and 6 in Table 2.7A-3 and showed these water rights in Figure 2.7A-1 of Addendum 2.7-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC reviewed the status of the 10 surface water rights shown in SER Figure 2.4-5 that were within 2 km of these wellfields using the WSEO water rights database. The NRC staff found two of the surface water rights, P2585.0R and P2586.0R, granted in 1913 and 1916 respectively, were off-channel irrigation impoundments. These permits expired in 1917. Two other permits for impoundments, P12228.0D and P12230.0D, granted in 1913, were issued for irrigation ditches. These permits expired in 1915 and 1917, respectively. Permit 14136.0D, granted in 1916 for an irrigation ditch, is expired. Permits P1061.0E and P6066.0E, were issued in 1903 and 1961 as enlargements on RDD, a canal used for irrigation. The surface water right, P1061.0E, is expired. The surface

water right to P6066.0E is fully adjudicated (permanently granted). Surface water rights for 9139.0D and 1556.0R were granted in 1909 and 1913 and are fully adjudicated (permanently granted) for irrigation. The remaining permit, P15113.0D, granted in 1918 for an irrigation ditch, is fully adjudicated (permanently granted). In summary, the NRC staff verified only four of the surface water rights are still in existence at this time.

The NRC staff finds only one of these surface water rights, P1566.0R, is an impoundment located on a drainage downgradient of Wellfield 5. It is therefore potentially hydrologically connected to surface water flows from the drainage in Wellfield 5. The licensee has placed a surface water sampling site, SW-21, at this impoundment. The licensee has conducted pre-operational water sampling and has committed to operational sampling of surface water at this location as described in SER Section 5.7.8.3.2. The NRC staff finds the remaining 3 surface water rights are not hydrologically connected to Wellfields 5 or 6 and are located more than 1 mile from either wellfield. The NRC staff therefore finds it is unlikely they could be impacted by wellfield operations.

The licensee reported 7 surface water sampling points, SW-17, 18, 19, 20, 21, 22, 28, were located near Wellfields 5 and 6. These sites were sampled to evaluate surface water quality before operations. A discussion of pre-operational water quality at these locations is provided separately in SER Section 2.5.3.1.

The licensee reported that portions of Wellfield 5 and Wellfield 6 are located in a hydrologic zone which is covered under the Modified North Platte River Decree in the Ludeman Project Revised Environmental Report (Uranium One USA 2017e). This decree was issued by the Supreme Court of the United States on November 13, 2001 and addresses water use from the North Platte River. In this decree, portions of the North Platte River watershed are identified as hydrologically connected to the North Platte River. Within these regions, surface water and ground water use for irrigation and other purposes are strictly controlled by a court order. This decree therefore places limitations on the extraction and use of surface water and ground water in these zones.

The NRC staff's review of the Modified North Platter River Decree regional map confirmed that a portion of Wellfield 5 and all of Wellfield 6 are located within the hydrologically connected region (https://sites.google.com/a/wyo.gov/seo/documents-data/maps-and-spatial-data). Therefore, NRC staff concluded that all water use from these wellfields, whether surface or ground water, must meet the requirements of the decree. In the State of Wyoming, the WSEO is responsible for enforcing the decree. Specifically, all water use which is determined to be hydrologically connected to surface water flows of the North Platte River must meet the mitigation requirements in the WSEO Platte River Recovery Implementation Program (PRRIP) Any evaporation or surge ponds must also meet the mitigation requirements of the PRRIP.

To address this issue, the licensee conducted an evaluation of its proposed ground water use during the operation of Wellfield 5 and 6 with respect to the requirements of WSEO PRRIP using the WSEO approved 28:40 criteria. The 28:40 criteria requires a finding that if water from the wellfields were intentionally withdrawn for 40 years, the cumulative stream depletion would be less than 28 percent of the total ground water withdrawn from the wells. If that conclusion cannot be reached, mitigation is required. As the licensee does not plan to install any ponds in this location, surface water use was not addressed. The licensee presented the details of the analysis using the WSEO 28:40 criteria and results in Addendum 4-A of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) The licensee determination was that

the proposed Wellfield 5 and Wellfield 6 ground water use would not violate the WSEO 28:40 criteria.

The WSEO evaluated the licensee's assessment of ground water use at the Ludeman Project Wellfields 5 and 6 with respect to compliance with the requirements of the PRRIP. In a letter dated November 25, 2015 (WSEO 2015), WSEO reported its determination "that the portion of Wellfield 5 and all of Wellfield 6 are not hydrologically connected to the surface water flows of the North Platte River, and thus are not considered depletive under the PRRIP." Therefore, the WSEO concluded no mitigation is necessary; however, the WSEO did state if activity at the facility is found to have depletive effects, the licensee may be required to mitigate depletions at a future date. The NRC staff finds that given the conclusion in the WSEO letter, there is no new safety issue related to ground water or surface water use within Ludeman Project Wellfields 5 and 6 related to the Modified North Platte River Decree that requires evaluation for this license amendment.

Based on its review, the NRC staff finds the licensee adequately described the surface water hydrology of the Ludeman Project license area. The NRC also conducted site visit of the license area in the August 2012 and finds the surface water features the staff encountered meet the licensee descriptions. Consequently, staff finds that the licensee provided sufficient information to meet the surface water characterization acceptance criteria in SRP Section 2.7.3 to enable staff to conduct its evaluation of the surface water hydrology.

2.4.3.2 Ground Water

The licensee presented the regional hydrogeology in Section 2.7.2 and Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported the Ludeman Project license area is located in the south-central portion of the PRB in the Northern Great Plains aquifer system. The Northern Great Plains aquifer system is composed of numerous aquifers in the lower Tertiary, Upper and Lower Cretaceous and Upper and Lower Paleozoic rocks. The licensee provided a regional hydrostratigraphic column of the PRB displaying the units of this aquifer system in Figure 2.7B-1 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The regional aquifers of interest were identified from shallow to deep by the licensee as the Eocene Wasatch Formation, the Paleocene Fort Union Formation, and the late Cretaceous Lance Formation and Fox Hills sandstone. The Wasatch Formation is typically eroded in the license area, but some remnants remain with multiple water bearing sands. The majority of aquifers in the Wasatch Formation are confined (saturated), but some unconfined (partially saturated) aquifers also exist. Wasatch Formation wells were reported to yield 10-50 gpm.

The Fort Union Formation lies below the Wasatch Formation. The contact between the Fort Union and Wasatch Formations is about three miles north of the license area. The licensee described the Fort Union Formation as continental and shallow non-marine deposits of sandstone, carbonaceous shale and coal. The Fort Union Formation outcrops within the license area. The Lebo member of the Fort Union Formation is the target ore bearing formation in the license area. Ground water is produced from sandstone, jointed coal and clinker beds in the Fort Union Formation. Permitted wells in the Fort Union Formation aquifers near the Ludeman Project were reported by the licensee to yield 2-40 gpm.

The licensee reported the Lance Formation underlies the Fort Union Formation and is composed of mainly lenticular, clayey calcareous sandstone. It outcrops a few miles southwest

of the license area. The Fox Hills sandstone underlies the Lance Formation. It consists of fine to medium grain sandstone beds which were deposited in a marine environment. The Fox Hills sandstone lies above the Lewis shale, which is a thick sequence of shale. The Fox Hill sandstone acts as the basal aquifer of the Lower Tertiary/Upper Cretaceous hydrostratigraphic sequence in the Northern Great Plains aquifer system. The licensee reported that wells in the Fox Hills sandstone aquifer typically yield 5-50 gpm, with maximum yields of 200 gpm. The licensee reported there are no known faults which impact these formations within this portion of the PRB.

The licensee reported that recharge to ground water occurs in the PRB at higher elevations from precipitation or snow melt. Near the license area, recharge to the Fort Union Formation and overlying Wasatch Formation aquifers occurs along their formation outcrops along the western and southwestern edges of the basin. Discharge occurs into shallower aquifers in the center of the basin. This recharge /discharge pattern creates regional movement of ground water in the south central PRB which trends from southwest to northeast. The licensee provided a generalized potentiometric contours for the Lower Tertiary Unit of the Northern Great Plains aquifer system, which contains the target Fort Union Formation and overlying Wasatch Formation aquifers in Figure 2.7B -2 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The potentiometric contours showed ground water flows to the northeast.

The licensee characterized the license area site hydrogeology in Section 2.7.2 and Addendums 2.7-B, C, D, E, F and G of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that ground water aquifers may be present from the surface to depth within the 120, 110, 100, 90, 80, 70, 60, 50 and 40 sands. The location of the aquifers is dependent on the presence of these sandstones at specific locations within the license area as described in SER Section 2.3.3.2. Specifically, the 120 and 110 sands are eroded and not present as aquifers in the southeastern portion of the license area. The 110 and 100 sands are also absent in large portions of the license area.

The licensee installed a network of 23 monitoring wells to characterize the hydrogeology and pre-operational ground water quality of the license area. The licensee also installed 16 wells for aquifer testing. Information on the location, completion, depth, targeted aquifer, and water levels of these monitoring and aquifer test wells was provided by the licensee in Addendum 2.7-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also monitored several existing stock wells across the license area. The location and completion information for the stock wells is provided in Table 2.7B-17 of Addendum 2.7- B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The locations of the monitoring wells and stock wells are shown below in SER Figure 2.4-6 which was adapted by the NRC staff from Figure 2.7B-3 the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The licensee also provided an assessment of all private ground water use including the location of and completion information on private ground water wells and ground water rights across and within a three mile buffer of the license area. The NRC staff's review of the private wells, ground water rights, and water use is presented in SER Section 2.4.3.3.

The licensee reviewed historical aquifer tests and conducted new aquifer tests within the license area to characterize the hydrogeologic behavior of the ore zone aquifers. The aquifer tests were used to determine the transmissivity, conductivity and storativity of the production zone aquifers in specific wellfields. In addition, the tests were used to assess if there is a hydrologic connection to overlying and underlying aquifers which may allow production fluids to escape

from the ore zones and contaminate overlying and underlying ground water. For the new aquifer tests, the licensee used select pumping and observation wells installed in Wellfields 1, 3, and 6 to assess the hydrogeologic characteristics of the targeted ore zone aquifers and integrity of ore zone confining aquitards overlying and underlying the ore zones. The location of the aquifer test and observation wells for Wellfields 1, 3, and 6 are shown in Figure 2.7B-3 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The licensee provided aquifer potentiometric contours developed from water levels measured in February and March 2009 from the monitoring well network and aquifer test and observation wells. The potentiometric contours for the 70, 60, 80, 90, 100, and 110 sands are shown in Figures 2.7B-5 to 2.7B-10 of Addendum 2.7-B, respectively, of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff finds the licensee correctly used water levels from the monitoring and aquifer test wells (non-pumping) to estimate the potentiometric contours. The number and location of water level measurements, however, did not enable the contours to be continuously mapped in the aquifers across the entire license area.

The NRC staff found the licensee's characterization the Ludeman Project hydrogeology demonstrated the aquifers vary greatly across the license area as many of the sandstones in the Fort Union Formation pinch out, separate into several sandstones, or are eroded. As a consequence, the NRC staff conducted the review of the hydrogeologic characterization of each wellfield separately.

Wellfield 1

Wellfield 1 is located in T34N, R74W Section 14 in the far northwestern corner of the license area as shown in SER Figure 2.4-6. The licensee characterized the hydrostratigraphy of Wellfield 1 as shown in SER Table 2.4-1. The licensee stated it will conduct uranium recovery in ore zones in both the 80 and 90 sand aquifers in Wellfield 1 in Table 2.7B1-a. The licensee reported the 100 sand or 110 sand may act as the overlying aquifer. However, where the110 and 100 sand are merged, the licensee stated it does not consider the 100 sand to be present and the 110 sand acts as the overlying aquifer. The 70 sand will act as the underlying aquifer.

The licensee reported that ore zones targeted in Wellfield 1 are the same that were targeted in the historical Teton ISL Pilot project which operated in this location. The NRC staff review of the historical Teton Leuenberger mining application (Teton 1980) and Final Environmental Statement (NRC 1983) confirmed the hydrostratigraphy matches the licensee description although the naming convention is different. As shown in SER Table 2.4-1 from surface to depth, the Teton ISL hydrostratigraphy was defined as the O2 sand aquifer (110 sand), O1 sand aquifer (100 sand), N sand ore zone aquifer (90 sand), M sand ore zone aquifer (80 sand), and the Basal aquifer (70 sand).

The NRC staff reviewed the ground water levels measured in February and March 2009 in monitoring wells located in aquifers in and near Wellfield 1 as reported by the licensee in Addendum 2.7-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). As shown in SER Table 2.4-1, the ground water levels in wells in the 110 sand, 90 sand, 80 sand and 70 sand were 5172, 5141-5165, 5138-5162, and 5152 ft, respectively. A difference in water level of approximately 7 ft was found between the 110 and 90 sand aquifers in wells LMO-1 and LPW-2. Essentially no water level difference was found between the 90 and 80 sands. A water level difference of 10 ft was found between the 80 and 70 sand aquifers in LPW-1 and LMU-1. Based on the minimum thickness of aquitards reported in SER Table 2.3-1, the NRC

staff calculated a vertical gradient of 0.1 and 0.20 between the 110 and 90 sand and the 80 and 70 sand aquifers. NRC staff find these significant vertical gradients (>0.10) support a finding that the overlying and underlying aquitards are sufficiently thick and competent to provide hydrologic separation of ore zone aquifers from the overlying and underlying aquifers in Wellfield 1.

Formation (Teton Pilot)	Hydro-stratigraphy	Monitoring Well	TOC Elevation (ft msl)	Top of Formation (ft msl)	Monitoring Well WL (ft msl)
110 Sand (O2)	Overlying Aquifer	LMO-1	5194	5109	5172
110/100 Shale	Aquitard	NA	NA	NA	NA
100 Sand (O1)	Overlying Aquifer	NA	NA	NA	NA
100/90 Shale	Overlying Aquitard	NA	NA	NA	NA
90 Sand (N)	Ore Zone Aquifer	LPW-2 LMP-3 LMP-4	5217 5225 5220	4992 4980 4995	5165 5142 5141
90/80 Shale	Aquitard	NA	NA	NA	NA
80 Sand (M)	Ore Zone Aquifer	LPW-1 LMP-2 LMP-1 M-8	5217 5220 5225 5257	4890 4875 4898 4867	5162 5140 5140 5138
80/70 Shale	Underlying Aquitard	NA	NA	NA	NA
70 Sand (Basal)	Underlying Aquifer	LMU-1	5217	4752	5152

Table 2.4-1 Hydrostratigraphy and Monitoring Well Water Levels in Wellfield 1

The licensee reported that the 90 and 80 sand ore zone aquifers within the wellfield are confined aquifers (saturated). The NRC staff confirmed the measurements provided in SER Table 2.4-1 showed the water levels ranged from 162-173 ft above the top of the 90 sand formation and 265- 272 ft above the top of the 80 sand formation in Wellfield 1. The NRC staff finds these water levels are greater than 10 ft above the top of the sand and therefore demonstrate the 90 and 80 sand aquifers are confined (saturated).

The NRC staff estimated the ground water flow direction and magnitude using the available potentiometric contours for February and March 2009 timeframe provided by the licensee in Figures 2.7B-6 through10 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The direction of ground water flow in the 110 sand was estimated to be northwest with a gradient of approximately 0.021. The direction of flow in the 100 sand was to the southeast with a gradient of 0.0075. The direction of flow in the 90 sand was estimated to be southeast with a gradient of 0.0067. The direction of flow in the 80 sand was to the southeast at a gradient of 0.0025. No estimate was possible for the ground water flow direction in the 70 sand or 60 sand in the area near Wellfield 1.

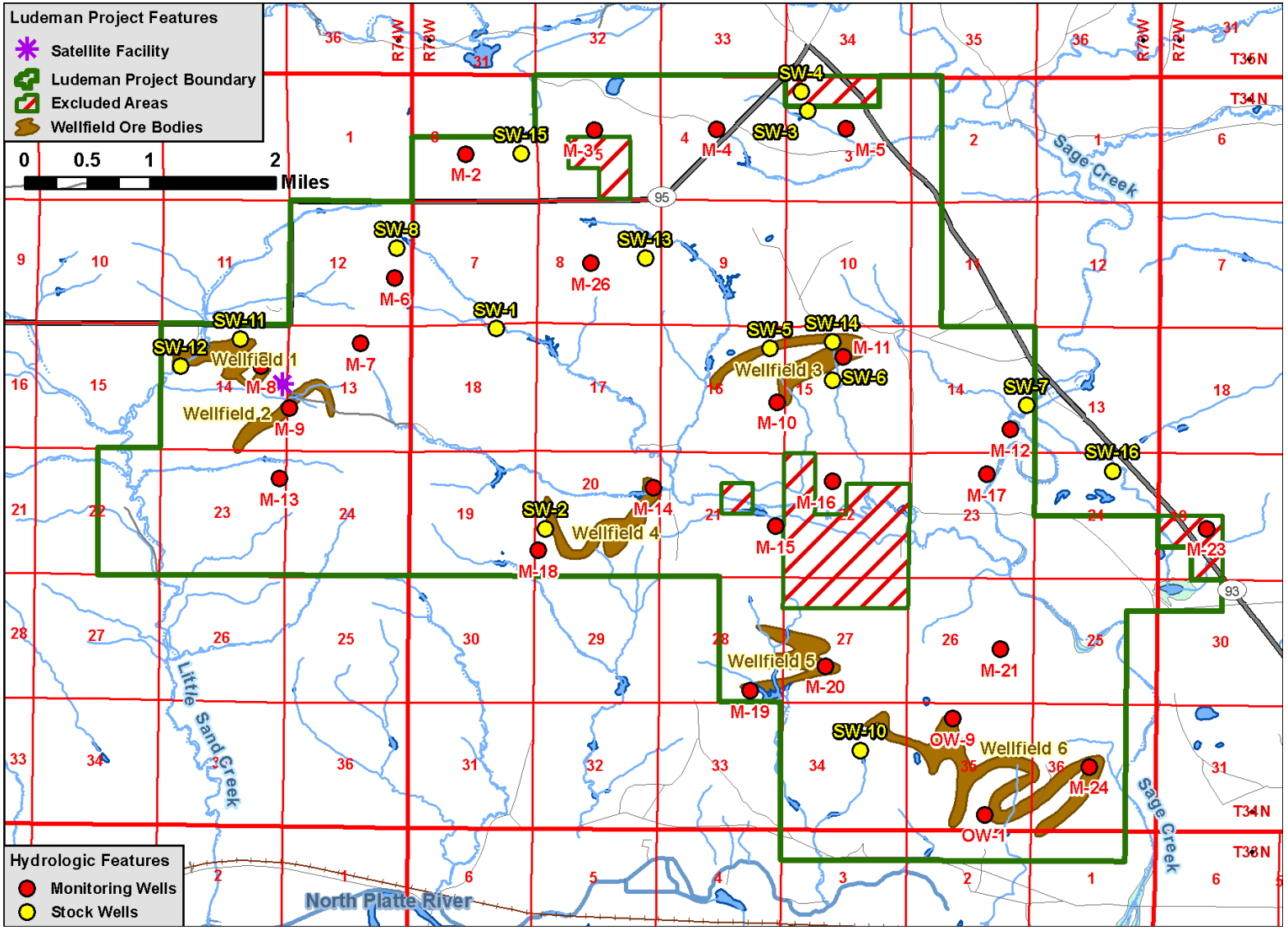

Figure 2.4-6 Ludeman Project Monitoring Wells and Stock Wells

The NRC staff reviewed the historical water levels reported for the aquifers within and near Wellfield 1 at the Teton ISL Pilot (Teton 1980). The NRC staff found the historical water levels in 1980 in the O1 and O2 sands (100 and 110 sands) were reported to range from 5170 to 5177 ft. Water levels in the N aquifer (90 sand) were reported as 5135-5137 ft and 5137 to 5139 ft in the M aquifer (80 sand) (NRC 1982). Water levels were not reported for the Basal sand (70 sand). NRC found these water levels were similar to those reported by the licensee.

NRC staff also reviewed the historical ground water flow direction reported at the Teton ISL Project (Teton 1980). The ground water flow direction in the O1 and O2 sands (100 and 110 sands) was shown to be to the southwest, reportedly following the topography (Teton 1980). The ground water flow direction was to the northeast in the N sand (90 sand) and M sand (80 sand) (Teton 1980). The ground water direction for the Basal sand (70 sand) was not reported.

The NRC staff noted that there were differences between the reported 2009 and 1980 historical ground water flow directions. Specifically, the licensee reported the ground water flow direction was to the northwest in the 110 sand and southeast in the 100 sand in 2009. However, the direction in these aquifers was reported to the southwest in 1980 (Teton 1980). The licensee reported and the NRC confirmed the ground water direction in the 90 and 80 sands was to the southeast in 2009. Teton reported in 1980 that the ground water flow direction was to the northeast in the N sand (90 sand) and M sand (80 Sand) (Teton 1980).

The licensee stated it could provide no explanation for the difference in direction of the ground water flow in the 110, 100, 90, and 80 sands between these periods. The NRC staff also has no specific explanation for the difference; however, the NRC staff noted the 1979 and 1980 reported water levels in the N sand (90 sand) were in the range of 5135-5137 ft and in the M sand (80 sand) to be 5137-5139 ft. These ranges are somewhat lower than those reported in 2009 for the 90 sand and 80 sand as shown in SER Table 2.4-1. The NRC staff finds these historic water levels may have been impacted by the water level drawdown associated with the prior Teton pilot ISL operations. Therefore, the NRC staff finds the 2009 water levels that have not been subjected to site pumping for more than 25 years are likely to be most representative of the ambient ground water levels which are now present at the site.

The licensee presented the results and analysis of the 1979 and 1980 historical aquifer tests from the original Teton Leuenberger ISL Pilot Project in Section 2.7.2.3 and Addendum 2.7-D of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). This pilot was conducted in January 1980 to February 1981 in the same N sand (90 sand) and M sand (80 sand) ore zones targeted in Wellfield 1. Teton, Inc. performed three multi- well aquifer tests in the M sand (80 sand), one test in the N sand (90 sand), two tests in the Basal sand (70 sand) and one test in the combined O2 and O1 sands (110 and100 sands). For the M sand (80 sand) tests, Teton monitored the overlying N sand (90 sand) and the underlying Basal aquifer (70 sand). For the N sand test (90 sand), Teton monitored the overlying combined O2 and O1 sands (110 and 100 sands) and the underlying M sand (80 sand). Unlike the licensee, Teton did not separate the overlying O1 and O2 sands, but treated them as a continuous overlying unit with discontinuous shales.

The aquifer test pumping wells, rates, test times and results for these seven historical aquifer tests are provided in SER Table 2.4-2. The NRC staff finds the rates and duration of all the 90 and 80 sands test sufficient to stress the aquifer to obtain the required hydrogeologic parameters. The transmissivity for the 90 sand was reported as 93.6 ft2/d. The storativity was 8.3 E-5. For the three 80 sand tests, the transmissivity was reported as 54.7, 38.7 and 34.7 ft2/d, respectively. The storativity ranged from 2.6e-4 to 6.5 E-5. The NRC staff finds the

storativity values reported for the 90 and 80 sand tests are representative of confined (saturated) aquifers.

The licensee reported that during the 90 sand aquifer test there was no significant response between the 90 sand and the overlying 100 /110 sand aquifers, and a minor response (< 0.5 ft) in the 80 sand aquifer. The licensee also reported here were minor (<0.6 ft) or no drawdown responses in the overlying 90 and underlying 70 sand aquifers during the three 80 sand tests. NRC staff finds the overlying or underlying aquifer observation well responses do not indicate a hydrologic connection as they represented less than 1percent of the drawdown response realized in observation wells in the ore zone aquifer. The licensee concluded and the NRC staff agree these historic tests indicate competent confining layers with no hydrologic communication between the 80 and 90 ore zone aquifers and the overlying and underlying aquifers.

Aquifer Test	Well	Rate (gpm)	Time (hrs)	T (ft2/d)	K (ft/d)	Storativity
90 sand (N)	PN5-L317	43.1	36.5	93.6	1.9	8.3E-5
80 sand (M)	PN5-L301	44	48	54.74	1.9	2.6E-4
80 sand (M)	PN5-LMM6	29.8	96	38.71	0.6	6.5E-5
80 sand (M)	PN5-LMM10	26.3	96	34.7	0.6	2.6E-4
110/100 sand (O)	LaPlant (R)	19	1.67	82.8	NR	NR
70 sand (Basal)	PN5-LBM2 (R)	15.2	1.67	16	NR	NR
70 sand (Basal)	PN5-LBM2 (R)	28.6	1.67	72.1	NR	NR
(R) = recovery response						

Table 2.4-2 Historic Teton Aquifer Tests in Wellfield 1

The licensee also provided aquifer test data and results from two recent aquifer tests conducted in the 80 and 90 sands by the licensee in 2008 in the “Hydrologic Pumping Test Report” in Addendum 2.7-E of Ludeman Project Revised Technical Report (Uranium One USA 2017d). The aquifer test pumping and observation wells for the 80 sand and 90 sand were located in Wellfield 1 as shown in Figure 2.7B-3 of Addendum 2.7-B of the Revised Technical Report. The results of these tests are shown in SER Table 2.4-3.

For the 80 sand aquifer test at LPW-1, the licensee provided the conditions of the test in Table 7-1 in Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The test was conducted for 15,765 minutes at a rate of 27 gpm. The NRC staff finds this is a sufficient rate and time to stress the aquifer to assess its behavior. The observation wells, LMP-1 and LMP-2, in the 80 sand were located at 300 ft and 380 ft, respectively, directly north and south from the pumping well. The NRC staff found the location of the observation wells relative to the pumping well acceptable for the purpose of assessing the hydrogeologic parameters and establishing a hydrologic connection during the tests.

The licensee provided the traditional aquifer water level vs. time curves with the barometric pressure response for the 80 sand pumping well and all of the observation wells for both the drawdown and recovery periods in Figures 7-1 through 7-8 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported and the NRC staff verified that the water level responses in the overlying 90 sand wells, LPW-2, LMP-3 and LMP-4, demonstrate that no drawdown response was detected. However, the underlying aquifer monitoring well, LMU-1, in the 70 sand showed a steady increase in water level which started before and continued after the test. The licensee stated it may be due to a casing leak in which water from a shallow aquifer was entering the 70 sand. The licensee conducted a mechanical integrity test (MIT) in December 2009 on the well to assess its condition. The well passed the MIT, indicating that the well maintained its integrity. The drawdown the aquifer test would cause a decrease in water level, not an increase, if there was a hydrologic connection between the 80 sand and the 70 sand aquifers. Therefore, the NRC staff finds the test does not indicate a hydrologic connection.

For the 90 sand ore zone aquifer test at well LPW-2, the conditions were presented in Table 7-2 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The test was conducted for 17,205 minutes at rate of approximately 32 gpm. The NRC staff finds this test used a sufficient rate and time period to stress the aquifer to assess its behavior. The ore zone aquifer observation wells, LMP-3 and LMP-4, in the 90 sand, were located at 300 ft and 380 ft respectively, from the pumping well directly north and south. The NRC staff found the location of the observation wells relative to the pumping well acceptable for the purpose of assessing the hydrogeologic parameters and establishing a hydrologic connection during the tests.

The licensee provided the traditional aquifer water level vs. time curves with the barometric pressure response for the 90 sand pumping well and all of the observation wells for the drawdown and recovery periods in Figures 7-9 through 7-16 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).The licensee reported and NRC staff verified that no drawdown response was detected in the overlying well, LMO-1. The licensee also reported that the underlying 80 sand aquifer monitoring wells, LPW-1, LMP-1, and LMP-2, showed no response which would indicate hydrologic communication between the 90 and 80 sand aquifers. In its review of the response curves for these wells during the test, as shown Figures 7-13, 7-14 and 7-15, respectively, the NRC staff noted a continuing increase in water level in the 80 sand wells before, during and after the 90 sand aquifer test. In addition, the underlying aquifer monitoring well, LMU-1, in the 70 sand also showed a similar steady increase in water level in Figure 7-16. As described above, the NRC staff agrees with the licensee that the drawdown in the 90 sand aquifer test would cause a decrease in water level, not an increase if there was a hydrologic connection between the 90 sand and the 80 sand or the 70 sand. Therefore, the NRC staff agrees these water level responses do not indicate a hydrologic connection.

The analysis of the drawdown and recovery response and curve matching for the LPW-1 and LPW-2 aquifer tests were presented in several figures in Attachments 1-1 through 1-8 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff found the licensee appropriately used the widely accepted Theis type curve fitting method for analysis of the aquifer tests. The results for transmissivity, conductivity, and storativity the 80 and 90 sand tests in Wellfield 1 were provided in Table 7-5 and are shown below in SER Table 2.4-3. The NRC staff finds the observation wells tests, LMP-1 and LMP-3, provide the most representative values as they not subject to error associated with wellbore storage or frictional loss at the pumping wells. The average transmissivity (geometric mean) for

the 80 and 90 sand aquifers are 60.8 ft2/day and 96.4 ft2/day from these wells. The conductivity was reported to range from 0.86 to 0.96 ft/day in the 80 sand and 1.71- 2.27 ft/d in the 90 sand. The average storativity for the 80 and 90 sand aquifers are 7.85E-5 and 1.76 E-4, respectively, which are in the range which is representative of confined (saturated) aquifer behavior. The NRC staff finds these values are in agreement with the historic Teton 90 and 80 sand aquifer tests (NRC 1983).

Aquifer Test	Well	T (ft2/d)	K (ft/day)	Storativity
80 sand (D)	LPW-1	46.37	0.70	2.28E-2
80 sand (R)	LPW-1	49.83	0.75	3.94E-4
80 sand	LMP-1	65.13 (D) 56.72 (R)	0.98(D) 0.86 (R)	6.87E-5 (D) 8.78E-5(R)
90 sand (D)	LPW-2	131.1(D)	2.69	5.76E-2
90 sand (R)	LPW-2	135.7 (R)	2.78	3.58E-2
90 sand	LMP-3	111.0 (D) 83.68 (R)	2.27(D) 1.71(R)	1.04E-4(D) 2.48E-4(R)
(D) = drawdown response (R)= recovery response				

Table 2.4-3 Ludeman Project Aquifer Tests in 80 sand and 90 sand in Wellfield 1

Wellfield 2

Wellfield 2 is located adjacent to Wellfield 1 in Sections 13 and 14 as shown in SER Figure 2.4-6. As described in SER Section 2.3.3.2, the licensee incorrectly identified the 70 sand as the ore zone aquifer in Wellfield 2 when it is located in the 60 sand. The licensee did not characterize the 60 sand or conduct any aquifer tests in the 60 sand to enable the staff to conduct a safety assessment to make findings regarding the hydraulic control of production fluids in Wellfield 2. As discussed by the NRC staff in SER Section 2.3.3.2, the licensee acknowledges this error (Uranium One Americas 2013c; NRC 2016c, 2017a). The licensee has also agreed to a license condition which prohibits any construction or operation to recover uranium in Wellfield 2 as part of this license amendment. Therefore, the NRC staff will add a new License Condition 10.22 to the Willow Creek Source Material License SUA-1341 as described in Section 3.1.4 and shown in SER Table 1.1-1.

Wellfield 3

Wellfield 3 is located in the eastern and central portion of the license area in Sections 15 and 16 of T34N, R73W as shown in SER Figure 2.4-6. The licensee reported that the Wellfield 3 ore zone aquifer is the same one targeted in the historical Uranium Resources, Inc. (URI) North Platte ISL R&D Project licensed by NRC (NRC 1981b). NRC staff verified the North Platte Pilot ISL operated in this same location in the 1979-1980 time frame as described in the associated Environmental Impact Assessment (EIA) (NRC 1981d).

The hydrostratigraphy of Wellfield 3 was described by the licensee and confirmed by NRC staff as shown in SER Table 2.4-4. The licensee reported it will conduct uranium recovery in 70 sand aquifer in Wellfield 3. The licensee reported the 80 sand is the overlying unit and the 60 sand is the underlying unit in Table 2.7B1-a, but stated this is a preliminary assessment. The NRC staff finds the 80 and 90 sands are not continuous based on a review of the geology of Wellfield 3 provided in SER Section 2.3.3.2. These sands may therefore be absent or too thin to act as significant aquifers. As discussed below, the North Platte ISL pilot combined the 70 and 80 sands as one production zone and did not identify the 90 sand. In addition, the licensee did not find either the 80 or 90 sand to be present at the Wellfield 3 aquifer test site in 2009. The NRC staff finds where the 80 and 90 sands are not present, there is more than 100 ft of shale which is sufficient to prevent hydrologic communication with the overlying 100 sand aquifer.

The NRC staff were able to match the aquifers in Wellfield 3 to the historical North Platte ISL pilot aquifers using information from the North Platte ISL R&D Project EIA (NRC 1981d). For the ISL pilot, the aquifer naming convention from surface to depth was the 4 sand (110 sand), 3 sand (100 sand), 3 clay, 2c sand (80 sand), 2 clay, 2 ab sand (70 sand), 1 clay and 1 sand (60 sand) as shown in SER Table 2.4-4. The ISL pilot targeted the combined 2ab and 2c (70 and 80 sands) aquifers as one production unit. The NRC staff found that the 90 sand was not historically identified at the North Platte ISL. NRC staff concluded the North Platte description considered the 90 sand to be one of the sand stringers located within the 260 ft thick 3 clay.

Formation (North Platte Pilot)	**Hydro-stratigraphy**	**Monitoring Well**	**TOC Elevation (ft msl)**	**Top of Formation (ft msl)**	**Monitoring Well Water Level (ft msl)**
100 Sand (3 sand)	Overlying Aquifer	LMO-2A	5206	4974	5058
100/90 Shale (3 clay)	Overlying Aquitard	NA	NA	NA	NA
90 Sand (3 clay)	Nominal Aquifer	NA	NA	NA	NA
90/80 Shale (3 clay)	Overlying Aquitard	NA	NA	NA	NA
80 Sand (2c sand)	Nominal Aquifer	NA	NA	NA	NA
80/70 Shale (2 clay)	Overlying Aquitard	NA	NA	NA	NA
70 Sand (2 ab sand)	Ore Zone Aquifer	LPW-3A LMP-5 M-10 M-11	5205 5206 5176 5212	4650 4646 4706 4662	5039 5044 5041 5042
70/60 Shale (1 clay)	Underlying Aquitard	NA	NA	NA	NA
60 sand (1 sand)	Underlying Aquifer	LMU-2A	5205	4480	5051

Table 2.4-4 Hydrostratigraphy and Monitoring Well Water Levels in Wellfield 3

The NRC staff reviewed the ground water levels reported in February and March 2009 by the licensee in monitoring wells located in aquifers in and near Wellfield 3 in Addendum 2.7-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). As shown in SER Table 2.4-4, the ground water levels in wells in the 100 sand, 70 sand and 60 sand were 5058, 5039-5042, and 5051 ft, respectively. The NRC staff found the only historic water levels reported for the North Platte ISL pilot were 5042.69- 5042.79 ft in the 70 sand (NRC 1981d). These water levels are in agreement with the 2009 values.

The NRC staff determined the difference in water level between LPW-3A (70 sand) and LM0-2A (100 sand) was 19 ft. The water level difference between LPW-3A (70 sand) and LMU-2A (60 sand) was of 12 ft. The difference in water levels supports a finding that the 100 and 60 sand aquifers are hydrologically separated from the 70 sand aquifer. Based on the minimum thickness of aquitards reported in SER Table 2.3-2, the NRC staff calculated a vertical gradient of 0.11 and 0.48 between the 100 and 70 sand and the 70 and 60 sand aquifers, respectively. The NRC staff finds these significant vertical gradients (>0.10) demonstrate that the overlying and underlying aquitards are sufficiently thick and competent to provide hydrologic separation between the ore zone and the overlying and underlying aquifers in Wellfield 3.

The licensee reported that the 70 sand ore zone aquifer within Wellfield 3 is a confined aquifer (saturated). The NRC staff confirmed the this aquifer is saturated using the 70 sand monitoring well water levels and top of sand elevation information provided in SER Table 2.4- 4 which show the water levels ranged from 335-398 ft above the top of the 70 sand formation in Wellfield 3.

The NRC staff estimated the ground water flow direction and magnitude using the potentiometric contours provided by the licensee in Figures 2.7B-6 to 2.7B-10 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). NRC staff could not determine the direction of flow near Wellfield 3 in the 110 and 100 sand because of a lack of monitoring wells in these aquifers. The direction of flow in the 90 sand in 2008 was to the southeast at a gradient of 0.005. The direction of flow in the 80 sand was to the southeast at a gradient of 0.0075. The direction of flow in the 70 sand was to the southeast at a gradient of about 0.0037. The direction of flow in the 60 sand was also to the southeast at an estimated gradient of about 0.005.

The NRC staff compared the reported ground water flow and direction to the historical descriptions at the North Platte Site ISL pilot operation EIA (NRC 1981d). The 1980 potentiometric contours of the 70 sand were reported as flat, showing no clear direction of ground water flow. The historic ground water flow direction in the other aquifers could not be determined as no water levels or potentiometric contours were reported for them in the North Platte EIA.

The licensee reported and provided information on the historical aquifer tests in Wellfield 3 in Section 2.7.2.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff confirmed that historical aquifer tests were conducted at the North Platte Pilot ISL in 1980 in the same location in Wellfield 3 using maps in the North Platte EIA (NRC 1981d). The tests targeted the North Platte 2ab sand beds located 620-620 ft bgs. The NRC staff confirmed that the North Plate 2ab sand is the same formation as 70 sand aquifer ore zone targeted in Wellfield 3 as shown the SER Table 2.3-2. The North Platte EIA stated the historical aquifer tests were conducted in one pumping well with 10 observations wells in the 70 sand (2ab sand) aquifer. Observation wells, NPMW1 to NPMW-6, were located in a five spot well completion pattern about 200 ft from the pumping well. Observation wells I1-4 were located at distances of 35-39 ft from the pumping wells. One observation well, MW-1, was located in the

overlying 80 sand aquifer (2c sand). Another observation well, MW-2, was located in the overlying 100 sand aquifer (3 sand). One well, DM-1, was located in the underlying 60 sand aquifer (1 sand). The licensee provided the aquifer test results for the transmissivity and for these aquifer tests in Table 2.7B-2 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The transmissivity ranged from 54.7-61.4 ft2/day and the conductivity ranged from 1.5-2.9 ft /day. The storativity values were in the range of 1.0E-5 to 1.2E-4 which are representative of confined (saturated) aquifers.

During the test, Uranium Resources, Inc. reported a drawdown response in the overlying 80 sand (2c sand). It was reported that the clay between the 70 and 80 sand pinched out so these two sands were treated as one production zone (2 abc sand). There was no response in the overlying 100 sand (3 sand) that was reported to be separated by 260 ft of clay. A nominal response was detected in the underlying 60 sand (1 sand) which was reported to be separated by clay 12-15 ft thick. The NRC staff concludes the 1 and 3 clay aquitard which underlie and overlie the 70/80 (2abc) sand aquifer appeared sufficient in terms of vertical thickness and continuity to demonstrate there was no hydrologic communication with the overlying and underlying aquifers.

The licensee also provided aquifer test data and results from a recent multi-well aquifer test conducted in the 70 sand in 2008 in the " Hydrologic Pumping Test Report" in Addendum 2.7-E of Ludeman Project Revised Technical Report (Uranium One USA 2017d). The pumping and observation wells for the 70 sand were located in Wellfield 3 as shown in Figure 2.7B-3 of Addendum 2.7-B of the Ludeman Project Revised Technical Report. The results of the test are shown in SER Table 2.4-5.

For the 70 sand aquifer test at LPW-3A, the conditions of the test were presented in Table 7-3 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The test was conducted for 17,886 minutes at rate of approximately 22.6 gpm. The NRC staff finds this test used a sufficient rate and time period to stress the aquifer to assess its behavior. One overlying observation well, LMO-2a, was located 10 ft from the pumping well. This well was originally reported to be in the 90 sand but was later identified as in the 100 sand. The licensee reported that the 80 sand was not present at the test site. The absence of the 90 and 80 sand supports the prior finding that these sands are likely to be too thin or missing to act as the overlying aquifers. The underlying observation well, LMU-2a, was located 10 ft from the pumping well in the 60 sand. The observation wells in the 70 sand, LMP-5 and M-11, were located at 525 ft and 615 ft, respectively, from the pumping well. The NRC staff found the location of the observation wells relative to the pumping well acceptable for assessing the hydrogeologic parameters and establishing a hydrologic connection during the tests.

The licensee provided the traditional aquifer water level vs. time curves with the barometric pressure response for the pumping wells and all of the observation wells for the drawdown and recovery periods in Figures 7-17 through 7-21 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported and NRC verified no drawdown response was detected in the overlying 100 sand or underlying 60 sand aquifer monitoring wells which would indicate hydrologic communication between these aquifers and 70 sand ore zone aquifer.

The licensee presented the analysis of the drawdown and recovery response and type curve matching for the LPW-3A aquifer test in several figures in Attachments 1-9 through 1-12 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff found the licensee appropriately used the widely accepted Theis curve matching

method. The results for transmissivity, conductivity, and storativity the 70 sand test in LPW-3A in Wellfield 3 were reported by the licensee in Table 7-5 and are shown below in SER Table 2.4-5. The NRC staff finds the results from the observation well, LMP-5, to provide the most representative values as this well is not subject to error associated with wellbore storage or frictional loss at the pumping well. The average transmissivity (geometric mean) for the 70 sand is 60.8 ft2/day from this well. The average storativity for the 70 sand was 2.01 E-4, which is representative of the expected confined (saturated) aquifer behavior. NRC staff found these values were in agreement with the historical aquifer tests.

Aquifer Test	Well	T (ft2/d)	K (ft/day)	Storativity
70 Sand (D)	LPW-3A	36.79	0.99	3.94E-2
70 sand (R)	LPW-3A	42.55	1.14	1.6E-6
70 sand	LMP-5	77.03 (D) 52.39(R)	2.07 (D) 1.22 (R)	4.01E-5 (D) 3.62E-4(R)
(D) = drawdown response (R) = recovery response				

Table 2.4-5 Ludeman Project Aquifer Tests in 70 sand in Wellfield 3

Wellfield 4

Wellfield 4 is located in Section 20 of T34 N, R73 W as shown in SER Figure 2.4-6. The hydrostratigraphic sequence and water levels in the aquifers at Wellfield 3 were described by the licensee and confirmed by NRC staff as shown in SER Table 2.4-6. The licensee reported it will conduct uranium recovery in 70 sand aquifer in Wellfield 4. The licensee reported the 80 sand is the overlying unit in Table 2.7B1-a, but stated this is a preliminary assessment. Similar to the nearby Wellfield 3, the NRC staff finds the 80 and 90 sands are not continuous based on a review of the geology of Wellfield 4 provided in SER Section 2.3. These sands may therefore be absent or too thin to act as significant aquifers. As shown in SER Table 2.3-3, the NRC staff finds where the 80 and 90 sands are not present, there is more than 100 ft of shale which is sufficient to prevent hydrologic communication with the overlying 100 sand aquifer.

The NRC staff reviewed the ground water levels reported in February and March 2009 by the licensee in monitoring wells located in aquifers in and near Wellfield 4 in Addendum 2.7-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). As shown in SER Table 2.4-6, the ground water levels in the 70 sand were reported as 5041-5051 ft. No water levels were reported in Wellfield 4 for the overlying or underlying sands. Therefore, NRC staff cannot assess the presence or absence of a hydrologic connection between the 70 sand and overlying 80 sand or the underlying 60 sand based on a difference in water level alone (i.e. significant differences in water levels indicate no connection).

The licensee reported that the 70 sand ore zone aquifer is a confined aquifer (saturated). NRC staff confirmed this aquifer is saturated using the 70 sand monitoring well water levels and top of sand elevation information provided in SER Table 2.4-6. These measurements showed the water levels ranged from 239-386 ft. above the top of the 70 sand formation in Wellfield 4. The NRC staff finds these water levels are greater than 10 ft above the top of the sand and therefore demonstrate the 70 sand aquifer is confined (saturated).

Formation	Hydro-stratigraphy	Monitoring Well	TOC Elevation (ft msl)	Top of Sandstone (ft msl)	Monitoring Well Water Level (ft msl)
100 Sand	Overlying Aquifer	NA	NA	NA	NA
100/90 Shale	Overlying Aquitard	NA	NA	NA	NA
90 Sand	Overlying Aquifer	NA	NA	NA	NA
90/80 Shale	Overlying Aquitard	NA	NA	NA	NA
80 Sand	Overlying Aquifer	NA	NA	NA	NA
80/70 Shale	Overlying aquitard	NA	NA	NA	NA
70 Sand	Ore zone Aquifer	M-14 M-18	5110 5153	4655 4812	5041 5051
70/60 Shale	Underlying Aquitard	NA	NA	NA	NA
60 sand	Underlying aquifer	NA	NA	NA	NA

Table 2.4-6 Hydrostratigraphy and Monitoring Well Water Levels in Wellfield 4

The NRC staff estimated the ground water flow direction and magnitude using the 2009 potentiometric contours provided by the licensee in Figures 2.7B-6 to 2.7B-10 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For Wellfield 4, the direction of flow in the 110 and 100 sands could not be determined. The direction of flow in the 90 sand in 2009 was interpreted to the southeast at a gradient of 0.005. The direction of flow in the 80 sand was to the southeast at a gradient of 0.0075. The direction of flow in the 70 sand was to the southeast at a gradient of about 0.0037. The direction of flow in the 60 sand was also to the southeast at an estimated gradient of about 0.005. No aquifer tests were performed on the 70 sand in Wellfield 4.

The licensee stated it will conduct additional aquifer tests in Wellfield 4 as part of the Wellfield Hydrologic Data Package described in SER Section 5.7.8.3.1 to evaluate the specific hydrogeology and other operating conditions before ISR will be undertaken. The NRC staff finds the Wellfield 4 geology described in SER Table 2.3-3 is very similar to the nearby Wellfield 3 geology. Therefore, the NRC staff finds the 70 sand aquifer tests in the nearby Wellfield 3 are sufficient to provide an initial characterization of the likely hydrogeologic behavior in Wellfield 4 for this safety evaluation.

Wellfield 5

Wellfield 5 is located in Sections 27 and 28 of T34N, R73W. The hydrostratigraphy of the wellfield was described by the licensee and confirmed by NRC staff as shown in SER Table 2.4-7. The licensee reported in Table 2.7B1-a of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that it will conduct uranium recovery in 70 and 80 sand aquifers. It

stated the 90 sand aquifer will act as the overlying aquifer and the 60 sand as the underlying aquifer.

Similar to the nearby Wellfields 3 and 4, the NRC staff finds the 90 sand is not continuous based on the stratigraphy of Wellfield 5 shown in SER Table 2.3-4. As discussed in Section 2.3.3.2, the NRC staff also found the minimum thickness of the 80/90 shale in Wellfield 5 was 5 ft and therefore provided marginal isolation between the 80 sand ore zone and overlying 90 sand. The NRC staff therefore finds the 90 sand may be absent or too thin to act as a significant aquifer. NRC staff also finds where the 90 sand is not present, there is more than 100 ft of shale which is sufficient to prevent hydrologic communication with the overlying 100 sand aquifer.

Formation	Hydro-stratigraphy	Monitoring Wells	TOC Elevation (ft msl)	Top of Sandstone (ft msl)	Monitoring Water Level (ft msl)
90 Sand	Overlying Aquifer	NA	NA	NA	NA
90/80 Shale	Aquitard	NA	NA	NA	NA
80 Sand	Ore zone Aquifer	M-19	5032	4832	4979
80/70 Shale	Overlying aquitard	NA	NA	NA	NA
70 Sand	Ore zone Aquifer	M-20	5039	4738	4978
70/60 Shale	Underlying Aquitard	NA	NA	NA	NA
60 sand	Underlying Aquifer	NA	NA	NA	NA

Table 2.4-7 Hydrostratigraphy and Monitoring Well Water Levels in Wellfield 5

The NRC staff reviewed the ground water levels reported by the licensee in monitoring wells located in aquifers in and near Wellfield 5 for February and March 2009 in Addendum 2.7-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). As shown in SER Table 2.4-7, the ground water levels in non- pumping wells in the 80 and 70 sand were reported as 4979 and 4978 ft, respectively. NRC staff finds the similarity in water level does not provide evidence that the aquifers area hydrologically isolated. Water levels were not reported for either the overlying 90 sand or underlying 60 sand.

The licensee reported that the 80 and 70 sand ore zone aquifers within the wellfield are confined aquifers (saturated). NRC staff evaluated if these aquifers were saturated using the 80 and 70 sand monitoring well water levels and top of sand elevation information provided in SER Table 2.4-7. These measurements showed the water level was 147 ft above the top of the 80 sand and 240 ft above the top of the 70 sand in Wellfield 5. NRC staff finds these water levels

are greater than ten ft above the top of the sand and therefore demonstrate the 80 and 70 sand aquifers are confined (saturated).

The NRC staff estimated the ground water flow direction and magnitude using the potentiometric contours provided by the licensee in Figures 2.7B-6 to 2.7B-10 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For Wellfield 5, the direction of flow in the 110 and 100 sands could not be determined. The direction of flow in the 90 sand in 2009 was interpreted to the southeast at a gradient of 0.005. The direction of flow in the 80 sand was to the southeast at a gradient of 0.0075. The direction of flow in the 70 sand was to the southeast at a gradient of about 0.0037. The direction of flow in the 60 sand was also to the southeast at an estimated gradient of about 0.005.

The licensee did not conduct any aquifer tests in Wellfield 5. The licensee stated it will conduct additional aquifer tests in the 70 and 80 ore zone aquifers in Wellfield 5 as part of the Wellfield Hydrologic Data Package described in SER Section 5.7.8.3.1 to evaluate the specific hydrogeology and other operating conditions before ISR operations will be undertaken. This testing will also enable an evaluation of the overlying 90 sand to determine if it is a significant aquifer. Given the geological setting, NRC staff finds the 80 and 70 sand aquifer tests in the Wellfields 1 and 3 are sufficient to provide an initial characterization of the likely hydrogeologic behavior of the 70 and 80 sand aquifers in Wellfield 5 for this safety evaluation.

Wellfield 6

Wellfield 6 is located in Sections 34, 35, 36, of T34N, R73W as shown in SER Figure 2.4-6. The licensee characterized and the NRC staff confirmed the hydrostratigraphy of Wellfield 6 as shown in SER Table 2.4-8. The licensee reported in Table 2.7B1- of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that the 90 sand is the ore zone with the 100 sand as the overlying unit and the 80 sand as the underlying unit. As shown in SER Table 2.3-5, NRC staff found that the overlying 100 sand is discontinuous and acts as the surficial aquifer in Wellfield 6. NRC staff also found the underlying 80 sand is not continuous. This sand may therefore be absent or too thin to act as significant underlying aquifer. NRC staff finds where the 80 sand is not present, there is more than 100 ft of shale which is sufficient to prevent hydrologic communication with the underlying 70 sand aquifer.

The licensee reported and NRC staff confirmed that Wellfield 6 will conduct operations in the same ore zone aquifer that was targeted in the Arizona Public Services, Inc. (APS) Peterson In –Situ Uranium Extraction Pilot ISL. This pilot was licensed by the NRC (NRC 1981a). The Peterson site was never operated and the license was terminated in 1988 (NRC 1988a). NRC staff were able to match the Wellfield 6 aquifer description to the historical Peterson Pilot ISL aquifer naming convention based on reported depths from monitoring wells from the Peterson Site EIA (NRC 1981c). For the Peterson ISL pilot, the aquifer naming convention from surface to depth was the shallow A sand (100 sand), 170 ft of mudstone, the B sand (90 sand), 25-30 ft of mudstone, and the C sand (80 sand) as shown in SER Table 2.4-8.

The NRC staff reviewed the ground water levels reported by the licensee in monitoring wells located in aquifers in and near Wellfield 6 for February and March 2009 in Addendum 2.7-C of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). As shown in SER Table 2.4-8, the ground water levels in the 90 sand range from 4940-4972 ft msl. Water levels were not reported for the overlying 100 sand. The water level in the underlying 80 sand was reported as 4974 ft msl. These water levels are very similar in magnitude and do not enable

NRC staff to make a determination of no hydrologic communication between the ore zone aquifer and the underlying aquifer based on the values alone.

Formation (Peterson)	Hydro-stratigraphy	Monitoring Well	TOC Elevation (ft msl)	Top of Sandstone (ft msl)	Monitoring Water Level (ft msl)
100 Sand (Shallow A Sand)	Overlying Surficial Aquifer	NA	NA	NA	NA
100/90 Shale	Overlying Aquitard	NA	NA	NA	NA
90 Sand (B sand)	Ore Zone Aquifer	LPW-4 LMP-6 LMP-7 M-24	5108 5104 5106 4988	4871 4872 4882 4868	4970 4972 4972 4940
90/80 Shale	Underlying Aquitard	NA	NA	NA	NA
80 Sand (C sand)	Underlying aquifer	LMU-3	5108	4823	4974

Table 2.4-8 Hydrostratigraphy and Monitoring Well Water Levels in Wellfield 6

The NRC also reviewed the ground water levels for the Peterson In –Situ Uranium Extraction Pilot ISL as reported in the original application dated June 1980 (APS 1980). The water level in the shallow A sand (100 sand) was reported as 5110.6 ft msl, the B sand (90 sand) was reported as ranging from 4968.7-4969.2 ft msl and the C sand (80 sand) as 4980.5 msl in January 1980. The significant water level difference between the ore zone aquifer and the overlying aquifer (141 ft) and the underlying aquifer (11 ft) support a NRC staff finding of no hydrologic communication between these aquifers at that time.

