LOST CREEK ISR, LLC
Lost Creek Project

Mine Unit 1

WDEQ-LQD MU1 Application

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ABBREVIATIONS AND ACRONYMS

°C	degrees Celsius
µmhos/cm	micromhos per centimeter
AATA	AATA International, Inc.
BPT	Best Practicable Technology
EPA	United States Environmental Protection Agency
ISR	In Situ Recovery
fault	Lost Creek Fault
ft/ft	foot per foot
ft/day	feet per day
ft^2/day	square feet per day
ft/year	feet per year
GIS	Geographic Information System
gpm	gallons per minute
LC ISR, LLC	Lost Creek ISR, LLC
LFG	Lower FG Sand
LHJ	Lower HJ Sand
MCC	motor control center
MCL	maximum contaminant level
mg/L	milligrams per liter
MHJ	Middle HJ Sand
MIT	mechanical integrity test
MO well	overlying aquifer monitor well
MP well	production zone monitor well
MU1	Mine Unit 1
MU well	underlying aquifer monitor well
M well	monitor ring well
NRC	Nuclear Regulatory Commission
NRCS	National Resource Conservation Service
pCi/L	picoCuries per liter
Permit Area	Lost Creek Permit Area
Petrotek	Petrotek Engineering Corporation
PLC	Programmable Logic Controller
Project	Lost Creek Project
PV	pore volume
QA/QC	quality assurance/quality control
ROI	radius of influence
SMU	soil mapping unit
SU	standard unit
TDS	total dissolved solids
UCL	Upper Control Limit

UHJ	Upper HJ Sand
UKM	Upper KM Sand
U_3O_8	uranium oxide
US	United States
WDEQ-LQD	Wyoming Department of Environmental Quality - Land Quality Division
WDEQ-WQD	Wyoming Department of Environmental Quality - Water Quality Division

1.0 Introduction

Lost Creek ISR, LLC (LC ISR, LLC) has prepared this Mine Unit 1 (MU1) Application for the Wyoming Department of Environmental Quality - Land Quality Division (WDEQ-LQD) in support of a permit to conduct In Situ Recovery (ISR) of uranium in Sweetwater County, Wyoming. The Lost Creek Project (Project) will use existing ISR technology and best industry practices to extract uranium from permeable, uranium-bearing sandstones, located at depths ranging from 300 to 700 feet below the surface, through a series of mine units. MU1, as well as the other mine units, will consist of a "pattern" of production and injection wells, ringed by monitor wells. Once extracted from a mine unit, the uranium will be recovered by means of ion exchange, using commercially available anionic resin, and prepared for shipment as uranium oxide (U_3O_8) "yellowcake" slurry to a facility licensed to process the slurry into dry yellowcake. When production from a mine unit is complete, the groundwater will be restored and the surface reclaimed.

The information for the Lost Creek Permit Area (Permit Area) as a whole is included in the main portion of the permit application, which includes the Adjudication File, the baseline Appendices D1 through D11, the Operations Plan, and the Groundwater Quality Restoration and Surface Reclamation Plan. This Mine Unit Application includes the detailed information specific to the surface and subsurface conditions and operation within the area of MU1.

1.1 Project Location

The Permit Area is located in the northeast portion of Sweetwater County, south-central Wyoming (**Figure MU1 1-1**). A series of paved and unpaved county and United States (US) Bureau of Land Management roads provide access to the Permit Area. The Permit Area is within Township 25 North and Ranges 92 and 93 West of the Sixth Principal Meridian; and approximately centered at 42 degrees, eight minutes North latitude and 107 degrees, 51 minutes West longitude. MU1 is located within the Permit Area in Sections 17, 18, 19 and 20 of Township 25 North and Range 92 West, and covers approximately 37 acres. **Figure MU1 1-2** shows the location of MU1 within the Permit Area, while **Figure MU1 1-3** shows the MU1 layout. The layout of MU1 is shown in both its original and revised forms on **Plate OP-1** and **Figure OP-2a**. The original form was based on limited historic drilling and was therefore conceptual in nature. The revised form is based on the results of both historic and recent drilling that have enabled the geologists to more precisely select the pattern areas. Additional minor revisions to the pattern area are likely as geologists learn more about the ore during the installation of recovery wells.

The Permit Area is geographically located in the northeastern portion of the Great Divide Basin. The Great Divide Basin is an oval-shaped structural and topographic depression, encompassing approximately 3,500 square miles in Sweetwater and Fremont Counties, in south-central Wyoming. The Great Divide Basin is broadly bounded by mountains and hills on all sides: the Wind River and Granite Mountains to the north, the Rawlins Uplift to the east, the Wamsutter Arch to the south, and the Rock Springs Uplift to the west. The Great Divide Basin occurs between two bifurcating branches of the North American Continental Divide, which separates south of and rejoins north of the Great Divide Basin.