The licensee reported that the 90 sand ore zone aquifer is a confined aquifer (saturated). NRC staff confirmed the 90 sand aquifer was saturated as the water levels measured in the 90 sand monitoring wells ranged 72-100 feet above the top of the 90 sand formation as shown in SER Table 2.4-8. NRC staff finds these water levels are greater than 10 feet above the top of the sand and therefore demonstrate the 90 sand aquifer is confined (saturated).

The NRC staff estimated the ground water flow direction and magnitude using the available potentiometric contours for February and March 2009 provided by the licensee in Figures 2.7B-6 through 10 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For Wellfield 6, the direction of flow in the 100 and 80 sand could not be determined due to a lack of water level data. The direction of flow in the 90 sand was to the southeast at a gradient of 0.0045. These ground water flow directions were compared to the original potentiometric contours of the aquifers at the Peterson Pilot ISL. For this site, the only reported gradient was in the B sand (90 sand) at a value of 0.005, with an inferred direction to the northwest (APS 1980).

The licensee stated that historic aquifer tests were conducted in Wellfield 6 by APS for the Peterson In-Situ Uranium Extraction Project pilot site in the 90 and 80 sands in 1979. However, the licensee reported it was not able to find any information on the tests in Section 2.7.2.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). NRC staff were able to find the description of these historic aquifer tests in the permit to mine application submitted to State of Wyoming by APS for Peterson Pilot ISR (APS 1980). These aquifer tests were conducted in November 1979 in the northern portion of Section 35 near the location of the licensee aquifer test in Wellfield 6 conducted in 2008. APS stated the aquifer test targeted the stratigraphic beds located 220-260 ft deep in the area. The NRC staff confirmed that aquifer tests took place in the 90 sand aquifer ore zone based on stratigraphy presented in SER Table 2.3-5.

The APS long term aquifer test was conducted in pumping well, PW-1a, located in the B sand (90 sand). The aquifer test was conducted for 50 hours at a rate of 5.7 gpm. The drawdown portion of the test lasted 26.5 hrs and the recovery portion lasted 23.5 hrs. APS reported there were six observations wells, OW-1 to OW-6, in the B sand (90 sand) ore zone aquifer. One observation well, OW-7, was located in the overlying A sand (100 sand). One observation well, OW-9, was located in the underlying aquifer C sand (80 sand). One observation well, OW-8, was located in the underlying D sand (70 sand).

The results of this historic aquifer test indicated the transmissivity of the 90 sand to ranges from 32.3-49.7 ft2/d. The conductivity ranged from 0.72-1.17 ft/d. The storativity ranged from 1.8E-5 to 3.7E-4. During the test, nominal water level drawdowns were noted the overlying A sand (100 sand) of 0.2 ft and the underlying C sand (80 sand) of 0.1 ft. The overlying A sand was reported to be separated from the B sand by 170 ft of overlying mudstone. The underlying C sand was reported to be separated from the B sand by 25 to 30 ft of underlying mudstone. NRC staff concluded the mudstones overlying and underlying the B sand (90 sand) appear sufficient in terms of vertical thickness and continuity, with no major leakage shown on pumping test (APS 1980). These historic results support a lack of hydrologic communication between the B sand (90 sand) ore zone aquifer and the overlying A sand (100 sand) and underlying C sand (80 sand) aquifers at that time. A steep increase in drawdown (negative boundary) was encountered during the aquifer test about 290 ft to the northwest. APS attributed this boundary to a thinning of the B sand northwest of the aquifer test well (APS 1980).

The licensee also provided aquifer test data and results from a recent multi-well aquifer test conducted in the 90 sand aquifer in 2008 in the “Hydrologic Pumping Test Report” in Addendum 2.7-E of Ludeman Project Revised Technical Report (Uranium One USA 2017d). The pumping and observation wells for the 90 sand were located in Wellfield 6 as shown in Figure 2.7B-3 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The results of this test are shown in SER Table 2.4-9

For the 90 sand aquifer test at LPW-4, the conditions of the test were presented in Table 7-4 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The test was conducted for 16,036 minutes at rate of approximately 8.9 gpm. The NRC staff finds this test used a sufficient rate and time period to stress the aquifer to assess its behavior. Two ore zone aquifer observation wells, LMP-6 and LMP-7, were located in the 90 sand at 334 and 228 ft., respectively, from the pumping well, LPW-4. One observation well, LMU-3, was located in the underlying 80 sand aquifer at a distance of 15 ft from the pumping well. There was no overlying observation well as the licensee stated there is no overlying aquifer in the location. The NRC staff found the location of the observation wells relative to the pumping well acceptable to assess the hydrogeologic parameters and establish a hydrologic connection.

The licensee provided the traditional aquifer water level vs. time curves with the barometric pressure response for the pumping wells and all of the observation wells for the drawdown and recovery periods in Figures 7-22 through 7-25 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Unlike the historic aquifer test, none of the steep drawdown (negative boundary) seen in the historic aquifer test was present in any of the aquifer test data in Figures 7-22 to 7-25. The licensee reported no water level response was detected in the underlying 80 sand aquifer monitoring well, LMU-3, which would indicate hydrologic communication with the 90 sand aquifer. The NRC staff, however, noted that the water level response shown in Figure 7-25 indicates a drop of approximately 0.5 ft in the underlying 80 sand well, LMU-3. NRC does not find this to be significant response as it represents less than 1 percent of the drawdown in the pumping well, LPW-4, which was 59.68 ft at the end of the test. In addition, SER Table 2.3-5, shows the stratigraphy of the 90/80 shale is 10 -20 ft thick in the location of LMU-3, which supports adequate hydrologic isolation.

The licensee presented the analysis of the drawdown and recovery response and type curve matching for the LPW-4 aquifer test in several figures in Attachments 1-13 through 1-16 of Addendum 2.7-E of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff found the licensee appropriately used the widely accepted Theis curve matching method for analysis of the aquifer test. The results for transmissivity, conductivity, and storativity of the 90 sand test in LPW-4 in Wellfield 6 were reported by the licensee in Table 7-5. These results are shown below in SER Table 2.4-9. The NRC staff finds the results from the observation well, LMP-7, to provide the most representative values as this well is not subject to error associated with wellbore storage or frictional loss at the pumping well. The average transmissivity (geometric mean) for the 90 sand is 26.64 ft2/day from this well. The average storativity for the 90 sand was 9.28 E-5, which is representative of the expected confined (saturated) aquifer behavior. These values are in agreement with the historical aquifer tests.

Aquifer Test	Well	T (ft2/d)	K (ft/day)	Storativity
90 Sand (D)	LPW-4	34.73	0.93	2.12E-2
90 sand (R)	LPW-4	36.69	0.98	1.3E-2
90 sand	LMP-7	29.01(D) 24.48(R)	0.78 (D) 0.66 (R)	6.47E-5 (D) 1.21E-4(R)
(D)= drawdown response (R)=recovery response				

Table 2.4-9 Ludeman Project Aquifer Tests in 90 sand in Wellfield 6

2.4.3.3 Ground Water Use

The licensee reported there were numerous private wells across the license area in Section 2.7.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee provided the ground water rights, completion information and permitted use of all private wells within 3 miles of the Ludeman Project license area in Table 2.7B-6 of Addendum 2.7-B. The licensee showed the locations of these wells in Figure 2.7 B-11 of Addendum 2.7-B.

NRC Regulatory Guide 4.14, Revision 1, “Radiological Effluent and Environmental Monitoring at Uranium Mills,” recommends pre-operational and operational monitoring of ground water within

2 km of a uranium milling operation. Based on this guidance, the NRC staff conducted an in-depth review of all ground water rights, private wells, and permitted ground water use within a 2 km boundary around Wellfields 1 and 2; Wellfield 3; Wellfield 4; and Wellfields 5 and 6. The NRC staff reviewed private wells near Wellfield 2 even though it is not part of this licensing action as described in SER 2.3.3.2 because the licensee has indicated it plans to submit an amendment to operate Wellfield 2 in the future.

Wellfields 1 and 2

Wellfields 1 and 2 are located in T34N, R74W Sections 13 and 14 in the far northwestern corner of the license area. The NRC staff determined there are 39 ground water rights within 2 km of Wellfields 1 and 2 using licensee provided information and an independent review of the Wyoming State Engineers Office (WSEO) water rights database. The location of these ground water rights are shown in SER Figure 2.4-7. This figure also shows the WSEO permit names and the names used by the licensee to identify specific private wells (e.g. SW-1). This figure includes an insert map of Section 11, which contains private wells in the Negley Subdivision that are described separately.

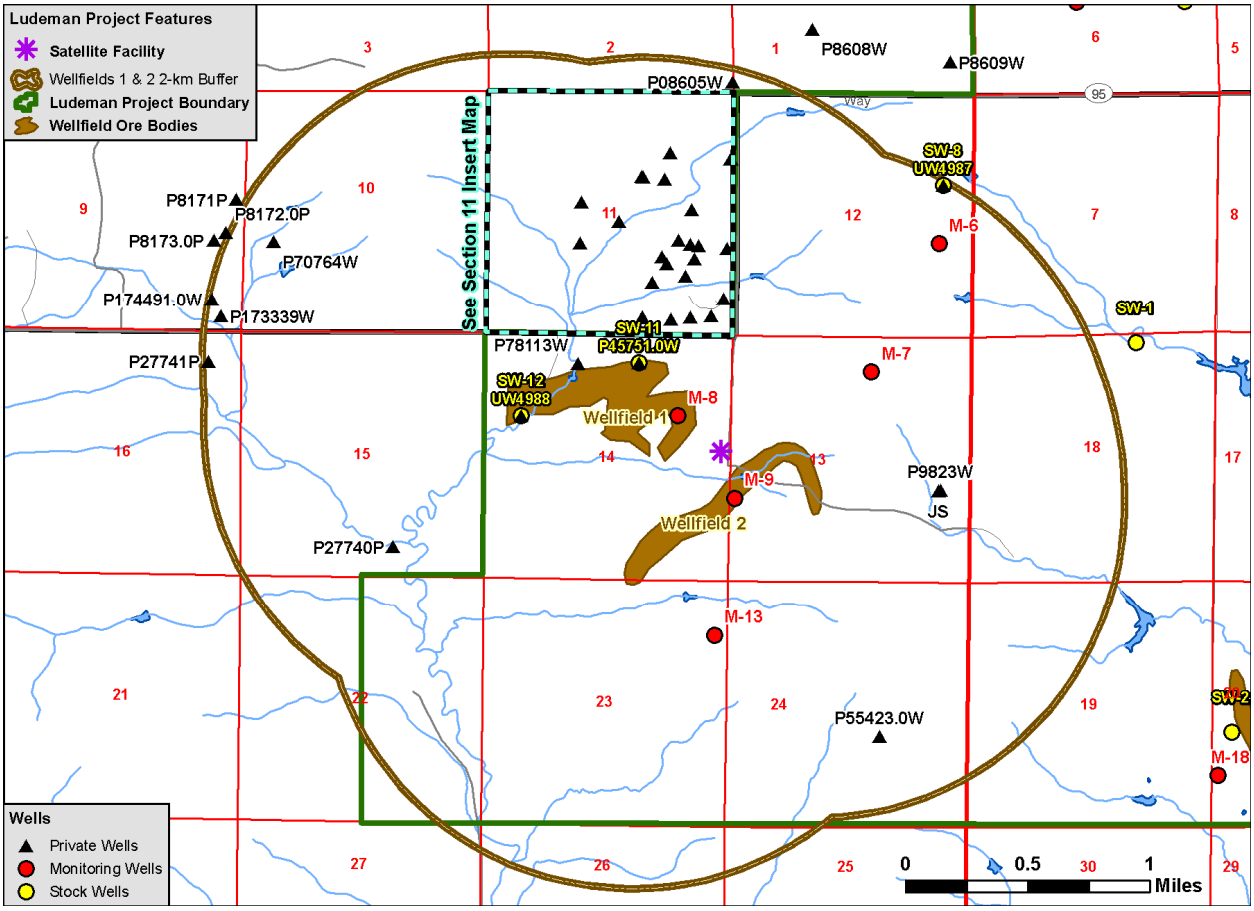

Figure 2.4-7 Ground Water Rights and Private Wells within 2 km of Wellfields 1 and 2.

The NRC staff compiled the ground water rights, well name, well completion information, and permitted use within 2 km of Wellfields 1 and 2 excluding Section 11 from the licensee information and staff's independent review of the WSEO water rights database. In addition, the

NRC staff estimated the distance of the wells from the nearest point in Wellfield 1. A total of 16 ground water rights and private well completions were identified as shown in SER Table 2.4-10.

The NRC staff found only one domestic well, P9823W, identified by the licensee as the JS Well, was located in the license area at an estimated distance of 5475 ft from Wellfield 1. The licensee reported this well is currently associated with a residence and used for domestic purposes. The NRC staff reviewed the WSEO permit for the well, P9823W, and found it is reported as deepened to 160-180 ft. The NRC staff located the closest boring log (3473-18-1004) to this well on Cross Section C-C' in Figure 2.6A-7 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). At this location and depth, Cross Section C-C' indicates the well is most likely completed in the 110 or 100 sand which overlies the 90 and 80 sand ore zones in Wellfield 1.

The NRC staff found seven other private domestic wells listed in SER Table 2.4-10 were completed within 2 km of Wellfield 1 but outside the license area. The permit numbers for these wells are P8171P, P70764W, P27740P, P8172P, P8173P, P173339W and P80605W (N-11). Staff found all of these wells except for P173339W were reported by the licensee to be located in the 100, 110 or 120 sands based on their depth. The licensee reported that P173339W (N-8) is in the 80 sand at a distance of 2 km from Wellfield 1.

Other permits listed in SER Table 2.4-10 were for stock, irrigation, miscellaneous or industrial wells. Three of these wells, P4988 (SW-12), P45751.0W (SW-11) and P78113W were located within the footprint of Wellfield 1. The NRC staff compared the depth and location of these wells to Cross Section O-O' in Figure 2.6A-19 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA, 2017d). NRC staff concluded that Well P4988 (SW-12) is located in the 100 sand and Well P4751.0W (SW-11) is completed in the 110 sand, above the 90 and 80 sand aquifers. The licensee reported that the well P78113W was in the 60 sand below the targeted 90 and 80 ore sand aquifers.

The remainder of the other non-domestic wells were located at distances greater than 3500 ft from Wellfields 1 and 2. The NRC staff found P27741P was a shallow stock well (20 ft deep), likely completed in the in 120 sand at this location. Another stock well, P4987P (SW-8), was 140 to 150 ft deep. The NRC staff determined that P4987P was located near MW-6 on Cross Section B-B' in Figure 2.6A-6 of Addendum 2.6-A. At this depth, NRC concluded it is completed in the 110 sand. The NRC staff determined that stock well P55423W was 200 ft deep and may be completed in the 90 sand based on Cross Section G-G' in Figure 2.6A-11 of Addendum 2.6-A. Irrigation Well P177491.0W is 300 ft deep. Staff determined that no cross sections were available at its location, but given its proximity to Well P173339W and similar depth, the NRC staff concluded it is completed in the 90 or 80 sand. The remaining stock well, P8608W (N-9), is located outside the 2 km boundary, but was included because it was identified by the licensee in their assessment of Negley Subdivision private wells. The licensee reported it was completed in the 120 sand.

In conclusion, the NRC staff finds these private wells are hydrologically isolated from the 80 and 90 production zone sands at Wellfield 1, as they are located in overlying or underlying sands which are separated by competent confining aquitards as described in SER Sections 2.3.3.2 and 2.4.3.2. Staff found that one domestic well, P173339W, one stock well, P55423W, and one irrigation well, P177491.0W, were completed in the 80 or 90 sands. These wells are located almost 2 km from Wellfield 1 or 2, which NRC concludes is a sufficient distance to support a finding of hydrologic isolation. The licensee reported and the NRC staff confirmed that numerous ground water rights and private wells are located in Section 11 of T34N R74W which

is outside the license area but within 2 km of Wellfield 1. The licensee stated that Section 11 contains a large unplatted acreage neighborhood known as the Negley Subdivision. The NRC staff mapped the location of these ground water rights in SER Figure 2.4-8. This figure shows not only the WSEO permit numbers but also the numbers used by the licensee to identify the existing Negley Subdivision wells (e.g. N-1).

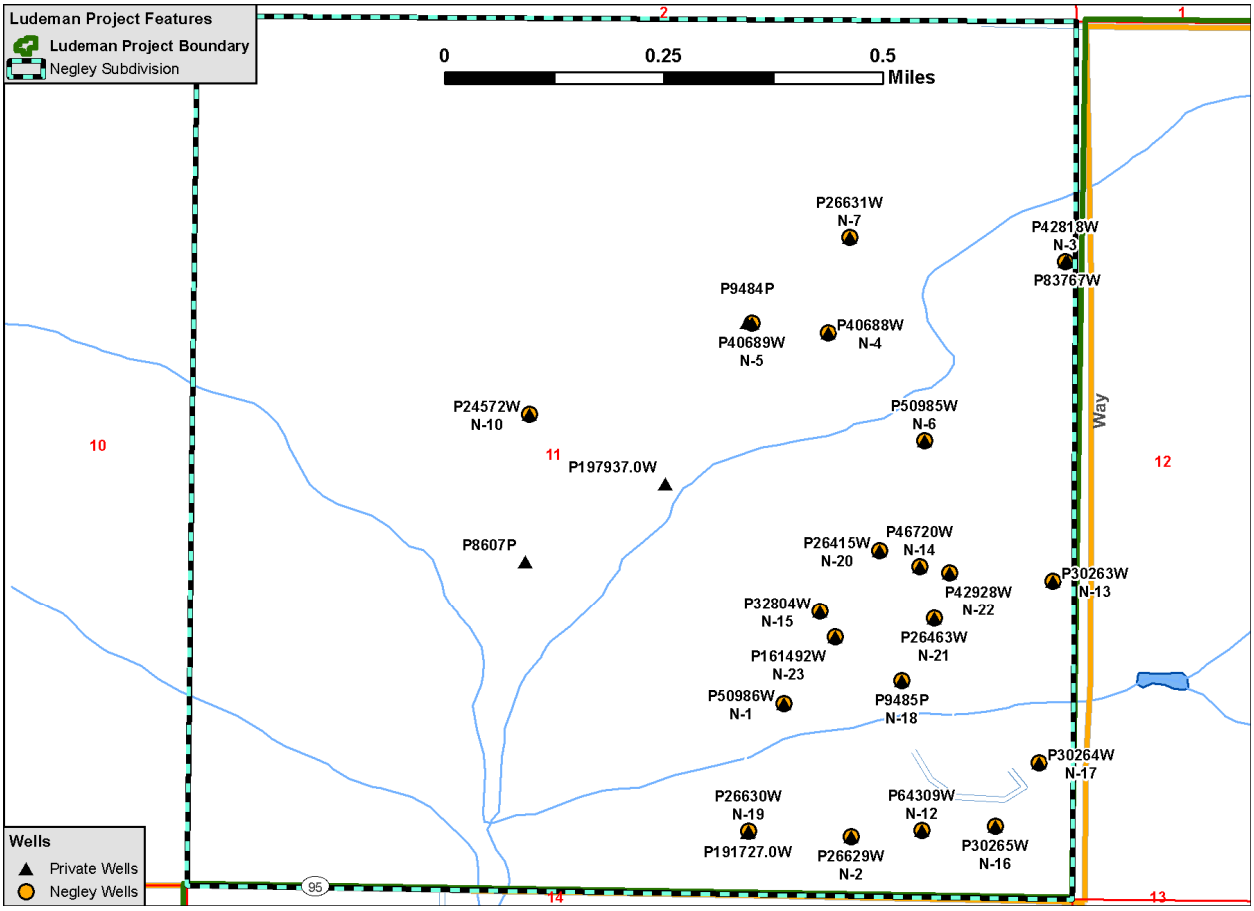

Figure 2.4-8 Ground Water Rights and Private Wells within 2 km of Wellfields 1 and 2 in Section 11.

The NRC staff verified the ground water rights, well name, well completion information, and permitted ground water use inside Section 11 using the licensee provided information and an independent review of the WSEO ground water rights database. In addition, the NRC staff estimated the distance of the wells from the nearest point in Wellfield 1. The NRC staff identified a total of 25 ground water rights. This information is shown in SER Table 2.4-11.

WSEO Permit #	Uranium One Name	Install Date	Well Depth (ft bgs	Completion Interval (ft bgs)	Aquifer Completion	Well Name	Permitted Use	Yield (gpm)	Distance from Wellfield 1 (ft)
P8171P	NA	Deepen 11/21//2007	100	60-100	120 sand	HENRY KEENAN #1	Domestic; Stock	5	7144
P70764W	NA	12/16/1986	180	90-114	120 sand	KEENAN #4	Domestic; Stock	24	5960
P4987P	SW-8	12/31/1945	150	140-150	110 sand	SMITH #4 (WINDMILL)	Stock	10	7064
P9823W	JS well	07/24/1971	180	160-180	110 and100 sand	SMITH #45 (DEEPENED)	Stock; Domestic	7	5475
P78113W	NA	07/23/1988	617	500-617	60 sand	PN5 L314	Stock	30	137
P27740P	NA	12/31/1949	20	NA	120 sand	HILDEBRAND #1 (WINDMILL)	Domestic; Stock	7.5	3593
P27741P	NA	12/31/1968	20	NA	120 sand	HILDEBRAND #2	Stock	17.5	6496
P174491W	NA	11/21/2012	300	200-240 and 280-300	90 or 80 sand	WOECK 2	Irrigation	40	6680
P8172.0P	NA	04/30/1953	60	20-60	120 sand	HENRY 2	Domestic, Stock	5	6957
P8173P	NA	04/30/1920	41	20-41	120 sand	HENRY KEENAN 3 (WINDMILL)	Domestic, Stock	3	7104
P4988	SW-12	12/31/1945	145	130-145	100 sand	SMITH #5	Stock	10	0
P55423.0W	NA	03/07/1981	200	160-200	90 sand	L. JOE WHITING (WINDMILL)	Stock	25	7557
P45751W	SW-11	02/15/1979	78	40-78	110 sand	PN5 L300	Miscellaneous	20	0
P173339	N-8	11/02/2007	380	340-380	80 sand	WOECK #1	Domestic	25	6395
P8608W	N-9	01/18/1961	215	191-215	120 sand	LAYTON #5	Stock	10	7917
P08605W	N-11	07/31/1942	140	120-140	120 sand	LAYTON #1	Domestic; Stock	4	6285

Table 2.4-10 Ground Water Rights and Private Well Completions within 2 km of Wellfield 1 and 2 (no Section 11).

WSEO Permit #	Uranium One Name	Install Date	Well Depth	Completion Interval	WSEO Well Name	Permitted Use	Yield (gpm)	Distance from Wellfield 1 (ft)
P50986W	N-1	11/15/1979	131	71-131	LA PLANT #1	Monitor	0	1695
P26629W	N-2	06/02/1974	120	80-120	NEGLEY #3	Domestic	25	978
P42818W	N-3	04/01/1979	120	40-120	ANDERSON #1 P83767W (reassigned NEGLEY #6)	Domestic	8	4650
P40688W	N-4	03/25/1979	200	140-200	BOURQUIN #2	Stock (windmill)	12	3943
P40689W	N-5	11/15/1978	125	60-125	BOURQUIN #1	Domestic	12	3977
P50985W	N-6	11/16/1979	196	106-186	KT-2	Misc.	0	3402
P26631W	N-7	06/03/1974	120	80-120	NEGLEY #5	Domestic	25	4536
P24572.0W	N-10	No report	150	NR	AC#1	Domestic	25	3610
P64309W	N-12	09/28/1983	160	120-160	HUXTABLE #1	Domestic	10	1146
30262/30263	N-13	No report	210	200-210	BOBBIE 1/JEAN 1	Domestic	25	2843
P46720W	N-14	04/27/1979	180	135-175	ELRU #1	Domestic	23	2657
P32804W	N-15	06/18/1976	195	160-195	HICKERSON #1	Domestic	6	2276
P30264W	N-16	10/10/1975	160	120-160	HIGHWAY CORNER #1	Domestic	10	1431
P30265W	N-17	10/10/1975	180	140-180	HIGHWAY CORNER #2	Domestic	10	1889
P9485P	N-18	07/31/1956	130	50-130	NEGLEY #2	Domestic; Stock	25	1958
P26630W	N-19	06/05/1974	135	95-135	HART#1 P191727.0W (reassigned from NEGLEY#4)	Domestic	25	914
P26415W	N-20	05/25/1974	180	120-160	KT #1	Domestic	12	2703
P26463W	N-21	06/20/1974	180	140-180	LUCKY FIVE #1	Domestic	5	2368
P42928W	N-22	05/25/1979	180	135-175	LUCK FIVE #2	Domestic	20	2661
P161492	N-23	No report	165	NR	ALBAUGH 1	Domestic	25	2143
P8607P	NA	06/29/1946	114	100-114	LAYTON #3 (windmill)	Stock	3	2739
P9484P	NA	08/01/1922	130	85-130	NEGLEY #1	Domestic; Stock	7	3982
P197937W	NA	11/11/2014	135	115-135	BRODY #1	Domestic	10	3061

Table 2.4-11 Ground Water Rights and Private Well Completions in Section 11 (Negley Subdivision).

The licensee provided its evaluation of the Negley Subdivision ground water rights and private water wells in Section 2.7.2.8 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).The licensee also provided a current summary of the private wells in and next to the Negley Subdivision in Table 2.7B-18 of Addendum 2.7-B. Excluding wells N8, N-9 and N-11, which are located adjacent to Section 11, the licensee reported the presence of only 20 well completions in Section 11 whereas the NRC staff identified 23 wells. The NRC staff is aware that the licensee has done an exhaustive review of the Negley Subdivision wells, from both records and field surveys, so the staff investigated this difference in well numbers. The NRC staff found two well permits had been assigned new permit numbers. In particular, Well N-3, P42818W, was revised to P83767W and well N-19, P26630W, was revised to P191727.0W. The NRC staff, however, found the licensee had not included the P197937.0W, Brody #1, well which was installed in 2014 in Table 2.7B-18 or in Table 2.7B-6 of all wells within the 3 mile buffer. Two wells, P8607P and P9484, reported as installed in 1946 and 1922, were also not included, but the NRC staff concluded the licensee was not able to find these wells in their field surveys. In conclusion, the NRC staff finds there are 21 private wells currently located in the Negley Subdivision in Section 11.

The licensee reported and the NRC staff found many of the private wells in Negley Subdivision are located close to Wellfield 1 as shown in SER Figure 2.4-7. The NRC staff estimated the distance of these wells to the nearest Wellfield 1 boundary as shown in SER Table 2.4-11. The closest wells, N-2, N-19, N-12 and N-16, which are all domestic, are located less than 1500 ft from the boundary of Wellfield 1.

To assess the risk to the private wells in the Negley Subdivision from ISR operations, the licensee conducted a comprehensive assessment of Negley Subdivision private wells to evaluate their relationship to the targeted ore zone aquifers in Wellfield 1. The licensee provided their evaluation in a report titled “Assessment of the Hydraulic Relationship of the Negley Subdivision to the Ludeman ISR Uranium Project,” dated February 2011 (Uranium One Americas 2011a). The licensee also resubmitted this report in Addendum 2.7-F of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff found the version in the Ludeman Project Revised Technical Report refers to many figures and tables that are not included in Addendum 2.7-F but were present in the original report of the same name and date submitted to NRC in February 2011 (Uranium One Americas 2011a). Therefore, staff relied on the 2011 version of the report in their review of the Negley Subdivision wells.

In this assessment, the licensee conducted a thorough review of Negley Subdivision well records, published reports, WSEO well permit applications and completions, available site specific geologic and hydrologic data and historic and recent water quality sampling results. The licensee also developed detailed geological structure maps and cross sections to examine the stratigraphic relationship of the ore zone aquifer and the well completion intervals of the Negley Subdivision wells. Specifically, the license evaluated the completion intervals of the wells to determine if they were hydrologically connected to the ore zone aquifers in Wellfield 1. The licensee also conducted field surveys to verify the location, depth and current use of private wells in the Negley Subdivision in 2011.

The licensee reported that the Negley Subdivision wells within Section 11 were completed in aquifers that overly the 90 and 80 sand production ore zone aquifers in Wellfield 1. Specifically, the licensee reported that all of the Negley Subdivision wells in Section 11 were completed in the 100, 110, or 120 sand aquifers in Table 1 of the “Assessment of the Hydraulic Relationship of the Negley Subdivision to the Ludeman ISR Uranium Project,” report (Uranium One Americas 2011a). The NRC staff determined that the Brody #1 Well was completed in the 110 sand. The

Brody #1 Well was not included in the analysis because it was installed in 2014, after the analysis was completed. The licensee found that seven of the wells were not in use. Eleven of the wells were used for domestic purposes. Three wells were used for stock. One well was used to supply a home workshop.

SER Table 2.4-12 summarizes the information provided by the licensee on the Negley Subdivision private wells including their use in 2011 (Uranium One Americas 2011a; Uranium One USA 2017d). This table also includes information on N-8, N-9 and N-11 which are not located in Section 11, but the licensee reviewed as part of its Negley Subdivision assessment. The NRC staff was able to verify the licensee provided the correct completion interval for all of the Negley Subdivision wells through a review of the well completion reports provided by the licensee (Uranium One Americas 2011a). The NRC staff also reviewed the detailed geological cross sections prepared by the licensee for the Negley Subdivision and concluded the licensee had selected the appropriate sand interval completion for all of the Negley Subdivision wells. The NRC staff found all of the wells were being used in accordance with their permitted use in 2011.

In conclusion, the NRC staff finds the licensee identified and comprehensively evaluated all existing Negley Subdivision wells and their relationship to the 90 and 80 production zone sands in Wellfield 1. The NRC staff finds the licensee has established that the Negley Subdivision wells are completed in the 120, 110, or 100 sands which are separated from the 90 sand by more than 80 ft of shale. The staff therefore finds these wells are sufficiently hydrologically isolated from the Wellfield 1 ISR operations. In addition, the licensee also stated it will conduct adequate aquifer testing, to characterize the degree of hydraulic communication (if any) between the target production zone aquifer and the overlying and underlying aquifers at the Ludeman Project. As discussed in SER Section 5.7.8.3.1, the aquifer testing will be conducted as part of the Wellfield Hydrologic Data Package. The NRC staff finds the planned aquifer testing will also further characterize and verify the hydraulic relationship between the production zone aquifer and the Negley Subdivision wells.

The licensee provided another report on the Negley Subdivision wells titled “Hydraulic Effects of Negley Subdivision Pumping on the Proposed Project,” (Uranium One USA 2015b). This report used ground water flow modeling and particle tracking to evaluate the potential contaminant migration from a worst case scenario of a leaking injection well in the 110 sand aquifer toward the private wells which are pumping in the Negley Subdivision. The modeling and was used as a basis to design a guard well monitoring system to detect any contamination which could migrate toward the Negley Subdivision private wells. This report and its conclusions are reviewed by the NRC staff in detail in SER Section 3.1.3.8.
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Uranium One Well Name	WSEO Permit No.	Current Use (Reported 2011)	Pump Method (Reported 2011)	Surface Elevation (ft msl)	Total Depth (ft bgs)	Total Depth (ft msl)	Completion Interval (ft bgs)	Sand Interval	Distance Bottom of Well to Top of 90 Sand (ft)
N-1	P50986W	None	None	5262	131	5131	71-131	110	160
N-2	P26629W	Stock	Submersible	5255	120	5135	80-120	110	145
N-3	P42818W	None	None	5277	120	5157	40-120	110/120	287
N-4	P40688W	None	None	5269	200	5069	140-200	120	169
N-5	P40689W	None	None	5307	125	5182	60-125	120	287
N-6	P50985W	None	None	5260	196	5064	106-186	110	137
N-7	P26631W	Domestic	Submersible	5290	120	5170	80-120	120	290
N-8	P173339	Domestic	None	5215	380	4835	340-380	80	NE
N-9	P8608W	Stock	Windmill	5371	180	5191	NA	120	411
N-10	P24572.0W	Stock	Windmill	5237	150	5087	NA	110	174
N-11	P08605W	Domestic	Submersible	5310	140	5170	NA	120	352
N-12	P64309W	Domestic	Submersible	5288	160	5128	120-160	110/120	142
N-13	30262/30263	Domestic	Submersible	5293	210	5083	200-210	110	133
N-14	P46720W	None	None	5272	180	5100	135-175	110/120	150
N-15	P32804W	Domestic	Submersible	5258	195	5063	160-195	100	106
N-16	P30264W	None	None	5281	160	5121	120-160	110/120	140
N-17	P30265W	Domestic	Submersible	5261	180	5081	140-180	110/120	111
N-18	P9485P	Domestic	Submersible	5252	130	5122	50-130	110	154
N-19	P26630W	Domestic	Submersible	5214	135	5079	95-135	110	86
N-20	P26415W	Shop	Submersible	5289	180	5109	120-160	120	163
N-21	P26463W	Domestic	Submersible	5285	180	5105	140-180	110/120	147
N-22	P42928W	Domestic	Submersible	5265	180	5085	135-175	110/120	133
N-23	P161492	Domestic	Submersible	5260	165	5095	NA	110/120	134

Table 2.4-12 Negley Subdivision Private Well Reported Use and Well Completion

Wellfields 3 and 4

Wellfield 3 is located in T34N, R73W Sections 15 and 16 of the license area. The NRC staff determined there are three ground water rights within 2 km of Wellfield 3 using licensee provided information and an independent review of the WSEO water rights database. The location of these ground water rights were mapped by the NRC staff as shown in SER Figure 2.4-9. This figure also shows the WSEO permit names and the names used by the licensee to identify specific private wells (e.g. SW-14) in the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

Wellfield 4 is located in T34N, R73W Section 20 of the license area. Figure 2.4-10 shows that there is one additional ground water right within 2 km of Wellfield 4 and one it shares with Wellfield 3.The licensee reported and the NRC staff verified all of the water rights are for stock or miscellaneous use. The ground water rights, well name, well completion information, and permitted use within 2 km of Wellfield 3 and 4 are shown in SER Table 2.4-13.

The Wellfield 3 ore zone is located in the 70 sand aquifer. Based on values reported in SER Table 2.4-4, the 70 sand is located at a depth of 555, 560, 470 and 500 ft bgs in wells LPW-3a, LMP-5, M-10 and M-11, respectively, in Wellfield 3. The private wells reported in SER Table 2.4-13, all have depths reported at less than 300 ft bgs. Based on Cross Section Q-Q' in Figure 2.6A-21 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the NRC staff concludes Well P60274.0W (SW-14) is completed in the100 sand. Based on Cross Section B-B' in Figure 2.6A-6 of Addendum 2.6-A, the NRC staff concludes that Well P22299P is also completed in the 100 sand. The NRC staff finds Well P14294W, is located in the 80 or 90 sand, according the nearest log point in Cross Section C-C' in Figure 2.6A-7 of Addendum 2.6-A. The NRC staff therefore concludes none of these wells are located in the 70 sand production zone aquifer In Wellfield 3

The Wellfield 4 ore zone is also located in the 70 sand aquifer. Based on values reported in SER Table 2.4-6, the 70 sand is located at a depth of 455 and 341 ft in Wells M-14 and M-18, respectively, completed in Wellfield 4. Well P4567W, with a depth of 265 ft bgs, was located almost 2 km away from Wellfield 3 outside the license area. The closest Cross Section I-I' in Figure 2.6A-13 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), would suggest it is completed in the 80 sand which overlies the 70 production sand.

The licensee did not report and the NRC staff was not able to find water rights or completion information for wells SW-5 or SW-6 which are located in or very close to the footprint of Wellfield 3 or SW-13, which is almost 2 km distant. No water right was found for SW-2 in the footprint of Wellfield 4. The NRC staff finds it cannot verify that these wells are not in the production ore zone aquifer. The NRC staff concludes that any well that may be located in the production ore zone within 500 ft of the wellfield monitoring well ring is not hydrologically isolated from wellfield operations. The NRC staff finds any use of such a well could affect hydraulic control of fluids in the wellfield and impact receptors.

The licensee stated in Section 4.4.2.2.1 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) that no stock or drinking water wells will be located in the currently proposed ISR wellfields and will not be completed in the production ore zone aquifer. The licensee also stated that if future development includes an area(s) where a stock well is located in an ISR production ore zone aquifer, the licensee would consider the following measures: (1) replacing the wells with new wells completed in either shallower or deeper sands that are not

impacted by ISR operations; or (2) providing another source of stock water. The licensee also committed in Section 3.4.2.5 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) that all wells that are located within 500 ft of a wellfield perimeter monitor well ring will be accurately surveyed through the use of field verification (GPS or surveying) and corresponding information provided within each individual Wellfield Hydrologic Data Package as described in SER Section 5.7.8.3.

The NRC staff finds, however, the licensee has not committed to plug and abandon private wells that are in the production ore zone aquifer of any wellfield in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Therefore, the NRC staff will issue a new License Condition 10.26 for the Willow Creek Source Material License SUA-1341 that will state that the licensee will plug and abandon all private wells completed within the production ore zone aquifer within 500 ft of the perimeter excursion monitoring well ring as described in SER Section 5.7.8.3.1 and shown in SER Table 1.1-1.

The NRC staff finds the licensee identified all private wells within 2 km of Wellfields 3 and 4. The NRC staff was able to assess that the majority of these wells are located in the 80, 90, and 100 sands which overlie the 70 production ore zone sand. The NRC staff finds these wells are hydrologically isolated from the 70 production ore zone sands at Wellfield 3 and 4, as they are located in overlying or underlying sands which are separated by competent confining aquitards as described in SER Sections 2.3.3.2 and 2.4.3.2.

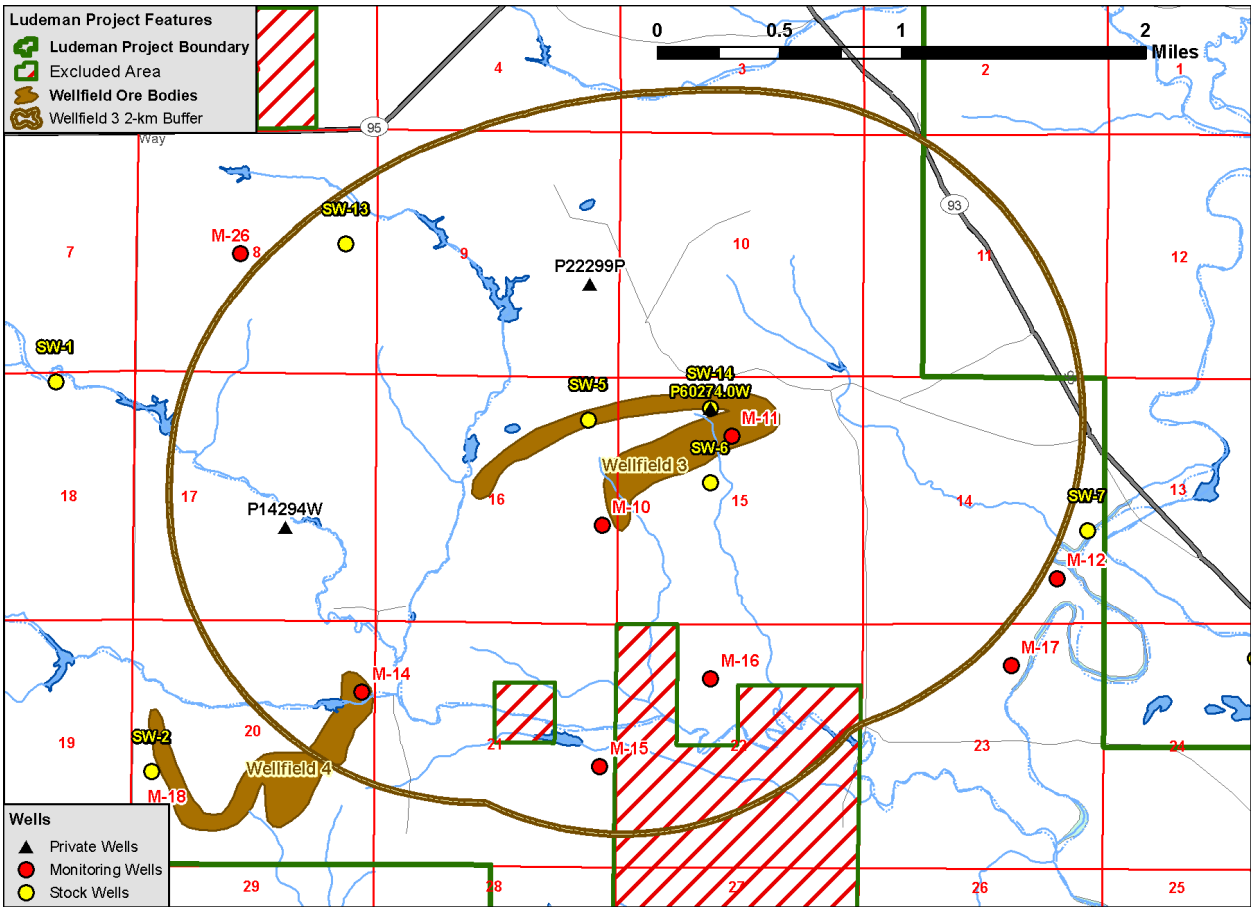

Figure 2.4-9 Ground Water Rights and Private Wells within 2 km of Wellfield 3

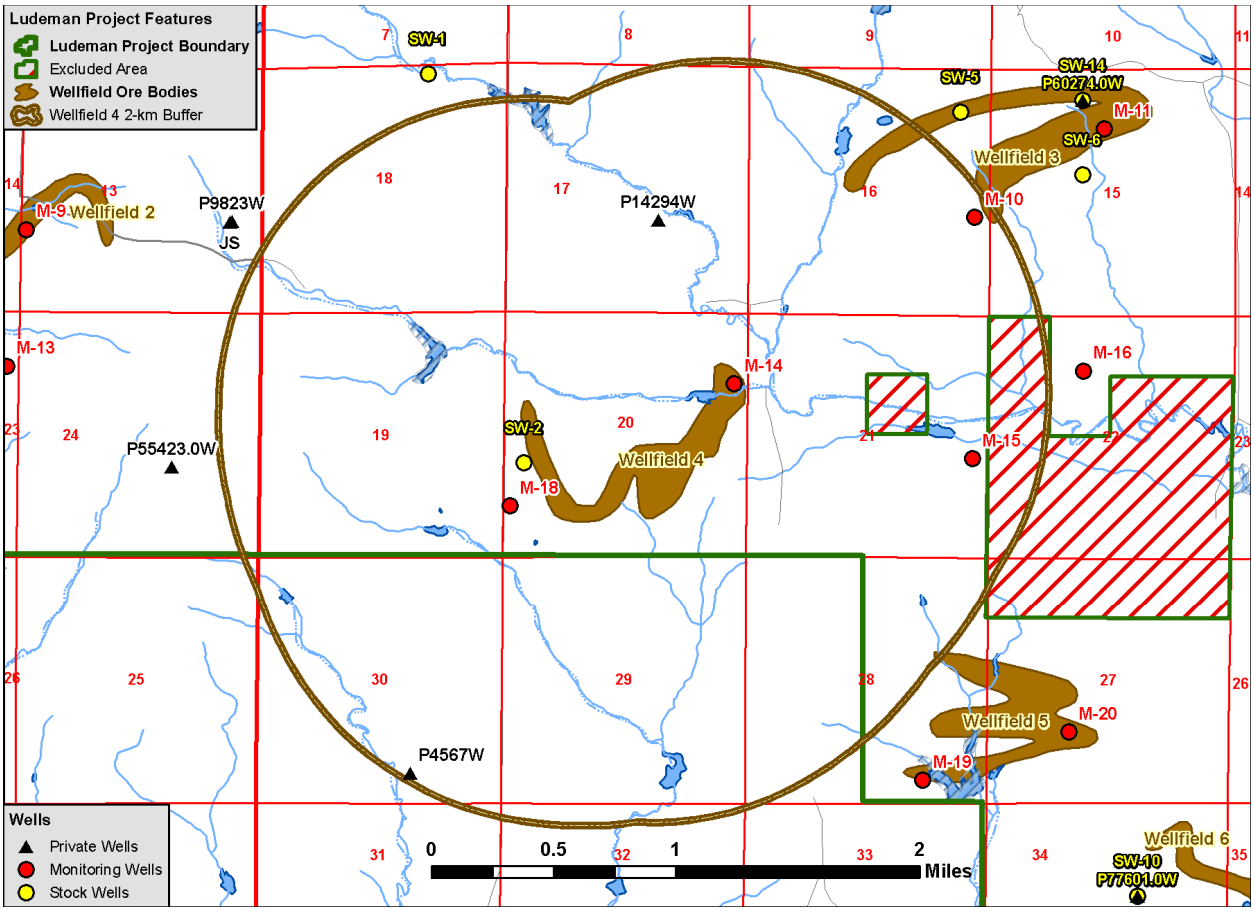

Figure 2.4-10 Ground Water Rights and Private Wells within 2 km of Wellfield 4

Wellfields 5 and 6

Wellfields 5 and 6 are located in T34N R73W Sections 27, 28, 34, 35 and 36 in the far southeastern corner of the license area. The NRC staff determined there are nine ground water rights within 2 km of Wellfield 5 and 6 using licensee provided information and an independent review of the WSEO water rights database. The location of these ground water rights were mapped by the NRC staff as shown in SER Figure 2.4-11. This figure also shows the WSEO permit names and the names used by the licensee to identify specific private wells (e.g. SW-14) in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). All of these water rights are associated with private domestic or stock wells. The ground water rights, well name, well completion information, and permitted use within 2 km of are shown in SER Table 2.4-14.

The Wellfield 5 ore zones are located in the 70 and 80 sands. Based on values reported in SER Table 2.4-7, the 70 sand is located at a depth of 300 ft in Well M-20. The 80 sand is located at a depth of 200 ft bgs in Well M-19. The Wellfield 6 ore zones are located in the 90 sand. Based on values reported in SER Table 2.4-8, the 90 sand is located at depths of 309, 232, 224, and 120 ft bgs at Wells LPW-4, LMP-6, LMP-7 and M-24. The 80 sand is located at a depth of 285 ft bgs in Well LMU-3.

WSEO Permit #	Uranium One Name	Well Depth (ft bgs)	Completion Interval (ft bgs)	Aquifer Completion	Well Name	Use	Yield (gpm)
P22299P	NA	260	NR	100 sand	MOORE 9-34-73	Stock	5
P4567W	NA	265	235-265	80 sand	SMITH #39 (windmill)	Stock	8
P14294W	NA	292	216-246 251-288	80 or 90 Sand	ED MOORE, SPRING PASTURE WELL #1	Stock	4
P60274W	SW-14	250	200-250	100 sand	WATER WELL 1	Misc.	5

Table 2.4-13 Ground Water Rights, Private Well Completions and Use within 2 km of Wellfields 3 and 4

WSEO Permit #	Uranium One Name	Well Depth (ft bgs)	Completion Interval (ft bgs)	Aquifer Completion	Well Name	Use	Yield (gpm)
P77522W	NA	340	283-323	80 sand 70 sand	OW 9	Stock	15
P77601W	SW-10	340	140-165	90 sand	LISCO #3	Stock	15
P126595W	NA	30	10-18	Alluvium	LISCO #5	Domestic; Stock	25
P184773.0	NA	140	100-140	Unknown	WEST REED	Stock	10
P19404P	NA	80	NR	90 sand 100 sand	MOORE #1 (RANCH HOUSE)	Domestic; Stock	25
P22297P	NA	45	NR	100 Sand	MOORE 2-33-73	Domestic	6.5
P25898W	NA	22	10-22	Alluvium	J WHITING #1	Domestic; Stock	6
P75291W	NA	20	NR	Alluvium	LISCO #2	Domestic; Stock	10
P77521W	NA	175	127-167	90 sand	OW 1	Stock	15

Table 2.4-14 Ground Water Rights, Private Well Completions and Use within 2 km of Wellfields 5 and 6

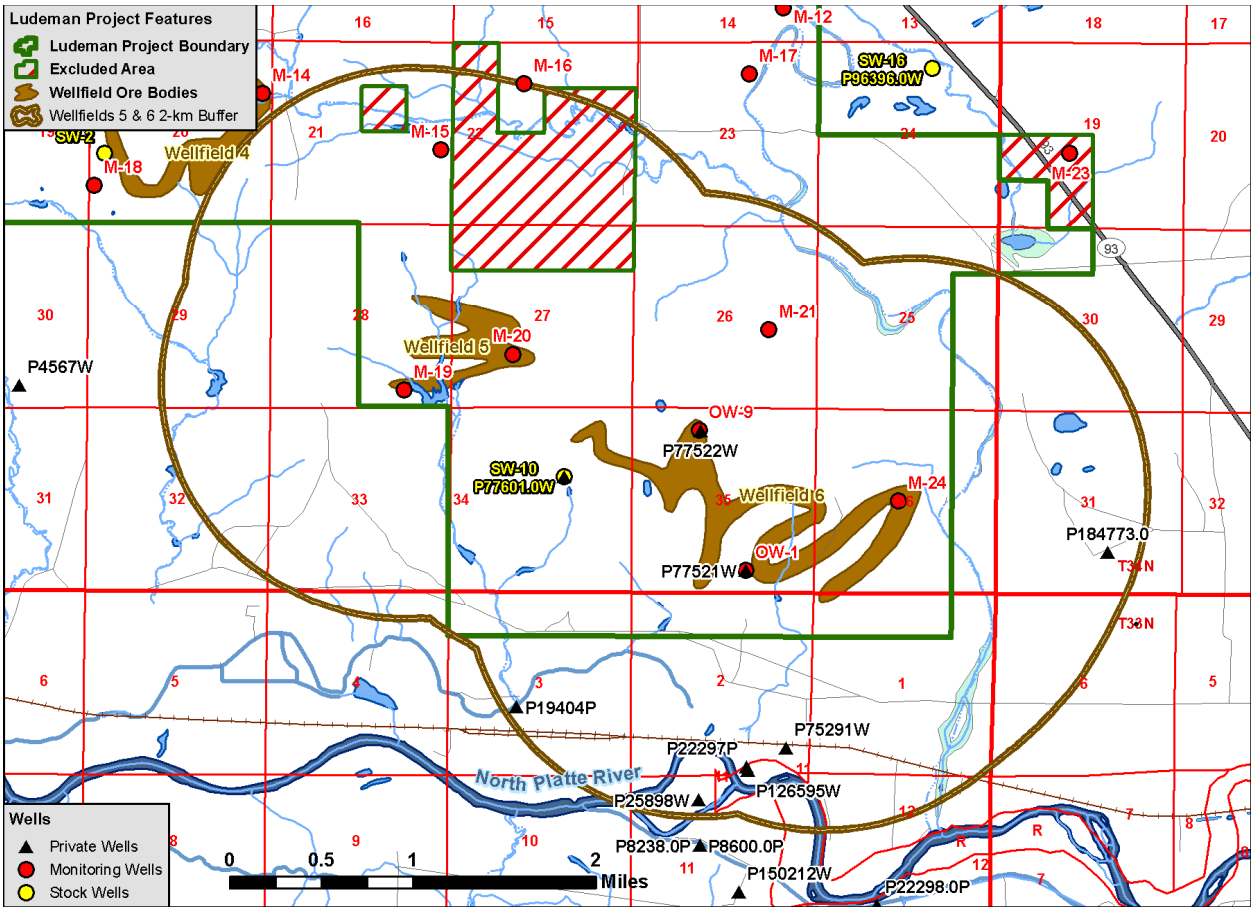

Figure 2.4-11 Ground Water Rights and Private Wells within 2 km of Wellfields 5 and 6

The private well completion descriptions as provided by the licensee are shown in SER Table 2.4-14. Well P77601.0W (SW-10), with a screen interval of 140-165 ft bgs, is located west of Wellfield 6. The NRC staff determined it was completed in the 90 sand based on the nearest log point 3473-NAC23-835 of Cross Section F-F' in Figure 2.6A-10 of Addendum 2.6-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The 90 sand is the production ore zone aquifer in Wellfield 6. In the table in Addendum 2.7-C, the licensee reported that Well P77521W (OW-1) and Well P77522W (OW-9), both stock wells, were completed in the 80 and 60 sands. The NRC staff, however, determined that Well P77521W (OW-1) with a well screen depth of 127-167 is likely to be completed in the 90 production zone sand based on the nearest log point 3473-35-2018 on Cross Section T-T" Figure 2.6A-24 of Addendum 2.6-A.

The remaining wells were much farther south and east of the wellfields outside the license boundary and almost at the 2 km boundary. No cross sections were available for staff to confirm their sand completion independently. As shown in SER Table 2.3-14, the licensee reported well P19404P, a domestic well, was completed in the 90 and 100 sands. Well P22297P, a domestic well, was reported competed in 100 sand. The licensee did not report a sand interval for the remaining wells at the southern 2 km boundary limits, P126595W, P25898W and P75291W. All of these wells were less than 30 ft deep and the NRC staff concluded they were likely be in the shallow alluvium of the North Platte River flood plain. The remaining well permit, P184773.0, a stock well, was located to the east near the 2 km boundary, outside the license area. The

licensee did not provide and the NRC staff was not able to determine a sand interval for this well.

The NRC staff finds the licensee identified all private wells within 2 km of Wellfields 5 and 6. The majority of the wells are sufficiently distant or located in overlying or underlying sand layers from the 70 and 80 sand production zones in Wellfield 5 or 90 sand production zone in Wellfield 6 by shale layers. The staff therefore finds wells P77522W, P19404P, P22297P, P126595W, P25898W and P75291W, are sufficiently hydrologically isolated from operations in the Wellfield 5 and 6 production zone. However, the NRC staff finds Well P77601.0W (SW-10), with a screen interval of 140-165 ft bgs, is likely to be completed in the 90 production zone sand of Wellfield 6. In addition, the NRC staff finds Well P775221W (OW-1) is likely to be located in the 90 production zone sand in the footprint of Wellfield 6. The NRC staff finds these wells are not hydrologically isolated from the 90 sand production zone aquifer in Wellfield 6. The NRC staff finds any use of these wells could affect hydraulic control of fluids in the wellfield and impact receptors.

The licensee stated in Section 4.4.2.2.1 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) that no stock or drinking water wells will be located in the currently proposed ISR wellfields and will not be completed in the production ore zone aquifer. The licensee also stated that if future development includes an area(s) where a stock well is located in an ISR production ore zone aquifer, the licensee would consider the following measures: (1) replacing the wells with new wells completed in either shallower or deeper sands that are not impacted by ISR operations; or (2) providing another source of stock water. The licensee also committed in Section 3.4.2.5 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) that all wells that are located within 500 ft of a wellfield perimeter monitor well ring will be accurately surveyed through the use of field verification (GPS or surveying) and corresponding information provided within each individual Wellfield Hydrologic Data Package as described in SER Section 5.7.8.3.

The NRC staff finds, however, the licensee has not committed to plug and abandon private wells that are in the production ore zone aquifer of any wellfield in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Therefore, the NRC staff will issue a new License Condition 10.26 for the Willow Creek Source Material License SUA-1341 that will state that the licensee will plug and abandon all private wells completed within the production ore zone aquifer within 500 ft of the perimeter excursion monitoring well ring as described in SER Section 5.7.8.3.1 and shown in SER Table 1.1-1.

2.4.4 Evaluation Findings

The NRC staff evaluated the licensee's characterization of the surface water hydrology, ground water hydrology and ground water use at the Ludeman Project in accordance with the review procedures in SRP Section 2.6.2 and the acceptance criteria in SRP Section 2.6.3.

Surface Water Hydrology

The NRC staff finds the licensee has acceptably characterized the Ludeman Project surface water hydrology and permitted use by providing: a description and maps of all watersheds and drainages; a description and maps of all surface water features in and near the license area including type, size, behavior ; an assessment of the potential for flooding of the satellite facility, wellfields and associated infrastructure using FEMA 100-year flood hazard maps and modeling

to estimate peak flow rates in major perennial drainages; maps and tables of all surface water rights within 2 miles of the project boundary.

Based on the information provided by the licensee, and the NRC staff's review conducted of the characterization of the surface water hydrology at the Ludeman Project, the NRC staff concludes that the characterization information is sufficient as it meets the applicable acceptance criteria of SRP Section 2.7.3.

Staff also finds the information is sufficient for staff to conclude as described in SER Section 2.4.3.1, that in all but one case, the licensee can protect surface water features and surface water users in the license area from production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c). The NRC staff finds in one case, any wellfield infrastructure installed in the footprint of an apparently perennial but variable surface water feature in Wellfield 5 that is listed as a FEMA 100 yr flood hazard zone would be subject to damage from periods of standing water and flooding. The NRC staff addresses the safety issues arising from wellfield infrastructure installations in this surface water feature in Wellfield 5 in SER Section 3.1.3.8. Because of the safety concerns with this feature in Wellfield 5, the NRC staff will require a new License Condition 10.23 to be added to the Willow Creek Source Materials License as described in SER Section 3.1.4 and shown in SER Table 1.1-1.

Ground Water Hydrology

The NRC staff finds the licensee has acceptably characterized the Ludeman Project ground water hydrology by presenting a site wide evaluation of the hydrogeology using a monitoring well network installed by the licensee, historic and current aquifer testing and an evaluation of hydrologic connectivity of aquifers. The characterization included: the hydrostratigraphy within each wellfield describing the targeted ore zone aquifers, aquitards, and overlying/underlying aquifers including depth, thickness, material type; aquifer water levels and ore zone production aquifer behavior (confined/unconfined) in each wellfield ; maps of potentiometric contours of all aquifers and estimates of ground water flow direction and magnitude; review of historic aquifer tests and new aquifer tests to provide production zone aquifer hydrogeological parameters (transmissivity, conductivity) and to evaluate any hydrologic connection to overlying and underlying aquifers to the production ore zone aquifer(s) in the wellfields.

Based on the information provided by the licensee, and the NRC staff's review conducted of the characterization of the ground water hydrology at the Ludeman Project, the NRC staff concludes, with the exception of Wellfield 2, that the information is sufficient as it meets the applicable acceptance criteria of SRP Section 2.7.3. As described in SER Section 2.4.3.2, the licensee incorrectly identified the 70 sand as the ore zone aquifer in Wellfield 2 when it is located in the 60 sand. The licensee did not characterize the 60 sand or conduct any aquifer tests in the 60 sand to enable the staff to conduct a safety assessment of the hydraulic control of production fluids in Wellfield 2. As discussed by the NRC staff in SER Section 2.4.3.2, the licensee acknowledges this error (Uranium One Americas 2013c, NRC 2016c, 2017a) and has agreed to a license condition which prohibits any construction or operation to recover uranium in Wellfield 2 as part of this license amendment. Therefore as described in SER Section 3.1.4, the NRC staff will add a new License Condition 10.22 to the Willow Creek Source Material License SUA-1341 as described in Section 3.1.4 and shown in SER Table 1.1-1.

With the exception of Wellfield 2, the NRC staff finds the information is sufficient for staff to conclude as described in SER Section 2.4.3.2 that the hydrogeologic setting in all of the

wellfields supports a finding that the licensee will have the ability to maintain control over production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c).

Ground Water Use

The NRC staff finds the licensee has acceptably characterized the ground water use within and near the Ludeman Project by providing: maps and tables of all ground water rights and well completions and permitted water use within 3 miles of the project boundary; and a comprehensive description and assessment of Negley Subdivision private wells to evaluate their current use and any hydrologic connection to the targeted ore zone aquifers in nearby Wellfield 1 in a report titled "Assessment of the Hydraulic Relationship of the Negley Subdivision to the Ludeman ISR Uranium Project," (Uranium One Americas 2011a).

Based on the information provided by the licensee, and the NRC staff's review of the characterization of the ground water use within 2 km of all wellfields at the Ludeman Project, the NRC staff concludes that information is sufficient as it meets the applicable acceptance criteria of SRP Section 2.7.3.

Staff also finds the information is sufficient for staff to conclude, as described in SER Section 2.4.3.3, that the majority of private wells within 2 km of a wellfield, including those at Negley Subdivision, are not hydrologically connected to the production zone aquifer(s) in nearby wellfields. The NRC staff therefore concludes these private wells will not impact or be impacted by the licensee's ability to maintain control over production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c).

The NRC staff, however, found that a few of the private wells in and near some wellfields may impact or be impacted by the licensee's ability to maintain control over production fluids containing source and byproduct materials, as required in 10 CFR 40.41(c). Specifically as described in Section 2.4.3.3, the licensee did not report and the NRC staff was not able to find water rights or completion information for several private wells completed within or very near Wellfields 3, 5, and 6. The NRC staff also found significant evidence that some private wells for which well completion information was provided may be in the production ore zone aquifer within the footprint of these wellfields.

The NRC staff concludes that any well that may be located in the production ore zone aquifer within 500 ft of the wellfield monitoring well ring is not hydrologically isolated from wellfield operations. The NRC staff finds any use of any such well could affect hydraulic control of fluids in the wellfield and impact receptors. As described in Section 2.4.3.2, the licensee has not explicitly committed to plug private wells that are in the ore sand production zone aquifer of any wellfield in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Therefore, the NRC staff will issue a new License Condition 10.26 for the Willow Creek Source Material License SUA-1341 that will state that the licensee will plug and abandon all private wells completed within the production ore zone aquifer within 500 ft of the perimeter excursion monitoring well ring as described in SER Section 5.7.8.3.1 and shown in SER Table 1.1-1.

2.5 Pre-Operational Surface Water and Ground Water Quality

This section describes the NRC staff's evaluation of the licensee's description of the pre-operational surface water and ground water quality at the Ludeman Project. The licensee provided information on the pre-operational surface water and ground water quality of the Ludeman Project in Section 2.7 of the Ludeman Project Revised Technical Report (Uranium

One USA 2017d). This information is needed to provide a basis for evaluating potential effects of ISR operations on the quality of local ground water and surface water resources.

2.5.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that the characterization of pre-operational background surface and ground water quality at the Ludeman Project has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the NRC staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7, using the acceptance criteria outlined in SRP Section 2.7.3 (NRC 2003).

2.5.3 Staff Review and Analysis

The following sections include the NRC staff's evaluation of the pre-operational background surface water and ground water quality within the proposed Ludeman Project.

2.5.3.1 Surface Water

The licensee characterized the surface water quality for the proposed license area in Section 2.7.1.6.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Surface water samples were collected between 2008 and 2009 from 25 sampling sites. The locations of the sites across the license area are shown in SER Figure 2.4-2. The results were provided in Table 2.7A-6 in Addendum 2.7-A. No samples were available from SW-5, SW- 14, SW-23, or SW- 27 as these locations were dry at all sampling times. The licensee stated it was not able to assess any seasonal trends in surface water quality because of the ephemeral nature of the streams within the license boundary. The NRC staff found the licensee evaluated the recommended constituents listed in Table 2.7.3-1 in NUREG- 1569 (NRC 2003). The NRC staff also found that the sampling sites provided good coverage of the license area, with at least one sampling location in each sub-watershed, either within a drainage or surface impoundment.

Name	TDS (mg/l)	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cl (mg/l)	Fe (mg/l)	Mg (mg/l)	Mn (mg/l)	Pb (mg/l)	Se (mg/l)	SO4 (mg/l)	Ra 226 (pCi/l)	Ra 228 (pCi/l)	U (mg/l)	GAA (pCi/l)
Standard	**500 (WY)**	**0.01**	**2.0**	**0.005**	**250 (WY)**	**0.3 (WY)**	**NA**	**0.05 (WY)**	**0.015**	**0.05**	**250 (WY)**	**5.0**	**5.0**	**0.03**	**15.0**
SW-1	**2516**	0.006	0.1	0.005	58.8	0.06	149.6	**0.26**	0.003	0.003	**1556**	0.42	**0.96**	**0.2127**	**416.6**
SW-2	382	0.004	0.1	0.005	2	**5.62**	4	0.02	0.005	0.001	44	0.71	0.33	0.004	12.33
SW-3	139	0.002	0.1	0.005	1	**0.74**	2	0.02	0.002	0.001	16.5	0.16	0.50	0.0003	3.25
SW-4	219.5	0.004	0.1	0.005	1	**0.86**	2	0.02	0.003	0.001	18	2.65	0.75	0.0006	7.6
SW-6	**898.83**	0.007	0.1	0.005	21.33	**0.44**	31.83	**0.07**	0.001	0.001	**509.3**	0.09	0.23	0.003	2.06
SW-7	241	0.009	0.1	0.005	3	**1.15**	8.67	**0.11**	**0.022**	0.001	55.33	0.17	1.17	0.0004	7
SW-8	179.5	0.007	0.1	0.005	1	**2.03**	1	**0.07**	0.006	0.001	13.5	0.42	0.28	0.0003	2.45
SW-9	394.2	0.008	0.1	0.005	1	**0.95**	2.6	0.04	0.002	0.001	15.6	0.43	0.54	0.0003	5.92
SW-10	205.4	0.004	0.1	0.005	1.2	0.08	9.4	**0.15**	0.001	0.001	24.8	0.12	0.36	0.0044	6.92
SW-11	243.5	0.01	0.1	0.005	1	**1.34**	3.5	**0.12**	0.003	0.001	27	0.66	0.16	0.0006	9.1
SW-12	**848.75**	0.002	0.1	0.005	18	0.07	3.5	**0.06**	0.001	0.003	**352.75**	0.24	0.35	0.0269	**47.58**
SW-13	303.33	0.01	0.1	**0.01**	1	**1.51**	11	0.04	0.001	0.001	46.67	0.76	0.07	0	10.23
SW-15	**693**	**0.011**	0.2	0.005	1	**12.1**	11	**0.27**	0.014	0.001	19	2.8	1.0	0.0014	5.1
SW-16	**4928**	**0.014**	0.14	0.005	121.8	0.17	195.4	**0.34**	0.003	0.002	**3050**	0.52	0.74	0.0203	**22.6**
SW-17	**879.25**	0.008	0.1	0.005	30.25	0.07	40	**0.2**	0.013	0.001	**443.75**	0.27	.58	0.0177	**20.45**
SW-18	254	0.008	0.1	0.005	1	**5.54**	5	**0.06**	0.005	0.001	37	0.2	.7	0.0025	1.3
SW-19	297.2	0.004	0.1	0.005	1.2	0.004	5.6	0.01	0.005	0.001	24.4	0.49	0.40	0.0018	1.4
SW-20	346.75	0.002	0.1	**0.009**	1	0.003	5.5	0.02	0.004	0.002	25.25	0.67	1.3	0.0008	1.23
SW-21	342.25	0.002	0.1	**0.01**	1	0.005	4	0.03	0.003	0.001	36.25	0.7	0.68	0.0005	1.5
SW-22	250.4	0.004	0.1	**0.008**	4	0.002	7	**0.12**	0.005	0.001	23	0.34	0.26	0.0009	1.54
SW-24	**609.4**	0.005	0.1	0.005	1.6	0.004	8.2	**0.07**	0.004	0.001	30.4	0.85	0.56	0.0058	1.4
SW-25	**1149**	0.003	0.1	0.005	7.8	0.006	30.4	**0.07**	0.006	0.002	**346.4**	1.18	0.71	0.0108	2.7
SW-26	**881.5**	0.004	0.13	0.005	1	0.003	2.5	0.02	0.003	0.002	23.75	0.21	0.58	0.0005	2.93
SW-28	**2533.33**	0.002	0.1	0.005	40.67	0.001	99.67	**0.16**	0.001	0.001	**1440**	0.81	0.73	0.0128	13.27
SW-29	**3350**	0.001	0.1	0.005	47	0.001	179	**0.09**	0.001	0.001	**1665**	0.02	0.50	**0.159**	12.4
Bold text indicates an exceedance EPA primary or Secondary Drinking Water or Wyoming Domestic Use Standards															

Table 2.5-1 Average Surface Water Quality of Select Constituents at Ludeman Project License Area

The NRC staff evaluated the average surface water quality results at each sampling site as shown in SER Table 2.5-1. The NRC staff found that the average surface water quality at some sampling sites exceeded EPA primary or secondary and Wyoming domestic use standards. EPA drinking water standards were exceeded at 2 sites for arsenic (0.01 mg/l), 4 sites for cadmium (0.005 mg/l), 1 site for lead (0.015 mg/l), 2 sites for uranium (0.03 mg/l) and 4 sites for gross alpha (15 pCi/L). The Wyoming domestic use standards were exceeded for TDS (11 of 25 sites), iron (11 of 25 sites), sulfate (8 of 11 sites) and manganese (16 of 25 sites) levels.

The NRC staff also evaluated the surface water quality at the sampling sites with respect to their location to proposed wellfields within a specific watershed. Three surface water quality sampling points are located near Wellfields 1 and 2 as shown in SER Figure 2.4-3. Two of the surface water sampling points, SW-1 and SW-24, are located in the Little Sand Creek tributary within the Sand-20 sub-watershed. SW-25 is located in the Sand-10 sub-watershed. The NRC staff finds the location and spread of these sampling points sufficient for characterizing the pre-operational surface water quality near these wellfields.

As described in SER Section 2.1, the historical Teton ISL pilot project operated in the footprint of Wellfield 1 in the late 1970s (NRC 1983). The pilot project used two evaporation ponds, known as the North and South evaporation ponds, to dispose of operation and restoration liquid wastes. These ponds were associated with WSEO surface water right permits P8065R and P8066R and were located within the Sand -20 subwatershed as shown in SER Figure 2.4-3. These ponds were successfully decommissioned before the Teton Pilot ISL license was terminated (NRC 1986).

The surface water quality of sampling sites near Wellfields 1 and 2 are shown in SER Table 2.5-2. The NRC staff found the water quality at the sampling site, SW-1, on Little Sand Creek down gradient of Wellfield 1, showed anomalously high average values for several constituents including TDS, chloride, sulfate, uranium and gross alpha when compared to the measured values of these constituents at the upgradient site, SW-24. In addition, another sampling site, SW-29, located downgradient from SW-1 in Little Sand Creek (see SER Figure 2.4-1), also showed relatively high values for these constituents when compared to the upgradient values at SW-24.

Sample Point	Watershed/ Subwatershed	Location	Average TDS (mg/l)	Average Cl (mg/l)	Average SO4 (mg/l)	Average U (mg/l)	Average GAA (pCi/l)
SW-24	Sand Creek/ SAND-20	Upgradient Wellfield 1	609.4	1.6	30.4	0.0058	1.4
SW-1	Sand Creek/ SAND-20	Downgradient Wellfield 1	2516	58.8	1556	**0.2127**	**416.6**
SW-25	Sand Creek SAND-10	Downgradient Wellfield 2	1149	7.8	346.4	0.0108	2.7
SW-29	Sand Creek	Downgradient Wellfields 1 and 2	3350	47	1665	**0.159**	12.4
Bold text indicates an exceedance EPA primary drinking water standards							

Table 2.5-2 Average Surface Water Quality of Select Constituents Wellfields 1 and 2

The NRC staff asked the licensee if the sampling results at SW-1 and SW-24 could be an indicator of legacy contamination from the Teton ISL Pilot project that may exist in Little Sand Creek tributary or the surficial aquifer which discharges to it. The licensee stated that they knew of no legacy contamination which could explain the surface water quality differences between SW-24 and SW-1 (Uranium One Americas 2013b). The licensee did report, however, that stock well SW-12 acted as a seep or spring that feeds into Little Sand Creek 100 yards above surface water sampling point SW-1 (Uranium One Americas 2013c). Stock well SW-12 also has elevated cations, anions and radionuclides. The NRC staff concludes the seepage from stock well SW-12 is the likely source of these elevated constituent levels as described in SER Section 2.5.3.2.

The licensee has stated it is aware that the background surface water quality is elevated at these locations. The NRC staff has informed the licensee that these elevated background values may affect the ability to distinguish future contamination from leaks or spills at the Ludeman operations. The licensee has committed to continue to monitor the surface water quality during operations. The NRC staff is therefore satisfied that the license will be aware of and take these elevated background water quality information into consideration in its surface water monitoring program as described in SER Section 5.7.8.3.2.

The location of surface water sampling sites near Wellfields 3 and 4 is shown in SER Figure 2.4-4. Surface water sampling points, SW-9 and SW-11, are located upgradient and downgradient, respectively, of Wellfield 3 in the Sage-13 subwatershed. Sampling points SW-5 and SW-12 located upgradient of both Wellfields 3 and 4 in the Sage-11 watershed. Sampling points SW-23 and SW-13 are located upgradient of Wellfield 4 in the Sage -11 subwatershed. SW-14 and SW-15 are located downgradient of both Wellfields 3 and 4. The NRC staff finds the location and spread of these sampling points sufficient for characterizing the pre-operational surface water quality near these wellfields. SW-5 and SW-14 were dry for the entire sampling period. The water quality reported for remaining surface water sampling sites did not display any anomalies of specific concern to the NRC staff.

The location of surface water sampling sites near Wellfields 5 and 6 as shown in SER Figure 2.4-5. Surface water sampling points, SW-19 and SW-21, are located within and downgradient of Wellfield 5 in the RD-10 subwatershed. Sampling point SW-22 is located downgradient of Wellfield 6. The NRC staff finds the location and spread of these sampling point sufficient for characterizing the pre-operational surface water quality near these wellfields. The water quality of all of these surface water sampling sites did not display any anomalies of concern to the NRC staff.

Two other surface water sampling locations within the license area indicated anomalous values for cations, anions and gross alpha with respect to the general surface water quality reported for the license area. These sites were SW-16 and SW-28 which are located upgradient downgradient, respectively, on Sage Creek on the east side of the proposed license area as shown in SER Figure 2.4-2. The average values of specific constituents at each these two locations are also shown in SER Table 2.5-1. The NRC staff asked the licensee to evaluate if the sampling results at these sites could be an indicator of legacy contamination that may exist in this tributary or the upper aquifer which discharges to it. The licensee indicated it was not aware of any possible source of contamination which could explain the reported values (Uranium One Americas 2013c). The NRC staff evaluation of this region of the license area did not discover any legacy uranium recovery or other operations near these sites which could be the source.

The licensee has committed to continue to evaluate surface water quality all surface water sampling sites during operations. The licensee has stated it is aware that the background surface water quality is elevated at some locations. The NRC staff has informed the licensee that these elevated background values may affect the ability to distinguish future contamination from leaks or spills at the Ludeman operations. The NRC staff is satisfied that the licensee will take this information into consideration in its operational surface water monitoring program as described in SER Section 5.7.8.3.2.

2.5.3.2 Ground Water Quality

This section describes the pre-operational ground water quality monitoring that was conducted as part of the initial site characterization of the license area. SER Section 5.7.8 provides an evaluation of the programs for baseline ground water monitoring, which takes place as part of well field development and operational ground water monitoring. SER Section 6.1 addresses restoration monitoring, which is conducted during ground water restoration.

The licensee evaluated the pre-operational ground water quality in the 60, 70, 80, 90, 100 and 110 sand aquifers of interest in the Ludeman Project license area in Section 2.7.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Ground water samples were collected quarterly from twenty-five licensee monitoring wells, two private wells (OW-1 and OW-9) and eight aquifer test wells within the license area between in 2008 and 2009. The licensee provided the sampling dates and individual results for all measured constituents at these wells in Tables 2.7B-9 through 14 in Addendum 2.7-B. The location of the monitoring wells is shown in SER Figure 2.4-6. The location of the aquifer tests wells is shown in Figure 2.7B-3 of Addendum 2.7-B. The completion information for these wells was provided in Addendum 2.7-C. The NRC staff finds the number and location of well sampling sites provided sufficient spatial coverage of the license area. NRC also staff found the licensee evaluated the recommended constituents listed in Table 2.7.3-1 in NUREG-1569 (NRC 2003).

The licensee provided Piper diagrams of the water quality in the 60, 70, 80 and 90 sands in Figure 2.7B-13 in Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d. These diagrams allow the assessment of the type of water with respect to major cations and anions. The licensee reported the water in the license area was calcium-sulfate type in the upper aquifers becoming sodium-bicarbonate type in the deeper aquifers. The licensee also provided Piper diagrams of the major anions and cations in selected wells in each of the aquifers for four quarters in Figure 2.7B-14 in Addendum 2.7-B. Based on these diagrams, the licensee reported there were no significant seasonal trends in the water quality in any aquifer. The NRC staff agreed no seasonal trend was evident.

The NRC staff calculated the average ground water quality of select constituents in the 60, 70, 80, 90, 100 and 110 aquifers. The results are presented in SER Table 2.5-1. The NRC staff used the values provided by the licensee with two exceptions. The licensee had previously informed the NRC staff that M-9 is completed in the 60 sand and M-13 is completed in the 90 sand (Uranium One Americas 2013c). The NRC staff, however, found the licensee incorrectly placed the M-9 water quality results in the 70 sand and M-13 in the 100 sand results in Tables 2.7B-10, 2.7B-11, 2.7B-13 and 2.7B-14 in Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) NRC therefore corrected these reporting errors before calculating the average water quality.

Water Quality Constituent	Sample Location (number of samples)					
	60 sand (N=12)	70 sand (N=40)	80 sand (N=35)	90 sand (N=27)	100 sand (N=7)	110 sand (N=8)
Bicarbonates as HCO3 (mg/L)	208.36	195.27	199.10	227.04	215.29	212.00
Carbonates as CO3(mg/L)	2.9	3.209	3.26	2.63	1.29	1.00
Chloride (mg/L)	3.82	3.651	3.37	6.27	2.17	3.38
Conductivity (umhos/cm)	512.09	496.54	516.55	759.44	862	721.25
Fluoride (mg/L)	0.60	0.62	0.51	0.326	0.39	0.66
pH (s.u.)	8.255	8.29	8.05	8.03	7.92	7.64
Total Dissolved Solids (mg/L)	315.6	348.70	329.27	494.18	599.5	501.00
Sulfate (mg/L)	91.72	90.88	100.93	215.07	292.42	214.38
Nitrogen, Nitrate+Nitrite as N (mg/L)	0.22	0.163	0.06	0.132	0.05	0.86
Aluminum (mg/L)	0.01	0.10	0.10	0.10	0.10	0.10
Arsenic (mg/L)	0.001	0.005	0.001	0.018	0.002	0.002
Barium (mg/L)	0.10	0.10	0.10	0.10	0.10	0.10
Boron (mg/L)	0.10	0.10	0.10	0.10	0.10	0.10
Cadmium (mg/L)	0.005	0.005	0.005	0.009	0.005	0.005
Calcium (mg/L)	26.91	23.66	33.06	70.55	101.0	101.38
Chromium (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Copper (mg/L)	0.01	0.01	0.01	0.01	0.01	0.01
Iron (mg/L)	0.03	0.03	0.03	0.03	0.03	0.03
Lead (mg/L)	0.001	0.001	0.001	0.04	0.001	0.001
Magnesium (mg/L)	7.82	7.50	10.04	18.92	25.29	21.13
Manganese (mg/L)	0.02	0.03	0.03	0.04	0.04	0.04
Mercury (mg/L)	0.001	0.001	0.001	0.001	0.001	0.001
Molybdenum (mg/L)	0.10	0.10	0.10	0.10	0.10	0.100
Nickel (mg/L)	0.05	0.05	0.05	0.05	0.05	0.05
Potassium (mg/L)	6.09	5.79	6.69	9.92	13.00	9.25
Selenium (mg/L)	0.001	0.001	0.001	0.003	0.001	0.009
Sodium (mg/L)	79.82	78.38	68.87	69.81	48.71	24.88
Radium-226 (pCi/L)	**49.77**	**61.34**	**41.58**	**236.02**	**433.26**	1.16
Uranium (mg/L)	**0.034**	0.017	0.01	**0.047**	**0.048**	0.019
Vanadium (mg/L)	0.10	0.10	0.10	0.10	0.05	0.10
Zinc (mg/L)	0.01	0.01	0.01	0.01	0.005	0.02
Gross Alpha (pCi/L)	**133.82**	**190.51**	**167.56**	**586.63**	**1033.77**	**46.84**
Gross Beta (pCi/L)	47.72	64.43	60.27	141.63	373.97	16.48
Bold text indicates an exceedance of EPA primary drinking water standards						

Table 2.5-3 Average Pre-Operational Ground Water Quality in Ludeman Project

SER Table 2.5-3 shows the average pre-operational ground water quality in all of the aquifers. The average water quality was good for major cations, anions and other constituents of concern (e.g. arsenic, selenium); however, the results show the average water quality exceeds the primary drinking water standards for radionuclides in all of the aquifers. EPA primary drinking water standards were exceeded in the 60, 70, 80, 90 and 100 sands for radium-226 (5 pCi/l); the 60, 70, 80, 90, 100 and 110 sands for gross alpha activity (GAA) (15 pCi/l); and the 60, 90 and 100 sands for uranium (0.03 mg/l).

The NRC staff noted one well, LMO-1, in the footprint of Wellfield 1, appeared to show anomalous values for radionuclides. The licensee reported the LMO-1 well is completed in the uppermost 110 sand aquifer, which is not identified to contain an ore zone. The water quality reported in LMO-1 showed consistently high values for uranium (0.036, 0.032, 0.034 mg/l) which exceeded the EPA primary drinking water standard for uranium (0.03 mg/l). The LMO-1 samples also had GAA values (65.8, 72.3, 80.1, 66.1 pCi/l), which exceeded the EPA primary drinking water standards (15 pCi/l). Based on the information provided, the NRC staff found that the licensee has conducted a satisfactory characterization of pre-operational ground water quality for the aquifers of interest in the Ludeman Project license area.

Private Well Sampling

The licensee sampled many private wells within and around the Ludeman Project license area. Specifically, the license sampled twelve stock wells once or twice in 2008-2009 for the constituents listed in Table 2.7.3-1 of the SRP (NRC 2003). The locations of the stock wells are shown on SER Figure 2.4-6. The licensee provide completion information for some of the stock wells in Table 2.7B-17 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported it was not able to confirm the completion interval or condition for many of these wells.

The licensee provided the sampling dates and individual results for all measured constituents in the stock wells in Table 2.7B-15 in Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff review of these results found that the ground water quality in some of the individual stock wells exceeded drinking water standards. Specifically, EPA primary drinking water standards were exceeded in eight wells for GAA (15 pCi/l) and two wells for uranium (0.03 mg/l).

The NRC staff found the water quality at stock well SW-12 located in the footprint of Wellfield 1 showed anomalous values. Specifically, the well exceeded primary drinking water standards for uranium (0.203 mg/l, 0.146 mg/l) and GAA (315 pCi/l, 216 pCi/l). It also exceeded the Wyoming domestic use standards for Total Dissolved Solids (TDS) and sulfate. As described in SER Table 2.4-10, the licensee reported that the well completion for stock well SW-12 (P4988W) is 130-145 ft bgs and in the 100 sand. The 100 sand was not reported to contain ore. The licensee reported it was aware of the elevated cation, anion and radionuclide values at this well (Uranium One Americas 2013c). In their on- site evaluation for the well, the licensee also found that it acted as a seep or spring that feeds into Little Sand Creek 100 yards above surface water sampling point SW-1 (Uranium One Americas 2013c). As described in SER Section 2.5.3.1, staff found elevated cations, anions and radionuclides in surface water quality measured at SW-1. The NRC staff concludes the seepage at stock well SW-12 to Little Sand Creek is the likely source.

The licensee also sampled twenty-three private wells outside the license area, mainly within the adjacent Negley Subdivision. The samples were collected quarterly between November 2008 and September 2009. The NRC staff found the licensee evaluated the recommended constituents listed in Table 2.7.3-1 in NUREG- 1569 (NRC 2003).

The licensee conducted the evaluation of the water quality in the Negley Subdivision as part of a comprehensive assessment of Negley Subdivision private wells to evaluate their relationship to the targeted ore zone aquifers in Wellfield 1. The evaluation was first provided to NRC in a comprehensive report titled “Assessment of the Hydraulic Relationship of the Negley

Subdivision to the Ludeman ISR Uranium Project," dated February 2011 (Uranium One Americas 2011a). The licensee resubmitted this report in Addendum 2.7-F of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff found the version in the Ludeman Project Revised Technical Report refers to many figures and tables that are missing but were present in the original report of the same name and date submitted to NRC in February 2011. Therefore, staff relied on the 2011 version of the report in their review of water quality in the Negley Subdivision wells.

The licensee provided the average water quality of the Negley Subdivision wells in Tables 3, 4, and 5 of the February 2011 report (Uranium One Americas 2011a). The results are shown in SER Table 2.5-4. With respect to radionuclides, the EPA primary drinking water standards were exceeded in all of the Negley Subdivision wells for GAA (15 pCi/l), in nine wells for uranium (0.030 mg/l), and in four wells for radium 226+228 (5.0 pCi/l). The EPA primary drinking water standards were also exceeded in two wells for selenium (0.05 mg/l). All but three of the wells exceeded the Wyoming domestic use standard for TDS (500 mg/l) and ten exceeded this standard for sulfate (250 mg/l).

In the report, the licensee also evaluated the spatial distribution of the water quality in the Negley Subdivision wells in an effort to determine if wells with elevated levels of radionuclides and other constituents could have been impacted by the operation of the historical Teton ISL pilot project (Uranium One Americas 2011a). After a comprehensive evaluation, the licensee concluded it is unlikely that the pilot test negatively impacted water quality in the Negley Subdivision wells based on several lines of evidence.

First, the licensee established that all of the Negley Subdivision wells were completed in the 100, 110 and 120 sands. These sands are separated from the 90 and 80 ore zone sands which were also targeted at the Teton ISL project by at least 80 ft of shale. The NRC staff reviewed this information in SER Section 2.4.3.3 and agreed with the licensee conclusion that the Teton ISL pilot production ore zones were not hydrologically connected to the Negley Subdivision wells.

Second, the licensee also reported that the water quality in the Negley Subdivision wells exhibited a trend of elevated constituents which increased to the northwest, away from the Teton ISL pilot area with the exception of one well, N-18 (Uranium One Americas 2011a). Well N-18 is completed in the 110 sand. The licensee reported that Well N-18 had the highest average concentration of TDS, sulfate, chloride, uranium, gross alpha and selenium of any of the Negley Subdivision wells. Other Negley Subdivision wells located to the south, closer to the area where the Teton pilot test was conducted, did not show increases in constituent concentrations. Therefore, the licensee concluded it was unlikely that the changes in water quality at N-18 were related to the Teton pilot project.

Third, the licensee compared the 2008-2009 quarterly water quality baseline data to historical water quality collected in 1979 in several of the Negley Subdivision wells before the Teton ISL pilot project operated. This comparison was shown in Table 6 of the report (Uranium One Americas 2011a). The historical results in Negley Subdivision wells N-1, N-2, N-6, N-11, N-13, N-15, N-16, N-17, N-18, N-20, N-21 and N-22 showed that the water quality in many of the Negley Subdivision wells were high or exceeded EPA primary drinking water standards for uranium in the samples collected in 1979. Other constituents were found to be essentially the same as the water quality measured in the 2008 and 2009 samples as the 1979 samples. The exception was N-18, where the concentration of most major ions, as well as TDS, nitrate (as N) and uranium showed sharp increases from 1979 to 2008-2009. The licensee suggested the

dramatic increase in nitrate in the well indicated it may have received some form of surface contamination or infiltration. A field survey conducted by the licensee found the well was in poor condition and may be prone to surface infiltration.

Finally, the licensee stated that uranium ore has been identified in borings drilled into the 100 Sand in areas near the Negley Subdivision and may be the cause of the elevated radionuclide levels observed in the wells.

Based on these lines of evidence, The NRC staff found that none of the Negley Subdivision wells are completed in the historical or targeted Wellfield 1 production zones; adequate confinement exists between the production zone and the overlying zones; and the existing water quality in the Negley Subdivision wells is similar to the water quality noted during pre-operational testing for the Teton Pilot Project. The NRC staff therefore agreed with the licensee conclusion that the elevated levels of radionuclides and other constituents in the Negley subdivision wells is likely naturally occurring.

2.5.4 Evaluation Findings

The NRC staff evaluated the licensee's site characterization information addressing pre-operational background surface water and ground water quality at the Ludeman Project in accordance with the review procedures in SRP Section 2.7.2 and the acceptance criteria in SRP Section 2.7.3.

Pre-Operational Surface Water Quality

The NRC staff finds the licensee has acceptably characterized pre-operational surface water quality by: selecting pre-operational surface water sampling sites that provided good coverage of the license area and included impoundments and drainages upgradient and downgradient of all wellfields; collecting samples from surface water sampling sites quarterly when possible or when water was present; conducting appropriate chemical and radiochemical analyses of water samples as recommended in Table 2.7.3-1 of the SRP (NRC 2003); evaluating the surface water quality for seasonal trends and exceedance of water quality standards; addressing anomalies in the surface water quality when possible.

Based on the information provided by the licensee, and the NRC staff's review of the characterization of the surface water quality at the Ludeman Project, the NRC staff concludes that the characterization information is sufficient as it meets the applicable acceptance criteria of SRP Section 2.7.3.

Staff also finds the information is sufficient for staff to conclude as described in SER Section 2.5.3.1 that the licensee has demonstrated that the characterization of pre-operational background surface water quality at the Ludeman Project has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

Pre-Operational Ground Water Quality

The NRC staff finds the licensee has acceptably characterized pre-operational ground water quality by: installing ground water monitoring wells that provided good coverage of the aquifers within and outside wellfields in the license area; collecting samples from ground water monitoring wells quarterly for at least one year; collecting samples from private stock wells in the license area and Negley Subdivision private wells near Wellfield 1 quarterly for one year;

conducting appropriate chemical and radiochemical analyses of all ground water samples collected as recommended in Table 2.7.3-1 of the SRP (NRC 2003); evaluating the monitoring well ground water quality for seasonal trends and exceedance of ground water quality standards; addressing anomalies in the ground water quality in monitoring wells and stock wells; and conducting an evaluation of the Negley Subdivision private well water quality to compare its recent (2008-2009) and historic (1979) constituent levels to demonstrate the private well water quality was not impacted by the Teton Pilot ISL operations in a report titled “Assessment of the Hydraulic Relationship of the Negley Subdivision to the Ludeman ISR Uranium Project,” (Uranium One Americas 2011a).

Based on the information provided by the licensee, and the NRC staff’s review of the characterization of the ground water quality at the Ludeman Project, the NRC staff concludes that the characterization information is sufficient as it meets the applicable acceptance criteria of SRP Section 2.7.3.

Staff also finds the information is sufficient for staff to conclude, as described in SER Section 2.5.3.2, that the licensee has demonstrated that the characterization of pre-operational background ground water quality at the Ludeman Project has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

Name	Aquifer Sand	Quarterly Samples	TDS (mg/l)	As (mg/l)	Cl (mg/l)	Fe (mg/l)	NO3 (mg/l)	Mn (mg/l)	Se (mg/l)	SO4 (mg/l)	Ra 226 (pCi/l)	Ra 228 (pCi/l)	U (mg/l)	Gross Alpha (pCi/l)
Standard	NA	NA	500	0.01	250	0.3	10	0.05	0.05	250	5.0	5.0	**0.03**	**15.0**
N-1	**110**	3	**574**	<0.001	1	<0.03	<0.05	**0.06**	<0.001	242	0.52	2.0	0.0113	**31.0**
N-2	110	3	**582**	0.001	2	<0.03	0.10	<0.01	0.003	249	0.31	1.9	0.0203	**52.8**
N-3	120	4	**1238**	0.001	115	<0.03	3.29	<0.01	**0.110**	578	0.56	2.6	**0.0395**	**124.8**
N-4	110	4	**588**	<0.001	8	<0.03	3.24	<0.01	0.028	191	0.62	3.1	**0.0732**	**98.3**
N-5	**120**	4	**599**	0.003	5	<0.03	3.55	<0.01	0.027	197	0.75	2.5	**0.0803**	**96.1**
N-6	110	4	**555**	0.,001	1	<0.03	<0.05	**0.15**	<0.001	245	0.67	3.5	.0096	**48.4**
N-7	120	4	338	0.001	7	<0.03	3.83	<0.01	0.036	253	0.87	5.5	**0.0997**	**172.8**
N-8	80	3	331	<0.001	3	<0.03	<0.05	0.03	<0.001	79	0.59	<1.3	0.0005	<4.0
N-9	120	2	**854**	<0.001	13	<0.03	6.7	0.01	0.048	348	0.27	1.6	**0.0815**	**182**
N-10	110	2	**659**	<0.001	6	<0.03	3.0	0.01	0.014	168	0.32	1.6	**0.0972**	**168**
N-11	**120**	4	**712**	0.001	35	<0.03	**18.7**	<0.01	0.042	210	0.87	4.4	**0.0644**	**122**
N-12	**110**	4	**600**	0.001	1	<0.03	0.29	0.02	<0.001	**261**	0.32	1.6	0.0130	**39.7**
N-13	**110**	4	**576**	0.002	9	<0.12	0.50	<0.01	0.006	235	1.0	4.2	0.0151	**46.6**
N-14	**110**	1	455	<0.001	71	<0.03	4.2	<0.01	0.007	59	0.90	2.1	**0.0368**	**66.5**
N-15	**100**	4	**593**	0.001	2	<0.03	<0.13	**0.13**	<0.001	**250**	0.69	2.7	0.0148	**41.7**
N-16	**110**	4	**643**	0.001	8	<0.03	<0.07	**0.07**	0.003	**286**	1.0	2.4	0.0287	**44.3**
N-17	**110**	4	**612**	0.001	2	<0.03	0.09	**0.12**	<0.001	**276**	0.66	2.1	0.0126	**42.5**
N-18	**110**	3	**1417**	<0.001	122	<0.03	**14**	<0.01	**0.121**	**586**	0.46	<1.3	**0.1780**	**284**
N-19	**100**	4	486	0.001	5	<0.04	0.25	<0.01	0.007	185	0.74	4.2	**0.0337**	**56.4**
N-20	**110**	1	**582**	0.001	<1	<0.03	<0.05	**0.11**	<0.001	**260**	0.52	4.3	0.0102	**27.8**
N-21	**110**	4	**600**	0.001	<1	<0.03	<0.07	**0.17**	<0.001	**256**	<0.77	2.9	0.0103	**41.4**
N-22	**110**	4	**567**	0.001	2	<0.03	<0.1	**0.16**	<0.001	245	0.59	4.7	0.0111	**37.3**
N-23	**110**	4	**817**	0.002	8	<0.05	9.10	**0.12**	0.024	**346**	1.00	2.5	0.0116	**40.3**
Bold text exceeds EPA Primary or Secondary Drinking Water or WY Domestic Use Standards														

Table 2.5-4 Average Ground Water Quality at Negley Subdivision Private Wells in 2008-2009

2.6 Background Radiological Characteristics

This section describes the NRC staff's evaluation of the licensee's description of the background radiological characteristics at the Ludeman Project. The licensee provided information on the background radiological characteristics of the Ludeman Project in Section 2.9, "Baseline Radiological Characteristics," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Background radiological characteristics are used to evaluate the potential radiological impact of operations on human health and the environment. Such impacts could result from spills, routine discharges from operations, and other potential releases to the environment. In addition, the data collected are used to identify a radiological baseline for ground water restoration and decommissioning.

2.6.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that the background radiological characteristics or the pre-operational environmental monitoring program is in compliance with 10 CFR Part 40, Appendix A, Criterion 7.

2.6.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the NRC staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7, using the acceptance criteria presented in SRP Section 2.9.3 (NRC 2003). Also, as discussed in Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC 1980a), the pre-operational monitoring program should include at least 12 consecutive months of data, in accordance with 10 CFR Part 40, Appendix A, Criterion 7, including the submittal of complete soil sampling, direct radiation, and radon flux data, prior to any major site construction.

2.6.3 Staff Review and Analysis

The licensee provided background radiological characteristics for the Ludeman Project in Section 2.9, "Baseline Radiological Characteristics," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee measured radionuclide concentrations in the following environmental media: air, flora and fauna, surface soil, subsurface soil, and sediment. The licensee's measurements of radionuclides in air included both particulate matter radionuclides and gaseous radon-222. The licensee also assessed gamma radiation levels in the Ludeman Project environment by taking instantaneous measurements of radiation exposure rates in air and quarterly measurements of total radiation exposure.

2.6.3.1 Environmental Air Sampling for Particulate Matter and Radon-222

In Section 2.9.5, "Ambient Gamma and Radon Monitoring," Section 2.9.6, "Air Particulate Monitoring," Figure 2.9-39, "Average Ambient Rn-222 Results Across All Stations by Quarter," and Figure 2.9-40, "Air Particulate Mean Baseline Radionuclide Levels," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described 5 pre-operational environmental air sampling locations for particulate matter and 6 locations for radon-222. Four of these locations are near the site boundary and one is near an on-site residence which is the location of the individual expected to receive the highest dose. With winds predominantly from the west, as shown in Figure 2.5-18, "Ludeman Site Baseline Year and Quarterly Wind Roses," of the Ludeman Project Revised Technical Report, sample location LUD-5, which is located on

the western boundary of the site, is a remote location that represents background conditions. The licensee collected samples continuously for a year at all locations.

The licensee reported particulate matter sample results in Table 2.9-6, “Air Particulate Monitoring Results,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), and the radon sample results in Table 2.9-5, “Ambient Radon Air Concentration Averages: Summary.” The particulate matter samples were assayed for natural uranium, thorium-230, radium-226, and lead-210. The NRC staff determined that all samples were collected such that minimum detectable concentrations met the guidance in Regulatory Position 5 of Regulatory Guide 4.14 (NRC 1980a).

2.6.3.2 Radon Flux Monitoring

In Section 2.9.7, “Radon Flux Measurements,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee explained, and the NRC staff agrees, that since there will be will be no tailings impoundments, pre-operational radon flux measurements are not required.

2.6.3.3 Vegetation Sampling

The licensee described pre-operational vegetation sampling methods in Section 2.9.10, “Vegetation Sampling,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) and described sampling locations in Figure 2.9-54, “Vegetation Mean Sampling Results.” The vegetation sampling results are reported in Table 2.9-9, “Summary Statistics for Radionuclides in Vegetation for Sampling Dates and Locations.” The licensee collected eight samples over a 3-month period during the grazing season at 3 different times. Each sample mass was 3-5 kilograms to ensure the requirements for minimum detectable concentration would be met. The results are within the same range as samples collected at the licensee’s Willow Creek site [see Tables 5.17 and 5.18 of the License Renewal Application (Uranium One USA 2008)].

2.6.3.4 Food Sampling

In Section 2.9.11, “Food Sampling,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee explained why it did not collect pre-operational livestock and game animal samples. The licensee explained that pre-operational samples of other food items earlier in the animal food chain (soil, sediment, water, and vegetation) provide a comprehensive baseline, and that modeling could be used to assess radiological impacts on livestock, if needed. The licensee also explained that bioaccumulation of radionuclides from the site in game animals is likely to be small because game animals have a large range, which reduces the fraction of food game animals derived from the site. For the reasons provided by the licensee, the NRC staff agrees that pre-operational livestock and game animal samples are not required to assess compliance with any radiation protection standard, to evaluate the performance of effluent controls, or to establish baseline data for decommissioning.

2.6.3.5 Direct Radiation

In Section 2.9.5, “Ambient Gamma and Radon Monitoring,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee summarized the results of its ambient gamma dose rate monitoring using optically-stimulated dosimeters (OSLs). The licensee described 6 pre-operational environmental ambient gamma dose rate locations shown

on Figure 2.9-35, “Mean Gamma Dose Rate Results by Quarter for Each Monitoring Station,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), which are located at the air sampling locations plus one additional location (i.e., LUD-3). Ambient gamma dose rates ranged from 9 microRoentgen per hour (µR/hr) to 15 µR/hr.

In Section 2.9.2, “Baseline Gamma Radiation Survey,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described an alternative approach to the direct radiation survey described in NRC Regulatory Guide 4.14 (NRC 1980a). Regulatory Position 1.1.5 of NRC Regulatory Guide 4.14 calls for up to 80 gamma exposure rate measurements on a radial grid using passive integrating devices, pressurized ionization chambers, or properly calibrated portable survey instruments. The licensee’s alternative approach includes taking numerous 1-2 second measurements using three Ludlum Model 44-10 sodium iodide (NaI) gamma detectors mounted on each of two Rhino off-highway vehicles (OHVs). The OHVs covered about 10-15 percent of the 11,000-acre scanned area, and provided about 350,000 paired results of individual gamma measurements and global positioning system (GPS) coordinates. The raw NaI-based results are depicted in Figure 2.9-9, “Raw, NaI-based Gamma Survey Results,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NaI detector results were then correlated to high-pressure ionization chamber (HPIC) measurements taken at discrete locations, so that the baseline gamma scan data collected using NaI detectors could be expressed in terms of HPIC-equivalent measurements. These HPIC-equivalent results are displayed by the licensee in Figure 2.9-14, “Continuous, Kriged Estimates of 3-foot HPIC Equivalent Gamma Exposure Rates,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee then correlated the HPIC-equivalent results to results of radium-226 analyses in Ludeman Project soil samples to produce continuous, kriged estimates of radium-226 and natural uranium concentrations in surface soils (0-15 cm depth) based on gamma survey results (see Figures 2.9-21 and 2.9-22 of the Ludeman Project Revised Technical Report).

The NRC staff accepts the licensee’s extensive characterization of gamma dose rates because the number of samples (i.e., 350,000) far exceed the recommended 80 samples stated in Regulatory Guide 4.14 (NRC 1980a), and the sample devices are of a type approved for this purpose. However, as stated in a previous NRC staff evaluation (NRC 2016b), the extrapolation of gamma dose rates to estimate radium-226 is reasonable, but the extrapolation to natural uranium soil concentrations is not. The NRC staff’s evaluation of the licensee’s characterization of background concentrations of radium-226 and natural uranium is provided in the next section.

2.6.3.6 Soil Sampling

In Section 2.9.3, “Soil Sampling,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described the results of soil sampling performed in the fall of 2008. The samples were collected in accordance with Regulatory Guide 4.14 protocols (NRC 1980a), including 5-cm deep samples of surface soils and incremental soil profile sampling up to depths of 1 meter for subsurface samples. Surface samples were collected in 800-m intervals along transects radiating in 8 compass directions centered on the originally-planned 3 satellite facilities. This resulted in 123 total surface soil samples. The licensee also collected subsurface samples at five locations around each originally-planned satellite facility.

Table 2.9-1, “Summary Statistics: Surface Soil Samples,” and Table 2.9-2, “Summary Statistics: Subsurface Soil Samples,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) contains a statistical summary of the licensee’s sample results for surface soils and subsurface soils, respectively. The results are within the range of expected uranium series

concentrations in soils (NCRP 1988). The NRC staff determined that baseline soil sampling is acceptable because it meets Regulatory Guide 4.14 (NRC 1980a).

2.6.3.7 Sediment Sampling

In Section 2.9.4, “Sediment Sampling,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described the results of 26 sediment samples from surface water sampling locations, including stock ponds, small natural impoundments, and ephemeral stream drainage channels. Similar to Table 2.9-1, “Summary Statistics: Surface Soil Samples,” and Table 2.9-2, “Summary Statistics: Subsurface Soil Samples,” for soil sample results, the sediment sample results presented in Table 2.9-3, “Summary Statistics: Sediment Samples,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) are within the range of expected uranium series concentrations in soils and sediments (NCRP 1988). The NRC staff determined that baseline sediment sampling is acceptable because it meets Regulatory Guide 4.14 (NRC 1980a).

2.6.3.8 Ground Water

The NRC staff’s evaluation of the licensee’s assessment of ground water quality in pre-operational samples is provided in SER Section 2.5. For this section, the NRC staff evaluated the licensee’s description of background radiological ground water sample locations, frequency, and types of radiological analyses, as described in Section 2.9.8 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The licensee reported it conducted a background radiological assessment of the ground water to conform to the applicable Regulatory Guide 4.14 guidance for pre-operational (background) radiological characterization of ground water (NRC 1980a). Ground water samples were collected quarterly from twenty-five licensee monitoring wells, two private wells (OW-1 and OW-9) and eight aquifer test wells within the license area between 2008 and 2009. The location of the monitoring wells is shown in SER Figure 2.4-6. The location of the aquifer tests wells is shown in Figure 2.7B-3 of Addendum 2.7-B. The completion information for these wells was provided in Addendum 2.7-C. The NRC staff finds the number and location of well sampling sites provided sufficient spatial coverage of the license area and aquifers of interest at the Ludeman Project.

The licensee reported it sampled all wells quarterly for the parameters of dissolved uranium, Ra-226, Ra-228, Th-230, Pb-210, and Polonium-210 (Po-210). The NRC staff finds these constituents are the same parameters identified in Regulatory Guide 4.14, Table 2 (NRC 1980). The licensee reported the methods it used for sampling in Section 2.9.8.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) which the NRC staff found to be acceptable.

The licensee provided the radiological ground water quality results in Section 2.9.8.2 and the summary statistics for the measured constituents at these wells in Table 2.9-7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also provided the average quarterly results by well location in Figures 2.9-42 through 2.9-47. The licensee reported that a number of wells had pre-operational baseline ground water concentrations of uranium and combined Ra-226+228 that exceeded respective EPA maximum contaminant levels (MCL) for drinking water. The licensee reported that the following wells exceeded both the uranium and combined Ra 226+228 standards in the production ore zone aquifers across the license area : MWs 4, 6, 8, 9,11,12,13,14,15,17,18,19, 20 and 24; Aquifer test wells LPW-

1,LPW-3A and LPW-4; and private well OW-1. The licensee attributed all of these elevated levels to the naturally occurring uranium. The licensee stated that none of the monitoring wells in aquifers underlying or overlying the production zone aquifers had ground water results which exceeded the MCLs for uranium or combined Ra-226 +228.

For the pre-operational monitoring program, the licensee has sampled some private wells within 2 km of the Ludeman Project wellfields. Specifically, the licensee sampled the Negley Subdivision private wells located just north of the Ludeman Project Wellfield 1. The NRC staff presented their review of the private well pre-operational ground water quality monitoring in the Negley Subdivision in SER Section 2.5.3.2 and presented the results in SER Table 2.5-4. The table shows that the pre-operational baseline water quality exceeds the EPA MCLs in all of the Negley Subdivision wells for gross alpha (15 pCi/l), in 9 wells for uranium (0.035 mg/l), and in 4 wells for combined Ra-226+228 (5.0 pCi/l). The licensee has committed as discussed in SER Section 5.7.8.3.1 to conduct pre-operational and operational monitoring of all private wells within 2 km of a wellfield consistent with the guidance in Regulatory Guide 4.14 (NRC 1980a).