The regional rolling landscape has draws, rock outcroppings, ridges, and bluffs. The Permit Area is characterized by low-relief, sagebrush-dominated plains, dissected by small, ephemeral drainage networks. Within the Permit Area, there are no drainages with perennial surface water flow or permanent water bodies.

1.2 Report Organization

For ISR, the subsurface hydrogeologic conditions are an integral part of the mining process. **Attachment MU1 1-1** describes the construction and monitoring of the well network for evaluating the MU1 subsurface conditions. **MU1 Section 2.0** summarizes the subsurface conditions, including the structural geology and the results of the hydrogeologic pump tests in MU1. **MU1 Section 3.0** provides a description of the surface conditions of MU1, including the mine unit layout, site-specific soil and vegetation conditions. **MU1 Section 4.0** discusses the results of the baseline water quality sampling results. **MU1 Section 5.0** discusses the mine unit operations, including UCL calculations, historic drill hole locations, and updated well permit information. **MU1 Section 6.0** discusses the restoration and reclamation information, and **MU1 Section 7.0** contains a list of references.

2.0 Subsurface Conditions

The hydrogeologic conditions for the Permit Area as a whole are discussed in **Appendix D5** (Geology) and **Appendix D6** (Hydrology) of the main permit document. The entire Permit Area is covered by the Battle Spring Formation of Eocene age. Generally, in the Great Divide Basin, the Battle Spring and Wasatch formations, which are time equivalent, interfinger with one another. In the Permit Area, the upper half of the Eocene lithologic units consists of the Battle Spring Formation and the lower half is made up of the Wasatch Formation. The total thickness of the Battle Spring and Wasatch formations under the Permit Area is about 6,200 feet, and the formations both consist of fine to coarse grained arkosic sandstones and conglomerates, typical of alluvial fan complexes.

The upper portion of the Battle Spring Formation is the host to the uranium mineralization within the Permit Area. In the Permit Area, the top 700 feet of the Battle Spring Formation are divided into at least five horizons marked from top to bottom as BC, DE, FG, HJ, and KM. These horizons are separated from one another by various thicknesses of shale, mudstone and siltstone.

Within MU1, the production zone is the HJ Horizon. The HJ Horizon has been subdivided into the Upper HJ (UHJ), Middle HJ (MHJ), and the Lower HJ (LHJ) sands. The HJ Horizon is continuous throughout MU1 with an average thickness of 120 feet, ranging from 100 to 151 feet thick. The HJ Horizon is bounded above and below by laterally extensive confining units. The Lost Creek Shale overlies the HJ Horizon and the Sagebrush Shale occurs below the HJ Horizon.

The FG Horizon aquifer overlies the Lost Creek Shale and consists of upper, middle and lower sand sequences, with the deepest sand designated as the Lower FG (LFG) Sand. The KM Horizon aquifer occurs beneath the Sagebrush Shale and consists of an upper and lower sand sequence with the uppermost sand designated as the Upper KM (UKM) Sand. The DE Horizon overlies the FG Horizon and is the shallowest aquifer within the Permit Area.

2.1 Structural Geology

In MU1 (and the Permit Area as a whole), the Battle Spring Formation dips gently to the northwest at roughly three degrees. This pattern is broken locally by a fault referred to as the Lost Creek Fault. The geologic structure in the Permit Area is illustrated on the cross sections (**Plates D5-1a**, **b**, **c**, **d** and **e**) and isopach maps (**Plates D5-2a**, **b**, **c**, and **d**) in **Appendix D5** of the main permit document. The Lost Creek Fault was initially interpreted to be a scissor fault, with a reversal of displacement direction occurring in the western third of the Permit Area. Recent interpretation has revealed that it is, instead, a sequence of sub-parallel faults with opposite displacement occurring in an en echelon configuration (**Plate D5-3**, Geology of Lost Creek Permit Area, in the main permit document).