The NRC staff finds that the background radiological sampling of monitoring wells and private wells for the Ludeman Project is consistent with guidance in Regulatory Guide 4.14 (NRC 1980a) and in general, effluent monitoring programs currently being conducted at existing ISR facilities. The NRC staff finds the types of radiological analyses performed for these samples acceptable because natural uranium and radium isotopes are the primary soluble contaminants resulting from operation of an ISR wellfield, and establish overall radiological conditions. The staff finds that the pre-operational radiological ground water monitoring programs are satisfactory and meet the recommendations in Regulatory Guide 4.14 (NRC 1980a) and the acceptance criteria of SRP Section 2.9.3 (NRC 2003).

2.6.3.9 Surface Water

The NRC staff's evaluation of the licensee's assessment of surface water quality in pre-operational samples is provided in SER Section 2.5. For this section, the NRC staff evaluated the licensee's description of background radiological surface water sample locations, frequency, and types of radiological analyses, as described in Section 2.9.9 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The licensee reported it conducted a background radiological assessment of the surface water quality to conform to the applicable Regulatory Guide 4.14 guidance for pre-operational (background) radiological characterization of surface water (NRC 1980a).The guidance in Regulatory Guide 4.14 addresses background surface water sampling around mill tailings impoundments (NRC 1980a). However, some of the guidance is generally applicable to ISRs. For example, the guidance states pre-operational (background) radiological water samples should be collected quarterly from each onsite water impoundment and at least monthly from streams, rivers, any other surface waters or drainage systems that cross the site boundary.

The licensee collected surface water samples between 2008 and 2009 from 25 sampling sites. The locations of the sites across the license area are shown in SER Figure 2.4-2. The licensee stated it was not able to collect all quarterly samples for surface water quality because of the ephemeral nature of the streams within the license boundary (Uranium One Americas 2013b). No samples were available from SW-5, SW- 14, SW-23 or SW- 27 as these locations were dry at all sampling times. The NRC staff found that the sampling sites provided good coverage of the license area, with at least one sampling location in each sub-watershed, either within a drainage or surface impoundment.

The licensee reported it sampled all surface water sampling sites for the parameters of dissolved uranium, Ra-226, Ra-228, Th-230, Pb-210, and Polonium-210 (Po-210). The NRC staff finds these constituents are the same parameters identified in Regulatory Guide 4.14, Table 2 (NRC 1980a). The licensee reported the methods it used for sampling in Section 2.9.9.1.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) which the NRC staff found to be acceptable. The licensee provided the radiological surface water quality results in Section 2.9.9.1.2. The licensee provided the summary statistics for the measured constituents at these sites in Table 2.9-8. The licensee also provided the average quarterly results by surface water site location in Figures 2.9-48 through 2.9-53.

The licensee reported that a number of surface water sites had pre-operational baseline concentrations of uranium and combined Ra-226+228 that exceeded respective EPA MCLs for drinking water. These sites were SW-1, SW-4, SW-12, SW-16 and SW-23. The licensee noted that at SW-1 there were also elevated levels of uranium and Ra-226 in the surface soils identified in the gamma survey. The NRC staff analyzed the anomalous surface water quality at SW-1 in SER Section 2.5.3.1. The staff found that the licensee reported that stock well SW-12 acted as a seep or spring that feeds into Little Sand Creek 100 yards above surface water sampling point SW-1 (Uranium One Americas 2013c). Stock well SW-12 also has elevated cations, anions, and radionuclides. The NRC staff concludes the seepage from stock well SW-12 is the likely source of these elevated constituent levels in the surface waters and sediments described by the licensee.

The staff finds that the background radiological sampling of surface water for the Ludeman Project is consistent with guidance in Regulatory Guide 4.14 (NRC 1980a) and in general, effluent monitoring programs currently being conducted at existing ISR facilities. The NRC staff finds the types of radiological analyses performed for these samples acceptable because natural uranium and radium isotopes are the primary soluble contaminants resulting from operation of an ISR wellfield, and establish overall radiological conditions. The staff finds that the pre-operational radiological surface water monitoring programs are satisfactory and meet the recommendations in Regulatory Guide 4.14 (NRC 1980a) and the acceptance criteria of SRP Section 2.9.3 (NRC 2003).

2.6.4 Evaluation Findings

The NRC has completed its review of the characterization information concerned with the background radiological characteristics at the Ludeman Project. This review included an evaluation using the review procedures in standard review plan Section 2.9.2 and acceptance criteria outlined in SRP Section 2.9.3.

The licensee has acceptably established the background radiological characteristics by providing monitoring programs to determine background radiologic characteristics that include radionuclides monitored, sampling frequency, and methods, location, and density; (ii) air quality stations located consistent with the prevailing wind directions; (iii) time periods for pre-operational monitoring that allow for 12 consecutive months of sampling; and (iv) radiologic analyses of soil samples at 5-cm (2-in.) and 15-cm (6-in.) depths. The licensee has acceptably established the background radiological ground water and surface water quality by providing ground water and surface water monitoring programs to determine background radiologic characteristics that include radionuclides monitored, sampling frequency, and methods, location, and spatial coverage of the license area. Based on the information provided by the licensee, and the detailed review conducted of the characterization of the background radiological

characteristics at the Ludeman Project, the staff concludes that the information is acceptable to allow evaluation of the radiological background of the site.

3.0 Description of the Proposed Facility

In this section, the NRC staff evaluates the licensee's description of its ISR process and equipment, CPP and instrumentation and control systems proposed for use at the Ludeman Project as presented in its Ludeman Project Revised Technical Report (Uranium One USA 2017d). As noted below, several elements of the proposed facility description remain unchanged under the Ludeman Project amendment from what the NRC staff approved for the Willow Creek Facility. NRC's evaluation of these unchanged elements is provided in the SER for the Willow Creek Facility (NRC 2013b).

3.1 In Situ Recovery Process and Equipment

This section describes the NRC staff's evaluation of the licensee's description of the ISR process and equipment to be used at the Ludeman Project. The licensee provided information on ISR process and equipment at the Ludeman Project in Section 3.0 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). This information is needed to evaluate whether ISR fluids can be contained within the equipment, systems, and geologic formations as described.

3.1.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that the equipment and processes used in the wellfields during operation of the Ludeman Project meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in SRP Section 3.1.3 (NRC 2003).

3.1.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the ISR processes and equipment proposed for the Ludeman Project. Review areas addressed in this section include: facility description, ore body characteristics and wellfield infrastructure, examining such features as well installation and completion, mechanical integrity testing, wellfield piping, header house design, spill and leak prevention, detection and monitoring, water balances, and wastewater disposal capacity and the proposed schedule for operations. Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by the licensee in its Ludeman Project Revised Technical Report (Uranium One USA 2017d).

3.1.3.1 ISR Facility Description

The licensee described the Ludeman Project satellite facility, process and equipment to be used in Section 3.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The Ludeman Project will occupy 7633 ha (18861 acres) of privately-owned land. The controlled area will cover approximately 533 ha (1317 acres). Construction of the satellite ion exchange facility, evaporation and permeate ponds will result in the disturbance of 372 ha (920 ac) of land surface. There will be no CPP located in the Ludeman Project and all ion exchange resins from

the satellite facility will be transported and processed at the CPP located at the existing Willow Creek Facility (SUA-1341). The licensee provided a conceptual infrastructure map of the locations of the satellite facility, ponds, wellfields, monitoring well rings, trunk lines and deep disposal wells (DDWs) in Figure 3-1 of the Revised Technical Report.

The licensee has requested a maximum production flow rate of 9000 gpm for the Ludeman Project, but did not request an increase in yellow cake production at the Willow Creek which shall not exceed 2.5 million pounds. Therefore, the NRC staff will revise License Condition 10.5 in the Willow Creek Source Material License SUA- 1341 to include the maximum production flow rate of 9000 gpm for the Ludeman Project as described in SER Section 3.1.4 and shown in SER Table 1.1-1.

3.1.3.2 Ore Bodies

The licensee described the ore bodies within the Ludeman Project license area in Section 3.1.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated six wellfields will be installed for extraction from the ore zones within the license area as shown in Table 3-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee incorrectly identified the production ore zone as the 70 sand in Wellfield 2 in Table 3-1, when the licensee had reported in an RAI response that the ore zone is in the 60 sand (Uranium One USA 2013b). The NRC staff finds, as described in SER Sections 2.3.3.2 and 2.4.3.2, that the licensee did not characterize the geology, hydrogeology or ore zone in Wellfield 2 in the 60 sand. NRC will therefore issue a new License Condition 10.22 to Willow Creek Source Material License SUA-1341 prohibiting any construction of or uranium recovery operations within Wellfield 2:

> License Condition 10.22
>
> <u>The licensee will not construct or conduct uranium recovery operations within Wellfield 2 of the Ludeman Project.</u>

The licensee stated that the economic uranium deposits at the Ludeman Project occur in roll front deposits in medium to coarse-grained sands of the 90, 80, and 70 sands of the Lebo member of the Paleocene Fort Union Formation. The ore is located at different depths in the 90, 80 and 70 sands. The ore zones are variable in thickness, ranging from 0.3 to 9.1 m (1 to 30 ft) thick. The 90 sand mineralization is about 2.7 m (8.3 ft) thick and has an average grade of 0.09 percent U3O8. The 80 sand mineralization averages 3.08 m (9.5 ft) thick and has an average grade of 0.13 percent U3O8. The ore zone in the 70 sand averages 3.44 m (10.6 ft) and has an average grade of 0.074 percent. The ore zone thickness, grade of uranium as percent uranium oxide (U_3O_8), and depth within each host sand for each wellfield was reported by the licensee as shown in SER Table 3.1-1.

The licensee will conduct ISR operations in Wellfields 1, 3, 4, 5 and 6 which are located as shown in SER Figure 2.1-1 which is based on Figure 3-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The production ore sands targeted in each of the wellfields are listed in SER Table 3.1-1. The stratigraphy including the ore zone sand in each wellfield is also described, respectively, in SER Tables 2.3-1, 2.3-2, 2.3-3, 2.3-4, and 2.3-5.

The licensee stated it will continue delineation in the license area to define future wellfield patterns in Section 3.0 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff finds future delineation may be conducted, but this license amendment

only applies to wellfields and ore zones specifically reviewed and approved in this SER. ISR operations in any additional wellfields or additional ore sands including those within an existing wellfield will not be authorized without an amendment.

Ludeman Project Ore Zones			
Ore Zones (Wellfield)	Thickness (ft)	Percent U_3O_8	Depth Range (ft bgs)
Wellfield 1			
90(1)	8.3	0.090	195 – 345
80(1)	9.5	0.130	295 – 450
Wellfields 3 and 4			
70(3)	10.6	0.074	470 – 690
70(4)			480 – 590
Wellfields 5 and 6			
70(5)	4.6	0.093	300 – 550
80(5)			225 – 385
90(6)			55 – 275

Table 3.1-1 Ludeman Project Wellfield Ore Zones and Mineralization

The NRC staff reviewed the wellfield ore body information and finds, with the exception of Wellfield 2 as described, it is consistent with the Acceptance Criterion (1) of SRP Section 3.1.3 because the ore body characteristics including grade, mineralogy and roll-front deposit type have been evaluated.

3.1.3.3 Well Completion and Development

The licensee described the well completion materials and methods in Sections 3.1.3.1 and 3.1.3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that all injection, recovery and monitoring wells will be installed using the same completion methods. The licensee provided a schematic for a typical well completion in Figure 3-3. The licensee stated that using the same well completion will enable injection and recovery wells to be interchanged. In addition, it will allow excursion monitoring wells to be used to correct excursions. The licensee described in detail the well installation procedures, including materials to be used and cementing procedures, to protect overlying and underling aquifers and prevent cross-contamination. The licensee also described the well development in Section 3.1.3.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). All wells will be developed after completion using air lifting, swabbing, pumping or other accepted techniques to ensure that well samples are representative of aquifer water quality.

The NRC staff found the well completion materials, installation and development methods are consistent with Acceptance Criterion (2) of SRP Section 3.1.3 because they reflect standard industry practices for ISR operations and have been accepted by the NRC staff as protective safety measures for such operations. The NRC staff also finds that the licensee's proposed well design, construction and development is consistent which that which has been successfully used at the currently licensed Willow Creek facility (SUA-1341). The NRC staff has not identified any new safety-related concerns pertaining to these well completion, installation and

development methods based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. Therefore, the NRC staff finds that the licensee's proposed well design, construction and development procedures area acceptable.

3.1.3.4 Well Mechanical Integrity

The licensee described the mechanical integrity test (MIT) procedures to be employed at the Ludeman Project in Section 3.1.3.4 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that, after installation, all recovery, injection and monitoring wells will undergo a mechanical integrity test before being placed into service for any regulatory use. The licensee stated it will also test wells every five years after they go in-service and after any workovers or suspected surface or subsurface damage. The MIT procedure involves isolating the well casing above the top of the production zone to ground surface using a down hole packer and wellhead cap. The licensee then increases the pressure inside the casing using water to a specified pressure equivalent to the maximum allowable pressure plus a safety factor of 20 percent. For the well to pass the MIT, the pressure must be maintained within 10 percent of this pressure for 10 minutes.

The licensee stated that if a well fails the MIT, the licensee will repair and retest the well. If a repaired well passes the MIT, it will be employed in service. If the licensee cannot repair the well, the licensee will plug and abandon the well. The licensee also stated that if a well fails an MIT after being in service as a production or injection well, the licensee will assess the cause of the failure and evaluate it the well failure may have released fluid to a non-exempt aquifer. The licensee will document all MITs and maintain the records on site for NRC review. In addition, the WDEQ will be notified quarterly of any well that fails the MIT.

The NRC staff reviewed the licensee's information and finds the mechanical integrity testing procedures are consistent with Acceptance Criterion (2) of SRP Section 3.1.3 because these procedures reflect standard industry practices for ISR operations and have been accepted by the NRC staff as protective safety measures for such operations. In addition, the NRC staff also finds that the licensee's proposed MIT procedures have been successfully used at the currently licensed Willow Creek facility (SUA-1341). The NRC staff has not identified any new safety-related concerns pertaining to these MIT procedures based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. The Willow Creek Source Materials License SUA-1341 has a License Condition 10.2 that addresses the MIT procedures and applies to operations in any production area, including the Ludeman Project. The NRC staff will therefore revise License Condition 10.2 to include the Ludeman Project as described in SER Section 3.1.4 and shown in SER Table 1.1-1. Therefore, staff concludes that the licensee's proposed MIT procedures are acceptable.

3.1.3.5 ISR process

The licensee described the ISR process to be used at the Ludeman Project in Section 3.1.4 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that uranium recovery will be conducted by injecting barren lixiviant into the orebody and recovering pregnant lixiviant. The pregnant lixiviant is then transported to the satellite plant where the uranium will be removed by passing it through a series of down flow ion exchange columns. After the lixiviant has passed through the ion exchange, it will be refortified with carbonate solution and then recycled back to the injection wells in the wellfield to continue

production. The resin loaded with uranium will be transferred from the satellite plant to the Willow Creek CPP via tanker truck. Once the resin has been processed it will be returned to the Ludeman Satellite facility for reuse in the ion exchange circuit.

The licensee described the lixiviant in Section 3.1.4.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the lixiviant will be composed of varying concentrations and oxygen, and carbon dioxide added to native ground water. Sodium bicarbonate or sodium carbonate may be added if carbon dioxide alone is not adequate. The licensee also stated it may use hydrogen peroxide as an oxidant, although oxygen would remain the primary oxidant utilized. The lixiviant will be mixed in batches which will be added continuously to the injection stream. The licensee provided the typical lixiviant concentrations expected in Table 3-2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The NRC staff found that this composition of lixiviant with dissolved oxygen is consistent with Acceptance Criterion (5) of SRP Section 3.1.3 (NRC 2003). This lixiviant composition has been used in other ISR operations in confined aquifers like those at the Ludeman Project and is known to be amenable to ground water restoration. In addition, the NRC staff also finds that the licensee's proposed lixiviant composition has been successfully used at the currently licensed Willow Creek facility (SUA-1341). The NRC staff has not identified any new safety-related concerns pertaining to lixiviant composition based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. The Willow Creek Source Materials License SUA-1341 has a standard License Condition 10.1 regarding the composition of lixiviant applies to operations in any production area, including the Ludeman Project. The NRC staff will revise License Condition 10.1 to include the Ludeman Project as described in SER Section 3.1.4 and shown in SER Table 1.1-1. Therefore, staff concludes that the licensee's proposed lixiviant composition is acceptable.

3.1.3.6 Wellfield Design and Operation

The licensee presented the wellfield design and operation in Section 3.1.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee provided a conceptual infrastructure map in Figure 3-1 which shows the location of the wellfields, header houses, wellfield patterns, monitoring well rings, and other related infrastructure.

The licensee stated that the wellfields will be composed of header houses and pipelines which will service the injection and recovery wells. A schematic of a typical header house was provided in Figure 3-5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the header houses will be of steel construction and approximately 3.05 m by 6.10 m (10 ft by 20 ft) in size. The interior will be equipped with injection and recovery manifolds with booster pumps. An oxygen line will be present on the injection manifold. The header house will have two trunk lines, one for receiving injection fluid from and one for returning recovered fluids to the satellite. The licensee stated the wellfield piping between wells and the header house will be constructed of high density polyethylene (HPDE) with some PVC and/or steel. The wellfield piping will be operated at pressures between 160- 300 psig, which will be less than the rated operating pressures. The individual trunk lines will be buried to protect from freezing or damage from vehicles.

The licensee stated they will employ a standard five spot pattern in the wellfields. The licensee also indicated that it may use alternating or line drive patterns. The pattern used will vary

depending on the formation and ore body characteristics. The licensee reported all wells in the wellfield will be completed as injection or recovery wells to increase flexibility in operations. The injection and recovery wells will be located 75 to 150 ft apart. To ensure the injection wells will be operated at pressures which will not exceed the formation fraction pressure (FFP) of the wellfield, the licensee will calculate a maximum injection pressure (MIP) for each header house. The MIP is based on the average bottom screen depth for the wells in the wellfield serviced by the header house. It will be calculated using the following standard equation:

MIP= SF * D * (FFP- VG)

SF= safety factor
D= average depth of bottom of well screen interval
FFP= formation fracture pressure
VG= vertical gradient of water

To maintain hydraulic control of production fluids within the wellfield, the licensee stated that more fluid will be recovered than injected to maintain an inward hydraulic gradient. The inward hydraulic gradient is used to create an overall cone of depression in the production zone. The licensee reported this bleed rate will be a nominal 0.5 percent of total wellfield production rate and the maximum bleed will be 1.5 percent. Maintaining an inward hydraulic gradient which draws ground water flow into the well field is a critical aspect of operations at ISR facilities to maintain hydraulic control of fluids to prevent excursions and lixiviant escaping the ore zone.

The NRC staff found the header house design and equipment, wellfield piping, wellfield patterns, well injection pressures and maintenance of an inward gradient were consistent with Acceptance Criteria (2) and (5) of SRP Section 3.1.3 and based on standard practices for ISR facilities. In addition, the NRC staff also finds that the licensee's header house design and equipment, wellfield piping, wellfield patterns, well injection pressures and maintenance of an inward gradient is consistent with that used at the currently licensed Willow Creek (SUA-1341). The NRC staff has not identified any new safety-related concerns pertaining to header house design and equipment, wellfield piping, wellfield patterns, well injection pressures and maintenance of an inward gradient based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. In addition, the Willow Creek Source Materials License SUA-1341 has a License Condition 10.1 requiring the licensee to maintain an inward hydraulic gradient in each individual production area that also applies to operations in any wellfield, including the Ludeman Project. Therefore, staff concludes that the licensee's proposed wellfield design and operation are acceptable.

3.1.3.7 Wellfield Operational Monitoring

The licensee described the wellfield operational monitoring in Section 3.1.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the wellfield ground water monitoring program will be designed to detect excursions which are defined as the movement of lixiviant away from the production zone during all operations. Monitoring wells will be installed in a perimeter ring around the production ore zone sand at a distance 500 ft from the edge of the production zone spaced 500 ft apart to detect horizontal excursions. The perimeter ring wells will be screened across the production zone of the aquifer. Vertical excursion monitoring wells will be installed in the overlying and underlying aquifers at a density of one well per every four acres of wellfield. The overlying and underlying monitoring wells will be screened across the aquifer in which they are completed. The excursion wells will

be monitored biweekly for excursion parameters. The licensee's wellfield monitoring program and procedures to detect and correct excursions at the Ludeman Project are further discussed in SER Section 5.7.8 "Ground Water and Surface Water Monitoring Programs."

The NRC staff observes that the licensee's proposed configuration and density of ground water monitoring wells are consistent with Acceptance Criterion (3) of SRP Section 3.1.3. The NRC staff also finds that the licensee's proposed wellfield excursion monitoring design is consistent with that used at the currently licensed Willow Creek facility. The NRC staff has not identified any new safety-related concerns pertaining to the wellfield excursion monitoring design based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. In addition, the Willow Creek Source Materials License SUA-1341 has License Condition 10.3 describing the same monitoring well density. The NRC staff will therefore revise License Condition 10.3 to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1. Therefore, the NRC staff finds that the licensee's proposed wellfield operational monitoring design is acceptable.

3.1.3.8 Spill and Leak Prevention and Detection

Wellfield Spill and Leak Prevention and Detection Design

The licensee described the design for prevention and detection of spills and leaks in the wellfields in Section 3.1.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported that the operations in each header house will be extensively monitored to prevent and detect spills and leaks. The injection and recovery rates will be continuously monitored with individual flow meters. Pressure gauges will be installed for each of the injection and recovery wells. High and low pressure and flow rate alarms will be in place to alert operators of upset conditions. Automatic shutoff valves will also be installed on injection and recovery lines to activate if significant changes in flow or pressure occur. The oxygen injection system will also have an automatic shutoff in the event of injection flow shutdown. The licensee stated all injection and recovery well heads will be enclosed in a wellhead cover containing leak detection and venting in the wellfields. The design of the injection and recovery wellheads was presented in Figures 3-6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Both have leak detection and the injection well has a pressure relief valve. The NRC staff finds these design, monitoring and detection systems will assist in the prevention and timely detection of spills and leaks in header houses, wellfields and associated piping.

The licensee stated in Section 2.7.1.7 that all wellheads will be designed to be protected from flooding and inundation. The NRC staff, however, as described in SER Section 2.3.1, found the licensee had not ruled out installation of injection and recovery wells and associated wellfield infrastructure in a surface water impoundment located within Wellfield 5. This impoundment was reported by the licensee to be within a FEMA 100- year flood hazard zone as shown in SER Figure 2.4-5. The licensee identified this impoundment as WB-43 in the Photo 23 of Addendum 3.5- K of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e). The NRC staff investigated the behavior of this feature and determined it is completely or partially inundated during the year.

The NRC staff finds that any wellfield infrastructure located in the footprint of this apparently perennial but variable surface water impoundment in Wellfield 5 would be compromised and/or subject to damage from periods of standing water and flooding. Specifically, continuously

standing water could damage and compromise the function of the wellhead leak detection systems and pressure relief valves. Submerged infrastructure in the wellfield could not be inspected by the licensee for wellhead leaks and subsurface piping leaks. In addition, spills and leaks from infrastructure inundated in this feature could not be recovered or remediated and would result in immediate contamination of surface water. Routine maintenance and MIT testing would be compromised in inundated areas. Because of the safety concerns with the installation of wellfield infrastructure within this feature in Wellfield 5, the NRC staff will therefore add the following new License Condition 10.23 to the Willow Creek Source Material License SUA-1341 to state:

> License condition 10.23
>
> The licensee will not install any wells or wellfield infrastructure in Ludeman Project Wellfield 5 within the boundary of the surface water impoundment located in Section 28 of T34N R73W as shown in Figure 2.7A-1 of Addendum 2.7-A of the Ludeman Project Revised Technical Report.

The NRC staff observes that the licensee's proposed methods for preventing and detecting spills and leaks in header houses, wellfields, wellheads, and associated piping are consistent with Acceptance Criterion (2) of SRP Section 3.1.3 with one exception. The NRC staff has identified one new safety concern with respect to installation of wellfield infrastructure in a surface water impoundment identified within the FEMA 100-year flood zone in Wellfield 5 as addressed above. Therefore, the NRC staff will add a new License Condition 10.23 to the Willow Creek Source Materials License SUA-1341 as described above. Otherwise, the NRC staff finds that the licensee's proposed methods to prevent and detect leaks is consistent with that used at the currently licensed Willow Creek facility. The NRC staff has not identified any other new safety-related concerns pertaining to the licensee's proposed methods for preventing and detecting spills and leaks in header houses, wellfields, wellheads, and associated piping based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. Therefore, staff concludes that the licensee's proposed wellfield spill and leak prevention and detection design is acceptable.

Guard Well Monitoring Network in Wellfield 1

As described in SER Section 2.4.3.3, the Negley Subdivision has numerous domestic and stock wells completed in the 100, 110 and 120 sands which overlie the 80 and 90 production zone sands in just north of Wellfield 1. In their safety review, the NRC staff concluded the presence of these wells and their use poses a risk that any spills and leaks in the 100 and 110 sand aquifers in Wellfield 1 could migrate toward and contaminate them. The NRC staff therefore issued a RAI to the licensee to address these concerns (NRC 2013a). In the response to the RAI (Uranium One USA 2015b), the licensee conducted ground water flow modeling and particle tracking to assess the risk of contamination to these private wells from leaks and spills in the overlying aquifers in Wellfield 1. Based on this modeling, the licensee recommended the addition of a guard well monitoring network in the 110 sand aquifer in Wellfield 1 in addition to the planned excursion monitoring well network in the overlying 100 sand aquifer.

The licensee originally provided the ground water modeling, particle tracking and guard well monitoring design in a separate report entitled, "Hydraulic Effects of Negley Subdivision Pumping on the Proposed Project," (Uranium One USA 2015b). The licensee also provided the same report in Addendum 4-B, "Hydraulic Effects of Negley Subdivision Pumping," of the

revised Environmental Report (Uranium One USA 2017e). In the report, the licensee developed a numerical ground water flow model and used particle tracking to evaluate the hydraulic effects of pumpage from private water supply wells in the Negley Subdivision on potential spills and leaks to the overlying aquifers in Wellfield 1.

As described in SER Section 2.4.3.3, the Negley Subdivision private wells produce water from the 100, 110, and 120 sand aquifers that overlie the 80 and 90 sand ore zone aquifers in Wellfield 1. To assess the potential for a leak or spill in Wellfield 1 to reach these aquifers in the Negley Subdivision, the licensee used ground water flow modeling and particle tracking to estimate the distance that a hypothetical leak from an injection well in the overlying aquifer could migrate undetected within a 5-year period under various Negley Subdivision private well pumping scenarios. The licensee selected an injection well leak to be a worst case scenario for contamination, as MITs will be conducted on these wells at five-year intervals and the longest period that a release could go undetected under a failed casing scenario is five years.

The NRC staff reviewed the model codes, model design, calibration, and the simulation results in the report. The licensee used the MODFLOW 2000 and MODPATH, Version 3, modeling codes. The MODFLOW 2000 code was used to simulate ground water flow. This code is a widely used public domain computer program developed by the U.S. Geological Survey (USGS). MODPATH is a particle tracking code that is used to estimate ground water velocities and directions. MODPATH is also a public domain code developed by the USGS. The NRC staff found these are standard modeling codes which are acceptable for the evaluation.

For the ground water flow model design, the NRC staff found the licensee used a model domain which provided adequate spatial resolution in the area of interest between the Negley Subdivision and Wellfield 1. This resolution was important to realistically simulate the response of the overlying aquifer(s) to pumping from the Negley Subdivision private water wells and a hypothetical leak from an injection well at the margins of Wellfield 1. Cell dimensions across this area were 12.5 ft by 12.5 ft. Cell dimensions gradually increased to a maximum size of 200 ft by 200 ft at the model boundary. The licensee simulated only the 110 sand as one layer in the model because the 100 sand is discontinuous in Wellfield 1 and most of the Negley Subdivision wells are located in the 110 sand. The licensee stated the simulation of the 110 sand layer would also result in the fastest travel time for contamination to support the worst case scenario. The thickness of this layer was based on geological picks from local well logs.

The licensee used the General Head Boundary (GHB) condition to represent ground water flow into and out of the model domain. The heads for the GHB were adjusted along with recharge to provide a reasonable approximation of the potentiometric surface of the 110 Sand with a north-northeast hydraulic gradient. The licensee assigned field measured values to the model for hydrogeological parameters. The average hydraulic conductivity for the 110 sand aquifer tests was 1.34 ft/d which is considered representative of the field values from aquifer pumping tests. The average storativity reported from aquifer pumping tests was 1.15E-04. The average saturated thickness from those tests was 49.5 ft. Therefore, the licensee used an average specific storage of 2.33E-06. The porosity used in the simulations was 0.25 and the specific yield, was 0.2. The NRC staff found the ground water flow model design and parameter assignments were acceptable for the intended evaluation.

The licensee ran a steady state ground water flow model to establish the natural ground water flow gradient in the 110 sand aquifer with no pumping. The licensee calibrated the model to observed heads in several wells in the Negley Subdivision. The licensee stated the recharge and the GHBs were adjusted until a reasonable model calibration was reached which matched the

potentiometric surface of the overlying 110 sand aquifer both in terms of water level elevation and flow direction. The calibrated recharge value was 8.0E-05 ft/d. which is approximately 3 percent of precipitation. The steady state simulation results shown in Simulation 1 in SER Table 3.1-2 indicated a natural ground water flow rate of 10 ft/year. NRC staff found the steady state model calibration and recharge assignment was acceptable for the intended evaluation.

The licensee ran numerous transient simulations to evaluate the hydraulic effect of pumping from the Negley Subdivision wells on a hypothetical leak into the 110 sand aquifer. In the simulations, the licensee considered the shortest pathway for contamination to reach the Negley Subdivision private wells would be from a leak in the casing of an injection well near the northern edge of the Wellfield 1 (a minimum distance of approximately 970 ft). The licensee assumed the fastest travel time would be under a scenario where the hydraulic gradient in the 110 sand between the Negley Subdivision wells and the failed injection well is maximized. The licensee stated the model simulations were designed to maximize that hydraulic gradient. The licensee used the well package of MODFLOW 2000 to simulate the pumping Negley Subdivision private wells pumping and the injection well. The licensee determined that the maximum pumping rates for the Negley Subdivision private wells would be 5 gpm based on USGS reported domestic use rates. An injection well was placed at the northern edge of Wellfield 1 at a maximum expected injection rate of 20 gpm. Simulations were also run using injection rates (10 gpm) and domestic well pumping rates (1 gpm) which the licensee stated were more reasonable for site conditions and typical domestic usage rates. The NRC staff found the leaking well injection rate, private well pumping rates and transient simulation scenarios were acceptable for the intended evaluation.

The licensee reported the results of seven transient simulations and particle tracking in the 110 sand in Table 4 of the report (Uranium One USA 2015b). The NRC staff provides some of the simulation results in SER Table 3.1-2. For Simulation 2, the results showed that the maximum contamination migration of a simulated 20 gpm casing leak from the northern edge Wellfield 1 after 5 years, without any pumping from the Negley Subdivision wells, was 455 ft (91 ft/yr). For Simulation 3, a 20 gpm injection leak coupled with pumping from the Negley Subdivision wells totaling 110 gpm (5 gpm per well) increased the migration distance to 535 ft after five years (107 ft/yr). Therefore, the pumping from the Negley Subdivision wells increased the migration rate by approximately 16 ft/yr. In Simulation 4, an injection well leak of 10 gpm without Negley Subdivision pumping wells resulted in a 5 year migration distance of 350 ft. The addition of the Negley Subdivision wells pumping at 1 gpm per well increased the migration distance to 357 ft. Therefore, the increased migration attributable to pumping from the Negley Subdivision wells was only 7 ft after 5 years (1.4 ft/yr).

The licensee stated that the model results demonstrate that the hydraulic impacts of pumping from the Negley Subdivision at rates substantially higher than would be expected are not great enough to overcome the spreading of the leak from the failed casing in the injection well. Specifically, the results show that the maximum width of the contamination migration from the injection well leak is always greater than the maximum downgradient travel distance within the first 5 years of the release. Overall, the NRC staff found the results showed that pumping from the Negley Subdivision private wells had a negligible impact on migration of the contamination. The NRC staff agreed with the licensee that lateral spread of the contamination mitigated the impact of migration toward the Negley Subdivision wells.

Based on the modeling results which showed some migration in the overlying 110 sand aquifer toward the Negley Subdivision, the licensee recognized a risk of contamination exists. The licensee therefore used particle tracking to design a downgradient guard well monitoring

network that would enable detection of leaks and spills into the 110 sand aquifer in Wellfield 1 to protect the Negley Subdivision private wells. The licensee demonstrated from this modeling that a row of guard monitoring wells spaced between 450 and 500 ft apart along the north margin of Wellfield 1 to monitor the 110 sand aquifer would detect a leak or spill. The licensee stated the 120 sand is not anticipated to be saturated in the immediate vicinity of the Wellfield 1. However, the licensee stated if it is determined that saturated conditions are present in the 120 sand, additional guard monitoring wells will be installed along the north perimeter of Wellfield 1 within the 120 sand at the same spacing as for the 110 Sand. The licensee also concluded that leaks and spills in the overlying 100 sand aquifer of Wellfield 1 would be detected by the proposed excursion monitoring network with a density of one well every four acres.

The NRC staff concludes the licensee adequately conducted ground water flow modeling and particle tracking to predict contamination migration from leaks and spills in the 110 sand overlying aquifer in Wellfield 1 to the Negley Subdivision private wells. The NRC staff finds the licensee used a realistic worst case leak scenario in the simulations to estimate the distance and rate of movement of contamination toward Negley Subdivision wells from spills, leaks or excursions into these sands in Wellfield 1.

The NRC staff finds the licensee has identified a new safety concern with spill or leak contamination migration from the overlying aquifers in Wellfield 1 toward the Negley Subdivision private wells. The NRC staff finds the licensee has adequately evaluated the risk of contamination migration and proposed a combined excursion and guard well ground water monitoring network that will adequately detect contamination from leaks and spills in the 100, 110 and any 120 sand aquifers in Wellfield 1. The licensee, however, did not describe the constituents or frequency of the monitoring. The NRC staff will therefore add a new License Condition 10.25, to the Willow Creek Source Material License SUA-1341, as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1, to state the licensee will install these guard wells in Wellfield 1 as described and monitor them the same as the required excursion monitoring wells. In addition, as the licensee did not specifically mention or commit to install the guard well network in the Revised Technical Report, the NRC staff will revise License Condition 9.3 of the Willow Creek Source Material License SUA-1341 to add the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) to provide a tie- down to Addendum 4-B which describes the technical basis and licensee commitment to install the guard well network as described in Wellfield 1. With this new and revised tie-down in license condition 9.3, the NRC staff finds that the licensee's proposed excursion and guard well monitoring network in the overlying aquifers of Wellfield 1 will be adequate to detect and therefore prevent contamination migration to the Negley Subdivision private wells.

Model Simulation	Condition	Time	Stress Periods	Injection Well	Injection Rate	Negley Subdivision Well Pumping Rates	Maximum travel distance in 5 years	Maximum width in 5 years	Description
		(years)			(gpm)		(ft)	(ft)	
1	Steady State	-	1	No	NA	0	50	NA	Steady state run to establish natural ground water hydraulic gradient
2	Transient	5	1	Yes	10	0	455	835	Simulate leak from injection well under natural ground water hydraulic gradient with no pumping
3	Transient	10	2	Yes	20	22 wells @ 5 gpm ea.	525	835	Simulate leak from injection well under extreme generalized ground water hydraulic gradient
4	Transient	5	1	Yes	10	0	350	600	Simulate leak from injection well under natural ground water hydraulic gradient
5	Transient	10	2	Yes	10	22 wells @ 1 gpm ea.	357	600	Simulate leak from injection well under more representative ground water hydraulic gradient

Table 3.1-2 Ground Water Modeling and Particle Tracking Simulations for Injection Well Casing Leak in Wellfield 1

3.1.3.9 Water Balance and Consumptive Water Use

The licensee described the water balance for the Ludeman Project ISR operations in Section 3.1.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee provided three water balances that reflect the three operational phases. The three phases are (1) production only, (2) concurrent production and restoration, (3) restoration only.

The licensee provided the water balance for the production phase only in Figure 3-7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).The licensee has requested a maximum allowable production rate of 9000 gpm from the wellfields. In Figure 3-7, the licensee showed it will take a bleed of 180 gpm from this maximum rate. Of that bleed, the licensee will send 67 gpm to the evaporation pond or DDWs and treat 113 gpm with a primary wellfield RO unit. The licensee will return 90 gpm permeate from the wellfield primary RO to the injection circuit to maintain an overall bleed of 90 gpm (1 percent). The remaining 23 gpm of RO reject brine will be sent to the evaporation pond. In total there will be 9000 gpm production with 90 gpm combined bleed and reject brine sent to the evaporation pond or DDWs for waste disposal. The NRC staff finds the total consumptive use during the production phase is therefore 90 gpm.

The licensee provided the water balance for the concurrent production and restoration phase in Figure 3-8 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). In this phase, the licensee will have a maximum production rate of 9000 gpm. The licensee will take a bleed of 180 gpm from the production wellfields. It will send all 180 gpm bleed to the wellfield primary RO. The wellfield primary RO will produce a permeate of 144 gpm and reject brine of 36 gpm. The licensee will send 90 gpm of permeate back to the production wellfields to maintain a 90 gpm production bleed (1 percent). The reject brine from the primary RO unit is sent to the secondary RO unit. The remaining 54 gpm permeate will be sent to the wellfields in restoration. The wellfields in restoration will produce 1000 gpm which will be sent to a primary restoration RO unit. The primary restoration RO unit will produce 800 gpm permeate which will be returned to the wellfields in restoration. The primary restoration RO reject brine will be sent to the secondary RO unit. The secondary RO unit will produce 118 gpm of brine which will be sent to the evaporation pond or DDWs. The remaining 172 gallons of permeate will be used to return 100 gpm to the wellfields in restoration and 72 gpm will go to the permeate pond. The overall bleed rate during restoration will therefore be 100 gpm (10 percent). The NRC staff finds the total consumptive use during the concurrent production and restoration phase is therefore 190 gpm (72 gpm to permeate pond and 118 gpm to evaporation pond).

The licensee provided the water balance for the restoration only phase in Figure 3-9 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). In this phase, the licensee will have a maximum restoration flow rate of 1000 gpm which will be sent to the primary restoration RO unit. The permeate from this RO unit will produce 800 gpm which will be returned to the wellfields in restoration. The 200 gpm reject brine from the primary RO unit will be sent to the secondary RO unit. The permeate stream from the secondary RO unit of 100 gpm will be returned to the wellfields in restoration. The remaining RO reject brine of 100 gpm will be sent to the evaporation pond or DDWs. The overall bleed rate during the restoration only phase will therefore be 100 gpm (10 percent). The NRC staff finds the total consumptive use during the restoration only phase is therefore 100 gpm (RO reject brine).

The NRC staff finds the consumptive use rates for the production only, production and restoration and restoration only phases are 90 gpm, 190 gpm, and 100 gpm, respectively. To evaluate the impact of this consumptive use on drawdown on the 70, 80 and 90 production zone

aquifers in the license area, the licensee provided some analytical ground water drawdown calculations in Addendum 2.7-G, " Hydraulic Drawdown Report," in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). In this report, the licensee used the Hantush-Jacob model for leaky confined aquifers in the proprietary AQTESOLV software to calculate the predicted magnitude and extent of drawdown in each aquifer over the life of the Ludeman Project. The maximum drawdown in a wellfield is important to assess if the production zone aquifer may be dewatered during operations. Drawdown of water level can lead to evolution of a free dissolved oxygen phase in the production zone aquifer which create "gas lock," which is a safety issue because it can reduce the well injectivity and conductivity in the aquifer. Dewatering that causes conversion of the aquifer from confined (saturated) conditions to unconfined (unsaturated) conditions is another safety issue as it changes the behavior of ground water flow in the aquifer that can impact hydraulic control of production fluids.

The NRC staff reviewed the "Hydraulic Drawdown Report' and found the drawdown analysis was conducted in 2012. The rates in the analysis were therefore based on the rates of ground water withdrawal from the original Ludeman Project Technical Report (Uranium One Americas 2011b) before the licensee requested a "change of design" to reduce the number of satellite facilities from three to one (Uranium One Americas 2013a). The NRC staff determined the main difference was that the maximum production consumptive use rate from an individual wellfield was assumed to be 30 gpm going to one of three satellite facilities in the original Ludeman Project Technical Report. In the current request, the maximum consumptive rate of 90 gpm may come from one wellfield to the single satellite facility as described in the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The NRC staff, however, found that some calculations in the report were done for a maximum consumptive rate of 105 gpm in a single wellfield during restoration which is slightly above the maximum consumptive rate for production in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For these calculations the ground water withdrawal was simulated by a single well located at the geographic center of the wellfield using the estimated schedule of operations. The NRC staff finds this to be a worst case scenario for drawdown in an individual wellfield as the true operating scenario would spread the drawdown across all of the recovery and injection wells in the entire wellfield. Therefore, the NRC staff finds the drawdown calculations for the maximum 105 gpm rate in one wellfield can be construed to present the maximum drawdown that will be expected during the proposed production operations. Although, the maximum consumptive rate of restoration and production phase is190 gpm, that rate would not be applied to a single wellfield, and therefore is not a realistic worst case scenario for predicted drawdowns in the wellfield production zone aquifer.

The NRC staff determined the drawdown calculations were performed separately for each aquifer over the lifetime of the operations according to the proposed schedule. Hydrogeological parameters such as hydraulic conductivity and aquifer thickness were assigned using site specific data from aquifer pumping tests. The leakage values of the confining layers were also assigned realistic values. The calculations were done assuming that the drawdown results from all the wellfield operations in the same aquifer could be added to provide the cumulative drawdown using the principle of superposition, which the NRC staff finds to be a widely accepted principal and appropriate for the purpose of this evaluation.

The licensee showed the results of the drawdown calculations Figures 1 through 3 of Addendum 2.7-G of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff estimated the maximum drawdown in each wellfield from these figures. The results showed an approximate maximum drawdown in the 90 sand of 85 m (262 ft) would occur

in Wellfield 1 at 5.5 years. The same approximate maximum drawdown would occur in the 90 sand in Wellfield 6 at 11 years. An estimated maximum drawdown in the 80 sand of 105 m (324 ft) would occur in Wellfield 1 at 5.5 years. The same maximum drawdown of the 105 m (324 ft) would also occur in the 80 sand in Wellfield 5 at 11 years. The 70 sand in Wellfields 3, 4, and 5 displayed a maximum drawdown between 80 m to 90 m (247-278 ft) at 9 years.

The NRC staff finds these drawdowns to represent an extreme value for each wellfield, as they are based on a single well pumping at the maximum rate in a wellfield for several years. In realistic wellfield operations, injection and recovery is occurring within the five spot patterns so the drawdown is spread out over the acreage of the wellfield and would be substantially reduced from these extreme values. However, the NRC staff evaluated the available water levels in each wellfield aquifer to assess if the aquifers will be dewatered under these extreme operating conditions.

The NRC staff notes dewatering occurs when the water level in the production zone aquifer drops below the top confining layer of the aquifer. The water level above the top of the aquifer is known as the available water column. The NRC staff calculated the available water columns from reported water level measurements in the 70, 80 and 90 sands in Wellfields 1, 3, 4, 5, and 6. The water column is shown to be 162-173 ft above the 90 sand and 265-272 ft above the 80 sand in Wellfield 1 in SER Table 2.4-1. The water column is 335-398 ft above the 70 sand in Wellfield 3 in SER Table 2.4-4. The water column is 239-386 ft above the 70 sand in Wellfield 4 in SER Table 2.4-6. In Wellfield 5, the water column is 147 ft above the 80 sand and 240 ft above the 70 sand in SER Table 2.4-7. Finally, in Wellfield 6, the water column is 72-100 ft above the 90 sand in SER Table 2.4-8. The NRC staff, therefore, finds the licensee maximum predicted drawdowns in the worst case scenarios indicate potential dewatering of the production zone aquifers in Wellfields 1, 3, 4, 5 and 6.

The NRC staff finds that although these worst case scenarios for drawdown are unlikely, lowering the water level to any substantial degree in the production zone aquifer can affect wellfield operation long before the ground water system dewaters enough to go from saturated to unsaturated conditions. In particular, the solubility of dissolved oxygen in the lixiviant will be impacted in the aquifer as the water column is reduced, as the reduction in head can lead to the evolution of a free oxygen phase in the aquifer. This free oxygen phase creates a two phase flow condition, known as “gas lock,” which can reduce the conductivity of the production zone aquifer to such an extent that well injectivity and ground water flow paths are negatively affected.

The licensee addressed the possibility of “gas lock’” in the production zone aquifers in Section 3.1.4.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated the avoidance of water level drawdown which can cause dissolved oxygen evolution and “gas lock” in a production zone aquifer was an operational goal. The licensee stated evidence of “gas lock” will be detected and corrected quickly within a wellfield as the continuous flow monitoring of the injection wells will detect any decrease in injectivity. This continuous flow monitoring will enable the operator to adjust injection and production flow rates to avoid drawdown which leads to “gas lock.” In addition, the licensee stated that wellfield operators will be prepared to take several actions to correct any “gas lock” condition occurring in a wellfield. The NRC staff finds the licensee is prepared to detect and correct water level drawdowns and associated “ gas lock” conditions should they occur addressing this safety concern. In addition, the NRC staff finds detecting and preventing “gas lock” will preclude water level drawdowns that would cause dewatering of aquifer to the point that it becomes unsaturated and creates a safety concern with hydraulic control of fluids.

The NRC staff finds the licensee has presented the facility water balance and consumptive use rates over the lifetime of the project. In addition, the licensee presented an analysis of anticipated drawdowns in the wellfields in response to the consumptive use and addressed the possibility of any safety issues which may arise from water level drawdown within and potential dewatering of the production zone aquifers. The NRC staff observes that the licensee's water balance and consumptive use have been described in a manner consistent with Acceptance Criterion (5) of SRP Section 3.1.3. Therefore, staff concludes that the licensee's proposed facility water balance and consumptive use description and evaluation is acceptable.

3.1.3.10 Waste Water Disposal Capacity

The NRC staff determined the consumptive use rates for the production only, concurrent production and restoration and restoration only phases are 90 gpm, 190 gpm, and 100 gpm, respectively as described in SER Section 3.1.3.9. These consumptive use rates represent the maximum 11 e. (2) byproduct liquid waste rates which will require disposal during the life time of the Ludeman Project.

The licensee presented its preferred option and two alternatives for ultimate disposal of this liquid 11e. (2) byproduct material in Section 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA, 2017d). Under the proposed action, liquid 11e. (2) byproduct material will be stored in an evaporation pond or permeate pond. The licensee stated the liquids in the permeate pond may be discharged to the surface under a Wyoming Pollutant Discharge Elimination System (WYPDES) permit. In the first alternative, the licensee stated it may add up to six DDWs to the evaporation and permeate ponds. In the second alternative, the licensee proposed DDWs and surge ponds.

The NRC staff reviewed the 11 e. (2) byproduct liquid waste disposal methods in SER Section 4.2. The NRC staff was only able to review the proposed option and first alternative as the licensee provided no design specifications for the second alternative. The NRC staff therefore does not approve the use of DDWs and surge ponds only. The NRC staff will therefore revise License Condition 10.7 of the Willow Creek Source Material License SUA-1341 to permit only the proposed and first alternative methods of liquid waste disposal as described in SER Section 4.2.4 and shown in SER Table 1.1-1.

For the proposed liquid waste disposal plan, the licensee provided the conceptual design for the waste disposal ponds in Addendum 4-A, "Conceptual Evaporation Pond Design "in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee plans to use the evaporation pond for the RO reject brine from production and restoration operations. The licensee will also use a permeate pond for RO permeate from wellfields in restoration. The licensee stated the evaporation pond and permeate pond would be composed of four separate cells. The design volume for each of the ponds was based on the anticipated waste liquid flow rates through the 8 year operational life of the facility, while taking into account net average natural evaporation rates. The rates of liquid waste disposal to the evaporation and permeate ponds for the three phases of operation are described in SER Section 3.1.3.9. The average natural evaporation rate was assumed to be 78.5 gpm, but the licensee reported this rate will vary from 20 gpm in the winter to 180 gpm in summer. The licensee also sized the ponds with 2 ft of freeboard to protect against extreme weather events and to add back-up storage capacity in the event of cell failure.

The licensee provided the calculations to determine the required size of the ponds in Attachment 1 of Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium

One USA 2017d). The required storage volume of the evaporation pond was determined to be 322,107 cubic yards and the permeate pond was 86,492 cubic yards as shown in SER Table 4.2-1. The NRC staff found these estimates were satisfactory because the licensee used methods to determine the design volumes for both the evaporation pond and permeate pond that accounted for anticipated liquid waste volumes and addressed the potential need for back-up storage. The NRC staff found the design volume calculation for the permeate pond was conservative as it did not include or require the use of surface water discharge throughout the eight year operational life to meet the required disposal capacity.

For the first alternative, the licensee stated it would install up to six DDWs in addition to the evaporation and permeate ponds. The licensee described the DDWs in Section 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also showed the locations of the six DDWs in the license area in Figure 3-1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the target zone for the DDWs will be the Lance Formation through the Parkman Formation. The depths for these formations range from 1,371 to 3,048 meters (m) (4,500 to 10,000 ft bgs). The NRC staff finds the field measured disposal injection rates for existing DDW in these formations (not projected permitted rates) at the analogous PRI Smith Ranch ISR facility are approximately 35-85 gpm on average. If all six wells achieve the minimum rate of 35 gpm, it will provide the licensee with an additional 210 gpm of disposal capacity.

The NRC staff finds the licensee has satisfactorily described the 11e.(2) liquid waste disposal proposed and first alternative options, but not the second alternative, for the Ludeman Project. The NRC staff finds the licensee has demonstrated that the proposed and first alternative liquid waste disposal methods are adequate to handle the projected waste volumes and rates anticipated at the Ludeman Project over the lifetime of operations. NRC staff will therefore revise License Condition 10.7 in the Willow Creek Source Materials License SUA-1341 as described in SER Section 4.2.4 and shown in SER Table 1.1-1 to include the approved 11e. (2) liquid waste disposal options at the Ludeman Project. The NRC staff finds the information on liquid waste disposal capacity is consistent with Acceptance Criterion (5) of SRP Section 3.1.3. Therefore, the NRC staff concludes that the licensee's proposed liquid waste disposal capacity is satisfactory.

3.1.3.11 Schedule

The licensee presented a general production, restoration and decommissioning schedule for its proposed ISR operations in Figure 1-3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). This schedule shows that production at Wellfield 1 will begin immediately after construction of the satellite ion exchange facility. Production in the other wellfields will start sequentially thereafter, and production in each wellfield will last almost 2 years. Restoration will begin immediately after production, and will consist of 3 months of GWS, followed by approximately 1 year of RO and finally a short period of recirculation. Once restoration for all wellfields are approved, decommissioning of the facility will begin.

Although not shown on explicitly on the schedule, the licensee stated it will conduct restoration stability monitoring at the end of restoration in Section 6.1.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). However, the licensee did describe or include the time period of the stability monitoring on the schedule. The Willow Creek Source Material License SUA-1341 has a License Condition 10.15 that requires the restoration stability monitoring period to last for at least a year as the licensee must demonstrate no statistically

significant increasing trends for individual constituents in four consecutive quarters. The NRC staff will therefore revise License Condition 10.15 as described in SER Section 6.1.4 and shown in SER Table 1.1-1 to include this stability monitoring commitment for the Ludeman Project.

The NRC staff found the proposed wellfield construction, operation, and restoration phases of the proposed schedule are consistent with Acceptance Criterion (6) of SRP Section 3.1.3. The NRC staff will, however, revise License Condition 10.15 as described above to ensure stability monitoring is appropriately conducted. The NRC staff recognizes the licensee may provide updates to the schedule as needed in order to comply with the requirements of 10 CFR 40.42. The NRC staff therefore concludes that the licensee's schedule is acceptable.

3.1.4 Evaluation Findings

The staff reviewed the ISR process and equipment proposed for use at the Ludeman Project in accordance with review procedures in SRP Section 3.1.2 and acceptance criteria in SRP Section 3.1.3.

The NRC staff finds the licensee satisfactorily described the satellite facility and production rates. The licensee has requested a maximum production flow rate of 9000 gpm for the Ludeman Project, but did not request and increase in yellow cake production at the Willow Creek which shall not exceed 2.5 million pounds. Therefore, the NRC staff will revise License Condition 10.5 in the Willow Creek Source Material License SUA-1341 to include the maximum production flow rate of 9000 gpm for the Ludeman Project as shown in SER Table 1.1-1.

The NRC staff finds the licensee has satisfactorily described the ore bodies at the Ludeman Project with one exception. Specifically, the NRC staff found the licensee had not correctly identified, nor characterized the ore body in the 60 sand aquifer in Wellfield 2 as described in SER Section 3.1.3.2. Therefore, the NRC staff will issue a new License Condition 10.22 to state:

> License Condition 10.22
>
> <u>The licensee will not construct or conduct uranium recovery operations within Wellfield 2 of the Ludeman Project</u>

The NRC staff finds the licensee has satisfactorily described the well completion and development and no new safety issues were identified.

The NRC staff finds the licensee satisfactorily described the well MIT procedures and no new safety issues were identified. Therefore, the NRC staff will revise License Condition 10.2 of Willow Creek Source Materials License SUA-1341 concerning MIT procedures to include the Ludeman Project as shown in SER Table 1.1-1.