The ‘main’ Lost Creek Fault trends northeast-southwest and bisects MU1 almost in half (**Figure MU1 1-2**). Downward displacement occurs on the south block. Throw is approximately 70 to 80 feet in the eastern portion of MU1, decreasing to approximately 50 feet in the central portion of MU1, and further decreasing to approximately 40 feet in the western portion of MU1. A minor sub-parallel ‘splinter’ fault (or ‘splay’) splits to the south from the main Lost Creek Fault near the center of MU1 (**Figure MU1 1-2**). The splinter fault trends roughly east-west, and the greatest distance between the main Lost Creek Fault and the splinter fault is about 200 feet. Displacement along the splinter fault is about 14 feet along its western portion, increasing to about 28 feet farther to the east, before losing identity about 2,000 feet east of the split from the main Lost Creek Fault. The downthrown block is to the north, which creates a small, localized graben feature between the main Lost Creek fault and the splinter fault. Both the main Lost Creek Fault and the splinter fault extend vertically through all the horizons of interest. Close spaced drilling indicates that the angle of the Fault is relatively high angle, approximately 85 degrees. The maps in this document, as well as the Permit to Mine Application, show the position of the Fault where it intersects the HJ horizon.

2.2 Summary of Hydrogeologic Pump Tests

This section summarizes the hydrogeologic pump tests conducted by Petrotek Engineering Corporation (Petrotek) within MU1. The Lost Creek Hydrologic Testing – Mine Unit 1 North and South Tests Report prepared by Petrotek in October 2009 – is included as **Attachment MU1 2-1**. The pump tests were conducted in accordance with the regulatory objectives of WDEQ-LQD's Non-Coal Rules and Regulations, Chapter 11 (In-Situ Mining) and the US Nuclear Regulatory Commission's (NRC's) Section 2.7 (Hydrology) of NUREG-1569 (WDEQ-LQD, 2005a; NRC, 2003). The pump tests were conducted to achieve the following objectives:

1. Determine the hydrologic characteristics of the Production Zone Aquifer;
2. Demonstrate hydrologic communication between the Production Zone pump well and the surrounding Production Zone monitor wells;
3. Assess the presence of hydrologic boundaries, if any, within the Production Zone Aquifer over the area evaluated by the Pump Test; and,
4. Evaluate the degree of hydrologic communication, if any, between the Production Zone and the overlying and underlying aquifers in the vicinity of the pump well.

Two pump tests were conducted within MU1 due to the faulting that bisects the mine unit from west-southwest to east-northeast. The north pump test was conducted on the north side of the Lost Creek Fault (and associated splinter fault) in November 2008, and the south pump test was conducted on the south side of the Lost Creek Fault (and associated splinter fault) in December 2008. Both pump tests were conducted in the HJ Horizon, with monitoring of the overlying and underlying aquifers as well. In the following discussion, reference to the fault includes both the main Lost Creek Fault and the associated splinter fault, unless otherwise noted.

The additional information collected from the two pump tests did not significantly alter the information on the aquifer characteristics attained from previous pump tests. This conclusion is based on a comparison with aquifer characteristics presented in **Appendix D-6** of the main permit document with the information presented in **Attachment MU1 2-1**. A comparison of the hydraulic gradients presented in **Table D6-7a** and **Section 4.3** of **Attachment MU1 2-1** for the FG, HJ and KM Horizons indicated no significant differences. Also, a comparison of the vertical hydraulic gradients between the three horizons indicated no significant differences (**Table D6-7b** of the main permit document and **Table 4-5** of **Attachment MU1 2-1**). Finally, a comparison of the transmissivity and storativity values for the HJ Horizon, presented in **Table D6-11** of the main permit document and **Tables 7-1** and **7-2** of **Attachment MU1 2-1**, indicated no significant differences.

2.2.1 Potentiometric Surfaces

Water levels were measured at all of the MU1 monitor wells completed in the HJ Horizon, LFG Sand, and UKM Sand on December 8, 2008. The data represent static conditions because the water levels were measured after an extended period without drilling activities or pump tests in the immediate vicinity of MU1. Groundwater flow within MU1 in the HJ Horizon on both sides of the fault is to the west-southwest. The potentiometric elevation on the north side of the fault is approximately 5 to 17 feet higher than on the south side, resulting in a steep gradient of the potentiometric surface across the fault. The hydraulic gradient on the north side of the fault was approximately 0.0052 foot per foot (ft/ft) and 0.0087 ft/ft on the south side.

Groundwater flow within MU1 in the LFG Sand aquifer is to the west-southwest. The hydraulic gradient on the north side of the fault was approximately 0.006 ft/ft and 0.0046 ft/ft on the south side, with an observed steep gradient across the fault similar to the HJ Horizon.

Groundwater flow within MU1 in the UKM Sand aquifer is to the west-southwest. The hydraulic gradient on the north side of the fault is approximately 0.006 ft/ft and approximately 0.0054 ft/ft on the south side of the fault. The fault does not appear to impede groundwater flow within the UKM Sand, as there is little or no displacement in the potentiometric surface across the fault.

Potentiometric surface data is presented in **Figures 4-1** to **4-3** of **Attachment MU1 2-1**. This data indicates that the FG, HJ, and KM Horizons within MU1 are not in direct hydraulic communication as evidenced by the difference in elevations of the potentiometric surfaces for each horizon.