The NRC staff finds the licensee adequately described the ISR process and lixiviant and no new safety issues were identified. Therefore, the NRC staff will revise License Condition 10.1 of Willow Creek Source Materials License SUA-1341 concerning lixiviant and inward gradient to include the Ludeman Project as shown in SER Table 1.1-1.

The NRC staff finds the licensee adequately described wellfield design and operation and wellfield excursion monitoring wells and no new safety issues were identified. NRC will revise License Condition 10.3 of Willow Creek Source Materials License SUA-1341 that describes the

excursion monitoring well density to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1.

The NRC staff finds the licensee satisfactorily described the wellfield spill and leak prevention and monitoring design; however, staff found a new safety issue in that the licensee did not state it would not install wells or wellfield infrastructure in a surface water impoundment located in a FEMA 100-yr flood hazard zone within Wellfield 5. Therefore the NRC will impose the following new License Condition 10.23 to state:

> License condition 10.23
>
> The licensee will not install any wells or wellfield infrastructure in Ludeman Project Wellfield 5 within the boundary of the surface water impoundment located in Section 28 of T34N R73W as shown in Figure 2.7A-1 of Addendum 2.7-A of the Ludeman Project Revised Technical Report.

The NRC staff finds that the licensee satisfactorily described and evaluated the risk of contamination migration from leaks and spills to overlying aquifers in Wellfield 1 to the Negley Subdivision private wells as presented in SER Section 3.1.3.8. To address the safety issue, the licensee stated it will install a guard well monitoring network in the overlying aquifers of Wellfield 1 to protect private wells in the adjacent Negley Subdivision. The NRC staff will therefore add a new License Condition 10.25 to install a monitor this guard well network in Wellfield 1 as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1. The NRC staff will also add a tie down to the Ludeman Project Revised Environmental Report (Uranium One USA 2017e), in License Condition 9.3, to include Addendum 4-B, “Hydraulic Effects of Negley Subdivision Pumping on the Proposed Project,” that describes the licensee technical basis and commitment to install these guard wells as described. The revision to License Condition 9.3 is shown in SER Section 1.4 and SER Table 1.1-1.

The NRC staff found the licensee satisfactorily described the water balance and consumptive water use for the facility to demonstrate that plant material balances and flow rates are appropriate. In addition, the licensee stated the production zone aquifer will be monitored for “gas lock” to ensure no safety issue is created by excessive drawdown or dewatering of the aquifer.

The NRC staff finds the licensee also satisfactorily provided reasonable estimates of 11e.(2) liquid waste effluent rates and sufficient waste disposal capacity in its proposed option and first alternative. The licensee, however, did not adequately describe the second waste disposal alternative. The NRC staff will therefore revise License Condition 10.7 of the Willow Creek Source Materials License SUA-1341 as described SER Section 4.2.4 and shown in SER Table 1.1-1 to include only the approved proposed and first alternative 11e.(2) liquid waste disposal options at the Ludeman Project.

Finally, the licensee satisfactorily described the Ludeman Project schedule of operations with one exception. The licensee did not include the required period of the stability monitoring. The Willow Creek Source Material License SUA-1341 has a License Condition 10.15 that requires the restoration stability monitoring period to last for at least a year as the licensee must demonstrate no statistically significant increasing trends for individual constituents for four consecutive quarters. The NRC staff will therefore revise License Condition 10.15 as described

in SER Section 6.1.4 and shown in SER Table 1.1-1 to include this stability monitoring commitment for the Ludeman Project.

Based the information provided by the licensee and the review conducted by the staff as indicated in this section including issuance of revised and new license conditions, NRC staff finds the licensee's program for ISR process and equipment meets the applicable acceptance criteria of SRP Section 3.1.3 and the requirements of 10 CFR 40.32(c) and10 CFR 40.41(c).

3.2 Processing Plant, Wellfields, and Chemical Storage Facilities

3.2.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that equipment and processes used in the processing plant and other facilities at the Ludeman 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

Unless specifically stated otherwise, the NRC staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) 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 description and operating characteristics of the major equipment that the licensee would use during processing at the satellite facility. These descriptions pertain to the satellite plant, the chemicals that the licensee would use on site, and the potential radiological and chemical hazards associated with the operations. The NRC staff's review and analysis, unless stated otherwise, is based on information presented in Section 3.1 and Section 3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

3.2.3.1 Description of Processing Plant

The licensee described the significant components to the satellite plant, including ion exchange tanks, resin loading equipment, resin transfer equipment, ground water restoration equipment, and an onsite laboratory in Section 3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that bulk hazardous chemicals will be stored in specialty tanks or containers with secondary containment outside of the satellite building. The licensee plans to store non-hazardous process chemicals with no potential to impact safety within the satellite building. The licensee also identified a storage yard and temporary storage area for 11e. (2) byproduct material outside of the satellite plant. 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 licensee described the uranium processing equipment that includes trunk lines into and out of the satellite plant, pressurized down flow ion exchange (IX) columns, resin transfer, chemical addition, and filtration. The ground water restoration equipment consists of a RO system that is primarily used to treat the restoration stream. As a satellite facility, the NRC staff observes that building will not contain elution, precipitation, or drying equipment.

The licensee described the planned approach for chemical storage in Section 3.2.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the materials stored in and around the satellite plant will consist of process-related chemicals (carbon dioxide, sodium carbonate/bicarbonate, oxygen, sodium sulfide, and hydrogen peroxide). The non-process chemicals include petroleum products and propane. The licensee stated that secondary containment of liquids will consist of concrete curbing (berms) within the satellite plant. The licensee stated that the curbing will be designed for at least 110 percent of the capacity of a tank if a tank failure poses a major health risk or potential recovery or product. The licensee stated that 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, but still desirable to contain spills. The NRC staff observes that the perimeter of the satellite building will also incorporate a containment curb that extends above the finished floor. The licensee also plans to incorporate a series of sumps and sloped floors to direct spill liquids within the satellite building. The licensee stated that liquids in the sump will be liquid 11e. (2) byproduct material disposal system.

The licensee showed the layout of the satellite plant in Figure 3-10 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff observes that the building is approximately 24.4 m (80 ft) in width and 57.9 m (190 ft) in length. The licensee stated that the satellite is designed to operate at a throughput of 34,069 liters per minute (9,000 gallons per minute). The process flow diagram for the production phase of operations was shown In Figure 3-7.

The staff reviewed the licensee's description of the satellite facility design and finds it sufficient to meet Acceptance Criterion (1) of SRP Section 3.2.3 because the licensee 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 licensee described the generation of fumes and gas sources in Section 7.5.1.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that sources of fumes at the satellite facility will be from the process-related chemicals present at the site. As discussed in the previous section, the NRC staff understands that the carbon dioxide, sodium carbonate/bicarbonate, oxygen, sodium sulfide, and hydrogen peroxide will be used on site. The licensee expected minimal fumes or gases emanating from the piping and tanks used in the satellite building. Section 3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) identified radon as the predominant radionuclide expected to be released from the ion exchange system. The NRC staff evaluates radiological effluents in SER Section 4.1.

The NRC staff observes that the Ludeman project is only an ion exchange satellite facility and no yellowcake dryer is planned. Therefore, no yellowcake dust will be generated at the facility.

The staff finds that the licensee's identification of the dust, fumes, or gas sources is acceptable in meeting Acceptance Criterion (2) of SRP Section 3.2.3 because the licensee identified potential sources of fumes and gases and provided a description of those sources in sufficient detail for staff to perform an independent evaluation.

3.2.3.3 Description of Ventilation System

Section 4.1.1 of Ludeman Project Revised Technical Report (Uranium One USA 2017d) provided the licensee's description of the ventilation system planned for the Ludeman satellite facility. The licensee stated it plans to install separate, independent ventilation systems at all process tanks and vessels where generation of radon is anticipated which were evaluated in SER Section 4.1. The licensee also discussed general ventilation within the satellite plant in Section 4.1.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that it plans to provide ventilation for work areas within the satellite plant through a combination of natural ventilation or forced-air ventilation. The ventilation system for the satellite plant is designed to move two air changes per hour.

The staff finds that the licensee's description of the ventilation, confinement, and dust collection meets Acceptance Criterion (3) of SRP Section 3.2.3 because the licensee described the size, location and capabilities of the ventilation system in sufficient detail for staff to perform an independent evaluation. The staff recognizes that as a satellite facility, no yellowcake will be generated at the Ludeman Project. The NRC staff's evaluation of radiological effluents generated at the satellite plant is further evaluated in SER Section 4.1.

3.2.3.4 Availability of Safety Equipment

The licensee presented the location of safety equipment within the satellite plant, such as sanitary showers and eye wash stations in Figure 3-10 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Additionally, the NRC staff observes that Section 7.5.1.2 discusses aspects of the licensee's industrial safety program related to chemical safety. Finally, the NRC staff observes that its past inspections of activities conducted under license SUA-1341 have not identified issues related to availability of safety equipment. The NRC staff's review of the inspection history of Willow Creek license SUA-1341 since the last license renewal (NRC 2013b) can be found in Appendix A. Because the NRC staff's inspections of Uranium One's safety program have not identified any new safety issues under license SUA-1341 and the Ludeman satellite facility will be operated under the same program and procedures, Acceptance Criterion (4) of SRP Section 3.2.3 has been satisfied.

3.2.3.5 Identifying Safe Operating Conditions

The licensee provided its plans related to chemical storage facilities in Section 3.2.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). This section includes a discussion of process related chemicals, including oxygen and carbon dioxide, chemical reductants, and non-process related chemicals. As previously discussed, the licensee identifies sources of fumes and gases at the Ludeman Project satellite facility in Section 7.5.1.2. The NRC staff observes that the licensee plans to provide proper ventilation to individual tanks and work areas within the satellite plant. Additionally, the licensee plans to construct ion exchange vessels, chemical storage tanks, and piping in the satellite plant to established standards. The NRC staff observes that Figures 3-7, 3-8, and 3-9 in the Ludeman Project Revised Technical Report (Uranium One USA 2017d) provide typical flow rates within the plant for the production only phase, concurrent production and restoration phase, and restoration only phase, respectively.

The licensee discussed liquid containment within the satellite plant in Section 3.2.3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it plans to install curbing within the satellite plant that will contain 110 percent of the largest tank. Additionally, the licensee plans to install sloped floors that drains to a series sealed sumps.

Finally, the licensee plans to install perimeter curbing extending above the finish floor around the perimeter wall of the satellite plant.

The NRC staff finds that by providing the information described above, the licensee has satisfied Acceptance Criterion (5) of SRP Section 3.2.3.

3.2.3.6 Applicable Regulations

The licensee identified the applicable regulations related to chemical storage in Section 3.2.3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The regulations the licensee identified include: International Building Code, National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Additionally, in Section 3.2.2.3, the licensee discussed preparation of a Spill Prevention, Control, and Counter (SPCC) measure plan, which is required by the Environmental Protection Agency (EPA). NRC staff finds that, by providing this information, the licensee has satisfied Acceptance Criterion (6) of SRP Section 3.2.3.

3.2.3.7 Description of Controls for Eliminating or Mitigating Hazards

The licensee described controls to minimize hazards in Sections 3, 3.2.1, 3.2.2, 3.2.3, 4.1.1, 5.7.1 7.5.1.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Some of the control measures described by the licensee included physical (fences, gates, valves, ventilation), monitoring (flow meters and alarms are two examples), and redundant measures such as secondary containment. The NRC staff recognizes that the use of pressurized downward flow IX columns described in Section 3.2.1 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 resin transfer process would be captured by ventilation systems and discharged outside of the satellite plant.

The NRC staff finds that by providing the information described above related to elimination or mitigation of hazards, the licensee has satisfied Acceptance Criterion (7) of SRP Section 3.2.3.

3.2.4 Evaluation Findings

The staff reviewed the proposed equipment to be used and materials to be processed in the satellite plant and associated chemical storage facilities at the Ludeman Project in accordance with the review procedures and the acceptance criteria in SRP Section 3.2.2 and Section 3.2.3, respectively. The licensee described the equipment, facilities, and procedures that would be used to protect health and minimize danger to life or property.

Based on the information provided by the licensee and the detailed review conducted of the equipment to be used and materials to be processed in the satellite plant, wellfields and chemical storage facilities for the Ludeman Project, as described above, the staff concludes that the proposed equipment to be used and materials to be processed in the satellite plant, wellfields, and chemical storage facilities are acceptable and are in compliance with 10 CFR 40.32(c), which requires that licensee 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 licensee 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 SRP Sections 4.0, “Effluent Control Systems and ” 5.0, “Operations;” are addressed In SER Sections 4.0 and 5.0.

3.3 Instrumentation and Control

3.3.1 Regulatory Requirements

The staff determines if the licensee 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

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in SRP Section 3.3.3 (NRC 2003).

3.3.3 Staff Review and Analysis

Information in this section, unless otherwise stated, is from Section 3.2.4 and Section 3.2.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The licensee stated it plans to measure production and injection flow on the main trunk lines in the facility control room. The circulation of lixiviant between the wellfield and IX columns will be in a continuous state, and the licensee will monitor deviations from the normal operating conditions that would be indicative of an upset condition. Within the satellite plant, operating parameters such as fluid levels, pressure, and flow will be monitored for process measurements. The licensee stated it plans to display this information continuously in the satellite plant control room. Within specific wellfields, the licensee plans to monitor and control flows in individual header houses.

In the event of instrumentation failure, the licensee indicated it would be able to conduct manual or visual measurements locally at the various pieces of equipment. 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. The licensee will determine maximum injection pressures (MIPs) for each wellfield header house as described in SER Section 3.1.3.6. In addition, sensors in the header house will detect the presence of liquids and will be set to automatically trigger an alarm to the satellite plant operator and wellfield operator. The licensee also plans to utilize a backup text messaging system to alert wellfield operators of an upset condition.

The staff reviewed the proposed instrumentation and finds that the licensee has described the monitoring and control plans for the Ludeman Project. The NRC staff observes that the licensee plans to utilize continuous monitoring in the satellite processing building and wellfields. Additionally, the NRC staff observes that the licensee plans to utilize backup systems in the event of a system failure. The staff concludes that the licensee has identified instrumentation; monitoring parameters and processes, including wellfield flows; and backup systems that are consistent with the staff‘s observation of practices at operating ISR facilities. The NRC staff finds that by providing this information, the licensee has met all of the Acceptance Criteria (1–3) in SRP Section 3.3.3. Thus, these aspects of the facility and approaches to overall control are

acceptable to the staff. The NRC staff's evaluation of Acceptance Criterion (4) of SRP Section 3.3.3 to monitor and keep wellfield operating pressures below MIP can be found in SER Section 3.1.3.6. Additionally, as the Ludeman satellite is only processing through the ion exchange step and no yellowcake production is planned to occur, Acceptance Criterion (5) of SRP Section 3.3.3 is not relevant to this review.

3.3.4 Evaluation Findings

The staff has completed its review of the instrumentation and control techniques proposed for use at the Ludeman 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 processing systems within the satellite. 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 would be part of the instrumentation systems.

Based on the information provided by the licensee and the staff's detailed review of the instrumentation and control for the Ludeman Project, the staff concludes that the proposed instrumentation is acceptable and is in compliance with 10 CFR 40.32(c) and 10 CFR 40.41(c).

4.0 Effluent Control Systems

In this section, the NRC staff evaluates the proposed ventilation, filtration, and confinement systems that the licensee proposes to use to control the release of radioactive materials to the atmosphere. The staff also evaluated analyses of equipment as designed and operated to prevent radiation exposures and to limit exposures and releases to as low as is reasonably achievable.

The NRC staff also evaluates the licensee's estimates of quantities and compositions of waste residues expected during construction and operation of the Ludeman Project and the procedures proposed for their management.

4.1 Gaseous and Airborne Particulates

This section describes the NRC staff's evaluation of the licensee's description of the design of effluent control systems for gaseous and airborne particulates at the Ludeman Project. The licensee provided information on gaseous and airborne particulates control systems at the Ludeman Project in Section 4.0, "Effluent Control Systems," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The purpose of the effluent control systems is to prevent and minimize the spread of gaseous and airborne particulate contamination to the atmosphere by the use of emission controls and to ensure compliance with radiation dose limits for the public.

4.1.1 Regulatory Requirements

For gaseous and airborne particulates generated at the Ludeman Project, the staff determines if the licensee has demonstrated compliance with Criterion 8 of Appendix A to 10 CFR Part 40, which requires that milling operations be conducted so that all airborne effluent releases are reduced to ALARA levels. Criterion 8 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." Although Criterion 8 focuses on effluent releases from a yellowcake dryer and tailings, it does not exclude radon releases from ISRs. The licensee must also demonstrate that releases of gaseous and airborne particulates comply with other relevant sections of 10 CFR Part 20 and 10 CFR Part 40.

4.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 20 and Part 40 using the acceptance criteria presented in SRP Section 4.1.3 (NRC 2003).

4.1.3 Staff Review and Analysis

The licensee described effluent controls for gases and particulate matter in Section 4.1, "Gaseous Emissions and Airborne Particulates," of its Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee described the following effluent controls:

1. A satellite facility design based on pressurized downflow ion exchange columns, which are designed to retain radon-222 gas in process solutions and reduce the release of radon-222 gas to occupied spaces in the satellite building and the environment.

2. Process vessel vents, which direct radon-222 gas that does escape from process solutions to the environment outside the satellite building.

3. Satellite building ventilation systems, which ensure fresh air is supplied to occupied spaces in the satellite building to reduce concentrations of radon-222 gas that escape the process.

The licensee explained that because the Ludeman Project does not involve yellowcake processing, it does not anticipate particulate matter effluent. The licensee explained that the design of the ventilation system will be adequate to ensure radon progeny concentrations remain below 25 percent of the derived air concentration (DAC) from 10 CFR 20, Appendix B, Table 1. The NRC staff determined this was acceptable because it meets design objectives described in Regulatory Position 3.3 of Regulatory Guide 8.31.

The NRC staff agrees that because the Ludeman Project will only process dissolved uranium in water and uranium attached to wet ion exchange resin and will not have uranium elution or drying circuits, the Ludeman Project will not produce a dried and finely-divided uranium yellowcake product that can become airborne. In addition, there are no other processes at the Ludeman Project likely to generate airborne radionuclides from radionuclides dissolved in ground water in sufficient quantities to warrant specific effluent controls aside from those proposed by the licensee. Therefore, the NRC staff agrees that radon-222 and its short-lived progeny are the principal radionuclides in air effluent from the Ludeman Project. The NRC staff also agrees that the use of pressurized downflow ion exchange columns that are not open to the atmosphere keeps radon-222 dissolved in process ground water and minimizes gaseous radon-222 releases to the atmosphere.

The NRC staff's review of recent experience at ISR satellites, including header houses and wellfields, indicates that the principal source of airborne radon-222 and radon progeny emissions is the process bleed. The process bleed is the approximately 1 percent of plant flow rate (e.g., a bleed of 90 gpm if the plant flow rate is 9,000 gpm) that is removed from the pressurized ion exchange system and treated and disposed of as liquid 11e. (2) byproduct material waste. As stated in SER Section 3.1.3.5, the process bleed maintains an inward gradient of ground water in the wellfields by recovering more ground water from the wellfields than is injected. The licensee's proposed use of vents on process vessels used to manage bleed, which direct gaseous radon-222 that escapes de-pressurized process solutions outside and away from occupied spaces in the satellite building, is a reasonable engineering control. A third layer of defense is provided by the licensee's proposed use of passive and active ventilation of occupied spaces in the satellite building to further reduce airborne concentrations of radon and radon progeny that could escape the satellite building ion exchange and liquid waste equipment.

The licensee described its procedures and methods for surveying occupied spaces for radon progeny to ensure occupational doses remain as low as is reasonably achievable (ALARA) in Section 5.7.3.2, "Radon Daughter Concentration Monitoring," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC's staff's evaluation of the licensee's radiation protection program is described in SER Section 5.7.

In Section 7.5.1.1, "Vessel or Tank Failure," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described the consequences of an accident involving tanks or piping in the Satellite facility. As described in an NRC risk assessment (NRC 2001), the

bounding unmitigated consequences for either a tank or pipe failure would be 1.3 rem TEDE to an employee standing near a failed tank for 30 minutes. This is less than the 5 rem annual occupational dose limit in 10 CFR Part 20. In Section 7.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated it would rely on accident response training and procedures to mitigate the consequences of an accident and no specific additional effluent control systems beyond the existing building ventilation system is needed to further mitigate the effects of accidents. The NRC staff finds this acceptable because the likelihood of catastrophic tank and piping failures is low and the maximum occupational dose in the unlikely event of an accident is below regulatory limits.

By letter dated June 13, 2017, the NRC verified the licensee's commitments to measure effluent quantities at the Willow Creek Project (NRC 2017b). The same procedures described for effluent monitoring at Christensen Ranch Satellite apply to the Ludeman Project Satellite and wellfields.

The NRC staff's evaluation of the licensee's estimated effluent quantities of radon-222 for reporting in semi-annual reports required by 10 CFR 40.65 is provided in Section 5.7.7 of this SER.

4.1.4 Evaluation Findings

The NRC staff has completed its review of the effluent control systems for gaseous and airborne particulates proposed for use at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 4.1.2, "Review Procedures," and the acceptance criteria outlined in SRP Section 4.1.3, "Acceptance Criteria."

The licensee has acceptably described the types of vents and estimated composition of effluents released to the atmosphere. The licensee has designated monitoring and control systems (e.g., confinement and ventilation) for the types of effluents generated. The licensee has demonstrated that ventilation systems are acceptable to prevent radon gas buildup where recovery solutions enter the plant and tanks are vented during the extraction process. By providing information on the health and safety impacts of system failures and identifying contingencies for such occurrences, the licensee has acceptably shown that effluent control systems will limit radiation exposures under both normal and accident conditions.

Based on the information provided in the Ludeman Project Revised Technical Report (Uranium One USA 2017d) and the detailed review conducted of the effluent control systems for gaseous and airborne particulates for the Ludeman Project, 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, which requires that an acceptable radiation protection program that achieves as low as is reasonably achievable goals is in place and that a constraint on air emissions, excluding radon and its progeny, will be established to limit doses from these emissions; 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, "Environmental Effects" are addressed in SER Section 5.7.7.

4.2 Liquids and Solids

This section describes the NRC staff's evaluation of the licensee's description of the design of effluent control systems for liquid and solid effluents at the Ludeman Project. The licensee provided information on liquid and solid effluent control systems at the Ludeman Project in the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The purpose of liquid and solid effluent control systems is to prevent and minimize the spread of liquid and solid contamination of the environment by the use of engineered controls and to ensure compliance with radiation dose limits for the public.

4.2.1 Regulatory Requirements

For liquid and solid effluents generated at the Ludeman Project, the NRC staff determines whether the licensee has demonstrated compliance with 10 CFR 20.1301; 10 CFR 20.2002, "Method for Obtaining Approval of Proposed Disposal Procedures" and 10 CFR 20.2007, "Compliance with Environmental and Health Protection Regulations"; 10 CFR Part 40, Appendix A, Criterion 2; and 10 CFR Part 40, Appendix A, Criterion 5A (1) through 5A (5), Criterion 5E, and Criterion 5F. In addition to the aforementioned regulations, the staff determines whether the licensee is following the guidance contained in RG 3.11, "Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities" (NRC 2008).

4.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) 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 the guidance contained in RG 3.11. Additionally, the staff reviewed the information for compliance with the requirements of 10 CFR Part 20 using Acceptance Criterion (13) of SRP Section 6.1.3 (NRC 2003).

4.2.3 Staff Review and Analysis

This section describes the NRC staff's evaluation of the licensee's description of the design of effluent control systems for liquid and solid effluents at the Ludeman Project. The licensee provided information on liquid and solid effluent control systems at the Ludeman Project in Section 4.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The purpose of liquid and solid effluent control systems is to prevent and minimize the spread of liquid and solid contamination of the environment by the use of engineered controls and to ensure compliance with radiation dose limits for the public.

4.2.3.1 Liquid 11e.(2) byproduct material

In Section 4.2.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee classified liquid 11e.(2) byproduct material in three types: (1) brine, (2) permeate, and (3) other liquid 11e.(2) byproduct material. The licensee reported the characteristics of the anticipated liquid 11e.(2) byproduct material in Table 4.1. Brine that is generated through the use of the primary and secondary RO units will be sent to the waste water collection system and eventually to an evaporation pond. Permeate will be recycled to either production or restoration wellfields, used as plant makeup water, or sent to a permeate pond. Other 11e.(2) liquid byproduct material includes spent eluate, resin transfer wash water, plant washdown water, and

fluids generated during spills in the wellfields. The licensee plans to collect any liquid 11e.(2) byproduct generated outside of the Ludeman satellite building and transport it to the waste water collection system using portable tanks or trucks.

The licensee identified its proposed action and two alternatives for the ultimate disposal of liquid 11e.(2) byproduct material in Section 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Under the proposed action, some of the liquid 11e.(2) byproduct material streams will be stored in an evaporation pond. Permeate from the restoration wellfield primary RO unit will be treated and discharged to a permeate pond. The liquids in the permeate pond may be discharged to the surface under a Wyoming Pollutant Discharge Elimination System (WYPDES) permit.

In the first alternative, the licensee stated it may add up to six DDWs to the evaporation and permeate ponds. The licensee described the planned DDWs in Section 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the target zone for the DDWs will be the Lance Formation through the Parkman Formation. The depths for these formations ranges from 1,371 to 3,048 m (4,500 to 10,000 ft bgs). The licensee showed the planned locations of the six DDWs in Figure 3-1, which are located within the Ludeman Project license boundary. In the second alternative, the licensee proposes DDWs and surge ponds. The NRC staff has only reviewed the proposed action and first alternative as the licensee provided no description of the second alternative. The NRC staff therefore cannot approve the use of DDWs and surge ponds only. The NRC staff will revise License Condition 10.7 of the Willow Creek Source Material license SUA-1341 as described in SER Section 4.2.4 and shown in SER Table 1.1-1 to include only the approved liquid waste disposal methods at the Ludeman Project.

The staff finds that the licensee'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 of via a combination of evaporation pond, permeate pond, surface water discharge, or DDWs, as described in Section 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff evaluated the waste disposal options for compliance with 10 CFR 20.2002 which requires that permanent waste disposal option demonstrate they are ALARA. The evaporation and permeate ponds do not require a 10 CFR 20.2002 evaluation as they will be decommissioned and all of the radioactive material in the pond sludge will be removed and disposed of at an off-site 11e.(2) byproduct material site, which is allowed under 20.2001(a)(1). However, the licensee has requested waste disposal in liquid effluents, which is allowed under 20.2001(a)(3), and DDWs, which requires NRC approval under 10 CFR 20.2002.

On-site disposal of 11e.(2) byproduct material waste by surface water discharge

In this section of the SER, the NRC staff evaluates information provided by the licensee regarding disposal of liquid effluents from the permeate pond. Under 10 CFR 20.2001(a)(3), a licensee may dispose of licensed material by release in effluents within the limits in 10 CFR 20.1301, "Dose limits for individual members of the public." The requirement in 10 CFR 20.1302(a), "Compliance with dose limits for individual members of the public," requires licensees to make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in 10 CFR 20.1301.

In addition to the requirements for waste disposal in 10 CFR Part 20, the NRC staff finds the surface water discharge for fluids in the permeate pond would require a WPDES permit from the State of Wyoming. These permits set strict limits on flow rate and the levels of constituents that may be released to the environment. The licensee reported the expected level of constituents in the RO permeate stream in Table 4-13 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) as shown in SER Table 4.2-1.

Constituent	Units	Typical Value	Min Value	Max Value
Conductivity	uS/cm	300	180	400
TDS	mg/L	200	100	250
pH	s.u.	8	6	6.5
Alkalinity as CaCO3	mg/L	100	50	200
Sulfate	mg/L	15	10	20
Bicarbonate	mg/L	150	50	200
Chloride	mg/L	15	5	25
Calcium	mg/L	0	0	1
Sodium	mg/L	50	20	100
Manganese	mg/L	0	0	0.1
Selenium	mg/L	0	0	0.1
Arsenic	mg/L	0	0	0.1
Uranium	mg/L	0	0	0.1
Radium	pCi/L	30	5	100

Table 4.2-1 Ludeman Project Expected RO Permeate Water Quality

In order to meet the requirements in 20.1302(b) for demonstrating compliance with the annual public dose limits in 10 CFR 20.1301, the licensee must either: (1) demonstrate by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit (as specified in 10 CFR 20.1302(b)(1)); or (2) demonstrate that annual average concentrations of radioactive material released in liquid effluents at the boundary of the unrestricted area do not exceed the values specified in table 2 of Appendix B to Part 20 (10 CFR 20.1302(b)(2)(i)); and if an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year (10 CFR 20.1302(b)(2)(ii)). The licensee did not perform dose assessments for liquid effluent from the permeate ponds that demonstrates compliance with either 10 CFR 20.1302(b)(1) or 10 CFR 20.1302(b)(2)(ii). Therefore, the NRC staff cannot find that the public dose limits would be met for this liquid effluent.

Though the licensee did not perform a dose assessment, the NRC staff did evaluate whether permeate pond average concentrations provided by the licensee would meet the 10 CFR 20.1302(b)(i) requirement that annual average concentrations of radioactive material in liquid effluents not exceed the values specified in table 2 of Appendix B to Part 20. The NRC staff used the permeate concentration values C_i provided by the licensee in SER Table 4.2-1 and the effluent concentrations in Table 2 of 10 CFR Part 20 Appendix B in the following equation to account for radionuclide mixtures:

$$\frac{C_a}{EC_a} + \frac{C_b}{EC_b} + \frac{C_c}{EC_c} < 1$$

As shown in the equation, the sum of the fractions must be less than 1. For the maximum radium and uranium values provided in Table 4.2-1, the combined value in the equation is greater than 1:

$$\frac{100\ pCi/l}{60 pCi/l} + \frac{68\ pCi/l}{300\ pCi/l} = 1.89 > 1$$

Therefore, the NRC staff finds that the permeate water quality may exceed the values in Table 2 of appendix B to 10 CFR Part 20. In addition, the licensee did not provide the location and features of the surface water body that will receive the liquid effluent. Without this information, the NRC staff cannot make a determination that the liquid effluent reaches any nearby surface water body and where public doses are likely to occur as a result of liquid effluent from the permeate pond.

The NRC staff therefore finds it does not have sufficient information to determine whether the public dose limits in 10 CFR 20.1301 would be met for liquid effluent from the permeate pond. The NRC staff will therefore add the following new License Condition 10.28 prohibiting liquid effluents from the permeate pond until the licensee provides this information for NRC review and approval:

> License Condition 10.28
>
> The licensee will not dispose of permeate pond water at the Ludeman Project as liquid effluent until it provides for NRC review and approval information to demonstrate that the dose limits for individual members of the public in 10 CFR 20.1301 are met.

On-site disposal of 11e. (2) byproduct material waste in deep disposal wells

In this section of the SER, the NRC staff evaluates information provided by the licensee in accordance with 10 CFR 20.2002 to authorize disposal of liquid 11e.(2) byproduct material in on-site deep disposal wells.

The staff finds 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 they are 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 finds that the liquid byproduct material is waste. The NRC staff observes that the DDWs will be permitted in accordance with WDEQ Water Quality Division (WQD) Class I UIC rules and regulations. The staff finds that approval of the deep disposal wells by WDEQ satisfies 10 CFR 20.2007, which requires that disposal by injection in deep wells must meet any other applicable Federal, State, and local government regulations pertaining to deep well injection. As of the writing of this SER, the licensee has not received approval for installation and use of the DDWs at the Ludeman Project.

The licensee provided the anticipated water chemistry of the liquid 11e.(2) waste stream to be sent to the evaporation pond or DDW as shown in Table 4.2-2 (Uranium One USA 2017g). This table includes both radiological and non-radiological parameters. The radiological parameters relevant to disposal under 10 CFR 20.2002 include uranium and radium. The licensee stated the maximum concentration of uranium is expected to be 15 mg/L (which the NRC staff estimated is about 10000 pCi/L of natural uranium), and the maximum concentration of radium-226 is 3000 pCi/L. The licensee estimated three different deep disposal well injection rates of 90 gallons per minute (gpm), 118 gpm, and 100 gpm, during three main phases of the Ludeman Project. Specifically, the licensee provided its proposed water balances in Figures 3-7, "Water Balance Production Phase Only," Figure 3-8, "Water Balance Concurrent Production and Groundwater Restoration Phases," and Figure 3-9, "Water Balance Restoration Phase Only." The NRC staff determined that this description meets 10 CFR 20.2002(a), which requires the licensee to provide a description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner and conditions of waste disposal.

Chemical Parameter	**Estimated Range of the Waste Stream Water Quality**	
	Minimum	Maximum
	(mg/L)	(mg/L)
pH (standard units)	6	9
Sodium	150	30,000
Calcium	200	1,000
Potassium	10	1,000
Bicarbonate as HCO_3	1,500	8,000
Carbonate as CO_3	0	500
Sulfate	80	20,000
Chloride	200	35,000
Uranium as U-nat	1	15
Radium (in pCi/L)	300	3,000
Total Dissolved Solids	2,500	50,000
Arsenic	<0.001*	0.2
Barium	<0.1*	2
Cadmium	<0.001*	0.002
Chromium	<0.01*	0.05

Table 4.2-2 Ludeman Project Expected Waste Water Quality

In Section 4.2.7, "Deep Disposal Well Permitting," of the Ludeman Project Technical Report (Uranium One USA 2017d), the licensee stated the target zones for disposal of liquid 11e.(2) byproduct material are the Lance Formation through the Parkman Formation at depths ranging from 4,500 to 10,000 ft. The licensee provided a description of the stratigraphic column in Figure 2.7B-1, "Generalized Stratigraphic Column," of the Ludeman Project Revised Technical

Report (Uranium One USA 2017d). The licensee also stated the Lance Formation is the primary target for disposal of the waste, and explained that water quality is likely to exceed Wyoming Class I, II, and III groundwater standards for parameters total dissolved solids, chloride, ammonia, trace metals, organic compounds, or oil and grease. The licensee stated the depth of the unit makes it unlikely to ever be a source of drinking water. The NRC staff determined that this description meets 10 CFR 20.2002(b), which requires the licensee to provide an analysis and evaluation of pertinent information on the nature of the environment.

In Section 4.2.7, "Deep Disposal Well Permitting," the licensee stated that the Lance Formation, the subsurface formation where waste would be disposed of, is an established oil and gas producing section in the PRB. In Section 3.1.6, "Mineral Resources," and Addendum 2.7-B, "Groundwater Tables and Figures," the licensee stated that there are three producing oil and gas well sites within the license area. In Section 7.1.1.3, "Mineral Rights," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated oil and gas are the only known minerals being recovered in the Proposed Project area. As shown in Figure 2.7B-12, "Wyoming Oil and Gas Conservation Commission Permitted Wells Within Three Miles," the nearest well is oil well number 34-74-24-1H, owned by Chesapeake Operating, Incorporated, which is located in the Frontier Formation. The NRC staff determined that this description meets 10 CFR 20.2002(c), which requires the licensee to provide the nature and location of other potentially affected licensed and unlicensed facilities.

The NRC staff evaluated potential exposure pathways for the licensee's proposed deep disposal wells. Deep disposal wells at ISR facilities are regulated as Class I non-hazardous injection wells and permitted in accordance with WDEQ Water Quality Division (WQD) Class I Underground Injection Control (UIC) rules and regulations. Class I wells are used to inject wastes into deep, isolated aquifers. Staff notes that for WDEQ to issue a UIC permit, no exposure pathway can exist to drinking water. The UIC review process requires an "area of review" (AoR) evaluation within ¼ mile of a proposed Class I non-hazardous injection well to demonstrate that the targeted injection zone(s) is below the lowest underground source of drinking water (USDW) and to identify and assess the presence of any artificial penetrations (e.g. oil and gas wells) in the targeted waste injection zone(s). If any artificial penetrations are identified in the AoR and found to be improperly plugged or completed, a corrective action plan is required to eliminate any exposure path. The AoR evaluation verifies that the injected fluids are isolated from the accessible environment, including potential sources of drinking water. In addition, deep disposal wells are required to be constructed with several layers of casing that provide redundant levels of protection to minimize the possibility of liquids contaminating USDW. Operators are also required to demonstrate that no significant leaks exist prior to operation through an MIT and every 5 years after for the life of the well. Operators must also monitor several parameters, such as injection pressure, that would indicate potential failure of a deep injection well. The NRC staff finds the WDEQ UIC permit review, well construction and operating requirements are sufficient to eliminate potential exposure pathways from the proposed deep disposal wells.

During both licensed operations and following license termination, the significant depth of waste emplacement and disposal precludes any significant dose to workers and the public. For example, the maximum total quantity of radium-226 emplaced, based on the maximum radium-226 concentration described above, the maximum flow rate of the deep disposal wells, and a 13-year project duration, would be about 8 Ci of radium-226. This quantity of radium-226 buried in soil and rock no less than 4,500 ft deep would result in a trivial direct exposure. Therefore, the worker and public total effective dose equivalent (a sum of external and internal doses) from emplaced waste would be essentially zero. Also, in accordance with 10 CFR 20.1003, a

licensee must maintain doses as low as is reasonably achievable (ALARA), which means "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."

Given that exposures to emplaced waste are effectively zero, the NRC staff determines that the licensee has made every reasonable effort to maintain exposures to radiation as far below the 10 CFR Part 20 dose limits as is practical. Therefore, the NRC staff determined that this description meets 10 CFR 20.2002(d), which requires an analyses and procedures to ensure that doses are maintained ALARA and within the 10 CFR Part 20 dose limits.

In conclusion, the NRC staff finds the licensee has provided sufficient information in accordance with 10 CFR 20.2002. Therefore, the licensee is authorized to dispose of liquid 11e.(2) byproduct material generated in the licensee's activities in on-site deep disposal wells.

4.2.3.2 Liquid Non-11 e.(2) Byproduct Material

The licensee stated that liquid non-11e.(2) byproduct material includes storm water runoff, domestic liquid wastes, as well as used petroleum products and chemicals in Section 4.2.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff recognizes that these other hazardous and non-hazardous wastes are not regulated by the NRC, but may be regulated by other Federal or State government agencies. The licensee stated it plans to control storm water runoff consistent with its WYPDES permit issued by the WDEQ. The licensee also plans to dispose of domestic liquid waste via a septic tank in accordance with a Class V UIC permit. As is the case with the Willow Creek facility, the licensee stated it anticipates that the Ludeman Project will be classified as a conditionally exempt small quantity generator for hazardous wastes.

The licensee discussed the closure activities for the Ludeman Project license area, including the evaporation pond and permeate pond in Sections 6.2, 6.3, and 6.4 of the Ludeman Project Revised Technical Report (Uranium One USA, 2017d). After completion of licensed activities, including uranium recovery operations, and ground water restoration, the licensee stated it plans to close and decommission the ponds. The licensee's closure activities would include removal and disposal of material in the evaporation pond and permeate pond, re-grading of the land surrounding the ponds, and revegetation. The licensee would conduct surveys to confirm that the area is suitable for release. The staff reviewed the licensee's plan for closure of these ponds. The NRC staff finds by providing this information on decommissioning of the evaporation and permeate ponds, the licensee has met Acceptance Criterion (1) of SRP Section 4.2.3.

The NRC staff finds that the licensee will properly control all fluids and discharges based on its review of the information in Sections 4.2.1, 4.2.2, and 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Additionally, the licensee has described its planned closure activities for the evaporation pond and permeate pond. 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 for evaporation or storage, deep well injection, and land application/irrigation.

The staff finds that the licensee has met Acceptance Criterion (1) of SRP Section 4.2.3 for liquid 11e.(2) byproduct material disposal at the Ludeman Project.

4.2.3.3 Surface Impoundments

The following section documents the NRC staff's evaluation of Uranium One's surface impoundments planned for the Ludeman Project. Unless otherwise noted, the NRC staff's review is based on information contained in Section 4.2.5.1 and Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The Acceptance Criteria (2), (3), and (4) in SRP Section 4.2.3 all relate to surface impoundments that are used to store or evaporate liquid 11e. (2) byproduct material (NRC 2003). These acceptance criteria direct the staff to determine that design and operation of surface impoundments protects the subsurface, is consistent with the guidance contained in NRC Regulatory Guide 3.11, Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities (NRC 2008) and consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 5(A).

The licensee stated it plans to construct one evaporation pond to contain brine and production permeate that is generated by the production wellfield RO system located within the facility. The location of this pond is shown in Figure 1 in Addendum 4-A, "Conceptual Pond Design", of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The evaporation pond will have four distinct cells and a series of leak detection sumps within each cell. The licensee plans to construct an additional pond to contain permeate generated during from RO treatment of fluids from wellfields in restoration. The location of this pond is also shown on Figure 1 in Addendum 4-A. The permeate pond will have four distinct cells and a series of leak detection sumps within each cell.

According to the licensee, the evaporation pond and permeate pond will have the physical characteristics shown in SER Table 4.2-3.

	Evaporation Pond	Permeate Pond
Overall Storage Volume	246,268 cubic m (322,107 cubic yards)	66,127 cubic m (86,492 cubic yards)
Liner System	Double liner with leak detection	Double liner with leak detection
Perimeter Leak Detection Sumps	Yes	Yes
Maximum Depth	1.83 m (6 ft)	3.05 m (10 ft)
Maximum Embankment Height	Approximately 12.19 m (40 ft)	Approximately 4.57 m (15 ft)

Table 4.2-3 Evaporation and Permeate Pond Design

The NRC 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.

Pond Site Characterization

The licensee completed a subsurface investigation to support construction of the evaporation pond and permeate pond. The details of this investigation can be found in Addendum 4-A of the

Ludeman Project Revised Technical Report (Uranium One USA 2017d). The investigation included a series of nine borings in the immediate vicinity of the evaporation pond and an additional five borings in the vicinity of the satellite facility. The borings were advanced to depths of approximately ranging from 4.6 meters (15 ft). According to the licensee, ground water was not encountered in any of the boreholes during drilling. The licensee 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 NRC staff finds that the soil properties were determined at various depths from borings in the vicinity of the evaporation pond and near the permeate 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 licensee determined soil properties near the evaporation pond and permeate pond using appropriate ASTM standards, the staff finds that the licensee has adequately characterized the subsurface conditions at the planned location of the evaporation pond and permeate pond. Therefore, the staff finds that the licensee's characterization is sufficient to support engineering assessments related to the performance of the evaporation pond, permeate pond, and related embankment.

Pond Slope Stability

The licensee performed a static slope stability analysis of the evaporation pond at the critical cross section as described in Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) . The licensee identified the critical cross section as being located in the southwest corner of the evaporation pond. At this location, the top of the evaporation pond embankment is approximately 12.19 m (40 ft) above the surrounding ground surface. The NRC staff observes that the maximum embankment height near the permeate pond is approximately 4.57 m (15 ft). Based on its review of the evaporation pond configuration, permeate pond configuration, and surrounding topography of each pond, the NRC staff agrees that the southwest portion of the evaporation pond represents the highest embankment height and the critical cross section. The staff reviewed the material properties and critical cross section geometry and finds them representative of area in the vicinity of the evaporation pond. The licensee performed the slope stability analysis using Rocscience software package, which is a widely available computer program. The licensee's factor of safety result of 1.6 exceeds the 1.5 minimum factor of safety values for static slope stability analysis used in standard practice.

The staff concludes that the licensee has demonstrated that the evaporation pond and permeate pond will be stable under the post construction condition. By demonstrating stability of the evaporation pond and permeate pond, the staff finds that the licensee has shown that this approach is consistent with Acceptance Criterion (4) of SRP Section 4.2.3. 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.

Pond Settlement

The licensee discussed settlement at the ponds in Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee's engineering drawings for the evaporation pond called for placement of approximately 9.14 m (30 ft) of fill above the

existing ground surface in the southwest corner of the evaporation pond. The licensee's engineering drawings called for approximately 3.048 m (10 ft) of fill for construction of the permeate ponds. The licensee estimated that 0.0254 meter (one inch) of settlement, at most, will occur after construction of the evaporation and permeate ponds. The licensee's estimate considered the subsurface profile and the engineering properties of the soils. The staff reviewed the licensee's approach for estimating embankment settlement and observed that the licensee considered the subsurface conditions and the planned embankment construction. For these reasons, the NRC staff finds the licensee's approach meets Acceptance Criterion (4) of SRP Section 4.2.3 (NRC 2003) and is consistent with the settlement analysis guidance in Section 2 of RG 3.11 (NRC 2008).

Pond Liquefaction Potential

The licensee briefly addressed the potential for liquefaction to occur in the vicinity of the evaporation and permeate ponds in Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee's subsurface investigation included a number of soil borings in the vicinity of the evaporation and permeate ponds. The licensee does not consider liquefaction to be a concern based on the past seismic history in Wyoming. The NRC staff reviewed subsurface investigation information and observes that the soils present at the site have some cohesion. Additionally, the NRC staff observes that no ground water was present near the surface and that the collected soil sampled had relatively low moisture content. The NRC staff is aware that the areas of Wyoming that may be susceptible to liquefaction are generally located in the northwestern portion of the State (Wyoming Office of Homeland Security 2014). Based on this information, the NRC staff determined that the soils present at the evaporation and permeate pond locations are not typically susceptible to liquefaction; therefore, no further analysis is warranted. Because the licensee's subsurface investigation indicated that liquefaction is not a concern, the staff finds this aspect of the storage pond design meets Acceptance Criterion (3) of SRP Section 4.2.3 (NRC 2003). Therefore, this approach is acceptable to the staff.

Pond Freeboard

The licensee evaluated the potential for overtopping of the evaporation and ponds determine the required freeboard in Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee's engineering design and drawings for the evaporation pond depict a configuration where a portion of the evaporation pond has a perimeter embankment and a portion is excavated from the surrounding topography. The licensee's design for the permeate pond showed a similar configuration.

The NRC staff reviewed the licensee's design and observes that the evaporation pond and permeate pond have been designed to prevent storm water run-on from entering the ponds. Therefore, the NRC staff recognizes that the only liquids entering the ponds would be: (a) liquid 11e. (2) byproduct material that is intended to be evaporated; (b) permeate generated from wellfields in restoration that may be discharged through a WYPDES permit; or (c) precipitation that falls directly into the pond. The licensee determined that the amount of rainfall that would occur during a 6 hour probably maximum precipitation event would be 0.56 m (1.83 ft). The licensee used guidance developed by the U.S. Army Corps of Engineers to estimate the amount of wave runup and anticipates wave runup of 0.46 to 0.58 m (1.5 to 1.89 ft). The NRC staff reviewed the rainfall event selected by the licensee as well as the proposed wave runup calculation method. The NRC staff observes that the licensee followed the guidance contained in Section 2.2 of NRC Regulatory Guide 3.11 (NRC 2008). The licensee 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 licensee has met SRP Acceptance Criterion (2) of SRP Section 4.2.3.

Pond Liner and Leak Detection

The licensee proposed constructing the liner system for the evaporation pond and permeate pond with a double geosynthetic liner. The licensee provided the engineering drawings which show the cross section for the evaporation pond liner in Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also stated that the design information for the permeate pond is the same as for the evaporation pond. Therefore, the licensee's proposed liner system for the evaporation pond and permeate pond will consist of the following components from top to bottom:

- a 0.15-cm (0.06-inch) thick (minimum) high density polyethylene primary geosynthetic liner
- a 0.51-cm (0.2-inch) thick geonet to serve as a drainage layer to transmit any leakage to the perimeter monitoring sumps
- a 0.076-cm (0.03-inch) thick (minimum) PVC secondary liner
- geotextile fabric
- native soil

The staff observed that, in the licensee's design, the geonet drainage layer will function as a leak detection layer. The geonet is a highly permeable layer located between the two low permeability geosynthetic liners. Additionally, the grading plan for both the evaporation pond and permeate pond shows that the bottom of the ponds are sloped toward a series of perimeter 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 Acceptance Criterion (2) of SRP Section 4.2.3. Additionally, the licensee identified the anticipated chemical composition of the liquid byproduct material on Table 4.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). By providing this information, the staff finds that the licensee has satisfied Acceptance Criterion (4) of SRP Section 4.2.3.

The licensee described its proposed operational inspection plan for the evaporation pond and permeate pond in Section 4.2.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The inspection plan includes daily, weekly, quarterly, and annual inspections. An overview of the inspection program is as follows:

- Daily inspections will include visual inspections of the piping, berms, diversion ditches, freeboard, and leak detection systems.
- Weekly inspections will checks of pond depth and embankments for signs of slumping. Weekly inspections will also include checks of perimeter fencing, restricted area signs, and piping.

- Quarterly inspections will include sampling of the liquids contained in the evaporation pond and permeate pond. The NRC staff's review of the licensee's ground water monitoring is discussed in Section 5.7.8.

- 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 licensee has committed so submitting a copy of the annual inspection to the NRC for review.

The staff reviewed the licensee'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 finds that the licensee's inspection plan is consistent with Acceptance Criterion (2) of SRP Section 4.2.3. The NRC staff also concludes that License Condition 11.4 of the Willow Creek Source Materials license (SUA-1341) addresses inspections of the ponds at the Willow Creek Project. The NRC staff discusses this more in the evaluation findings below.

The licensee committed to reporting pond leaks to the NRC project manager by phone or email within 48 hours Sections 4.2.6 and 5.2.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also committed to submitting a follow up report within 30 days of the initial notification in Section 5.2.5. The NRC staff observes that the 30 day follow up report will include discussion of corrective actions taken. The staff finds that the licensee has developed an adequate inspection and corrective action procedure to prevent migration of waste from the evaporation pond and the permeate pond to the subsurface, which is consistent with the SRP Acceptance Criterion (2) of SRP Section 4.2.3. As described in SER Section 4.2.4 and shown in SER Table 1.1-1, the NRC staff will revise License Condition 11.4 in the Willow Creek Source Material License SUA-1341 to include the reporting of leaks from the evaporation or permeate ponds at the Ludeman Project.

Evaporation Pond and Permeate Pond Monitoring Program

The NRC staff reviewed the evaporation and permeate pond monitoring program to determine if it meets the requirements for a ground water detection monitoring program in 10 CFR Part 40, Appendix A Criterion 7A because the evaporation pond and permeate pond will be used to retain 11e.(2) byproduct material.

The licensee stated it was not able to identify a source of near surface ground water in the vicinity of the evaporation pond and permeate pond. This finding was based on an evaluation of soil borings of less than 25 ft in depth from a subsurface investigation conducted and described by Tetra Tech in the "Geotechnical Engineering Study" report in Attachment 3 of Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it was not able to identify a source of near surface ground water in the vicinity of the evaporation pond and permeate pond; therefore, the licensee did not provide a plan to install ground water monitoring wells in the vicinity of the evaporation pond and permeate ponds.

The NRC staff does not find the licensee has sufficiently demonstrated that the lack of ground water in borings is sufficient justification to not provide ground water monitoring around the evaporation and permeate ponds. The NRC staff evaluation of the ground water hydrology indicates that the first aquifer is located in the 110 sand under the proposed evaporation and permeate ponds. The licensee reported that SW-11, a stock monitoring well, is located in

Wellfield 1 directly west of the proposed evaporation pond. According to Table 2.7B-17 of Addendum 2.7-B of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), this well has a water level of 14.5 ft bgs. As reported in SER Table 2.4-10, the WSEO permit for this well indicates a completion interval of 40-78 ft bgs which is in the 110 sand.

The NRC staff therefore finds that the 110 sand is a surficial aquifer which may be impacted by leaks from either the proposed evaporation or permeate ponds. In addition, the licensee reported that the 110 sand aquifer acts as the source of ground water to the Negley Subdivision private wells north of the evaporation pond. The licensee reported these wells may be at risk for contamination migration from an injection well leak into this aquifer in Wellfield 1 as presented in SER Section 3.1.3.8. The licensee has committed to install a guard well monitoring network in the 110 sand aquifer in Wellfield 1 to prevent any contamination migration from leaks and spills toward the Negley Subdivision wells as described in SER Section 3.1.3.8. The NRC staff, therefore, concludes there is a significant safety concern, similar to the case of leaks from an injection well in nearby Wellfield 1, that leaks from the evaporation and permeate ponds may also seep into the 110 sand aquifer and lead to contaminant migration toward the Negley Subdivision wells.

In conclusion, the NRC staff finds a safety concern exists with respect to leaks to the surficial 110 sand aquifer from the evaporation and permeate ponds. The NRC staff will therefore require ground water monitoring of this surficial aquifer near these ponds as required under 10 CFR Part 40 Appendix A Criteria 7A and 5B(1). The recommended ground water monitoring for impoundments is addressed in Regulatory Guide 4.14 (NRC 1980a). The guidance states samples of ground water should be collected from at least three wells located hydrologically down gradient from impoundments and from one background well located hydrologically up gradient. The guidance states the samples should be collected monthly through the first year of operation and quarterly thereafter. The NRC staff will therefore issue a new License Condition 10.24 to require the licensee to install three ground water monitoring wells upgradient and one monitoring well downgradient of both the evaporation pond and the permeate pond in the 110 sand aquifer. These wells will be required to be monitored in the same manner as required for the excursion monitoring wells in License Conditions 10.4 and 11.2 of the Willow Creek Source Material License (SUA-1341) with the exception that licensee will test the wells quarterly and the licensee will not be required to implement correction actions, but instead will inform the NRC of the actions it will take to determine if the excursion is associated with leaks from the evaporation pond. This license condition will state:

> License Condition 10.24
>
> <u>The licensee will install three downgradient and one upgradient ground water monitoring wells in the 110 sand aquifer at both the evaporation and permeate ponds shown in Figure 1 of Addendum 4-A of the Ludeman Project Revised Technical Report. The monitoring wells will be completed at a depth sufficient to obtain ground water adequate to monitor and to meet the requirements in License Conditions 10.4 and 11.2 with the exception that the licensee will monitor the wells quarterly. If an excursion is verified the licensee will not be required to implement immediate corrective actions, but will inform the NRC in 60 days of the actions it will take to determine if the excursion is associated with leaks from the evaporation and permeate ponds.</u>

Construction Considerations

The licensee provided a set of engineering drawings that provide details related to construction of the evaporation pond and permeate pond in Addendum 4-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The staff reviewed the drawings, which provide information on the location of the evaporation pond and permeate pond, liner system, details associated with the leak detection system, as well as the related pond infrastructure. With respect to engineering quality control for construction of the storage pond, the licensee committed to preparation of detailed specifications for material placement techniques as well as testing methods and frequencies. The licensee committed to developing a quality control program consistent with the guidance in NRC RG 3.11 (NRC 2008) 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.

The licensee provided a description of potential accidents that could occur at the evaporation pond in Section 7.5.1.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff observes that the same accidents could also occur at the permeate pond. The licensee identified overtopping of the pond and liner failure as potential accidents. As discussed earlier in this section of the SER, the licensee has designed the evaporation pond and permeate pond to prevent overtopping. Additionally, the ponds have been designed to include a leak detection system. The NRC staff observes that the leak detection system will allow pond leaks to be quickly identified. The licensee discusses reporting procedures in the event of a spill or release in Sections 4.2.6 and 5.2.5. This 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. As discussed above, these procedures are acceptable to the staff. The staff finds that, consistent with Acceptance Criterion (5) of SRP Section 4.2.3, the licensee has provided plans and procedures for addressing contingencies for all reasonably expected system failures.

4.2.3.4 Solid 11e. (2) Byproduct material

The licensee described its procedures for storage, packaging, and transport of solid 11e. (2) Byproduct material in Section 4.2.3, "Solid 11e. (2) byproduct Material," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). For example, the storage facility will be a restricted area with controlled access and posting. The licensee committed to have signed contracts for disposal of solid 11e. (2) byproduct material before beginning operations at the Ludeman Project. The licensee also committed to notify NRC in writing within 7 days if the agreement with the disposal facility is terminated or expires, in accordance with License Condition 9.7 of Willow Creek Source Materials License SUA-1341. The NRC staff will revise License Condition 9.7 to include the Ludeman Project as described in SER Section 4.2.4 and shown in SER Table 1.1-1.

The NRC staff finds these procedures acceptable because they meet Acceptance Criteria (6) in SRP Section 4.2.3 that solid 11e.(2) byproduct material is managed to control occupational doses; and that sufficient evidence is provided for disposal capacity at an existing solid 11e.(2) byproduct material disposal facility; and the licensee is required by License Condition 9.7 of Willow Creek Source Material License SUA-1341 to notify NRC in writing within 7 days if the disposal agreement expires or is terminated.

4.2.3.5 Discharge Permits

The licensee indicated that it will obtain permits for deep well injection, if that method is chosen method for liquid 11e. (2) byproduct material disposal in Section 4.2.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). 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 licensee stated that domestic waste from the restrooms, locker rooms, and lunchrooms will be disposed in a septic tank in Section 4.2.4.2. The staff observes that the licensee has identified the necessary WDEQ permits for on-site storage of hazardous waste, which is not considered 11e. (2) byproduct material. If surface water discharge from the permeate pond is to be used, permits will be obtained in accordance with the Wyoming Pollutant Discharge Elimination System issued by WDEQ/WQD. Acceptance Criterion (7) of SRP Section 4.2.3 states that water quality certification and discharge permits have been obtained or plans are in place to obtain them. The staff finds that the licensee has obtained or will obtain the proper water quality certification and discharge permits consistent with Acceptance Criterion (7) of SRP Section 4.2.3.

As discussed above, the NRC staff's review of the licensee's evaporation pond and permeate pond indicates that the design and operation will be in accordance with the guidance in NUREG 1569 (NRC 2003) and Regulatory Guide 3.11 (NRC 2008). The NRC staff also finds the licensee has proposed acceptable methods for effluent disposal including the evaporation pond, permeate pond, surface water discharge and DDWs which are consistent with Acceptance Criterion (8) of SRP Section 4.2.3.

In addition, the licensee is consistent with Acceptance Criterion (9) of SRP Section 4.2.3 in that it states that alternatives to liquid management activities have been considered and none were found to be superior to the selected options.

4.2.4 Evaluation Findings

The staff reviewed aspects of the solid and liquid effluents to be generated at the Ludeman Project in accordance with the procedures in SRP Section 4.2.2 and acceptance criteria in SRP Section 4.2.3.

The licensee described the solid and liquid effluents that would be generated. The licensee described the methods used to dispose of liquid effluents—evaporation pond, permeate pond, surface water discharge, and deep well injection. As described in SER Section 3.1, an acceptable disposal method is identified for liquid byproduct material, and the disposal method would be of sufficient capacity to handle liquids from production and restoration efforts. The licensee also continues to maintain a disposal agreement for solid byproduct material.

The NRC staff concludes that the effluent control systems for liquids and solids generated by the facility meet the applicable acceptance criteria of SRP Section 4.2.3 and 10 CFR Part 20 and Part 40 requirements with three exceptions. In the first case, the NRC staff identified a safety issue as described in Section 4.2.3.1 which will require the installation and upgradient and downgradient ground water monitoring wells for both the evaporation and permeate ponds in the 110 sand surficial aquifer. The NRC staff will therefore issue a new License Condition 10.24 to Willow Creek Source Material License SUA-1341 to state:

License Condition 10.24

The licensee will install three downgradient and one upgradient ground water monitoring wells in the 110 sand aquifer at both the evaporation and permeate ponds shown in Figure 1 of Addendum 4-A of the Ludeman Project Revised Technical Report. The monitoring wells will be completed at a depth sufficient to obtain ground water adequate to monitor and to meet the requirements in License Conditions 10.4 and 11.2 with the exception that the licensee will monitor the wells quarterly. If an excursion is verified the licensee will not be required to implement immediate corrective actions, but will inform the NRC in 60 days of the actions it will take to determine if the excursion is associated with leaks from the evaporation pond.

In the second case, the NRC staff was only able to review the proposed option and first alternative for 11 e.(2) liquid waste disposal as the licensee provided no design specifications for the second alternative of DDWs and surge ponds. Therefore, NRC staff will revise License Condition 10.7 of the Willow Creek Source Material license SUA-1341 as described in SER Table 1.1-1 to include only the approved liquid waste disposal methods at the Ludeman Project by appending the following statement:

License Condition 10.7 addition:

For the Ludeman Project, all liquid effluents from process buildings or other process waste circuits, with the exception of sanitary wastes, may be disposed of in the evaporation pond or deep disposal wells. Permeate from reverse osmosis of fluids from wellfields in restoration may be disposed of in the permeate pond.

In the last case, the NRC Staff could not determine if the surface water discharge of permeate in the permeate pond meets the unrestricted release requirements in Table 2 of 10 CFR Part 20 Appendix B for uranium, radium 226 and radium-228 because the licensee has not provided the average permeate water quality. Therefore, the NRC staff finds that the permeate water quality may exceed the values in Table 2 of Appendix B to 10 CFR Part 20. In addition, the licensee did not provide the location and features of the surface water body that will receive the liquid effluent. Without this information, the NRC staff cannot make determinations about the liquid effluent reaching any nearby surface water body and public doses likely to occur as a result of liquid effluent from the permeate pond. The NRC staff therefore cannot determine whether the public dose limits in 10 CFR 20.1301 would be met for liquid effluent from the permeate pond. The NRC staff therefore also cannot find that the release of these fluids would meet the 20 CFR 20.2002 requirements to be ALARA.

The NRC staff will therefore add the following new License Condition 10.28 prohibiting surface water discharge from the permeate pond until the licensee provides this information for NRC review and approval:

License Condition 10.28

The licensee will not dispose of permeate pond water at the Ludeman Project in liquid effluent until it provides for NRC review and approval information to demonstrate that the dose limits for individual members of the public in 10 CFR 20.1301 are met.

The NRC staff finds the licensee adequately described reporting of leaks from the evaporation and permeate pond and no new safety issues were identified. The NRC staff will revise License

Condition 11.4 in the Willow Creek Source Material License SUA-1341 to include the reporting of leaks from the evaporation or permeate ponds at the Ludeman Project as shown in SER Table 1.1-1.

The NRC staff finds the licensee committed to have signed contracts for disposal of solid 11e. (2) byproduct material before beginning operations at the Ludeman Project. The licensee also committed to notify NRC in writing within 7 days if the agreement with the disposal facility is terminated or expires, in accordance with License Condition 9.7 of Willow Creek Source Materials License SUA-1341. The NRC staff will revise License Condition 9.7 to include the Ludeman Project as shown in SER Table 1.1-1.

5.0 Operations

In this section, the NRC staff evaluates the licensee's description of its corporate organization, administrative procedures, and various safety programs as presented in its Ludeman Project Revised Technical Report (Uranium One USA 2017d). Several elements of the proposed operations remain essentially unchanged from the Willow Creek license renewal application (Uranium One USA 2008), which the NRC staff previously evaluated in the Willow Creek License Renewal SER (NRC 2013b). Where the NRC staff observed the program descriptions appear essentially unchanged from previously reviewed and evaluated licensee programs, the NRC staff evaluated the performance of the program, and its applicability to the proposed amendment, as part of determining that the NRC staff had the requisite adequate assurance that the program would meet applicable requirements at the Ludeman Project.

5.1 Corporate Organization and Administrative Procedure

In this section, the NRC staff evaluates the licensee's proposed organization and administrative procedures.

5.1.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that its corporate organization and administrative procedures for the Willow Creek Project are consistent with the requirements of 10 CFR 40.32(b), which requires that the licensee is qualified through training and experience to use source materials.

5.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed by the NRC staff for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in SRP Section 5.1.3 (NRC 2003).

5.1.3 Staff Review and Analysis

The NRC staff's evaluation is based on the licensee's description in Section 5.1, "Corporate Organization and Administrative Procedures," of its Ludeman Project Revised Technical Report (Uranium One USA 2017d).

The NRC staff evaluated the licensee's proposed corporate organization and position descriptions by reviewing whether clear responsibilities are assigned for the following programs: (1) radiation safety; (2) environmental protection; (3) ground water protection; (4) quality assurance; and (5) maintenance. For example, the licensee stated the Radiation Safety Officer (RSO) has direct responsibility for the development, review, implementation and adherence to the Radiation Safety Programs and associated Quality Assurance Programs for the Willow Creek and the proposed Ludeman Project operations. With regard to ground water protection, the licensee stated the Manager of Satellite Safety, Health, and Environment (SHE) has oversight for the development, review, approval, implementation, and adherence to environmental and ground water monitoring programs and associated quality assurance programs. The licensee also clearly defined management responsibilities for quality assurance and maintenance.

The NRC staff compared the authorities and responsibilities of the RSO described by the licensee to the authorities and responsibilities outlined in Regulatory Position C.2.1 of Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Is Reasonably Achievable” (NRC 2002a). For example, the licensee stated the RSO will have both the responsibility and authority to suspend, postpone or modify any work activity that is unsafe or potentially a violation of USNRC's regulations or license conditions, including the ALARA program. The NRC staff examined the proposed organizational structure and determined that the safety functions of the RSO and Manager Satellite Safety, Health and Environment are sufficiently independent of the operations department, and reports to a sufficiently high level of the licensee’s management. The NRC staff determined that the licensee has provided adequate descriptions of the corporate organization in accordance with Acceptance Criteria 5.1.3(1) and 5.1.3(5) of the SRP (NRC 2003), including the assignment of responsibilities and authority to a radiation safety officer as outlined in Regulatory Guide 8.31 (NRC 2002a).

The Safety and Environmental Review Panel (SERP) are the same as already described in the Willow Creek License Renewal Application (Uranium One USA 2008), which has been reviewed and approved by the NRC staff (NRC 2013b). On this basis, the NRC staff determined that Acceptance Criterion (3) of SRP Section 5.1.3 (NRC 2003) regarding establishment of a SERP has been satisfied.

5.1.4 Evaluation Findings

NRC has completed its review of the corporate organization and administrative procedures proposed for use at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.1.2 and the acceptance criteria outlined in SRP Section 5.1.3 (NRC 2003).

The licensee has an acceptable corporate organization that defines management responsibilities and authority at each level. The licensee’s definition of the responsibilities and procedures with respect to development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and ground-water monitoring programs, quality assurance programs, routine/non-routine maintenance activities, and changes to any of these is acceptable. The licensee has a previously-approved Safety and Environmental Review Panel with at least three individuals representing expertise in management/financial, operations/construction, and radiation safety matters. The licensee has demonstrated that specific technical issues will be dealt with by the Safety and Environmental Review Panel, with support from other qualified staff members, or consultants, as appropriate.

Based on the information provided by the licensee and the detailed review conducted of the corporate organization and administrative procedures for the Ludeman Project, the staff concludes that the proposed corporate organization and administrative procedures are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements. In addition, the requirements of 10 CFR 40.32(b), (c), and (d) are also met as they relate to the proposed corporate organization and Safety and Environmental Review Panel functions.

5.2 Management Control Program

In this section, the NRC staff evaluates the licensee’s proposed management control program and administrative procedures to ensure that activities affecting health, safety, and the

environment will be conducted in accordance with written standard operating procedures, including records keeping and reporting.

5.2.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that the management control program for the Ludeman Project is consistent with the requirements of 10 CFR Part 20, Subpart L, Subpart M and with 10 CFR 40.61. The staff also determines whether or not the licensee has demonstrated compliance with the health and safety requirement of 10 CFR 40.32(c).

5.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in SRP Section 5.2.3 (NRC 2003).

5.2.3 Staff Review and Analysis

In Section 5.2, "Management Control Program," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated that, in many cases, the same standard operating procedures (SOPs) will be applied to operations at the proposed Ludeman Project as are currently in use at the Willow Creek Project. Similarly, the licensee will use the same process for Radiation Work Permits and the Safety and Environmental Review Panel. The same standard exemption from radioactive materials posting requirements in 10 CFR 20.1902(e) would apply to the Ludeman Project. Also, the current License Condition 9.9 which requires to licensee to administer a cultural resources inventory before engaging in any development activity not previously assessed by NRC is sufficiently broad in scope to include licensed activities in the proposed Ludeman Project area. The NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of the Willow Creek Project and there have been no persistent safety issues related to the licensee's management control program (see SER Appendix A). Furthermore, the management control program is sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The NRC staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and the NRC staff's prior conclusions remain valid.

The NRC evaluated the licensee's description of record keeping and retention against the acceptance criteria in Section 5.2.3 of NUREG-1569, items (8) through (11) (NRC 2003). In Section 5.2.3, "Record Keeping and Retention," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to all of the applicable record keeping requirements. Similarly, in Section 5.2.5, "Reporting," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee identified applicable reporting requirements in 10 CFR Parts 20 and 40, and committed to an annual report based on guidance contained the NUREG-1569 standard review plan.

5.2.4 Evaluation Findings

The NRC staff has completed its review of the management control program proposed for use at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.2.2 and the acceptance criteria outlined in SRP Section 5.2.3 (NRC 2003).

The licensee has an acceptable management control program that assures that all safety-related operating activities can be conducted according to written operating procedures. The licensee has provided acceptable operating procedures or a process that will be used to develop standard operating procedures. The licensee has acceptably identified radiation protection, maintenance activities (especially in radiation areas), development of well fields, and Safety and Environmental Review Panel reviews as areas where standard operating procedures are acceptable and correctly applied. The licensee has demonstrated that non-routine work or maintenance activity will comply with radiation safety requirements and that radiation work permits will be issued for activities where standard operating procedures do not apply.

The licensee will administer a cultural resources protection program in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their implementing regulations. The licensee will cease any work resulting in the discovery of previously unknown cultural artifacts until such artifacts are inventoried and evaluated and authorization has been obtained from the NRC to proceed.

The licensee has acceptable record keeping and retention and reporting programs that will be adequate to ensure that the licensee 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 to license termination. The record keeping and retention plans will assist in ensuring that both on-site and off-site exposures are kept within regulatory limits and in documenting compliance with NRC regulations. The licensee has 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 licensee will maintain records for decommissioning, on-site and off-site disposal, personnel exposure, and off-site releases of radioactivity, as permanent records for the facility that will be transferred to any new owner or licensee, and ultimately to NRC, before license termination. Reports will be made to the NRC as required by regulations.

Based on the information provided by the licensee and the detailed review conducted of the management control program for the Ludeman Project, the staff concludes that the proposed management control program is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criteria 8 and 8A, which specify documentation requirements for airborne effluents and waste retention systems; 10 CFR 20.1101, which defines radiation protection program requirements; the National Historic Preservation Act and the Archeological Resources Protection Act, which define requirements for the protection of cultural resources; 10 CFR Part 20, Subpart L and Subpart M, which define requirements for record keeping and reporting; and 10 CFR 40.61(d) and (e), which also define requirements for record keeping.

5.3 Management Audit and Inspection Program

In this section, the NRC staff reviews the licensee's proposed management audit, inspection, and as low as is reasonably achievable program, including the frequencies, types, and scopes of reviews and inspections; action levels; corrective action measures; and the responsibilities of each participant.

5.3.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that it meets the requirements of 10 CFR 40.32 (b) and (c) for the Ludeman Project as it relates to the acceptability of management audits to ensure protection of health and minimize danger to life and property.

5.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in SRP Section 5.3.3 (NRC 2003).

5.3.3 Staff Review and Analysis

The licensee stated in Section 5.3, "Management Audit and Inspection Program," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that its program would be the same as that described in Section 5.3 of the License Renewal Application (Uranium One USA 2008) for the Willow Creek Project, except that it also included a description of its surge pond inspections. With the exception of the surge pond inspections, the NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent safety issues related to the licensee's management audit and inspection program (See SER Appendix A). Furthermore, the management audit and inspection program is sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff's prior conclusions remain valid.

In Section 5.4.3.3, "Personnel Designated by the Radiation Safety Officer," of its 2013 SER for the Willow Creek License Renewal Application (NRC 2013b), the NRC staff identified deficiencies in the licensee's program to qualify and train designees to perform daily visual inspections and weekly inspections in the temporary absence of the Radiation Safety Officer (RSO) and Health Physics Technician (HPT). As a result of this deficiency, the NRC staff imposed License Condition 9.12, which requires the licensee to obtain written verification from the NRC staff on its program to qualify and train designees. By letters dated August 8, 2014 and January 11, 2018, the licensee submitted a description of the qualifications, experience, and training of designees other than an RSO or HPT who perform daily visual inspections (Uranium One USA 2014a, 2018). The NRC staff evaluated the licensee's description by comparing it to other similar programs approved by NRC. The NRC staff, after comparing the licensee's description of designee qualification, training, testing, evaluation, and scope of job functions, found that the program is similar and, therefore, acceptable. Therefore, the August 8, 2014, and January 11, 2018, letters are added to License Condition 9.3 as shown in SER Section 1.4 and Table 1.1-1 (tie-down condition).

With regard to the surge pond inspections, the licensee stated its program would be consistent with Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities" (NRC 2008).

5.3.4 Evaluation Findings

NRC has completed its review of the management audit and inspection program proposed for use at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.3.2 and the acceptance criteria outlined in SRP Section 5.3.3.

The licensee 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 actions.

Based on the information provided by the licensee and the detailed review conducted of the management audit and inspection program for the Ludeman 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 as low as is reasonably achievable. 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.

5.4 Qualifications for Personnel Conducting the Radiation Safety Program

In this section, the NRC staff evaluates the licensee's proposed minimum qualifications and experience levels required for personnel who will be assigned the responsibility for developing, conducting, and administering the radiation safety program.

5.4.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the personnel conducting the radiation safety program at the Ludeman Project meet the requirements of 10 CFR 20.1101 and 10 CFR 40.32(b).

5.4.2 Regulatory Acceptance Criteria

The NRC staff evaluated the licensee's Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Parts 20 and 40, using the acceptance criteria outlined in the SRP Section 5.4.3 (NRC 2003). Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Are As Low As Is Reasonably Achievable," provides recommendations for technical qualifications of radiation safety staff (NRC 2002a).

5.4.3 Staff Review and Analysis

The licensee stated in Section 5.4, "Radiation Safety Staff Qualifications," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that its program would be the same as that described in Section 5.4 of the License Renewal Application for the Willow Creek Project (Uranium One USA 2008). The NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent safety issues related to the licensee's qualifications for personnel conducting the radiation safety program (see SER Appendix A). Furthermore, the licensee's qualifications for personnel conducting the radiation safety program are sufficiently broad in scope to encompass a second Satellite facility and

additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff's prior conclusions remain valid.

5.4.4 Evaluation Findings

NRC has completed its review of the qualifications of facility personnel conducting the radiation safety program at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.4.2 and the acceptance criteria outlined in SRP Section 5.4.3.

Based on the information provided by the licensee and the detailed review conducted of the qualifications of the personnel conducting the radiation safety program for the Ludeman Project, the staff concludes that the qualifications of the personnel are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), which provides requirements for licensee qualifications. The qualifications of personnel conducting the radiation safety program are acceptable consistent with NRC Regulatory Guide 8.31 (NRC 2002a).

5.5 Radiation Safety Training

In this section, the NRC staff evaluations the licensee's proposed radiation safety training program, including the content of the initial training or indoctrination, testing, on-the-job training, and the extent and frequency of retraining.

5.5.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that its radiation safety training program for the Ludeman Project meets the requirements of 10 CFR 20.1101 and 40.32(b).

5.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Parts 20 and 40, using the acceptance criteria outlined in SRP Section 5.5.3 (NRC 2003).

5.5.3 Staff Review and Analysis

The licensee stated in Section 5.5, "Radiation Safety Training," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that its program would be the same as that described in Section 5.5 of the License Renewal Application for the Willow Creek Project (Uranium One USA 2008). The NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent safety issues related to the licensee's radiation safety training program (see SER Appendix A). Furthermore, the licensee's radiation safety training program is sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff's prior conclusions remain valid.

5.5.4 Evaluation Findings

NRC has completed its review of the radiation safety training program at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.5.2 and the acceptance criteria outlined in SRP Section 5.5.3.

The radiation safety training program at the Ludeman Project is consistent with the guidance contained in NRC Regulatory Guides 8.31 (NRC 2002a), 8.13 (NRC 1999), and 8.29 (NRC 1996). The content of the training material, testing, on-the-job training, and the extent and frequency of retraining are acceptable. Radiation safety instructions for employees are acceptable.

Based on the information provided by the licensee and the detailed review conducted of the radiation safety training program for the *in situ* leach facility, the staff concludes that the radiation safety training program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), as it relates to licensee qualifications through training.

5.6 Security

In this section, the NRC staff evaluates the licensee's proposed security measures to prevent unauthorized entry into restricted and controlled areas.

5.6.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that its security program for the Ludeman Project meets the requirements of 10 CFR 20.1801 and 20.1802.

5.6.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with applicable requirements of 10 CFR Parts 20 using the acceptance criteria in SRP Section 5.6.3 (NRC 2003), which states the licensee has acceptable passive controls, such as fencing for well fields, and active controls, such as daily inspections and locks for plant buildings.

5.6.3 Staff Review and Analysis

The licensee provided a description of its security measures at the proposed Ludeman Project in Section 5.6, "Security" of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee's security measures are similar to those reviewed and approved by the NRC staff for the Christensen Ranch Site. The NRC staff previously evaluated the Christensen Ranch Site information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent security issues (see SER Appendix A). Furthermore, the licensee's security measures are sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as they currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff's prior conclusions remain valid.

With regard to transportation security, the licensee committed to a Security Plan for those hazardous materials for which a Security Plan is required under 49 CFR 172, Subpart I, "Security Plans." The licensee also described specific security measures for transport of hazardous material between the Ludeman Project satellite building and the Willow Creek Irigaray facility, including driver training; means and methods of protecting drivers, vehicles and cargo on the road; and SOPs for anticipated transportation security risks. The licensee also committed to locks and tamper indicators on material stored in vehicles; securing vehicles when off-site to prevent access; and maintaining constant surveillance outside restricted areas.

5.6.4 Evaluation Findings

NRC has completed its review of the security measures at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.6.2 and the acceptance criteria outlined in SRP Section 5.6.3.

The security measures at the Ludeman Project demonstrate that the licensee has acceptable active and passive constraints on entry to the licensed and restricted areas. The licensee has identified acceptable passive controls, for example, barbed wire fencing, locked gates, and warning signage for site control and active security systems for buildings.

Based on the information provided by the licensee and the detailed review conducted of the security measures for the Ludeman Project, the staff concludes that the security measures are acceptable and are 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

In this section, the NRC staff evaluates the licensee's proposed radiation safety controls and monitoring.

5.7.1 Effluent Control Techniques

The NRC staff has previously determined that the areas of review and acceptance criteria presented in Section 5.7.1 of NUREG-1569 (NRC 2003) are also addressed by the areas of review and acceptance criteria in Section 4.1 of NUREG-1569 (NRC 2013b). The NRC staff's review in this SER is based on the guidance in NUREG-1569. Therefore, the staff's evaluation of effluent control techniques at the Ludeman Project is addressed in Section 4.1 of this SER and is not repeated here.

5.7.2 External Radiation Exposure Monitoring Program

In this section, the NRC staff evaluates the licensee's program and procedures for measuring occupational dose from external sources of radiation (i.e., external dose).

The NRC staff reviewed survey methods, instrumentation, and equipment for determining occupational dose from external radiation during routine and non-routine operations maintenance, and cleanup activities. This review included the types of surveys conducted, criteria for determining survey locations, frequency of surveys, action levels, management audits, and corrective action requirements. The NRC staff also reviewed the program for personnel exposure monitoring, the criteria for including workers in the program, the sensitivity and range of devices used, and calibration frequency and methods.

5.7.2.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the proposed external radiation exposure monitoring program for the Ludeman Project described in Section 5.7.2, “External Radiation Exposure Monitoring Program,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) meets the requirements of 10 CFR Part 20, Subpart C, 10 CFR 20.1501(c), 10 CFR 20.1502, 10 CFR Part 20, Subpart L, 10 CFR Part 20, Subpart M, and 10 CFR 40.61.

5.7.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in SRP Section 5.7.2.3. Also, Regulatory Guides 8.30 (NRC 2002b) and 8.31 (NRC 2002a) provide guidance on how compliance with the regulations can be demonstrated.

5.7.2.3 Staff Review and Analysis

The NRC staff reviewed Section 5.7.2, “External Radiation Exposure Monitoring Program,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d): This section of the Ludeman Project Revised Technical Report describes the licensee’s programs for: performing surveys of area gamma and beta radiation; personnel dosimetry; and radiation surveys of equipment released from restricted areas. The NRC staff’s evaluation of the first two items is provided below. The NRC staff’s evaluation of the licensee’s proposed program for surveys of equipment released from restricted areas is addressed in SER Section 5.7.6,”Contamination Control Program.”

Area Surveys of Gamma and Beta Radiation

In Figure 5-2, “Ludeman Satellite Plant Radiological Survey Locations,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee depicts the facility layout and the location of gamma surveys. The NRC staff determined Figure 5-2 depicts a monitoring program sufficient to detect and control gamma radiation from uranium decay products in areas where large volumes of uranium and its decay products may be present (e.g., processing tanks, yellowcake storage areas). The NRC staff determined this is acceptable because the locations and types (i.e., gamma) surveys in these areas are consistent with Regulatory Guide 8.30 (NRC 2002b) and Acceptance Criteria (1) and (9) of SRP Section 5.7.2.3 (NRC 2003).

In Sections 5.7.2.1, “Gamma Surveys,” and 5.7.2.2, “Beta Surveys,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its minimum specifications for radiation detection instruments used in radiation surveys, and examples of specific make and models of equipment that meet those specifications. Radiation detectors are listed in Table 5-2, “Radiation Detectors,” and minimum detectable activities are listed in Table 5-3, “MDAs for Air Sample and Contamination Control Detectors.” The NRC staff determined these descriptions meet Acceptance Criterion (3) of SRP Section 5.7.2.3 (NRC 2003).

The licensee’s program for assessing hazards of beta radiation is addressed in Section 5.7.2.2, “Beta Surveys” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that surveys for beta radiation normally performed in yellowcake drying and

packaging areas is not necessary at the proposed Project because no yellowcake processing will occur. The NRC staff determined this is reasonable for the reason stated by the licensee. The licensee also proposed to use calculations of beta dose, in lieu of beta radiation measurements, to estimate occupational external dose from beta radiation. The NRC staff determined this is acceptable because surveys required to comply with 10 CFR 20, Subpart F, "Surveys and Monitoring," but which do not exceed the levels described in 10 CFR 20.1502, "Conditions requiring individual monitoring of external and internal occupational dose," may include the type of evaluations described by the licensee in lieu of actual physical surveys. The NRC staff determines this meets Acceptance Criterion (8) of SRP Section 5.7.2.3 (NRC 2003).

In the SER for the License Renewal of the Willow Creek Uranium In Situ Recovery Project (NRC 2013b), the staff determined that the licensee should provide, for NRC review, the surface contamination detection capability (minimum detectable concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. This requirement was included in License Condition 11.9. The NRC staff has verified the licensee's surface contamination detection capability (NRC 2017b). The licensee's additional commitments, statements, and representations relating to external exposure monitoring are added to License Condition 9.3 (tie-down condition) as shown in SER Section 1.4 and Table 1.1-1. The NRC staff determines this meets Acceptance Criteria (3) and (4) of SRP Section 5.7.2.3. (NRC 2003).

> License Condition 9.3 Additions:
>
> Letters dated May 30, 2014 (ML14153A103); April 17, 2017 (ML17111A945), and July 6, 2017 (ML17192A093), regarding responses to License Condition 11.9.

Personnel Dosimetry

In Section 5.7.2.3, "Personnel Dosimetry," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its program for determining which employees will be monitored for external dose using personnel dosimetry. The purpose of the personnel dosimetry program is to comply with the regulations in 10 CFR 20.1502(a)(1), which state the licensee shall perform exposure monitoring of all adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in 10 CFR 20.1201(a). The licensee stated all employees will be monitored, even though it believes none will receive external doses above the limit in 10 CFR 20.1502(a)(1). The licensee further stated that it will use quarterly exposure monitoring data collected from all employees to determine which, if any, employees it will continue to monitor. The NRC staff determined that short-term comprehensive monitoring program that seeks to determine which employees should continue to be monitored is consistent with Acceptance Criteria (2) and (10) of SRP Section 5.7.2.3 (NRC 2003).

The licensee stated that external dosimeters will be provided and processed by a vendor that is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP), and will ensure that all monitoring equipment will have a lower limit of detection that allows measurement of 10 percent of the applicable limits. The licensee stated that its Radiation Safety Officer will determine action levels for personnel dosimeter results above which the licensee will take corrective action. The NRC staff determined the measurement sensitivity and establishment of action levels are consistent with Acceptance Criteria (4) and (6) of SRP Section 5.7.2.3 (NRC 2003). The licensee also committed to keeping radiation doses as low as is reasonably achievable (ALARA) by following Regulatory Guide 8.10 (NRC 1975) and

Regulatory Guide 8.31 (NRC 2002a). The licensee's annual ALARA audit program is described in Section 5.3.1.4, "Annually," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff determines this meets Acceptance Criterion (7) of SRP Section 5.7.2.3 (NRC 2003).

In Section 5.7.4.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its plans for direct radiation exposure recording and reporting, which the NRC staff determined are consistent with the approach in Regulatory Guide 8.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data, Revision 2" (NRC 2005). The NRC staff determines this also meets Acceptance Criterion (5) of SRP Section 5.7.2.3 (NRC 2003).

With regard to external exposure monitoring, in the SER for the License Renewal of the Willow Creek Uranium In Situ Recovery Project (NRC 2013b), the staff determined that the licensee should provide, and the NRC staff should verify, additional information regarding how occupational dose (gaseous and particulate) received throughout the entire license area from licensee operations will be accounted for, and verified by surveys and/or monitoring. This requirement was included in License Condition 11.3. The NRC staff verified the licensees program for monitoring occupational dose (NRC 2017b). The licensee's additional commitments, statements, and representations relating to external exposure monitoring are added to License Condition 9.3 as shown in SER Section 1.4 and Table 1.1-1 (tie-down condition). The NRC staff determines this meets Acceptance Criterion (2) of SRP Section 5.7.2.3 (NRC 2003).

> License Condition 9.3 Additions:
>
> Letters dated September 25, 2013 (ML13273A017); January 20, 2015 (ML15040A077); June 5, 2015 (ML15181A357); and April 17, 2017 (ML17111A981) regarding responses to License Condition 11.3.

5.7.2.4 Evaluation Findings

NRC has completed its review of the external radiation exposure monitoring program at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.7.2.2 and the acceptance criteria outlined in SRP Section 5.7.2.3.

The licensee has proposed an acceptable external radiation exposure monitoring program at the Ludeman Project. The licensee has provided an acceptable drawing that depicts the facility layout and the location of external radiation monitors. The external radiation monitors are acceptably placed. The licensee has established appropriate criteria to determine which employees should receive external radiation monitoring. The licensee has 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. Planned documentation of radiation exposures is acceptable. The licensee's monitoring program is acceptable to protect workers from beta and gamma radiation.

Based on the information provided by the licensee and the detailed review conducted of the external radiation exposure monitoring program at the in situ leach facility, 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 20.1201(a), 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 record keeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting requirements.

5.7.3 Airborne Radiation Monitoring Program

In this section, the NRC staff evaluates the licensee's program and procedures for measuring occupational dose from internal sources of radiation (i.e., internal dose).

The staff should review the proposed airborne radiation monitoring program to determine concentrations of airborne radioactive materials (including radon) during routine and non-routine operations, maintenance, and cleanup. This review should include criteria for determining airborne radiation monitoring locations and sampling frequency with respect to process operations and personnel occupancy, as well as analytical procedures and sensitivity and instrument calibration requirements. Action levels, audits, and corrective action requirements should also be evaluated.

5.7.3.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the in-plant airborne radiation Monitoring program for the Ludeman Project meets the requirements of 10 CFR Part 20, Subpart B and Subpart C, 10 CFR 20.1501, and 10 CFR 20.1702.

5.7.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in SRP Section 5.7.3.3 (NRC 2003) and for conformance with Regulatory Guides 8.25 (NRC 1992a) and 8.30 (NRC 2002b) that provide guidance on how to demonstrate compliance with the regulations.

5.7.3.3 Staff Review and Analysis

In Section 5.7.3.1, "Airborne Uranium Particulate Monitoring," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee commits to collect air samples using air filters, and to perform gross alpha counting of air filters, to meet minimum detectable concentrations of 10 percent of the applicable derived air concentrations. Air particulate monitoring locations are depicted in Figure 5-2, "Radiological Sampling Locations, Ludeman ISR Project," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee's proposed program is acceptable because the licensee provided a drawing showing the layout of samplers, and described monitoring equipment, and its use, consistent with guidance in Regulatory Guide 8.30, as described in Acceptance Criteria (1) and (3) of SRP Section 5.7.3.3 (NRC 2003).

In Section 5.7.3.2, "Radon Daughter Concentration Monitoring," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee commits to surveys for radon daughters (i.e., working levels) in the satellite plant and wellfield header houses at a frequency and sensitivity consistent with guidance in Regulatory Guide 8.30. The licensee also committed to sample locations in accordance with Regulatory Guide 8.25. The NRC staff determined that the combination of engineering controls on air effluents (see Section 4.1 of this

SER) and confirmatory measurements described in Section 5.7.3.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) will ensure that workers are adequately protected from radon progeny. The NRC staff determined that this meets Acceptance Criterion (4) of SRP Section 5.7.3.3 (NRC 2003) regarding a sufficient monitoring program to protect works from gases released from process equipment.

In Section 5.7.3.3, "Respiratory Protection Program," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated that process and engineering controls will be the primary means of controlling airborne radioactive material. However, it also stated it will use the same Respiratory Protection Program described in Section 5.7.4.4 of the License Renewal Application for the Willow Creek Project (Uranium One USA 2008). The NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent safety issues related to the licensee's respiratory protection program (see SER Appendix A). Furthermore, the licensee's respiratory protection program is sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff's prior conclusions remain valid.

The licensee is also required by existing License Condition 11.3 to analyze air samples for natural uranium, radium-226, polonium-210, thorium-230, and lead-210 at each in-plant air particulate sampling location at a frequency of once every 6 months for 2 years, and annually thereafter, to ensure compliance with 10 CFR 20.1204.

The NRC staff determined that the licensee's description of its airborne monitoring program at the Ludeman Project meets the acceptance criteria in Section 5.7.3.3 of the SRP (NRC 2003).

5.7.3.4 Evaluation Findings

NRC has completed its review of the airborne radiation monitoring program at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.7.3.2 and the acceptance criteria outlined in SRP Section 5.7.3.3.

The licensee has an acceptable airborne radiation monitoring program at the Ludeman Project. The licensee has provided an acceptable drawing that depicts the facility layout and the locations of airborne radiation monitors. The airborne radiation monitors are acceptably placed. The licensee demonstrated that the range, sensitivity, and calibration of monitors of airborne radiation will enable accurate determinations of the concentrations of airborne radioactive species so as to protect the health and safety of employees during facility operations.

Planned documentation of radiation exposures is consistent with the requirements. The licensee's respiratory protection program is acceptable. The licensee 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 by the licensee and the detailed review conducted of the airborne radiation monitoring program at the Ludeman Project, the staff has concluded 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 20.1201(a), which provides individual occupational dose limits; 10 CFR

20.1201(e), which specifies allowed intake of soluble uranium; 10 CFR 20.1202, which describes the means of compliance when summing internal and external doses; 10 CFR 20.1203, for determination of dose from airborne external radiation; 10 CFR 20.1208, which specifies the exposure limits to a fetus during pregnancy; 10 CFR 20.1702, which allows employees to limit dose to individuals by controlling access, limiting exposure times, prescribing use of respiratory equipment, or use of other controls; 10 CFR Part 20, Subpart L, which specifies record keeping requirements; 10 CFR Part 20, Subpart M, which provides requirements for reports and notification; and 10 CFR Part 40, Appendix A, Criterion 8, which provides requirements for control of airborne effluents.

5.7.4 Exposure Calculations

In this section, the NRC staff evaluates the licensee's program and procedures for calculating occupational dose from internal sources of radiation (i.e., internal dose).

5.7.4.1 Regulatory Requirements

The NRC staff reviews the methodologies proposed for the Ludeman Project to calculate the exposures to radioactive materials by personnel in work areas where airborne radioactive materials could exist. This review should include methods to determine exposures during routine and non-routine operations, maintenance, and cleanup activities.

5.7.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in SRP Section 5.7.4.3 (NRC 2003) and for conformance with Regulatory Guides 8.25 (NRC 1992a) and 8.30 (NRC 2002b) that provide guidance on how to demonstrate compliance with the regulations.

The NRC staff used review procedures described in NUREG-1569, Section 5.7.4.2, "Review Procedures." The NRC staff used acceptance criteria described in NUREG-1569, Section 5.7.4.3, "Acceptance Criteria."

5.7.4.3 Staff Review and Analysis

In Section 5.7.3.5, "Natural Uranium Internal Exposure," and Section 5.7.3.6, "Radon Daughter Internal Exposure," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) , the licensee described its method of calculating uranium intake and radon daughter exposure adopted from guidance in Section 2, "Surveys," and Section 3, "Intake and Exposure Calculations," of Regulatory Guide 8.30 (NRC 2002b). This method is the same as described in the License Renewal Application for the Willow Creek Project (Uranium One USA 2008). The NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent safety issues related to the licensee's exposure calculations (see SER Appendix A). Furthermore, the licensee's internal dosimetry program is sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff's prior conclusions remain valid.

In Section 5.7.3.7, “Prenatal and Fetal Exposure,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its program to ensure that the dose equivalent to the embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed 0.5 (5 mSv). The licensee committed to monitor declared pregnant women in accordance with regulations in 10 CFR 20.1502 and will perform exposure calculations in accordance with guidance contained in Regulatory Guide 8.36, “Radiation Dose to the Embryo/Fetus” (NRC 1992c).

In Section 5.7.3.8, “Exposure Recording and Reporting,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to keep and report dose records in accordance with Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Dose Data,” (NRC 2005).

5.7.4.4 Evaluation Findings

NRC has completed its review of the exposure calculations at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.7.4.2 and the acceptance criteria outlined in SRP Section 5.7.4.3.

The licensee has provided acceptable techniques for exposure calculations at the Ludeman Project. The licensee has techniques to determine intake of radioactive materials by personnel in work areas. The licensee exposure calculations for natural uranium and airborne radon daughter exposure are acceptable and are in conformance with the guidance in Regulatory Guide 8.30 (NRC 2002b) and Regulatory Guide 8.34 (NRC 1992b). The licensee has acceptable methods to calculate prenatal and fetal radiation exposures consistent with Regulatory Guides 8.13 (NRC 1999) and 8.36 (NRC 1992c). All exposure calculation methods for routine operations, non-routine operations, maintenance, and cleanup activities are acceptable and are consistent with Regulatory Guide 8.30 (NRC 2002b) and Regulatory Guide 8.34 (NRC 1992b). The licensee has used parameters that are representative of the site, such as using both full- and part-time workers in exposure calculations. The licensee has considered maximum production capacity and anticipated efficiencies of airborne particulate control systems in exposure calculations. All reporting and record keeping is in conformance with Regulatory Guide 8.7 (NRC 2005).

Based on the information provided by the licensee and the detailed review conducted of the exposure calculations at the Ludeman Project, the staff has concluded that the exposure calculations are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements; 10 CFR 20.1201(a), which specifies individual occupational dose limits; 10 CFR 20.1201(e), which defines allowed intake of soluble uranium; 10 CFR 20.1202, which describes the means of compliance when summing internal and external doses; 10 CFR 20.1203, for determination of dose from airborne external radiation; 10 CFR 20.1204, which provides requirements for determination of internal exposure; and 10 CFR 20.1208, which specifies the exposure limits for a fetus.

5.7.5 Bioassay Program

In this section, the NRC staff evaluates the licensee’s bioassay program. The NRC staff reviewed whether the bioassay program monitors and documents potential intakes of radioactive materials, and confirms the results of airborne monitoring and to demonstrate adequate controls for airborne radioactive materials.

5.7.5.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the bioassay program for the Ludeman Project meets the applicable 10 CFR Part 20 Subpart C, L and M requirements.

5.7.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 20, using the acceptance criteria in SRP Section 5.7.5.3 (NRC 2003) and for conformance with Regulatory Guide 8.22 (NRC 1988c) that provides guidance on how to demonstrate compliance with the regulations.

5.7.5.3 Staff Review and Analysis

The licensee stated in Section 5.7.4, “Bioassay Program,” in the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that its program would be the same as that described in Section 5.7.5 of the License Renewal Application for the Willow Creek Project (Uranium One USA 2008). The NRC staff previously evaluated this information and found it acceptable (NRC 2013b). Since 2013, the NRC staff has continued oversight of operations at the Willow Creek Project and there have been no persistent safety issues related to the licensee’s bioassay program (see SER Appendix A). Furthermore, the licensee’s bioassay program is sufficiently broad in scope to encompass a second Satellite facility and additional wellfields at the Ludeman Project, in much the same manner as it currently encompasses the Christensen Ranch Satellite. The staff has found nothing to invalidate or call into question its previous findings; therefore, the original findings and staff’s prior conclusions remain valid.

5.7.5.4 Evaluation Findings

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

The licensee has established an acceptable bioassay program at the Ludeman Project that is consistent with Regulatory Guide 8.22 (NRC 1988c). An acceptable program for baseline urinalysis and exit bioassay is in place. An acceptable action program to curtail uranium intake is established, and appropriate actions levels are set. The licensee has established reporting and record keeping protocols in conformance with the requirements of 10 CFR Part 20, Subpart L.

Based on the information provided by the licensee and the detailed review conducted of the bioassay program at the Ludeman Project, the staff concludes that the bioassay program is acceptable and is in compliance with 10 CFR 20.1204, which provides requirements for the determination of internal exposure; and 10 CFR Part 20, Subpart L, which establishes record keeping requirements.

5.7.6 Contamination Control Program

In this section, the NRC staff evaluates the licensee’s contamination control program, which prevents employees from entering clean areas or from leaving the site while contaminated with radioactive materials.

5.7.6.1 Regulatory Requirements

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

5.7.6.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d)for compliance with the applicable requirements of 10 CFR Part 20, using the acceptance criteria in SRP Section 5.7.6.3 (NRC 2003) and for conformance with Regulatory Guide 8.30 (NRC 2002b) that provides guidance on how to demonstrate compliance with the regulations.

5.7.6.3 Staff Review and Analysis

In Section 5.7.5, “Contamination Control Program,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described surveys for: (1) surface contamination; (2) contamination of skin and personal clothing, and; (3) surveys of equipment prior to release to an unrestricted area. The NRC staff evaluated each program element separately.

In Section 5.7.5.1, “Surveys for Surface Contamination,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to weekly alpha surveys. The NRC staff determined this is acceptable because it is in accordance with Regulatory Guide 8.30, “Health Physics Surveys in Uranium Mills” and meets SRP Acceptance Criterion 5.7.6.3(2).

In Section 5.7.5.2, “Surveys for Contamination of Skin and Personal Clothing,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee noted its requirement in License Condition 10.11, which states that all employees who do not shower prior to leaving the restricted area shall monitor themselves with an alpha survey instrument. The licensee also committed that all personnel who could encounter potentially-contaminated solutions in wellfields (i.e., outside restricted areas) are required to monitor themselves prior to leaving the worksite. The licensee also described its program of quarterly unannounced spot checks of personnel to verify the effectiveness of the contamination control program. The NRC staff determined this is acceptable because it is in accordance with Regulatory Guide 8.30, “Health Physics Surveys in Uranium Mills” and meets Acceptance Criterion (1) for SRP Section 5.7.6.3.

In Section 5.7.5.3, “Surveys of Equipment Prior to Release to an Unrestricted Area,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its program for release of items from restricted areas for unrestricted use. The licensee committed to adopt the release limits in “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials,” (NRC 1993a). In Section 5.7.5.4, “Proposed Contamination Control Program,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated it would use the same Contamination Control Program in use at the Irigaray and Christensen Ranch facilities.

In Section 5.7.6.3.3 of its 2013 SER for the Willow Creek License Renewal Application (NRC 2013b), the NRC identified deficiencies in the licensee's contamination control program. In response to these deficiencies, License Condition 9.8 requires the licensee to apply the values in Regulatory Guide 8.30, Table 2, to the removal of equipment, materials, or packages that have the potential for accessible radiological surface contamination levels above background to unrestricted areas. Simultaneously, the licensee must apply separate standards in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (NRC 1993a) for release of surface contaminated equipment, materials, or packages from restricted areas for unrestricted use.

During its review of the licensee's revised contamination control program (Uranium One USA 2014b), the NRC staff determined that License Condition 9.8 should be revised to clarify certain requirements. The staff proposes to revise License Condition 9.8 as shown in SER Table 1.1-1 as follows:

> License Condition 9.8
>
> Release of surface contaminated equipment, materials, or packages for unrestricted use ~~from restricted areas~~ shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993 (ADAMS Accession No. ML003745526) (the Guidelines) or suitable alternative procedures approved by NRC prior to any such release.
>
> Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides shall apply independently.
>
> Personnel performing contamination surveys for items released for unrestricted use shall meet the qualifications as health physics technicians or radiation safety officer as defined in Regulatory Guide 8.31 (as revised). Personal effects (e.g., notebooks and flash lights) which are hand carried need not be subjected to the qualified individual survey or evaluation, but these items should be subjected to the same survey requirements as the individual possessing the items.
>
> Regulatory Guide 8.30 (as revised), Table 2, shall apply to the removal of equipment, materials, or packages that have the potential for accessible radiological surface contamination levels above background to unrestricted areas inside licensed boundaries. ~~The licensee shall submit to the NRC for review and written verification a contamination control program within 90 days of license renewal.~~ The contamination control program shall provide sufficient detail to demonstrate how the licensee will maintain control over the equipment, materials, or packages that have the potential for accessible radiological surface contamination levels above background, until they have been either disposed of or released for unrestricted use as specified in the Guidelines~~, and what methods will be used to limit the spread of contamination to unrestricted areas. The contamination control program shall demonstrate how the licensee will limit the spread of contamination when moving or transporting potentially contaminated equipment, materials, or packages (i.e. pumps, valves, piping, filters, etc.) from~~

~~wellfield areas (restricted or controlled areas) through uncontrolled areas. The licensee shall receive written verification of the licensee's contamination control program prior to its implementation~~.

The licensee may identify a qualified designee(s) to perform surveys, as needed, associated with the licensee's contamination control program when moving or transporting potentially contaminated equipment, materials, or packages from restricted or controlled areas through uncontrolled areas and back into controlled or restricted areas. The qualified designee(s) shall have completed education, training, and experience, in addition to general radiation worker training, as specified by the licensee. The education, training, and experience required by the licensee for qualified designees shall be submitted to the NRC for review and written verification. The licensee shall receive written verification of the licensees qualified designee(s) training program prior to its implementation.

The licensee consented to these changes by letter dated January 11, 2018 (Uranium One USA 2018). The proposed changes to License Condition 9.8 clarify that there are separate contamination control standards for: (1) release of surface contaminated equipment, materials, or packages from restricted areas <u>for unrestricted use</u>; (paragraph 1) and; (2) removal of equipment, materials, or packages that have the potential for accessible radiological surface contamination levels above background <u>to unrestricted areas inside licensed boundaries</u> (paragraph 4). For release <u>for unrestricted use</u>, the licensee must follow the instructions in the "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" (NRC 1993a). For removal of equipment, materials, or packages that have potential for accessible radiological surface contamination above background <u>to unrestricted areas inside licensed boundaries</u>, the licensee may meet similar, but different, quantitative contamination levels presented in Table 2 of Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities" (NRC 2002b). With the changes specified above, the licensee's program meets Acceptance Criteria (6), (7), and (9) of SRP Section 5.7.6.3 (NRC 2003).

License Condition 9.3 Additions:

<u>Letters dated August 8, 2014 (ML14309A456) and January 11, 2018 (ML18016A578) regarding responses to License Conditions 9.8 and 9.12.</u>

With regard to survey sensitivity, the NRC staff found in 2017 that the licensee had satisfied License Condition 11.9 and demonstrated that surface contamination detection capability was sufficient (NRC 2017d). Therefore, License Condition 11.9 is being removed and the licensee's commitments, statements and representations in the letters evaluated are added to the tie-down in revised License Condition 9.3, as described in Section 5.7.2 of this SER. Therefore, the NRC staff determined that the Acceptance Criterion (4) of SRP Section 5.7.6.3 regarding appropriate sensitivity and use of monitoring equipment in the contamination control program is met.

5.7.6.4 Evaluation Findings

NRC has completed its review of the contamination control program at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.7.6.2 and the acceptance criteria outlined in SRP Section 5.7.6.3.

The licensee has established an acceptable contamination control program at the Ludeman Project. Acceptable controls are in place to prevent contaminated employees from entering clean areas or from leaving the site. The standard operating procedures will include provisions for contamination control, such as maintaining changing areas and personal alpha radiation monitoring before leaving radiation areas. Acceptable action levels have been set in accordance with Regulatory Guide 8.30 (NRC 2002b) and the 1993 Guidelines (NRC 1993a), and plans for surveys are in place for skin and personal clothing contamination. The licensee has established that all items removed from the restricted area are surveyed by the radiation safety staff and meet release limits. All reporting and record keeping is done in conformance with protocols established in Regulatory Guide 8.7 (NRC 2005). The licensee has demonstrated that the range, sensitivity, and calibration of monitoring equipment will protect the health and safety of employees during the full scope of facility operations. The licensee has demonstrated that contaminated surfaces will not be covered unless, before covering, a survey documents that the contamination level is below the limits specified in the 1993 Guidelines (NRC 1993a). The licensee will determine the radioactivity on the interior surfaces of pipes, drain lines, or duct work by making measurements at appropriate access points that will have been shown to be representative of the interior contamination. The licensee has committed to establishing that contamination on equipment, or scrap will be within the limits in the 1993 Guidelines (NRC 1993a) before unrestricted release.

Based on the information provided by the licensee and the detailed review conducted of the contamination control program at the Ludeman 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 20.1501, which provides survey and monitoring requirements; and 10 CFR 20.1702, which allows employees to limit dose to individuals by controlling access, limiting exposure times, prescribing use of respiratory equipment, or other controls.

5.7.7 Airborne Effluent and Environmental Monitoring

5.7.7.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the airborne effluent and environmental monitoring program for the Ludeman Project meets the requirements of 10 CFR Part 20, Subparts B, C, and D, 10 CFR 20.1501, 10 CFR Part 20.1702, and 10 CFR Part 40, Appendix A, Criterion 7 and 8.

5.7.7.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in SRP Section 5.7.3.3 (NRC 2003) and for conformance with Regulatory Guide 4.14 (NRC 1980a) that provides guidance on how to demonstrate compliance with the regulations.

5.7.7.2.1 Staff Review and Analysis

In Section 5.7.6, “Airborne Effluent and Environmental Monitoring Programs,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described nine sub-programs for monitoring radionuclides in the following media or environmental compartments: (1) particulate matter in air; (2) radon in air; (3) surface soil; (4) sediment; (5) subsurface soil; (6)

vegetation and food; (7) direct radiation; (8) deep disposal well monitoring; and (9) fish. The NRC staff's evaluation of the licensee's proposal for each compartment is provided below.

In Section 5.7.6.1, "Air Particulate," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated that because the Ludeman Project satellite facility would produce no airborne uranium, it would not install particulate air monitors downwind of this facility. In its SER for the Willow Creek Project License Renewal Application (NRC 2013b), NRC found several deficiencies in the licensee's program for air effluent and environmental monitoring. For this reason, NRC staff imposed License Condition 11.3, which required the licensee to, among other things, either sample radionuclides in particulate matter in air downwind of the current Christensen Ranch satellite facility, or provide alternative procedures. In its assessment of the licensee's alternative procedures (NRC 2017b), the NRC staff accepted the licensee's rationale for not sampling particulate matter downwind of the Christensen Ranch satellite facility. As a result, the NRC staff will revise the fourth paragraph of License Condition 11.3, as shown below, and add the licensee's statements regarding the acceptable alternative approach to License Condition 9.3 as shown in SER Section 1.4 and Table 1.1-1 (tie-down condition). The NRC staff has also determined, as an administrative matter, the first sentence of License Condition 11.3 is a redundant requirement because Sections 5.7 and 5.8 of the Willow Creek Project License Renewal Application (Uranium One USA 2008) have already been added as requirements to License Condition 9.3 (tie-down condition). Therefore, the NRC staff is removing the first sentence from License Condition 11.3. For the same reasons, the staff's accepts the licensee's plan not perform operational particulate matter sampling downwind of the Ludeman Project. However, the NRC staff proposes a revised License Condition 11.3 which would require the licensee to use air sampling results at the Irigaray CPP in any assessments of public dose associated with operations at the Ludeman Project:

> License Condition 11.3
>
> ~~The licensee shall conduct effluent, personnel, and environmental monitoring programs in accordance with Sections 5.7 and 5.8 of the approved license application.~~
>
> The licensee shall conduct airborne samples for natural uranium, Ra-226, Po-210, Th-230 and Pb-210 at each in-plant air particulate sampling location at a frequency of once every 6 months for 2 years, and annually thereafter, to ensure compliance with 10 CFR 20.1204. The licensee shall also evaluate changes to plant operations to determine if more frequent radionuclide analyses are required to demonstrate compliance with 10 CFR 20.1204. The licensee may demonstrate compliance or provide alternative procedures specific to in-plant air particulate sampling to show compliance with 10 CFR 20.1204 to the NRC for review and verification within 6 months of license renewal.
>
> In its annual public dose calculations in accordance with 10 CFR 20.1302, the licensee shall evaluate public dose at the Ludeman Project using airborne sample results for natural uranium, radium-226, polonium-210, and lead-210 determined at the Irigaray location. ~~The licensee shall conduct airborne samples for natural uranium, Ra-226, Po-210, and Pb-210 at each Christensen Ranch environmental monitoring location at a frequency of once every 6 months for 2 years, and annually thereafter, to ensure compliance with 10 CFR 20.1301. The licensee shall also evaluate changes to plant operations to determine if more frequent radionuclide analyses are required to demonstrate compliance with 10 CFR Part 20.1301. The licensee may demonstrate compliance or provide alternative procedures specific to environmental monitoring for~~

~~natural uranium, Ra-226, Po-210, and Pb-210 to show compliance with 10 CFR 20.1301 to the NRC for review and verification within 6 months of license renewal.~~

~~The licensee shall describe how the environmental monitoring program demonstrates that 10 CFR Part 20 public dose limits in controlled and unrestricted areas are met. The documentation of the areas designated as restricted, controlled and unrestricted areas and the environmental monitoring station locations shall be updated periodically, as needed.~~

~~The licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall develop written procedures that shall be submitted to NRC for verification prior to implementation, to:~~

~~a. Discuss, in accordance with 10 CFR 40.65, how the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.~~

~~b. Evaluate, consistent with 10 CFR 20.1301 and 10 CFR 20.1302, the highest exposures likely for member(s) of the public from licensee operations.~~

~~c. Discuss how radon progeny (radon-222) will be factored into the determination of potential public dose from the licensee's operations consistent with 10 CFR Part 20, Appendix B, Table 2.~~

~~d. Discuss, in accordance with 10 CFR Part 20.1501, how the occupational dose (gaseous and particulate) received throughout the entire license area from licensee operations will be accounted for, and verified by surveys and/or monitoring.~~

In Section 5.7.6.1, "Radon," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated it would continue operational radon-222 sampling at the same locations and frequencies used for the pre-operational program. In its SER for the Willow Creek Project License Renewal Application (NRC 2013b), the NRC found several deficiencies in the licensee's program for air effluent and environmental monitoring. For this reason, the NRC staff imposed License Condition 11.3, which required the licensee to, among other things, describe how the environmental monitoring program demonstrates that public dose limits are met; evaluate the highest public dose from licensed operations; and describe how radon progeny are factored into the determination of public dose. In its assessment of the licensee's procedures (NRC 2017b), the NRC staff accepted the licensee's procedures. The commitments, statements, and representations in the licensee's proposed procedures are addressed in a revised License Condition 9.3. The NRC staff determined that, with the revised License Condition 9.3 (tie down) presented in SER Section 5.7.2.3 and Table 1.1-1, the licensee's proposed radon in air sampling components of the environmental monitoring program meets Acceptance Criteria (1), (2), (3) and (4) of SRP Section 5.7.7.3 regarding a proposed environmental monitoring program in accordance with guidance in Regulatory Guide 4.14.

In Section 5.7.6.3, "Surface Soil," Section 5.7.6.4, "Sediment," and Section 5.7.6.5, "Subsurface Soil," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee addressed operational soil and sediment sampling. The licensee committed to surface soil and sediment sampling for radionuclides, sample locations, and sample frequencies described in Regulatory Guide 4.14.

In Section 5.7.6.6, “Vegetation and Food Sampling,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated it would conduct forage vegetation sampling three times per year at locations determined using air effluent quantities and the MILDOS-AREA computer model. The licensee committed to meat sampling only if the forage vegetation sampling indicates that forage vegetation are a significant pathway to public dose.

In Section 5.7.6.7, “Direct Radiation,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to dosimeter measurements at locations and frequencies described in Regulatory Guide 4.14.

The licensee does not plan fish sampling due to lack of habitat and persistent water sources at the Ludeman Project.

The NRC staff determined that the licensee’s proposed sampling of vegetation and direct radiation as part of the environmental monitoring program meets Acceptance Criteria 5.7.7.3(1), 5.7.7.3(2), 5.7.7.3(3), and 5.7.7.3(4), regarding a proposed environmental monitoring program in accordance with guidance in Regulatory Guide 4.14.

In Section 7.3.2, “MILDOS-Area,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its estimate of public dose from operations at the Ludeman Project. The parameters used in the licensee’s MILDOS-AREA assessment are provided in Addendum 7-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Using these parameters, the licensee determined the individual likely to receive the highest dose is located at a residence east of the Satellite facility during the third year of operation. The licensee’s estimate of maximum annual total effective dose equivalent (TEDE) is 1.59 mrem/year. The second highest calculated TEDE of 1.27 mrem/year was calculated for the nearest resident in the nearby Negley Subdivision. The NRC staff evaluated the licensee’s calculation by examining:

- The licensee’s estimate of peak annual effluent quantities of radon-222;

- Other information on individuals who could receive dose, including Table 3.1-4, “Oil and Gas Wells Within Three Miles of the Project Area,” and Figure 3.1-1, “Land Use Within 2 Miles,” of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e), to ensure potential land uses and receptors other than nearby residents had been considered, and;

- The licensee’s meteorological data used in the MILDOS-AREA calculation provided in Addendum 7-A of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

With regard to maximum effluent quantities, the NRC staff observed that the licensee’s estimate is about 950 curies in the third year of operation. The NRC staff verified that this is higher than would be estimated using the methodology in Appendix D of NUREG-1569. The NRC staff determined, therefore, that the licensee’s effluent quantity estimate is conservative and bounding. With regard to other receptors, the NRC staff found, on the basis of its examination of other industries and land uses on-site and nearby, that there are no other public receptors likely to spend more than a few hours per year on or near the site. Therefore, the resident east of the Satellite facility is the individual likely to receive the highest annual dose. Finally, the NRC staff verified that the meteorological data used by the licensee in its calculation (i.e., p. 4 of the MILDOS-AREA output, Appendix B to Addendum 7-A) of the maximum annual total effective

dose equivalent of 1.59 mrem/year is the same on-site data described in Section 2.5, "Meteorology" of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). On the basis of the NRC staff's verification of these important parameters in the licensee's dose assessment, the NRC staff finds that operations at the Ludeman Project will comply with the public dose standard in 10 CFR 20.1301.

5.7.7.3 Evaluation Findings

The NRC has completed its review of the airborne effluent and environmental monitoring programs at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.7.7.2 and the acceptance criteria outlined in SRP Section 5.7.7.3.

The licensee has established acceptable airborne effluent and environmental monitoring programs at the Ludeman Project. The programs are consistent with guidance in Regulatory Guide 4.14 (NRC 1980a). The licensee will sample radon, air particulates, surface soils, subsurface soils, vegetation, direct radiation, and sediment. Locations of monitoring stations are consistent with Regulatory Guide 4.14 (NRC 1980a). Instrumentation is appropriate.

Based on the information provided by the licensee and the detailed review conducted of the airborne effluent and environmental monitoring programs at the Ludeman Project, the staff concludes that the airborne effluent and environmental monitoring programs are acceptable and are in compliance with 10 CFR 20.1302, which requires effluent monitoring to determine dose to individual members of the public; 10 CFR 20.1501, which specifies survey and monitoring requirements; 10 CFR Part 20, Subpart L, which establishes record keeping requirements; and10 CFR 40.65, which specifies effluent and environmental monitoring requirements.

5.7.8 Ground Water and Surface Water Monitoring Program

5.7.8.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that the proposed ground water and surface water monitoring program for the Ludeman Project meets the requirements of 10 CFR 40.32(c); 10 CFR 40.41(c); and 10 CFR Part 40, Appendix A, Criterion 5B(5) and 5D.

5.7.8.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) 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 ground water and surface water in Regulatory Guide 4.14 (NRC 1980a).

5.7.8.3 Staff Review and Analysis

In this section, the staff reviews the ground water and surface water monitoring programs to be implemented at the Ludeman Project to establish monitoring well placement, background water quality, and detect excursions during operations. SER Section 2.5 addresses pre-operational monitoring for ground water and surface water characterization before licensing, and SER Section 6.1 addresses restoration monitoring.

5.7.8.3.1 Ground Water Monitoring

The licensee described the ground water monitoring programs to be conducted at the Ludeman Project in Section 5.7.7.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The program includes pre-operational and operational private well monitoring. The program also includes baseline monitoring for the ore zone production aquifer and excursion wells in the overlying and underlying aquifers, as well as the perimeter ring in the production ore zone aquifer within a wellfield. The ground water monitoring program also includes operational monitoring of excursion wells in the overlying aquifer, underlying aquifer and the perimeter ring in the ore zone aquifer in each wellfield within the Ludeman Project license area. In addition, the licensee has committed to install and monitor a ground water network of guard wells in the 110 sand aquifer in Wellfield 1 for the reasons described in SER Section 3.1.3.8. The ground water monitoring at the Ludeman will be conducted before and during uranium recovery operations until the wellfield restoration is approved by NRC. The NRC staff reviewed each type of ground water monitoring in the following sections.

Private Well Monitoring

The licensee stated that all private wells used for drinking water, livestock watering, or crop irrigation within 2 kilometers (km) of a wellfield boundary will be sampled for baseline values and on a quarterly basis given the owner's consent in Section 5.7.7.2.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee also committed to measure the water levels of these wells during each sampling event, if conditions allow. The licensee stated the ground water quality results and water levels will be provided to the NRC in the semi-annual environmental and effluent reports.

The NRC staff reviewed the location, completion and use of private wells at the Ludeman Project in SER Section 2.4.3.3. The NRC staff also specifically evaluated all the private wells that are currently located within 2 km of Wellfields 1, 3, 4, 5, and 6. A total of 50 existing private wells were identified as described in SER Tables 2.4-10, 2.4-11, 2.4-13, and 2.4-14. The licensee has committed to sampling all of these wells quarterly with the owner's permission. In addition, License Condition 11.8 of the Willow Creek Source Material license SUA-1341 includes a requirement that the licensee identify the location of any new ground water wells or new use of existing wells, where the information is publicly available and/or known to the licensee, that are located within the license area and within 2 km of any production area monitoring ring wells. The NRC staff will therefore revise License Condition 11.8 of the Willow Creek Source Material License SUA -1341 to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1.

The licensee summarized the major constituents to be measured in the private ground water well monitoring program in Table 5-4 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The parameters to be analyzed will consist of dissolved and suspended uranium, Ra-226, Th-230, Pb-210, and polonium-210 (Po-210). The NRC staff finds these constituents are the same parameters identified in Regulatory Guide 4.14, Table 2 (NRC 1980a).

The staff finds that the proposed sampling of private wells for the Ludeman Project is consistent with guidance in Regulatory Guide 4.14 (NRC 1980a) and, in general, effluent monitoring programs currently being conducted at existing ISR facilities.

Wellfield Ore Zone and Excursion Wells Baseline Water Quality

The licensee provided its wellfield ore zone and excursion monitoring well baseline sampling program in Sections 5.7.2.2 and 5.7.2.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee committed to sampling select recovery and injection wells within the ore zone aquifer. The licensee also committed to conduct baseline sampling of all excursion monitoring wells in the overlying aquifer, underlying aquifer and perimeter ring in the ore zone aquifer. Each of these wells will be sampled four times, at least 2 weeks apart to establish the baseline water quality.

The licensee stated the excursion monitoring wells in the ore zone aquifer perimeter ring will be located 500 ft from the edge of the production zone and 500 ft apart. The NRC staff determined these perimeter ring well locations were acceptable in SER Section 3.1.3.7.
The licensee stated the selected ore zone baseline monitoring wells will be installed on a density of one well per 3 acres. The overlying and underlying aquifer excursion monitoring wells will have density of one well per four acres. This spacing was also found acceptable by the NRC staff as described in SER Section 3.1.3.7. The spacing of these wells is at the same density as is required in License Condition 10.3 of the Willow Creek Source Materials License SUA-1341; therefore, the NRC staff will revise this license condition to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1.

The licensee stated that four samples will be collected at least 2 weeks apart from the designated wells within the ore zone aquifer, overlying aquifer, underlying aquifer and ore zone aquifer perimeter ring to establish baseline water quality. The first and second samples will be sampled for all constituents listed in Table 5-5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The third and fourth sampling events may be analyzed for a reduced list of parameters. The parameters that may be deleted from the third and fourth sampling events are those that are below the minimum analytical detection limits during the first and second sampling events. The licensee will use the same well sampling procedures it has successfully employed at the Willow Creek facility. The NRC staff finds this sampling is the same as that required in License Condition 10.3 of the Willow Creek Source Materials License; therefore, this license condition will be revised to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1.

The licensee stated the baseline water quality will be used to establish the background ground water protection standards required in 10 CFR Part 40 Appendix A Criterion 5(B)(5)(a) for the ore zone aquifer and all of the excursion monitoring wells. Specifically, the licensee stated the Restoration Target Values (RTVs) for constituents in each wellfield ore zone aquifer will be set equal to the mean of the baseline sampling values using appropriate statistical techniques, including outlier analysis. The RTVs will therefore be equivalent to the background ground water protection standard for restoration as described in SER Section 6.1.3.

The NRC staff finds the licensee's proposed density of baseline water quality wells, sampling methods, and list of constituents to be measured are consistent with Acceptance Criterion (1) in SRP Section 5.7.8.3 and is therefore acceptable to establish the background ground water protection standards in Criterion 5(B)(5). The NRC staff also finds that the licensee's proposed density of baseline water quality wells, sampling methods, and list of constituents to be measured are consistent with that used at the currently licensed Willow Creek facility. The NRC staff has not identified any new safety-related concerns pertaining to proposed density of baseline water quality wells, sampling methods, and list of constituents to be measured based on the staff's evaluation of the performance of the Willow Creek facility since the last license

renewal safety evaluation (NRC 2013b) as described in SER Appendix A. In addition, the Willow Creek Source Materials License SUA-1341 has a License Condition 10.3 that the NRC staff will revise to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1. Therefore, staff concludes that the licensee's proposed baseline water quality well locations and density, sampling methods, and list of constituents is acceptable.

Excursion Detection Monitoring Program

The licensee described the excursion detection monitoring program for the Ludeman Project in Section 5.7.2.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that wells to be used for the excursion monitoring program will be located in the overlying aquifer and underlying aquifer and in the perimeter ring surrounding the ore zone aquifer. The location of these wells and their baseline sampling was reviewed in the prior section.

The licensee proposed the indicator parameters of chloride, conductivity, and alkalinity for the excursion monitoring program and provided its justification in Section 5.7.7.2.5 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it will set upper control limits (UCLs) for the excursion parameters of conductivity and total alkalinity at the mean value plus five standard deviations. The UCL for chloride will be determined by adding 15 mg/l to the baseline mean if that value is greater than the baseline mean plus five standard deviations. License Condition 10.4 of the Willow Creek Source Material License SUA-1341 states the licensee will establish UCLs for these three indicators; therefore, License Condition 10.4 will be revised to include the Ludeman Project as described in SER Section 5.7.8.4 and shown in SER Table 1.1-1.

The licensee described the excursion detection monitoring program and verification program in Sections 5.7.7.2.5 and 5.7.7.2.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The 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. The licensee stated that due to emergencies or similar unusual circumstances, sampling at a well may have to be delayed beyond the maximum of 5 days. The licensee stated that if the levels of two of the three indicator parameters exceed their respective UCLs at a well, an excursion is deemed to have occurred. The licensee will then perform additional sampling to verify the excursion. 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. The licensee stated that upon verification, the well is placed on excursion status. The licensee stated it will notify the NRC project manager by email or telephone within 24 hours of verifying the excursion status. While on excursion status, the licensee will conduct weekly sampling of the affected well(s) until the excursion status for the well is terminated. An excursion will be considered terminated when the concentrations of at least two excursion indicators remain below the established UCLs for three consecutive samples.

The licensee stated that once a well is placed on excursion status, the licensee will then implement corrective action until the excursion is terminated. Corrective action will include some or all of the following: (1) investigation of the probable cause of the excursion; (2) adjust

production and injection rates near the well to increase the hydraulic gradient toward the production zone; (3) pump individual wells to recover production fluids; (4) or suspend injection in the wellfield are near the monitoring well. The licensee will provide the NRC staff with a detailed written report, which documents the corrective actions taken, to the NRC project manager within 60 days. If an excursion status is not corrected within 30 days, the licensee will conduct sampling for a complete set of parameters per WDEQ requirements. If a well is on excursion status in excess of 60 days, the licensee stated that NUREG-1569, Criterion (5), requires the licensee to terminate lixiviant injection or provide additional reclamation surety that is agreeable to the staff. The NRC staff finds License Condition 11.2 of the Willow Creek Source Material License SUA -1341 addresses the same commitments to excursion monitoring, verification and corrective action; therefore, this license condition also applies to the Ludeman Project without revision.

The NRC staff finds the licensee's proposed excursion monitoring program is consistent with Acceptance Criteria (2), (3) and (5) in SRP Section 5.7.8.3 . Additionally, the licensee's corrective action and notification plans in the event of an excursion are consistent with the guidance Acceptance Criterion (5) in SRP Section 5.7.8.3. The NRC staff also finds that the licensee's proposed excursion monitoring program is consistent with that used at the currently licensed Willow Creek facility. The NRC staff has not identified any new safety-related concerns pertaining to the excursion monitoring program based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. In addition, the Willow Creek Source Materials License SUA-1341 has a License Condition 11.2 addressing excursions that NRC staff finds applies to the Ludeman without revision. Therefore, the NRC staff finds that the licensee's excursion monitoring program is also acceptable because the program will ensure 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. It is also acceptable to meet the ground water detection program standards in Criterion 5(D).

Guard Well Monitoring in Wellfield 1

As described by the NRC staff in SER Section 2.4.3.3, the Negley Subdivision has numerous private domestic and stock wells located in the 100, 110 and 120 sands which overlie the 80 and 90 production zone sands in Wellfield 1. The location of these wells and their proximity to Wellfield 1 is shown in SER Figure 2.4-7.

The licensee recognized that a potential risk exists that any spills and leaks in the surficial and overlying aquifers in Wellfield 1 could migrate toward and impact private wells in the Negley Subdivision. To address these concerns, the licensee conducted ground water flow modeling and particle tracking to assess the risk of contamination migration to these private wells from leaks and spills in the overlying aquifers in Wellfield 1. The licensee originally provided the ground water modeling, particle tracking and guard well monitoring design in a special report entitled, "Hydraulic Effects of Negley Subdivision Pumping on the Proposed Project," (Uranium One USA 2015b). It also provided the same report in Addendum 4-B, "Hydraulic Effects of Negley Subdivision Pumping," of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e).

The NRC staff evaluated the modeling report and its conclusions in SER Section 3.1.3.8. The NRC staff found that the licensee concluded that the ground water flow modeling and particle tracking results for a worst case scenario of leak in an injection well which remains undetected

for five years between MITs demonstrated there could be some risk of contamination migration in the overlying 110 sand aquifer toward the Negley Subdivision private wells.

The licensee therefore stated in the report in that it will install a row of guard monitoring wells spaced between 450 and 500 ft apart along the north margin of Wellfield 1 to monitor the 110 sand aquifer. The licensee also stated if it is determined that saturated conditions are present in the 120 Sand, additional guard monitoring wells will be installed along the north perimeter of Wellfield 1 within the 120 sand at the same spacing as for the 110 Sand. The licensee, however, did not describe the constituents or frequency of the monitoring. Therefore, the NRC staff will include a new License Condition 10.25 to state the licensee will install and monitor these wells in the same manner as required for the excursion monitoring wells in License Conditions 10.3, 10.4, and 11.2 of the Willow Creek Source Material License SUA-1341:

> License Condition 10.25
>
> The licensee will install guard monitoring wells in Wellfield 1 as described in Addendum 4-B of the Ludeman Project Revised Environmental Report and meet the requirements in License Conditions 10.3, 10.4 and 11.2 for these wells.

Evaporation and Permeate Pond Monitoring

The NRC staff evaluated the evaporation and permeate pond design and monitoring program in SER Section 4.2.3.2. The licensee stated that during its subsurface investigation, it was not able to identify a source of near surface ground water in the vicinity of the evaporation pond and permeate pond. Therefore, the licensee stated it does not plan to install ground water monitoring wells in the vicinity of the evaporation pond and permeate pond. The NRC staff disagrees with this finding as described in Section 4.2.3.2. Staff's evaluation of the ground water hydrology found that the 110 sand aquifer is located near the surface under the proposed evaporation and permeate ponds.

The licensee also reported and the NRC verified that the 110 sand aquifer acts as a source of ground water to the Negley Subdivision private wells located just north and west of the evaporation pond. The NRC staff evaluated the potential for contamination of the Negley Subdivision private wells from leaks and spills into the 110 sand aquifer in Wellfield 1 in SER Section 3.1.3.8. Based on this evaluation, the NRC agreed with the licensee proposal to install a network of guard monitoring wells in the 110 sand aquifer at the northern edge of Wellfield 1 to detect leaks or spills which could cause contaminant migration toward the Negley Subdivision wells.

Based on this analysis, the NRC staff has a safety concern that leaks from the evaporation and permeate pond into the 110 sand aquifer may lead to contamination of the 110 sand aquifer and possible contaminant migration toward the Negley Subdivision wells. The NRC staff will therefore issue a new License Condition 10.24 to require the licensee to install three ground water monitoring wells upgradient and one monitoring well downgradient at both the evaporation pond and the permeate pond in the 110 sand aquifer. The wells shall be required to be at least 50 ft deep. These wells will be required to be monitored in the same manner as required for the excursion monitoring wells in License Conditions 10.4 and 11.2 of the Willow Creek Source Material License (SUA-1341) with the exception that licensee will test the wells quarterly and the licensee will not be required to implement correction actions, but instead will inform the NRC of the actions it will take to determine if the excursion is associated with leaks from the evaporation pond. This license condition will state:

License Condition 10.24

The licensee will install three downgradient and one upgradient ground water monitoring wells in the 110 sand aquifer at both the evaporation and permeate ponds shown in Figure 1 of Addendum 4-A of the Ludeman Project Revised Technical Report. The monitoring wells will be completed at a depth sufficient to obtain ground water adequate to monitor and to meet the requirements in License Conditions 10.4 and 11.2 with the exception that the licensee will monitor the wells quarterly. If an excursion is verified the licensee will not be required to implement immediate corrective actions, but will inform the NRC in 60 days of the actions it will take to determine if the excursion is associated with leaks from the evaporation or permeate ponds.

This license condition meets the regulatory requirements in 10 CFR Part 40 Appendix A Criteria 7A and 5B(1). The new License Condition 10.24 to be added to the Willow Creek Source Material License SUA-1341 is presented in SER Section 4.2.4 and shown in SER Table 1.1-1.

Wellfield Hydrologic Data Package

The licensee stated it will conduct extensive hydrogeologic and baseline water quality testing of each wellfield before operation and provide this information to NRC in a wellfield hydrologic data package. The licensee described the information to be included in the wellfield hydrologic data package in Section 5.7.7.2.4 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). At a minimum the package will include wellfield monitoring well completion information; monitoring well location maps; isopach maps; geologic cross-sections; wellfield production zone aquifer pumping test results including a demonstration that there is a lack of hydraulic connection between the production ore zone aquifer and overlying and underlying aquifers; demonstration that the perimeter wells are properly located; baseline water quality measurements and proposed RTVs; and any other pertinent information. The licensee stated it will approve the information in the wellfield hydrologic data package using its SERP process, reviewed in SER Section 5.1.3, before it begins ISR operations in a wellfield.

The licensee finds the information in the wellfield hydrologic data package acceptable with one exception. As described in SER Section 2.4.3.3, the NRC staff found that some private wells are likely to be completed within the production zone aquifers of several of the Ludeman Project wellfields. The NRC staff finds that these wells are not hydrologically isolated from the production zone aquifer. The NRC staff finds the presence of any private well in the production zone aquifer is a safety issue as its use could interfere with hydraulic control of production fluids and impact the safety of receptors.

The licensee stated in Section 4.4.2.2.1 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) that no stock or drinking water wells will be located in the currently proposed ISR operation areas and will not be completed in the production ore zone aquifer. The licensee also stated that if future development includes an area(s) where a stock well is located in an ISR production ore zone aquifer, the licensee would consider the following measures: (1) replacing the wells with new wells completed in either shallower or deeper sands that are not impacted by ISR operations; or (2) providing another source of stock water. The licensee also committed in Section 3.4.2.5 of the Ludeman Project Revised Environmental Report (Uranium One USA 2017e) that all wells that are located within 500 ft of a wellfield perimeter monitor well ring will be accurately surveyed through the use of field verification (GPS or surveying) and corresponding information provided within each individual Wellfield Hydrologic Data Package.

However, the NRC staff finds the licensee did not explicitly commit to plug and abandon these private wells before operations. This finding represents a new safety issue. Therefore, the NRC staff will add a new License Condition 10.26 to Willow Creek Source Material License SUA-1341 that will require any private wells completed in a wellfield production zone aquifer and determined to be within 500 ft of the wellfield perimeter monitoring ring as defined in the wellfield hydrologic data package to be plugged and abandoned:

> License Condition 10.26
>
> The licensee will plug and abandon all private wells found to be completed in the production zone aquifer of a Ludeman Project Wellfield within 500 feet of the perimeter excursion monitoring well ring before injection of lixiviant into that wellfield production zone aquifer.

With this license condition, the staff finds that the proposed information to be included in the wellfield hydrologic data package is satisfactory as it meets Acceptance Criteria (1), (2), (3), and (4) in SRP Section 5.7.8.3.

5.7.8.3.2 Surface Water Monitoring

The licensee provided the surface water monitoring program for the Ludeman Project in Section 5.7.7.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that surface water from all pre-operational surface water sampling locations will be monitored quarterly when water is present. The parameters to be analyzed for the operational surface water monitoring program are presented in Table 5-4 and include dissolved and suspended uranium, Th-230, Ra-226, Po-210, and Pb-210. The licensee stated that the surface water monitoring results will be submitted within the semi-annual environmental and effluent monitoring reports. The NRC staff finds these constituents are the same parameters identified in Table 2 in Regulatory Guide 4.14 and therefore acceptable (NRC 1980a).

The NRC staff reviewed the location of the pre-operational surface water sampling sites and surface water quality at the Ludeman Project in SER Sections 2.4.3.1 and 2.5.3.1. The NRC staff presented surface water sampling locations in SER Figure 2.4-2. The NRC presented the average pre-operational surface water quality of all constituents in SER Table 2.5-1. The NRC staff found the licensee had provided a sufficient number of pre-operational surface water sampling sites upgradient and downgradient of the wellfields. The NRC staff also found the licensee had conducted satisfactory pre-operational sampling by collecting and evaluating surface water quality when water was present.

The staff finds that the proposed operational surface water monitoring programs are satisfactory and meet the recommendations in Regulatory Guide 4.14 (NRC 1980a) and the Acceptance Criteria (5) and (6) of SRP Section 5.7.8.3.

5.7.8.4 Evaluation Findings

The NRC staff evaluated the licensee's characterization ground water and surface water monitoring programs at the Ludeman Project in accordance with the review procedures in SRP Section 5.7.8.2 and the acceptance criteria in SRP Section 5.7.8.3.

The NRC staff finds the licensee has acceptably characterized the Ludeman Project ground water and surface water monitoring program by providing a description of the baseline, excursion, and private well monitoring to be conducted at the Ludeman Project and a description of the surface water monitoring to be conducted. The NRC staff, however, did find two new safety issues, described in Section 5.7.8.3.1 which require the issuance of new license conditions.

The NRC staff will add a new License Condition 10.25 to state the licensee will install guard wells in the 110 sand aquifer in Wellfield 1 and monitor these wells in the same manner as required for the excursion monitoring wells in License Conditions 10.3, 10.4, and 11.2 of the Willow Creek Source Material License SUA-1341:

> License Condition 10.25
>
> The licensee will install guard monitoring wells in Wellfield 1 as described in Addendum 4-B of the Ludeman Project Revised Environmental Report and meet the requirements in License Conditions 10.3, 10.4 and 11.2 for these wells.

The NRC staff will also add a new License Condition 10.26 to Willow Creek Source Material License SUA-1341 that will require any private wells completed in a wellfield production zone aquifer and determined to be within 500 ft of the wellfield perimeter monitoring ring as defined in the wellfield hydrologic data package to be plugged and abandoned:

> License Condition 10.26
>
> The licensee will plug and abandon all private wells found to be completed in the production zone aquifer of a Ludeman Project Wellfield within 500 feet of the perimeter excursion monitoring well ring before injection of lixiviant into that wellfield production zone aquifer.

In addition to the new license conditions, the NRC staff will revise some existing license conditions. The NRC staff finds License Condition 10.3 of the Willow Creek Source Materials License requires the same baseline sampling; therefore, this license condition will be revised to include the Ludeman Project as shown in SER Table 1.1-1:

> License Condition 10.3 revisions:
>
> The licensee shall establish pre-operational baseline water quality data for all production units. Baseline water quality sampling shall provide representative pre-mining ground water quality data and restoration criteria as described in the approved license application and Ludeman Project Revised Technical Report. The data shall be from wells established in the mining zone, the mining zone perimeter, the upper aquifer and the lower aquifer where present, with spacing and locations as specified in the approved license application. The data shall, at a minimum, consist of the sample analyses shown in Table 5.24 of Section 5.8.2.2 of the approved LRA, and Section 5.7.7.2 of the Ludeman Project Revised Technical Report unless superseded by this license condition.

The NRC staff finds License Condition 10.4 of the Willow Creek Source Material License SUA-1341 states the licensee will establish UCLs for the same three excursion parameter indicators; therefore, this license condition will be revised to include the Ludeman Project as shown in SER Table 1.1-1:

License Condition 10.4 revisions:

> Prior to mining in each production unit or Ludeman Project wellfield, the licensee shall collect ground water samples and establish Upper Control Limits (UCLs) in accordance with Section 5.8 of the approved license application or Section 5.7.7.2 of the Ludeman Project Revised Technical Report, respectively. UCLs shall be applied to all monitor wells (with the exception of the mine unit baseline wells) in conformance with the approved license application and appropriate SOPs. The UCL parameters shall be chloride, conductivity, and total alkalinity.

The staff will also revise the License Condition 11.8 of the Willow Creek Source Material License SUA-1341 which address the surface water and ground water monitoring programs to include the Ludeman Project as shown in SER Table 1.1-1:

License Condition 11.8

> The licensee shall identify the location of any new ground water wells or new use of existing wells, where the information is publicly available and/or known to the licensee, that are located within the license area and within 2 kilometers of any Willow Creek production area or Ludeman Project wellfield monitoring ring wells. The licensee shall also report publicly available information such as well depth, screen depth and estimated pumping rate. The licensee shall evaluate the impact of ISR operations on ground water wells and recommend any additional monitoring or other measures to protect ground water users. The evaluation shall be submitted as part of the annual reporting to the NRC.

Based on the information provided by the licensee, and the NRC staff's review conducted of the characterization of the ground water and surface water monitoring program at the Ludeman Project, the NRC staff concludes that the characterization information is sufficient as it meets the acceptance criteria outlined in SRP Section 5.7.8.3. In addition, the programs were also found to comply with the following regulations in 10 CFR 40.32(c), which requires the licensee'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 licensee 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 ground water protection standards for contaminants; 10 CFR Part 40, Appendix A, Criterion 5D, which requires a ground water corrective action program; and 10 CFR Part 40, Appendix A, Criterion 7, which requires a detection and compliance ground water monitoring program. The licensee has defined acceptable ground water 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.

5.7.9 Quality Assurance

In this section, the NRC staff evaluates the licensee's proposed quality assurance programs for all radiological, effluent, and environmental (including ground water) monitoring programs.

5.7.9.1 Requirements

There are no regulatory requirements for quality assurance at ISR facilities.

5.7.9.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) using the acceptance criterion (1) in SRP Section 5.7.9.3 that states a quality assurance program is acceptable if it is consistent with the guidance in Regulatory Guides 4.14, Section 3 and 6 (NRC 1980a) and Regulatory Guide 4.15 (NRC 1979).

5.7.9.3 Staff Review and Analysis

In Section 5.7.8, “Quality Assurance Program,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to implement a quality assurance program consistent with guidance in Regulatory Guides 4.14, Section 3 and 6 (NRC 1980a) and Regulatory Guide 4.15 (NRC 1979).

5.7.9.4 Evaluation Findings

NRC has completed its review of the quality assurance program at the Ludeman Project. This review included an evaluation using the review procedures in SRP Section 5.7.9.2 and the acceptance criteria outlined in SRP Section 5.7.9.3.

The licensee has established an acceptable quality assurance program at the Ludeman Project. The quality assurance program has been applied to all radiological, effluent, and environmental programs consistent with Regulatory Guides 4.14 (NRC 1980a) and 4.15 (NRC 1979). The licensee has agreed to retain survey and instrument calibration records for 3 years and to retain records to demonstrate compliance and evaluate dose, intake, and releases to the environment until NRC terminates the license. Based on the information provided by the licensee and the detailed review conducted of the quality assurance program at the Ludeman Project, the NRC staff concludes that the quality assurance program is acceptable and is in compliance with 10 CFR 20.1101, which provides requirements for radiation protection programs; 10 CFR Part 20, Subpart L, which specifies record keeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting and notification requirements.

6.0 Ground Water Quality Restoration and Decommissioning

In this section the NRC staff evaluates the licensee's plans for ground water, surface reclamation, and facility decommissioning for the Ludeman Project.

6.1 Plans and Schedules for Ground-Water Quality Restoration

6.1.1 Regulatory Requirements

The NRC staff determines if the licensee has demonstrated that the proposed plans and schedules for ground water quality restoration at the Ludeman Project meet the requirements of 10 CFR 40.32(c), 10 CFR 40.42, and 10 CFR Part 40, Appendix A, Criterion 5B(5).

6.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in Section 6.1.3 of NUREG-1569 (NRC 2003).

6.1.3 Staff Review and Analysis

In this section, the staff reviews the licensee's proposed plans for restoration activities at the Ludeman 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 Ground Water Restoration Standards

The licensee stated it will restore the ground water in the production ore zone aquifer on a constituent-by-constituent basis to the ground water protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) in Section 6.1.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The ground water 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)). The NRC staff will therefore revise License Condition 10.15 as described in SER Section 6.1.4 and shown in SER Table 1.1-1 to include this the Criterion 5B(5) ground water restoration standards for the Ludeman Project.

The licensee stated it will conduct restoration using Best Practicable Technology (BPT) and the principle of ALARA. If restoration of a wellfield cannot achieve the Commission-approved background or values listed in paragraph 5C, the licensee stated it will submit a license amendment for the NRC's approval of an ACL. The licensee stated that an ACL request would occur after the licensee has demonstrated that it has used the BPT in its efforts to restore the specified constituent for which the ACL request is sought. The staff acknowledges that the term "best practicable technology (BPT)," does not have a regulatory definition. 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 licensee's commitment to BPT meets, in part, the ALARA requirements of Criterion 5B(6).

The licensee provided the criteria it will use to determine if it has met the require ground water protection standards to request approval of restoration in a wellfield in Section 6.1.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it will establish the RTVs from the baseline ground water quality for each constituent collected from baseline wells in each wellfield using appropriate statistical methods as described in SER Section 5.7.8.3.1. After the licensee has conducted restoration and determined that it has achieved the ground water protection standards as described above, it will conduct stability monitoring. The licensee stated that if no statistically significant increasing trends in restoration values are identified at the end of stability monitoring period, the licensee will deem the restoration complete. The licensee stated once the restoration is deemed complete it will then provide a summary report of the restoration and the appropriate water quality data to request approval of the restoration. Once NRC approves the restoration, the licensee stated it will begin decommissioning of the restored wellfield.

The NRC staff finds the licensee did not correctly describe stability monitoring in the Ludeman Project Revised Technical Report. However, the required stability monitoring is defined in License Condition 10.15 of the Willow Creek Source Material License SUA-1341. According to the license condition, the licensee is required to conduct four rounds of sampling of all WDEQ-LQD Guideline 8, Assay Suite A constituents during stabilization monitoring, with each well sample being at least three months apart. The licensee is required to continue the stability monitoring until the data show the most recent four consecutive samples indicate no statistically significant increasing trend for individual constituents which would lead to an exceedance above the approved target restoration values. Therefore, the NRC staff finds the licensee must demonstrate no statistically significant trend for the most recent four consecutive samples, not at the "end of the stability period" before the licensee can deem the restoration is complete. The NRC staff will therefore revise License Condition 10.15 as described in SER Section 6.1.4 and shown in SER Table 1.1-1 to include this stability monitoring commitment for the Ludeman Project.

The staff finds that the licensee's commitments are consistent with Acceptance Criterion (4) of SRP Section 6.1.3. In addition, with the license condition 10.15 revision, the staff finds that the licensee's commitments satisfy the regulatory requirements for restoration of the ground water to the ground water protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5).

6.1.3.2 Restoration Methods

The licensee stated that the ground water restoration program will consist of two phases: (1) active ground water restoration and (2) stability monitoring in Section 6.1.4 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The proposed active restoration methods will consist of:

- ground water transfer
- ground water sweep (targeted or selective)
- ground water treatment RO treatment with permeate injection and reductant addition)

The licensee described the ground water transfer phase in Section 6.1.4.1 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated that the ground water transfer will consist of recovering ground water from one wellfield in restoration and re-injecting the same ground water into another wellfield beginning production, or moving ground water between two areas that are in different stages of restoration within a single wellfield. The licensee stated that ground water transfer will help to lower the total dissolved solids levels in the wellfield being restored by displacing ground water affected by ISR production with baseline quality ground water. Prior to re-injection, the licensee stated that the ground water to be transferred may be passed through ion exchange (IX) columns or filters for additional uranium recovery.

The licensee described the GWS phase in Section 6.1.4.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d).The licensee stated that GWS may be used as a stand-alone process or in conjunction with ground water treatment. During GWS, ground water is pumped out of the wellfield without injection to create an influx of ground water from outside the wellfield to sweep the portion of the aquifer affected by ISR. The primary goal of GWS is to recover flared lixiviant outside of the production area. The licensee reported that a disadvantage of GWS is the consumptive use of ground water. To reduce this consumptive use, the licensee stated it will use the following strategies: (1) all ground water produced during GWS will be treated by RO; (2) when possible, permeate from the RO treatment of GWS will be reinjected into a wellfield undergoing RO treatment with permeate injection; (3) GWS will be used selectively, as necessary, rather than throughout the entire wellfield.

The licensee described the ground water treatment phase in Section 6.1.4.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated ground water treatment will consist of uranium removal through the IX columns and then treatment through the RO system to reduce the dissolved constituents. During the restoration phase, the RO system will consist of a dedicated wellfield production primary RO unit, a dedicated wellfield restoration primary RO unit and a secondary RO unit. The permeate from the wellfield primary RO unit will be reinjected into wellfields in production or restoration. The permeate from the wellfield restoration primary RO unit will be sent to the wellfields in restoration or the permeate pond. The brine from both primary RO units will be treated in the secondary RO unit. The permeate from the secondary RO unit will be returned to the wellfields in restoration. The brine from the secondary RO unit will be sent to the evaporation ponds or DDWs. The licensee indicated the use of primary and secondary RO units in this fashion will reduce the consumptive use of ground water as the majority of RO permeate will be injected. In addition, secondary RO treatment of the RO reject brine from the primary RO units will reduce the final volume of RO reject brine that will require disposal.

The licensee reported that chemical reductants such as sulfide and/or sulfite compounds may be added to the RO permeate stream before re-injection into a wellfield undergoing restoration to establish reducing conditions within the production zone aquifer. The licensee stated that the addition of reductant will decrease the solubility of arsenic, molybdenum, selenium, vanadium, and uranium which cannot be removed by RO treatment alone. The licensee stated that it may also add sodium hydroxide during ground water treatment to return the ground water to baseline pH.

The NRC staff finds that the restoration methods, including the use of reductant, are acceptable because they reflect historical ISR industry restoration practices that have achieved the ground water protection standards of 10 CFR Part 40, Appendix A, Criterion 5B(5), and are included as acceptable methods in Acceptance Criterion (3) of SRP Section 6.1.3 (NRC 2003). The staff

finds that the licensee will be able to achieve restoration to the required ground water protection standards.

6.1.3.3 Effectiveness of Ground Water Restoration Methods

The licensee described the effectiveness of the proposed ground water restoration methods in Section 6.1.7 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee provided several examples of ISR operations which have used the restoration methods proposed by the licensee as analogs to demonstrate these methods have been effective in achieving ground water restoration which meets applicable regulatory standards. These facilities are located near the Ludeman Project in the PRB and one facility, the Teton Leuenberger Pilot ISL facility, was located within the same 80 and 90 sand ore zone aquifers targeted in proposed Wellfield 1 of the Ludeman Project (NRC 1983).

The licensee reported that the first example of successful restoration using the proposed methods was for Wellfields 1-9 at its Willow Creek Irigaray ISR, located in the PRB. These wellfields were restored using the GWS and treatment by RO. The licensee reported that 27 of 29 constituents were returned to baseline. Only two non-hazardous constituents did not reach baseline, but were restored to their pre-operational class of use. The NRC approved the restoration of Irigaray Wellfields 1-9 stating that the wellfields had been restored in compliance with applicable regulatory requirements.

The second example the licensee described was the successful restoration of the MU-A wellfield at the Smith Ranch–Highland Uranium Project which is located just to the northeast of the Ludeman Project. ISR operations were conducted at this facility in sandstones of the Fort Union Formation, which are also the sandstones targeted at the Ludeman Project. The restoration methods used at the MU-A wellfield included GWS, ground water treatment (RO) and addition of a chemical reductant (hydrogen sulfide). The licensee stated that not all constituents were returned to baseline following restoration at the MU-A wellfield but that the ground water quality was consistent with Wyoming's pre-operational class-of-use standard. The licensee reported that restoration at the MU-A was approved by the NRC and WDEQ.

The licensee also described the restoration of the Teton Leuenberger ISL pilot project in Section 6.1.6.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported this ISL pilot was conducted in 1980 in three five spot patterns in the 80 sand ore zone and one pattern in the 90 sand ore zone. NRC staff determined that all of these five spot patterns were located within the footprint of the Ludeman Project Wellfield 1 as described in SER Section 2.4.3.2. The licensee reported a bicarbonate lixiviant was used. The restoration of the three patterns in the 80 sand was conducted in four phases using various combinations of GWS, ground water treatment by ion exchange and electro dialysis reversal (EDR) and reinjection of treated water. The restoration of the 90 sand pattern was conducted in 5 phases which included periods of ground water treatment by ion exchange, GWS, and ground water transfer. The NRC staff found the restoration and decommissioning of the Teton Leuenberger ISL pilot was approved in 1986 (NRC 1986).

The staff finds that the licensee's evaluation of effectiveness of the restoration methods is consistent with Acceptance Criterion (3) of SRP Section 6.1.3 (NRC 2003).The NRC staff also finds that the licensee has provided satisfactory analogs to demonstrate the effectiveness of its proposed restoration methods because of the similarities in hydrogeologic settings, lixiviant composition and similar restoration methods. The NRC staff finds, based on the success of these analogous restorations, that the licensee's proposed restoration methods are acceptable

to achieve the NRC's ground water protection standards of 10 CFR Part 40 Appendix A Criterion 5(B)(5) at the Ludeman Project.

6.1.3.4 Pore Volume Estimates

The licensee provided its estimate of the number of pore volumes required to achieve restoration to the required ground water protection standards in Section 6.1.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated the number of pore volumes required is dependent on the efficiency of the RO treatment to reduce total dissolved solids and the success of the reductant in lowering the uranium and trace metals.

The licensee stated a pore volume (PV) is defined as the product of the thickness of the ore sand, the wellfield pattern area, effective porosity, flare, and a conversion factor. The thickness of the ore sand is the average completion thickness of the production wells. The flare is an estimate of the vertical and horizontal spread of the lixiviant outside the area of the wellfield pattern. The licensee stated it will use a flare factor 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. The licensee used a conversion factor of 7.48 to convert cubic ft to gallons. The licensee stated and the NRC staff agreed that this method to calculate pore volume is consistent with those used at existing licensed ISR facilities.

To estimate the number of pore volumes to achieve restoration, the licensee provided an analysis of pore volumes required for restoration at ISR wellfields which have been approved for restoration. In Section 6.1.6.1, the licensee reported that average number of pore volumes required to achieve restoration at its Willow Creek Christensen and Irigaray wellfields was 12.6 and 13.7, respectively. The licensee stated its review of the Christensen Ranch and Irigaray wellfield restorations showed that the number of pore volumes used was excessive because the GWS phase was often largely ineffective and that RO treatment was continued in some wellfields after it was apparent that water quality improvement was minimal. In Section 6.1.6.2 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee reported the restoration of the Teton Leuenberger Pilot ISL 80 sand wellfield patterns was accomplished with 4.4 pore volumes for all restoration phases and the restoration of the 90 sand wellfield pattern was accomplished with 2.4 pore volumes.

Based on its experience with the restoration of the Willow Creek Christensen and Irigaray wellfields, the licensee stated it will be able to more effectively apply GWS and RO treatment to reduce the number of pore volumes required. The licensee also indicated that the restoration experience at the Teton Leuenberger ISL pilot supported a finding that fewer pore volumes would be required to achieve restoration at the Ludeman Project. The licensee therefore stated its initial pore volume estimate to achieve restoration for Wellfields 1-6 is 4 to 6.

The NRC staff reviewed the licensee's estimated pore volumes and finds that this information is adequate because it meets Acceptance Criteria (1), (2), and (3) of SRP Section 6.1.3 (NRC 2003) by including descriptions of the PVs, flare factors, and the level of effort needed for restoration. The staff also finds the licensee's estimate of pore volumes to be acceptable because the estimate is within the range currently used by industry.

6.1.3.5 Ground Water Restoration Monitoring

The licensee described its ground water restoration monitoring program in Section 6.1.3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it will monitor the production zone aquifer undergoing restoration at a frequency adequate to determine the success of restoration, optimize efficiency of restoration techniques and determine if any areas of the wellfield require attention. The licensee provided a list of constituents to be measured at the start of and through restoration as needed in Table 6-1of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The NRC staff found this table contained all of the constituents recommended to be measured for wellfield baseline water quality as listed in Table 2.7.3-1 of NUREG-1569 (NRC 2003).

The licensee stated that it will decrease the sampling frequency of the excursion monitoring wells from semi-monthly (twice per month) to once every 60 days. The licensee stated the justification for this reduction in sampling 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 finds the licensee's proposed restoration monitoring is consistent with Acceptance Criterion (3) of SRP Section 6.1.3 by including a description of monitored constituents, sampling frequency, and sampling density. The staff finds it acceptable because similar restoration monitoring programs have been conducted at existing ISR facilities and have provided sufficient data to demonstrate the restoration was operated safely. The NRC staff also finds that the licensee's proposed wellfield restoration monitoring is consistent with that used at the currently licensed Willow Creek facility. The NRC staff has not identified any new safety-related concerns pertaining to the wellfield excursion monitoring design based on the staff's evaluation of the performance of the Willow Creek facility since the last license renewal safety evaluation (NRC 2013b) as described in SER Appendix A. Therefore, staff finds that the licensee's proposed restoration monitoring is acceptable.

6.1.3.6 Restoration Waste Water Disposal

SER Sections 3.1.3.9, 3.1.3.10 and 4.2.3.1 describe the licensee's disposal of wastewater during the different phases of wellfield operations. In these sections, the NRC staff finds that the licensee has demonstrated it has sufficient waste disposal capacity under the proposed option and first alternative for liquid waste from wellfield restoration. Therefore, the staff finds that the licensee's plans for disposing of restoration wastewater are acceptable and consistent with SRP Acceptance Criteria (8) and (13) of SRP Section 6.1.3.

6.1.3.7 Well Plugging and Abandonment

The licensee described the procedures for plugging and abandonment of wells in a wellfield after the regulatory agencies concur that ground water in a wellfield has been adequately restored and is stable in Section 6.1.9 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee 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.

The staff reviewed the licensee's proposed plugging and abandonment procedures and finds them to be acceptable because they meet Acceptance Criterion (7) of SRP Section 6.1.3 (NRC 2003), which states that plugging and abandonment procedures that are "codified in State regulations or rules are considered acceptable."

6.1.3.8 Restoration Schedule

The licensee described its schedule for restoration and stability monitoring schedule for the Ludeman Project in Section 6.1.8 and Figure 1-3 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee reported it will begin restoration immediately following uranium recovery operations at a wellfield. The schedule in Figure 1-3 shows active restoration will be completed in each wellfield in less than 24 months. The licensee, however, stated it expects that the combined active restoration, stability monitoring, and surface reclamation and decommissioning of all wellfields may exceed 24 months. The licensee stated it will therefore request that staff approve an alternate schedule in accordance with the timelines in decommissioning regulations pursuant to 10 CFR 40.42.

The staff reviewed the proposed restoration schedule and stability monitoring program and finds the proposed schedule meets Acceptance Criteria (3) and (6) of SRP Section 6.1.3 (NRC 2003), provided that the licensee 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 ground water restoration. The NRC staff will revise License Condition 10.15 of Willow Creek Source Material License SUA-1341 which has a requirement for the licensee to submit a request for an alternate schedule which will also be applicable to the Ludeman Project as described in SER Section 6.1.4 and shown in SER Table 1.1-1.

6.1.4 Evaluation Findings

The NRC staff evaluated the licensee's plans and schedules for ground water quality restoration for the Ludeman Project using in accordance with the review procedures in the SRP Section 6.1.2 and the acceptance criteria in the SRP Section 6.1.3.

The NRC staff finds the licensee has acceptably described the plans and schedules by providing: a commitment to achieve the ground water protection standards 10CFR Part 40 Appendix A Criterion 5(B)(5); a description of restoration methods; an evaluation of the effectiveness of proposed restoration methods; an estimate of pore volumes; a description of ground water restoration monitoring; a description of restoration waste water disposal; a commitment to well plugging and abandonment; and a restoration schedule.

Based on the information provided by the licensee, and the NRC staff's review conducted of the restoration plans and schedules at the Ludeman Project, the NRC staff concludes, that with one exception, the information is sufficient as it meets the applicable acceptance criteria of SRP Section 6.1.3. As described in SER Section 6.1.3.1, the licensee incorrectly described the stability monitoring period requirements for ground water restoration. The NRC staff will therefore revise License Condition 10.15 as described in SER Section 6.1.4 and shown in SER Table 1.1-1 to include this stability monitoring commitment for the Ludeman Project, as well as revisions to include the Ludeman Project commitment to achieve the ground water restoration standards and meet the requirements of 10 CFR 40.42:

License Condition 10.15

The licensee shall conduct ground water restoration and post-restoration monitoring as described in Section 6.1 of the approved license application and Section 6.1 of the Ludeman Project Revised Technical Report**.** The primary goal of restoration shall be to return the ground water quality, on a production-unit average, to baseline concentrations on a parameter-by-parameter basis. If the primary goal cannot be achieved, the ground water will, at a minimum, be returned to an alternate standard approved by the NRC. In submitting any license amendment application requesting review of proposed alternate concentration limits pursuant to 10 CFR 40, Appendix A, Criterion 5(B)(6), the licensee must also show that it has first made practicable efforts to restore the specified hazardous constituents to the background or MCLs (whichever is greater).

For the Willow Creek Project and the Ludeman Project, the licensee shall conduct four rounds of sampling of all WDEQ-LQD Guideline 8, Assay Suite A constituents during stabilization monitoring, with each well sample being at least three months apart. The licensee shall continue the stability monitoring until the data show the most recent four consecutive samples indicate no statistically significant increasing trend for individual constituents which would lead to an exceedance above the approved target restoration values.

Changes to ground water restoration or post-restoration monitoring plans shall be submitted to the NRC for review and approval at least 2 months prior to ground water restoration in a mining unit or Ludeman Project wellfield.

The licensee shall conduct ground water restoration activities in accordance with the approved LRA application and Section 6.1 of the Ludeman Project Revised Technical Report for Ludeman Project wellfields. Permanent cessation of lixiviant injection in a production area would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of ground water restoration and decommissioning for any particular production area. If the licensee determines that these activities are expected to exceed 24 months for any particular production area, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42.

Based on its review of the information provided in the Ludeman Project Revised Technical Report (Uranium One USA 2017d), and the revised license condition noted above, the staff is reasonably assured that the licensee will restore ground water to the ground water 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 this information demonstrates the licensee will meet requirements of 10 CFR 40.32(c), 10 CFR 40.42.

6.2 Decommissioning

6.2.1 Regulatory Requirements

The staff determines if the licensee has demonstrated that the proposed plans for decommissioning at the Ludeman Project meet the requirements of 10 CFR 40.42 and 10 CFR Part 40, Appendix A, Criterion 6(6).

6.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in NUREG-1569 Sections 6.2.3, 6.3.3, and 6.4.3 (NRC 2003).

6.2.3 Staff Review and Analysis

In this section, the NRC staff evaluates the licensee's plans for decommissioning the proposed Ludeman Project. The requirements for decommissioning an ISR facility are contained in 10 CFR 40.42, "Expiration and termination of licenses and decommissioning of sites and separate buildings or outdoor areas." The applicable standards for residual byproduct material concentrations in soil are contained in 10 CFR Part 40, Appendix A, Criterion 6(6).

Timely Submittal of Decommissioning Plans

In Section 6.2, "Plans and Schedules for Reclaiming Disturbed Lands," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to provide a final detailed decommissioning plan for each wellfield at least 12 months before commencing final decommissioning of these facilities. The licensee also committed to provide a final detailed decommissioning plan for the satellite plant, pipelines, and other infrastructure at least 12 months before commencing final decommissioning of these facilities. The NRC staff determined that these commitments are acceptable because they meet acceptance criteria 6.2.3(7) and 6.3.3(6) of the SRP.

The licensee also stated that it would perform pre-reclamation radiological surveys in a manner consistent with Acceptance Criterion (2) of SRP Section 6.2.3 (NRC 2003). This involves the use of instruments and techniques similar to those used in the pre-operational survey; current or updated survey technology, if necessary to ensure acceptable sensitivity; consideration of operational monitoring results; and consideration by the licensee of other information that provides insights into areas of expected contamination, such as diversion ditches, surface impoundments, well field surfaces, structures in process and storage areas, and transportation routes. Acceptance Criterion 6.2.3(2) of the SRP (NRC 2003) also notes that acceptable methods for sampling are provided in NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (NRC 2000). The NRC staff determined that the licensee's commitment to pre-reclamation radiological surveys is acceptable because it meets Acceptance Criterion (2) of SRP Section 6.2.3(2).

In accordance with 10 CFR 40.42(g), Acceptance Criteria 6.3.3(6) of the SRP, and the licensee's commitment, the NRC staff will impose a new License Condition 10.27 to Willow Creek License SUA-1341 requiring decommissioning plans for each wellfield and an additional decommissioning plan for the satellite plant, pipelines and other infrastructure. The plans may either be revisions or addenda to the existing Willow Creek Project Decommissioning Plan, or independent plans. The license condition will state:

License Condition 10.27

At least 12 months prior to initiation of any planned final site decommissioning, reclamation, or ground water restoration at the Ludeman Project, the licensee shall submit a detailed decommissioning plan for NRC staff review and approval. The plan shall represent as-built conditions at the Ludeman Project.

Description of Decommissioning Activities Prior to Surface Reclamation

In Section 6.3, "Procedures for Removing and Disposing of Structures and Equipment," of the Ludeman Project Revised Technical Report, the licensee described its characterization survey methodology for structures and equipment (Uranium One USA 2017d). In Section 6.3.1, "Preliminary Radiological Surveys and Contamination Control," the licensee stated, in general, it would use the same contamination control program it used during mining operations to determine where radiological contamination exists. The licensee also committed to using successively more aggressive techniques to remove surface contamination (e.g., high-pressure water, then dilute acid, if necessary). The NRC staff determined that the licensee's commitment to its contamination control program is acceptable because it meets Acceptance Criterion (4) of SRP Section 6.3.3 (NRC 2003).

In Section 6.3.2, "Removal of Process Buildings and Equipment," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated it intends to decontaminate, dismantle, and release all ISR project facility buildings for use at future locations by landowners, other ISR facilities, or other industries. What buildings cannot be released for unrestricted use will be disposed of as solid 11e. (2) byproduct material. The NRC staff observes that the licensee committed in Section 6.3.2.1, "Building Materials, Equipment and Piping to be Release for Unrestricted Use," to the radiation release limits in Regulatory Guide 8.30 and SRP Section 5.7.6. However, as described in Section 5.7.6 of this SER, the licensee is required by License Condition 9.8 to use the criteria in the 1993 Guidelines (NRC 1993) for release for unrestricted use. The NRC staff determined that the licensee's commitment to decontaminate, dismantle, and release all ISR project facility buildings for use at future locations by landowners, other ISR facilities, or other industries is acceptable because it meets Acceptance Criterion (1) of SRP Section 6.2.3, and Acceptance Criteria (1), (2), (3), and (4) of SRP Section 6.3.3 (NRC 2003).

In Section 6.3.2.2, "Preparation for Disposal at a Licensed Facility," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described procedures for disposing of contaminated facilities and equipment. In Section 6.3.4, "Waste Transportation and Disposal," the licensee described its current solid 11e. (2) disposal facility agreement, and its commitment to transport solid 11e. (2) byproduct material in accordance with applicable transportation regulations in 10 CFR 71. The NRC staff determined the licensee's procedures for disposing of contaminated facilities and equipment are acceptable because they meet Acceptance Criterion (6) of SRP Section 6.2.3 and Acceptance Criterion (5) of SRP Section 6.3.3. (NRC 2003)

In Section 6.4, "Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys," and Section 6.5, "Decommissioning Health Physics and Radiation Safety," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its cleanup criteria, source of background radiological data, surveys of known spill areas, final status surveys, and 95 percent confidence levels. The licensee also addressed the radiation safety program during decommissioning. In Section 6.4.1, "Cleanup Criteria," the licensee described its methodology for determining soil cleanup standards over the first 15 cm of soil below the surface using the benchmark approach described in 10 CFR 40,

Appendix A, Criterion 6(6). The NRC staff evaluated the licensee's benchmark calculations that the licensee performed using RESRAD Version 6.4. The licensee used appropriate assumptions and methodologies consistent with the criteria in Appendix E of the SRP (NRC 2003). The licensee did not calculate cleanup criteria for thorium-230. However, the NRC staff evaluated whether the licensee should calculate cleanup criteria for thorium-230 by considering the information provided by the licensee in Table 2.9-7, "Summary Statistics for Dissolved Radionuclides in Groundwater for All Individual Quarterly Samples," and Figure 2.9-44, "Groundwater Mean Quarterly Th-230 Results," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). Consistent with the NRC staff's general experience with thorium in ground water, the licensee's data indicates thorium-230 is usually not detected and would not be expected to be a contaminant during future decommissioning.

The NRC staff determined that the licensee's commitment to cleanup criteria, source of background radiological data, surveys of known spill areas, final status surveys, and 95 percent confidence levels is acceptable because it meets Acceptance criteria 6.2.3(3), 6.2.3(5), 6.4.3(1), 6.4.3(2) 6.4.3(3), 6.4.3(4), and 6.4.3(5) of the SRP (NRC 2003).

Surface Reclamation

Because there are no applicable NRC regulations for surface reclamation, the NRC staff did not evaluate in detail the information described below contained in the four sub-sections of Section 6.2, "Plans and Schedules for Reclaiming Disturbed Lands," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The State of Wyoming, Department of Environmental Quality (WDEQ) requirements (WDEQ 2013) for surface reclamation are addressed by the licensee in its permit application.

In Section 6.2.1, "Surface Disturbance," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee explained that the satellite building and ancillary buildings, evaporation/permeate ponds, header houses, pipeline corridors, and access roads are the primary surface disturbances. The licensee stated that topsoil stripped from these areas prior to construction will be saved for reuse later during reclamation. In wellfields, the licensee stated that it will complete final surface reclamation after approval of ground water restoration stability and after wells are abandoned. The licensee will not remove drill mud pits. In Section 6.2.2, "Topsoil Handling and Replacement," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described its process for salvaging topsoil and locating topsoil on the leeward side of hills to minimize wind erosion, applying seed to the piles, and clearly posting signs on or near the piles. In Section 6.2.3, "Final Contouring," the licensee committed to no major re-contouring of the site, and that post-reclamation contours will be reflect pre-operation contours. In Section 6.2.4, "Revegetation Practices," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated that revegetation will be in accordance with Wyoming Department of Environmental Quality/Land Quality Division regulations.

6.2.4 Evaluation Findings

The NRC staff has completed its review of the licensee's decommissioning program description at the Ludeman Project. This review included an evaluation of the methods that will be used using the review procedures in SRP Sections 6.2 through 6.4.

The licensee has acceptable plans for pre-reclamation (characterization) radiation surveys that will use instrumentation and techniques similar to the pre-operational survey used to establish baseline site conditions. The licensee has committed to consider results from operational monitoring and other information relative to areas of expected contamination in its decommissioning plans. Future decommissioning plans that meet 10 CFR 40.42(g) will address appropriate procedures for the pre-reclamation survey and the means used to identify areas for cleanup using the acquired data and any required changes to the radiation safety program identified as a result of the decommissioning work will be implemented before commencing the work.

The licensee has established an acceptable program for the measurement and control of residual contamination on structures and equipment. In future decommissioning plans, the licensee will propose 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. All premises, equipment, or scrap likely to be contaminated but that cannot be measured, will be assumed by the licensee to be contaminated in excess of limits and will be treated accordingly. For all premises, equipment, or scrap contaminated in excess of specified limits, the licensee will provide detailed, specific information describing the premises, equipment, or scrap in terms of extent and degree of radiological contamination. The licensee will provide a detailed health and safety analysis that reflects that the contamination and any use of the premises, equipment, or scrap will not result in an unacceptable risk to the health and safety of the public or the environment. The licensee 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. The licensee will have a contract with a licensed waste disposal site operator to dispose 11e. (2) byproduct material.

The licensee has developed acceptable methodologies for verification of cleanup (final status survey plan) that demonstrate that the radium concentration in the upper 15 cm [5.9 in.] of soil will not exceed 5 pCi/g and in subsequent 15 cm [5.9 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 (Appendix E), including a demonstration of ALARA.

Based on the information provided in the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the NRC staff concludes that future Decommissioning Plans will comply with 10 CFR 40.32(c), which requires licensee 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 licensee 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 licensee provide objective evidence of an agreement for disposal of 11e.(2) byproduct materials either in a licensed 11e.(2) byproduct materials disposal site to demonstrate non-proliferation of waste disposal sites; and 10 CFR Part 40, Appendix A, Criterion 6(6), which identifies cleanup criteria requirements.

The final decommissioning plans will specify the location of records of information important to the decommissioning as required by 10 CFR 40.36(f) and will meet the criteria of 10 CFR 40.42(g) (4) and (5). The final decommissioning plans will sufficiently demonstrate that the proposed decommissioning activities will result in compliance with 10 CFR 40.42(j) (2) requirements to conduct a radiation survey. The final decommissioning plans will comply with

the 10 CFR 40.42(k) (1) and (2) requirements that source material be properly disposed of and reasonable effort be made to eliminate residual radioactive contamination.

6.3 Financial Assurance

6.3.1 Regulatory Requirements

The staff determines if the proposed financial assurance for the Ludeman Project meets the requirements of 10 CFR Part 40, Appendix A, Criterion 9.

6.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the staff reviewed the Ludeman Project Revised Technical Report (Uranium One USA 2017d) for compliance with applicable regulations of 10 CFR Part 40 using the acceptance criteria in SRP Section 6.5.3 of the SRP (NRC 2003).

6.3.3 Staff Review and Analysis

The licensee presented its financial assurance commitments in Section 6.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it currently maintains financial surety instruments for its Willow Creek Project in the form of Irrevocable Letters of Credit to cover the cost of reclamation including the costs of groundwater restoration, decommissioning, dismantling and disposal of all buildings and other facilities and the reclamation and revegetation of affected areas.

The NRC staff finds the licensee has maintained an acceptable financial surety arrangement for the Willow Creek Project that is consistent with 10 CFR 40, Appendix A, Criterion 9. The current financial assurance instrument is an Irrevocable Standby Letter of Credit with a face value of $21,624,510 in favor of the WDEQ (NRC 2016a). The financial surety amount has been revised annually in accordance with Byproduct and Source Materials License SUA-1341. Each annual revision to the surety amount has been based on an annual detailed cost estimate provided by the licensee and approved by the NRC. The NRC staff observes that NRC's previous approval of the licensee's annual surety estimates have demonstrated that the licensee has maintained sufficient funds in the surety for completion of the above-referenced activities by an independent contractor (NRC 2016d).

License Condition 9.5 of the Willow Creek Source Materials License SUA-1341 requires that at least 90 days prior to beginning construction associated with any planned expansion or operational change, which was not included in the annual surety update, the licensee shall provide, for NRC approval, an updated surety to cover the expansion or change (NRC 2016a). Thereafter, the licensee will be required to provide annual surety updates to the NRC to include estimated annual costs for the Willow Creek Project each year in accordance with requirements of its license (NRC 2016a). According to this license condition, the licensee will be required to provide an updated surety to cover the Ludeman Project expansion for NRC review and approval. The NRC staff therefore finds License Condition 9.5 of the Willow Creek Source Material License SUA-1341 applies to the Ludeman Project without revision.

The licensee stated the ground water restoration costs for the updated financial assurance for the Ludeman Project will be based on one pore volume for GWS and 6 pore volumes for RO and reductant addition in Section 6.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d). The licensee stated it will use a flare factor of 1.44, which is the

same that was applied for the Willow Creek facility license SUA-1341. As discussed in SER Section 6.1, the NRC staff finds the licensee has provided adequate technical basis for this PV estimate for ground water restoration. The technical basis provided by the licensee includes an analog study comparing restoration efforts at other ISR facilities, as well as a commitment to follow timely and efficient restoration practices.

The licensee did not include a financial assurance estimate in the Ludeman Project Revised Technical Report (Uranium One USA 2017d); however, the licensee did provide a financial assurance estimate for the first year of Ludeman Project operations in a separate email submission in November 2017 (Uranium One USA 2017f). In this submission, the licensee provided a financial assurance estimate of $2,952,570 that includes costs for the first year of operations related to decommissioning, ground water restoration, and reclamation activities required for the satellite facility and ponds, the first wellfield and offsite disposal of all wastes, including byproduct material, to allow their release for unrestricted use.

The financial assurance documentation included a breakdown of costs, the basis for cost estimates, and a 15 percent contingency. The cost estimate included the costs for an independent contractor to complete facility decommissioning and waste disposal, ground water restoration and well plugging, pond decommissioning, radiological survey, and environmental monitoring to allow the site to be released for unrestricted use. The licensee committed 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 included operational costs, such as environmental sampling, that would be needed during ground water restoration and surface reclamation.

The financial assurance estimate did not identify specific costs related to the cleanup of spills in the wellfields. The licensee 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.

In Section 6.6 of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee also committed to perform the following administrative issues related to financial assurance:

- Provide an annual adjustment of the financial assurance value and 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.

6.3.4 Evaluation Findings

The NRC staff evaluated the licensee's financial assurance commitments and methods of cost estimation for the Ludeman Project in accordance with the review procedures in SRP Section 6.5.2 and the acceptance criteria in SRP Section 6.5.3.

The staff finds the licensee has developed its cost estimates to address items in Appendix C of the NRC's SRP (NRC 2003). In an email submission (Uranium One USA 2017f), the licensee provided a cost estimate that follows the outline in Appendix C of NRC's SRP (NRC 2003) and includes ground water 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 licensee 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 licensee has not proposed a revision to the 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. The NRC staff therefore finds License Condition 9.5 of the Willow Creek Source Material License SUA-1341 applies to the Ludeman Project without revision.

Based on the information provided and the staff's recent review of the existing financial surety under Willow Creek License SUA-341 and current review of the decommissioning cost estimate for the Ludeman Project, the staff concludes the licensee's financial assurance commitments and its methods of estimation are acceptable and consistent with 10 CFR Part 40, Appendix A, Criterion 9.

7.0 Accidents

In this section, the NRC staff evaluates accident scenarios described in the Ludeman Project Revised Technical Report (Uranium One USA 2017d) to determine whether they are reasonable based on descriptions of the proposed facility and operations. The NRC staff evaluates whether the design and operation of the licensee's proposed facilities are consistent with generic operating assumptions, site features, and designs previously examined by the NRC staff (NRC 1980c, 2001, 2009c, 2013b). Where the design and operation of proposed facilities are consistent with generic conditions previously analyzed, the NRC staff's evaluation focuses on accident response procedures and personnel training. If the licensee's operating assumptions, site features, and designs are not consistent with generic conditions previously analyzed, the licensee must conduct independent accident analyses.

7.1 Regulatory Requirements

The NRC staff determines if the licensee has addressed potential accidents at the Ludeman Project and demonstrated that it will meet the requirements of 10 CFR 40.32(c), that requires the licensee's proposed procedures be adequate to protect public health and minimize danger to life or property should an accident occur.

7.2 Regulatory Acceptance Criteria

Where the licensee has performed an independent analysis of the consequences of accidents because the proposed facilities are not consistent with the operating assumptions, site features, and designs examined in prior NRC analyses (NRC 1980c, 2001, 2009c, 2013b), the independent analysis is acceptable if:

(1) The licensee has provided analyses of credible accident consequences that are consistent with the facility design and planned operations and are sufficient to identify likely environmental impacts from operations.

(2) Analyses of accident consequences include mitigation measures, as appropriate.

(3) Analyses of accidents include results from operating experience at similar facilities.

(4) For radiological accidents, the licensee's response program provides for notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

Adequate procedures to respond to and mitigate or remediate the likely consequences of accidents are identified or referenced in the Ludeman Project Revised Technical Report (Uranium One USA 2017d).

7.3 Staff Review and Analysis

In accordance with the acceptance criteria above, the NRC staff first evaluated whether accidents described in Section 7.5, "Effects of Accidents" of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) were consistent with the operating assumptions, site features, and designs examined in prior NRC analyses (NRC 1980c, 2001, 2009c, 2013b). Because the Ludeman Project is a remote satellite facility comprised of wellfields, ion exchange equipment, and related supporting chemicals, equipment, and operations, the NRC staff focused its evaluation on its generic assessment of accident risk at ISRs (NRC 2001) to

determine which accident scenarios the licensee should consider. Because all the accidents evaluated below in SER Section 7.3.1, "Comparison to Previous Accident Analyses," are consistent with the operating assumptions, site features, and designs examined in prior NRC analyses, the NRC staff verified that training and procedures will be in placed to respond to accidents (see SER Section 7.3.2, "Accident Response Procedures and Personnel Training").

Though NRC's prior analyses considered both radiological and non-radiological hazards, the NRC staff observes that under its 2013 Memorandum of Understanding with the Occupational Safety and Health Administration (OSHA) (OSHA 2013), the NRC regulates three out of four types of hazards at NRC-licensed facilities: (1) radiation risk produced by radioactive materials; (2) chemical risk produced by radioactive materials; (3) facility conditions which affect the safety of radioactive materials and thus present an increased radiation risk to workers. For example, these might produce a fire or an explosion, and thereby cause a release of radioactive materials or an unsafe condition. The fourth hazard is regulated by OSHA: plant conditions which result in an occupational risk, but do not affect the safety of licensed radioactive materials. For example, there might be exposure to toxic non-radioactive materials and other industrial hazards in the workplace. In the following safety evaluation, the NRC staff identifies where the evaluated hazard is regulated by OSHA.

7.3.1 Comparison to Previous Accident Analyses

The NRC staff compared the accidents described in Section 7.5, "Effects of Accidents" of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) to the NRC staff's prior analyses to verify that the licensee's analyses were consistent with the operating assumptions, site features, and designs examined in prior NRC analyses (NRC 1980c, 2001, 2009c, 2013b).

Oxygen Fire and/or Explosion

In Section 4.1.3, "Hazardous Analysis for Oxygen," of NRC's baseline hazard analysis (NRC 2001), the NRC described the hazards at an ISR facility associated with the storage of oxygen and the practice of adding oxygen to barren lixiviant to facilitate the oxidation and dissolution of uranium in wellfield ore bodies. Because oxygen supports combustion, fire and explosion are the main hazards associated with its storage and use. However, no particular radiological consequences were assessed in NRC's prior analysis. As a result, this remains an OSHA-regulated hazard. The NRC's recommendation for reducing the risk of fires and/or explosions resulting from oxygen leaks was a prevention strategy. Specifically, NRC recommended that licensees follow design and operating practices published in accepted codes and standards that govern oxygen systems.

Consistent with NRC's prior analysis, the licensee proposed in Sections 3.2.2.1.1, "Oxygen Storage and Delivery System," and 7.5.2, "Fires and Explosion," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that oxygen at the Ludeman Project will be stored in tanks located at least 25 ft from buildings or as required by NFPA-50, "Standard for Bulk Oxygen Systems at Consumer Sites," (NFPA 1996) and OSHA standards in 29 CFR 1910, "Occupational Safety and Health Standards." Therefore, the licensee's proposed oxygen storage and use is consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Hydrogen Peroxide Leak

In Section 4.1.4, “Hazardous Analysis for Hydrogen Peroxide,” of NRC’s prior baseline hazard analysis (NRC 2001), the NRC described the hazards at an ISR facility associated with the storage of hydrogen peroxide and the practice of adding hydrogen peroxide to barren lixiviant to facilitate the oxidation and dissolution of uranium in wellfield ore bodies. Hydrogen peroxide is a strong oxidizer that decomposes rapidly under certain physical and chemical conditions. Hydrogen peroxide vapors are hazardous, causing body tissue irritation and blistering of the skin. In its prior analysis (NRC 2001), NRC did not identify any particular radiological hazards associated with hydrogen peroxide leaks. As a result, this remains an OSHA-regulated hazard. In its prior analysis (NRC 2001), the NRC calculated the potential concentration of hydrogen peroxide in air that could result from a 0.38 liter per minute (0.1 gallon per minute [gpm]) leak of 50 percent hydrogen peroxide solution that goes undetected for 10 minutes. The analysis concluded that the hydrogen peroxide concentration in air could exceed the immediately dangerous to life and health (IDLH) value (NIOSH 2017). As a result, NRC recommended that licensees follow design and operating practices published in accepted codes and standards that govern hydrogen peroxide systems.

Consistent with NRC’s prior analysis, the licensee proposed in Sections 7.5.1.1, “Vessel or Tank Failure,” and 7.5.1.2, “Chemical Spills and Accidents,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that storage and use of hydrogen peroxide will be in accordance with applicable ASME and ASTM codes. Therefore, the licensee’s proposed hydrogen peroxide storage and use is consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Carbon Dioxide Leak and Asphyxiation

In Section 4.1.7, “Hazardous Analysis for Carbon Dioxide,” of NRC’s prior baseline hazard analysis (NRC 2001), the NRC described the hazards associated with the storage of carbon dioxide and the common practice of adding carbon dioxide to barren lixiviant to facilitate the dissolution of uranium in wellfield ore bodies. The hazard associated with carbon dioxide leaks is its potential to displace oxygen and cause asphyxiation. No particular radiological consequences were assessed in NRC’s prior analysis of carbon dioxide leaks. As a result, this remains an OSHA-regulated hazard. The NRC’s recommendation for reducing the risk of asphyxiation resulting from carbon dioxide leaks was a prevention strategy. Specifically, NRC recommended that licensees should follow design and operating practices published in accepted codes and standards that govern carbon dioxide systems.

Consistent with NRC’s prior analysis, the licensee stated in Sections 3.2.2.1.2, “Carbon Dioxide Storage and Delivery System,” and 7.5.1.2, “Chemical Spills and Accidents,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that it will reduce the likelihood of asphyxiation by carbon dioxide by storing carbon dioxide outdoors in accordance with industry standards. Therefore, the licensee’s proposed storage and use of carbon dioxide is consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Sodium Carbonate Spill

In Section 4.1.9, “Hazardous Analysis for Sodium Carbonate and Sodium Chloride,” of NRC’s prior baseline hazard analysis (NRC 2001), the NRC described the hazards at an ISR facility associated with the storage of sodium carbonate and the common practice of using sodium carbonate to regenerate ion exchange resin. The hazard associated with sodium carbonate is

that it is a skin and eye irritant and is also moderately toxic if inhaled. The NRC concluded in its prior analysis (NRC 2001) that concentrated sodium carbonate solution is not volatile and a spill would not pose a significant radiological or non-radiological inhalation hazard to workers. As a result, this remains an OSHA-regulated hazard. Therefore, NRC recommended that licensees should adopt design and operating practices published in accepted codes and standards that govern sodium carbonate systems are adequate.

Consistent with NRC's prior analysis, the licensee stated in Section 7.5.1.2, "Chemical Spills and Accidents," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that it will store and use sodium carbonate in accordance with industry standards. Therefore, the licensee's proposed storage and use of sodium carbonate is consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Sodium Sulfide Spill

In Section 4.1.10, "Hazardous Analysis for Hydrogen Sulfide and Sodium Sulfide," of NRC's prior baseline hazard analysis (NRC 2001), the NRC described the hazards associated with the storage of sodium sulfide and the common practice of using sodium sulfide to immobilize heavy metals during ground water restoration. Sodium sulfide poses two types of hazards: it is flammable and corrosive. No particular radiological consequences were assessed in NRC's prior analysis of sodium sulfide spills. As a result, this remains an OSHA-regulated hazard. The NRC concluded in its prior analysis that licensees should follow design and operating practices published in accepted codes and standards that govern sodium sulfide systems (NRC 2001).

Consistent with NRC's prior analysis, the licensee stated in Section 3.2.2.2, "Chemical Reductants," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that it will store sodium sulfide outside process areas in a cool, dry, clean environment to prevent contact with other reactants. Therefore, the licensee's proposed sodium sulfide storage and use is consistent with operating assumptions, site features, and designs examined in prior analyses.

Hydrocarbon Fuel Fire / Explosion

The licensee stated in Sections 3.2.2.3, "Non-Process Related Chemicals," and 7.5.2, "Fires and Explosions," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) that propane will be used for building heat. Propane will be stored outside of process areas at the satellite facility. Gasoline and diesel storage tanks will be located above ground and within secondary containment. There are no prior NRC analyses that address hydrocarbon fuel fires and explosions. However, the licensee's commitments to federal, state, and local regulations for hydrocarbon fuel storage and use, and the fact that the licensed radioactive material at the Ludeman Project satellite facility will not be in readily dispersible form (e.g., such as yellowcake) provides reasonable assurance that potential propane fires and explosions do not pose a significant radiological risk.

Radon-222 Release

In Section 4.2.2, "Radon Release Consequence Analysis," of NRC's prior baseline hazard analysis (NRC 2001), the NRC described the hazard of radon-222 release into the air, especially in enclosed areas without adequate ventilation. In its analysis, the NRC assumed one ion exchange column containing 21,200 liters (5,600 gallons) of water containing a radon-222 concentration of 30,000 Bq/L (800,000 pCi/L) is released through a pipe or valve failure. The NRC assumed the radon-222 gas thus released is uniformly mixed in an occupied space with

an air volume of about 6,500 m^3 (230,000 ft^3). The NRC assumed a worker stays for 30 minutes after the spill, performing light activity without respiratory protection, resulting in a committed effective dose equivalent of 0.013 Sv (1.3 rem).

The NRC staff compared the parameter values above to the design and operation of the licensee's proposed facilities at the Ludeman Project to ensure they are consistent with generic operating assumptions, site features, and designs previously examined by the NRC staff. The licensee described parameters in the Ludeman Project Revised Technical Report (Uranium One USA 2017d), Addendum 7-A, "MILDOS Report," Table 2, "Parameters Used to Estimate and Characterize Source Terms at the Ludeman Facility." For example, the Ludeman Project estimated ion exchange column volume is 14,200 liters. Using values in Table 2 and Equation 1 from Addendum 7-A, "MILDOS Report," the NRC staff estimated the radon-222 concentration in ground water, using an average ore grade of 0.1 percent U_3O_8, to be about 190,000 pCi/L. In Section 3.2.1, "Satellite Plant Equipment," the licensee stated the building will be 80 ft wide and 190 ft long. Assuming a typical floor-to-roof height of 20 ft, the satellite building volume is about 304,000 ft^3. Since the radon-222 concentration in pregnant lixiviant will be lower than assumed in the prior analysis, the ion exchange column volume is lower, and the satellite building is larger, the resulting lower radon-222 concentration in air resulting from a spill results in a committed effective dose equivalent to a worker at the Ludeman Project satellite building that would be lower than 0.013 Sv (1.3 rem). Therefore, the licensee's radon release consequences are consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Pregnant Lixiviant and Resin Spills

In Section 4.2.3, "External Consequence from Pregnant Lixiviant and Loaded Resin Spills," of NRC's prior baseline hazard analysis (NRC 2001), the NRC staff evaluated the external radiation dose consequences from pregnant lixiviant and loaded resin spills. The NRC staff determined generically that pregnant lixiviant and loaded resin spills have no significant external radiological consequence. This is because uranium and its progeny that would be present in pregnant lixiviant and resin do not produce a significant direct radiation dose rates. Since the Ludeman Project would process the same material, the direct radiation hazard would be the same. Therefore, the NRC staff did not evaluate this accident scenario at the Ludeman Project.

Pregnant Lixiviant Field Spill

In Section 4.4.3, "Pregnant Lixiviant Field Spill Consequence Analysis for Retention in Soil," of NRC's prior baseline hazard analysis (NRC 2001), the NRC staff evaluated a leak of pregnant lixiviant from surface and near-surface pipes in the well field and between well fields and processing facilities. The NRC performed a risk assessment and concluded that a spill of pregnant lixiviant was probable and could result in soil contamination above the cleanup criteria set forth in 10 CFR 40, Appendix A, Criterion 6(6) (i.e., 5 pCi/g radium-226 and the radium benchmark). As a result, NRC staff recommended that licensees take steps to (1) mitigate against the occurrence of lixiviant spills; (ii) develop spill response procedures; (iii) remediate spills.

In Section 7.5.1.3, "Wellfield Spill/Pipeline Failure," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee committed to comply with all notification requirements set forth in 10 CFR Part 20.2202 and 20.2203; monitor trunklines, feeder lines and individual flow lines for changes in pressure or flow; investigate potential leaks indicated by control room alarms; and survey and document the area and extent of surface contamination

resulting from spills. The licensee also committed that all soils and clean-up materials will be disposed of at an off-site 11e.(2) byproduct material disposal facility. Therefore, the licensee's planned response to wellfield and pipeline failures are consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Excursion

In Section 7.5.1.4, "Lixiviant Excursion," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee summarized its procedures in response to lixiviant excursions that have a potential to impact adjacent, non-exempt aquifers. The NRC staff's evaluation of the licensee's procedures for detecting and responding to excursions is addressed in SER Section 3.1.

Transportation Accidents

In Section 4.5, "Transportation Hazard Risk Analysis," of NRC's prior baseline hazard analysis (NRC 2001), the NRC staff evaluated accidents associated with resin slurry. The NRC staff's analysis of transportation accidents involving yellowcake are not applicable to the Ludeman Project, which will not process yellowcake. The NRC, citing the Crownpoint Uranium Solution Mining Project Final Environmental Impact Statement (NRC 1997), determined that the probability of an accident involving a resin tank truck at the Crownpoint ISR site was about 0.009 in any year, and that the radiological consequences would be lower than for yellowcake spills because airborne releases from wet material are minimal if the spill is cleaned up quickly. The NRC's prior probability estimate was based on 100 truck shipments per year, over a distance of 67 km (42 miles), at an two-lane road accident rate of 1.4×10^{-6} accidents per kilometer (2.2×10^{-6} accidents per mile) (NRC 1997). The NRC also summarized the specific NRC and DOT requirements for transporting LSA-I material. The NRC concluded that transporters should have spill response plans, and actual accidents should continue to be evaluated to inform safety and equipment regulations.

In Section 7.5.3, "Transportation Accident Risk," of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated it would ship about 1,500 lbs. of U_3O_8-equivalent uranium in 500 yd^3-capacity resin trucks up to four times per day. Given that the distance to the Irigaray CPP is at least 184 km (115 miles) (see Table 4-3, "Anticipated Routes for Loaded Resin from the Proposed Project to the Willow Creek CPP," of the licensee's Environmental Report), which is larger than 67 km (42 miles) assumed in the prior analysis, and the number of shipments (about 1,460 per year) is larger than the value assumed in the prior analysis (100 per year), the probability per year of an accident involving a resin tank truck, using the NRC's 1997 methodology, would be larger. Using the 1997 methodology described above, the NRC staff estimated that the risk of a resin truck accident is about 0.37 per year, or about once every 3 years.

However, the licensee committed to make resin shipments under applicable requirements in 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," which requires the licensee to comply with the applicable requirements of 49 CFR Parts 107, 171 through 180, and 390 through 397, appropriate to the mode of transport. Applicable NRC and DOT requirements for transporting LSA-I (low specific activity) radioactive material address material classification, package design, hazard communication, training, and emergency response are sufficiently protective of this material. Therefore, the licensee's procedures for preventing and mitigating potential transportation accidents involving radioactive material are consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

Natural Phenomena Hazards

In Section 4.6, “Tornado Hazard and Consequence Analysis,” of NRC’s prior baseline hazard analysis (NRC 2001), the NRC concluded that tornado risk is very low at uranium ISL facilities and that no design or operational changes are required to mitigate the risk of tornado strikes on ISR facilities. Similarly, the NRC concluded that no special measures are required to protect uranium ISL facilities from seismic hazards.

In Section 7.5.3.6, “Natural Disaster Risk,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee stated that it would develop tornado evacuation procedures and training for response and mitigation of natural disasters and related spills of radioactive material. With regard to earthquakes, the licensee stated it would implement a recommendation from the NRC’s prior analysis (NRC 2001) and ensure storage tanks containing reactive chemicals are maintained in separate containment berms, to reduce the risk of incompatible chemicals mixing if more than one container spills. Therefore, the licensee’s procedures for mitigating potential chemical spills resulting from severe natural phenomena are consistent with operating assumptions, site features, and designs examined in prior NRC analyses.

7.3.2 Additional Accidents Analyzed by the Licensee

In Section 7.5.1.5, “Evaporation Pond Accidents,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee analyzed liquid waste spills or leaks resulting from overtopping or leaks at the evaporation ponds at the satellite facility. The licensee explained that the backup pond liners and leak detection system will meet the guidance in Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities” (NRC 2008). The NRC staff’s evaluation of the licensee’s proposed design and operation of the evaporation ponds is provided in SER Section 4.2.

In Section 7.5.3, “Transportation Accident Risk,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d), the licensee described several types of shipments not involving radioactive material in transport. These analyses were provided in Section 7.5.3.1, “Process Chemicals and Fuel Shipment”; Section 7.5.3.4, “Solid Non-11e. (2) Byproduct Material Shipments”; and Section 7.5.3.5, “Hazardous Waste Shipment.” Because these transportation activities are not regulated by NRC, the NRC staff did not evaluate this information.

7.3.3 Accident Response Procedures and Personnel Training

As described in SER Section 7.3.1, all the accidents considered by the licensee in the Ludeman Project Revised Technical Report (Uranium One USA 2017d) were consistent with previous NRC analyses (NRC 2001). Therefore, in accordance with the SRP, the NRC staff proceeded to evaluate the licensee’s description of emergency response procedures and personnel training. In Section 5.2.1, “Operating Procedures,” of the Ludeman Project Revised Technical Report (Uranium One USA 2017d) the licensee explained that the same procedures already reviewed and approved for operations at the Willow Creek Project, which includes a remote satellite facility at Christensen Ranch, will be used at the Ludeman Project. However, the licensee stated that site-specific (i.e., Ludeman Project-specific) procedures will likely be necessary for emergency response. In Section 5.2.5, “Reporting,” the licensee committed to reporting of spills,

leaks, excursions, and environmental monitoring exceedances in accordance with requirements in 10 CFR 20, Subpart M, “Reports,” and 10 CFR 40.64, 40.65, and 40.66. In Section 5.7.1.2.1, “Spill Contingency Plans,” the licensee stated the RSO will be charged with responsibility to develop and oversee procedures and establish employee emergency response training programs. The NRC staff’s evaluation of standard operating procedures and training programs are addressed in Chapter 5 of this SER.

In the SER on the License Renewal of the Willow Creek Uranium In Situ Recovery Project (NRC 2013b), the NRC staff concluded that there is a risk of accidents and accident scenarios not contemplated currently by the licensee that could occur within an ISR operation based upon industry experience or that later may be envisioned by the licensee as operations process. As a result, License Condition 9.18 was added to the license in 2013:

> The SERP shall review annually LRA Section 7.5, Effects of Accidents, and update the LRA as necessary to reflect newly identified accident analyses based on industry experience or the licensee’s lessons-learned.

The NRC staff concludes that this license condition should remain in the license.

7.4 Evaluation Findings

The NRC staff has completed its review of the licensee’s description of the effects of accidents for the Ludeman Project. This review included an evaluation using the review procedures in Section 7.5.2, and acceptance criteria in Section 7.5.3 of the SRP (NRC 2003).

The licensee has acceptably described likely significant effects of accidents from operations by providing an acceptable analysis of probable accidents and their consequences consistent with the project’s design, site features, and planned operations. The licensee discussed mitigation measures, preventative procedures, and training for personnel to implement adequate response and remedial measures.

Based on the information provided by the licensee and the detailed review conducted of the effects of accidents for the Ludeman Project, the staff concludes that the effects of accidents are acceptable and are in compliance with 10 CFR 40.32(c), which requires that the licensee’s proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; and 10 CFR 20.2202 and 20.2203, which define response program requirements for radiological accidents.

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WSEO (Wyoming State Engineers Office). 2015. Letter from M. Hoobler, to S. Schierman, Uranium One USA, dated November 25, 2015, RE: In-Situ Recovery Extraction Wells- Ludeman Project Area. ADAMS Accession No. ML17312A711.

A. Appendix A

Historical Aspects of Site Performance: Willow Creek ISR Project

The guidance in NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," Appendix A, "Guidance for Reviewing Historical Aspects of Site Performance for License Renewals and Amendments," (NRC 2003), describes specific areas relating to the licensee's compliance history or record of site operations and changes that the NRC staff should review as part of licensing actions. Appendix A states,

> If, after a review of these historical aspects of site operations, the staff concludes that the site has been operated so as to protect health and safety and the environment and that no unreviewed safety-related concerns have been identified, then only those changes proposed by the license renewal or amendment application should be reviewed using the appropriate sections of this standard review plan. Aspects of the facility and its operations that have not changed since the last license renewal or amendment should not be reexamined.

The NRC staff has reviewed historical aspects of site operations since the last license renewal (NRC 2013b), as described below. On the basis of this review, the NRC staff concludes that the Willow Creek ISR Project has been operated so as to protect health and safety and the environment and has identified no unreviewed safety-related concerns. Therefore, the NRC staff has determined that only those elements in the Ludeman Project Revised Technical Report (Uranium One USA 2017d) which represent changes from previous descriptions in the Willow Creek ISR Project license renewal application described in SUA-1341 License Condition 9.2, should be reviewed using the appropriate sections of the standard review plan (NRC 2003). The NRC staff has not reexamined those aspects of the Willow Creek ISR Project and its operations that have not changed since the last license renewal or amendment.

A.1 Amendments and changes to operating practices or procedures

NRC has issued 5 license amendments since issuance of Source Materials License SUA-1341 in March 2013. As shown in the table below, 4 out of 5 amendments are related to annual updates in the financial assurance provisions required by License Condition 9.5. The table below also shows the NRC's Agencywide Documents Access and Management Systems (ADAMS) package accession number for the individual amendments. The NRC staff's evaluation of financial assurance related to the Ludeman Project satellite facility license amendment request is addressed in SER Sections 1 and 6.3. The licensee's statements, commitments, and representations, that were relied upon to issue the license and its amendments are provided in correspondence included in License Condition 9.3.

License SUA-1341 Amendment No.	Reason for Amendment	ADAMS Accession No.
Amendment 1	Annual Surety Update	ML13136A136
Amendment 2	Annual Surety Update	ML14141A473
Amendment 3	Request to Redry Honeymoon, Australia Dried Yellowcake	ML14212A154
Amendment 4	Annual Surety Update	ML15202A122
Amendment 5	Annual Surety Update	ML16173A142

A.2 Changes to Operating Practices or Procedures

From March 7, 2013 through 2017, the licensee made 13 changes to the licensing basis approved by its Safety & Environmental Review Panel (SERP). The individual SERP process determinations are listed in the table below with the ADAMS Accession Number for the licensee's semi-annual reports containing a summary of each change. During routine inspections, the inspectors review licensee-initiated changes made through the SERP process to evaluate if program changes, tests, or experiments require an NRC license amendment prior to implementation. The inspectors concluded that the licensee had implemented the SERP process in accordance with License Condition 9.4 of Source Materials License SUA-1341.

Year	SERP Nos.	ADAMS Accession No.
2013	SERP 13-03. Test to operate the dryer at higher temperature and feed rate, and to test product solubility.	ML13246A011
	SERP 13-04. Review qualifications of a radiation safety technician.	ML13246A011
	SERP 13-06. Review qualifications of a radiation safety officer.	ML14069A008
2014	SERP 14-02. Review qualifications of a radiation safety technician.	ML14251A305
	SERP 14-03. Plant change to yellowcake scrubber system to add a spray nozzle.	ML14251A305
	SERP 14-04. Plant change to add a line from the brine side of the reverse osmosis unit to the injection stream to allow maintenance on the deep disposal wells.	ML15105A138
	SERP 14-05. 2013 annual review of Section 7.5, "Effects of Accidents" in License Renewal Application.	ML15105A138
	SERP 14-06. Review and implementation of root cause findings regarding drum pressurization incident.	ML15105A138
	SERP 14-07. Change in procedures to terminate use of organic filtration in Honeymoon Reprocessing Enclosure.	ML15105A138
	SERP 15-01. Change in procedures to increase dryer temperature to above 1,200 degrees Fahrenheit.	ML15105A138
2015	SERP 15-01. Review qualifications of a radiation safety technician.	ML15245A339
	SERP 15-03. Plant change to add resin storage tank for toll resin processing.	ML16095A076
2016	SERP 16-02. Change in procedures to reprocess yellowcake scrubber solids.	ML17079A334

A.3 License violations

The licensee was cited for several violations of NRC requirements at the Willow Creek Ranch ISR Project since Source Materials License SUA-1341 was issued on March 7, 2013. The NRC

staff finds the licensee adequately addressed these violations and no safety issues with respect to them are outstanding.

Year	Violation	ADAMS Accession No.
2013	EA-13-074; Severity Level IV; Failure to decommission mine unites within 24 months and failure to request an alternative schedule under 10 CFR 40.42.	ML13063A408
2014	EA-14-066; Severity Level IV; Licensee failed to process yellowcake with at least a minimum of 4.5 hours drumming rate per barrel.	ML14251A188
2015	040-08502/13-002 and 040-08502/14-001; Severity Level IV; Licensee performed work with a potential for significant radiation exposure without a Radiation Work Permit	ML14345B073
	040-08502/13-002 and 040-08502/14-001; Severity Level IV; Licensee failed to perform gamma exposure rate surveys in areas posted as radiation areas	ML14345B073
2016	040-08502/16-001; Severity Level IV; Licensee failed to maintain bleed in each wellfield as required by the license	ML16243A088
2017	040-08502/17-001; Severity Level IV; Licensee failed to secure from unauthorized removal or access licensed materials stored in controlled or unrestricted areas.	ML17257A102

A.4 Excursions, incident investigations, or root cause analyses

The licensee has had monitoring wells on excursion, incident investigations, or root cause analyses which were not evaluated as part of or occurred after the Willow Creek ISR license renewal on March 7, 2013. During this period, seven wells were reported on and went off excursion as shown in the table below. NRC staff finds the licensee followed all license condition commitments with respect to these excursions and no new safety issues were identified.

Date	Well Name	EXCURSION STATUS	ADAMS Accession Number
03/28/2012	2MW89, 5MW66	ON EXCURSION	ML12136A414
04/28/2012	2MW89,5MW66	OFF EXCURSION	ML12212A371
10/16/2012	7MW-41	ON EXCURSION	ML122910827
01/31/2013	7MW-41	OFF EXCURSION	ML13037A321
01/01/2015	7MW-27	ON EXCURSION	ML15014A110
03/02/2015	7MW-27	OFF EXCURSION	ML15091A290
07/31/2015	2MW-84	ON EXCURSION	ML15216A512
09/24/2015	2MW-84	OFF EXCURSION	ML15271A116
04/30/2016	8MW37-A	ON EXCURSION	ML16133A252
06/01/2016	8MW36-A	ON EXCURSION	ML16155A325
05/31/2016	8MW37-A	OFF EXCURSION	ML16162A051
08/04/2016	8MW36-A	OFF EXCURSION	ML16221A618

The licensee has issued 27 unplanned release reports in accordance with its Wyoming LQD Permit to Mine No. 478. Copies of these reports are provided to NRC. None of these events met NRC reporting criteria in either 10 CFR 20, Subpart M or 10 CFR 40.60. The NRC staff finds the licensee followed all license condition commitments with respect to these unplanned release incidents and no new safety issues were identified in the root cause analyses.

Report Date	Volume (gallons)	Substance Spilled	Location	Root Cause	ADAMS Accession Number
06/17/2012	500-700	Injection solution	Well 8AR217-1	Pop-off valve opened and failed to reseat	ML12199A066
06/18/2012	300	Injection solution	Well 8AK181-1	Pop-off valve failed to open causing wellhead to fail	ML12199A066
06/18/2012	1200	Production solution	Well 8AK190-2	Sanitary seal on wellhead failed	ML12199A066
06/30/2012	1500	Injection solution	Well 8A0194-2	Pop-off valve failed to open causing wellhead to fail	ML12199A066
09/07/2012	1000	Injection solution	Well 7I-46	Casing extension glue joint failed	ML12293A007
07/2012-10/2012	11000-12000	Injection solution	MU 8	Insufficiently plugged historic drill hole near injection well 8S214-1	ML12263A249 ML12298A016
12/09/2012	1500	Injection solution	Well 8U162-1	Pop-off valve opened and failed to reseat	ML12346A457 ML13003A196
12/23/2012	800	Injection solution	Well 8AL198-2	Pop-off valve opened at 125 psi	ML13002A082 ML13023A382
12/22/2012	950	RO Brine well solution	DDW-1 Pump house release	Steel plug on charge pump failed	ML13002A082 ML13023A382
02/11/2013	2100	Injection solution	Well 7I-30	Failed casing glue joint	ML13050A014 ML13073A028
06/15/2013	1400	Injection solution	Well 8S218-1	Failed casing glue joint	ML13169A076 ML13191A865
07/22/2013	2600	Injection solution	Well 7I-10	Failed casing glue joint	ML13211A008 ML13239A352
10/31/2013	740	Injection solution	Modular Building 7-3	End cap failure on injection bag filter manifold	ML13309A009 ML13337A172
11/26/2013	1060	Injection solution	Well 10-716	Pop-off valve opened and failed to reseat	ML13338A122 ML13353A139
01/6/2014 - 1/15/2014	77000	Production solution	Modular Building 5-5	Production manifold fold froze and broke when 6” butterfly valve failed. Root cause – extreme cold	ML14056A459 ML14059A462
03/03/2014	665	Injection solution	Well 8U158-1	Pop-off valve opened and failed to reseat	ML14063A424 ML14071A308
04/19/2014	616	Injection solution	Well 10-209	Pop-off valve opened and failed to reseat	ML14113A032 ML14139A388
07/25/2014	946	Injection solution	Well 10-637	Pop-off valve opened and failed to reseat	ML14211A035 ML14245A484
08/13/2014	535	Injection Solution	Modular Building 4-2	Isolation valve failure on injection line	ML14245A591

08/15/2014	492	Production solution	Christensen Ranch Header House 2	Pressure gauge on recovery line corroded and failed	ML14230A381 ML14245A615
03/10/2015	830	Injection solution	Well 8U187-1	Separation of casing under well box	ML15091A291
12/5/2015-12/07/2015	2100	Production solution	Modular Building 2-4	Well in building turned on with sample port open, Root cause - stop button not fully engage.	ML16103A374
10/11/2016	1405	Injection solution	Well 7I-319	NR	ML17011A214
10/5/2016-10/17/2016	3500	Injection solution	Modular Building 7-4	Modular Building shut down May 1, 2104. Root cause- Start of adjacent wellfield caused injection fluid to enter washed out butterfly valve into a manifold and injection filter which were not sealed.	ML17011A111
11/29/2016	3300	Injection solution	Well 8AA187-2	Broken collar at well head-root cause	ML17010A036
05/24/2017	3600	Injection solution	Well 10-818	Steel king nipple rusted out, leak detector failed.	ML17157B377
07/27/2017	5000	Injection and production solution	Well 8S199-1 Well 8S198-1	Injection well 8S198-1 1 inch steel union fitting corroded. Production well 8S199-1 transition fitting pin hole leak.	ML17212A191

A.5 Radiation-related regulatory exceedances

There have been no occupational or public radiation-related regulatory exceedances reported in either semi-annual effluent reports submitted in accordance with 10 CFR 40.65 or the annual ALARA audits. These reports provided since NRC issued a renewed license for the Willow Creek Project on March 7, 2013, are listed below.

Report Period	ADAMS Accession Nos.
1st Half 2013	ML13246A011
2nd Half 2013	ML14069A008
1st Half 2014	ML14251A209
2nd Half 2014	ML15105A137
1st Half 2015	ML15245A339
2nd Half 2015	ML16095A072
1st Half 2016	ML16246A013
2nd Half 2016	ML17079A333
1st Half 2017	Ml17272A146

B. Appendix B

Administrative Changes to License Conditions,
Source Material License SUA-1341, Willow Creek Project

B.1 Introduction

The purpose of this Appendix is to describe the NRC staff's evaluation of administrative changes to certain license conditions in Source Material License SUA-1341 for the Willow Creek Project. The NRC staff will revise license conditions in Source Material License SUA-1341 after completing its safety evaluation of a license amendment request to expand licensed activities to the Ludeman Project (Uranium One Americas 2011b). In the December 2011, license amendment request, the licensee proposed to add a remote satellite facility at the proposed Ludeman Project to existing operations at the Willow Creek Project authorized by Source Material License SUA-1341.

The NRC staff has identified two groups of new or modified license conditions that are addressed in this SER. The first group includes license conditions, new or modified, which relate directly to the NRC staff's evaluation of Ludeman Project license amendment request. The changes to license conditions in this first group, which are directly related to the Ludeman Project amendment, are described in the body of this SER.

The NRC staff initiated, and the licensee consented to, clarifying changes to other existing license conditions. These changes are part of a second group of license conditions, in which changes are not directly related to the staff's evaluation of ISR operations in the new Ludeman Project remote satellite. The NRC staff's evaluation of modifications within the second group of license conditions, which are entirely administrative changes, is provided in Section B.2. below.

B.2 Evaluation of License Condition Changes

Note: In the revised license conditions in this Appendix, new text is printed in underline and text being removed is struck out as shown in SER Table 1.1-1.

License Condition 9.10

This license condition states that the licensee shall maintain restricted area boundaries in accordance with statements, commitments, and representations it made in the approved license application. The license application and its amendments are already described and incorporated into the license in License Condition 9.2 (i.e., the so-called "tie-down" condition). Therefore, this requirement is redundant and will be removed.

License Condition 10.17

This license condition states that the licensee shall implement a respiratory protection program in accordance with statements, commitments, and representations it made in the approved license application. The license application and its amendments are already described and incorporated into the license in License Condition 9.2 (i.e., the so-called "tie-down" condition). Therefore, this requirement is redundant and will be removed.

License Condition 11.7

This license condition states that the licensee shall comply with: (1) 10 CFR 20.1502(a) (1) and 10 CFR 20.1502(b) (1), regulations pertaining to conditions requiring individual monitoring for external and internal occupational dose; and (2) corresponding sections of the license renewal application. Licensees are already required to comply with applicable regulations, whether or not so stated in a license condition. Furthermore, the license application and its amendments are already described and incorporated into the license in License Condition 9.2 (i.e., the so-called “tie-down” condition). Therefore, this requirement is redundant and unnecessary and will be removed.