2.2.2 Pump Test Design and Procedures

The pump tests were performed by collecting data from the two pump test wells (PW-102 on the north side of the fault and PW-101 on the south side) completed in the Production Zone (HJ Horizon) and a number of monitor wells (completed in the Production Zone and the overlying and underlying aquifers). The pump and monitor well locations are shown on **Figure 1-2** and **Figure 1-3** of **Attachment MU1 2-1**. The pump tests were performed with electrical submersible pumps powered by a portable generator. Flow from the pumps was controlled with a manual gate valve. Surface flow was monitored with two 1.5-inch turbine meters that displayed total flow in gallons and instantaneous flow rates in gallons per minute (gpm). Water was discharged to the ground surface, approximately 350 feet downgradient from the pump wells.

Water levels were continuously measured and recorded in a majority of the wells by In-Situ Level TROLL data-logging pressure transducers. The pressure transducers were programmed to record water levels at five-minute intervals during the pump and recovery periods. In addition to the wells continuously monitored, water levels were measured periodically in other wells using a manual electronic water level meter. This allowed for a more extensive assessment of the potentiometric surface before, during, and after the pump test. Only wells that were monitored continuously with LevelTROLL devices were used to develop aquifer characteristics and calculated drawdown and radius of influence.

The north pump test wells consisted of well PW-102 (pump well) and 98 monitor wells, including 44 Production Zone monitor wells, 25 monitor wells completed in the LFG Sand (overlying aquifer), and 26 monitor wells completed in the UKM Sand (underlying aquifer), and 3 monitor wells completed in the DE Horizon (uppermost aquifer). Water levels in 53 wells (including the pumping well, 28 HJ Horizon observation wells, and 24 wells in the overlying and underlying aquifers) were measured and recorded with In-Situ Level TROLL® pressure transducer dataloggers for the north test. Prior to conducting the long-term pump test at well PW-102, a short-term constant rate test was conducted at a flow rate of 86.4 gpm for 5.8 hours to evaluate pumping rates for the long-term test. Water levels were allowed to recover for approximately seven days, equilibrating to within approximately one foot or less prior to starting the pump test.

The north pump test was conducted from November 10 through November 20, 2008, and water level recovery data were collected through December 2, 2008. The pumping lasted for 2,880 minutes, with an average pumping rate of 70.9 gpm.

The south pump test wells consisted of well PW-101 (pump well) and 100 monitor wells, including 48 Production Zone monitor wells, 25 monitor wells completed in the LFG Sand (overlying aquifer), and 25 monitor wells completed in the UKM Sand (underlying aquifer), and 2 monitor wells completed in the DE Horizon (uppermost aquifer). Water levels in 52 wells (including the pumping well, 31 HJ Horizon observation wells, and 20 wells in the overlying and underlying aquifers) were measured and recorded with In-Situ Level TROLLs® for the south test. Prior to the long-term pump test at pump well PW-101, a step-rate test was conducted with rates of 39, 54.4, 72.9, and 80.9 gpm to evaluate pumping rates for the long-term test.

The south pump test was conducted from December 9 through December 12, 2008, and the water level data were collected through December 22, 2008. The pumping lasted for 4,185 minutes, with an average pumping rate of 58.1 gpm.

2.2.3 Drawdown during the Pump Tests

2.2.3.1 North Pump Test

During the north pump test, drawdown was observed in all of the wells completed in the HJ Horizon located on the north side of the fault. The pump well, PW-102, had the most drawdown at 111.1 feet. Drawdown in the closest observation well (MP-107) to PW-102 was 48.6 feet. Drawdown ranged from 2.8 to 36.5 feet in the perimeter observation wells located on the north side of the fault (M-114 to M-126).

Drawdown ranged from 0.0 to 2.7 feet in 13 monitor wells located on the south side of the fault. The largest drawdown occurred in wells closest to the fault. Based on the minimal drawdown in the monitor wells located on the south side of the fault, it appears that the fault is a partial barrier to groundwater flow within MU1, although there does appear to be some leakage.

Drawdown responses were observed in the overlying and underlying observation wells located on the north and south sides of the fault during the north pump test. The drawdown ranged from 0.1 to 3.4 feet in the overlying aquifer, and 0.0 to 2.2 feet in the underlying aquifer. There does appear to be a limited degree of communication between the HJ Horizon and the overlying and underlying aquifers however the responses on both sides of the fault are generally an order of magnitude less than the observed responses within the HJ Horizon.

2.2.3.2 South Pump Test

During the south pump test, drawdown was observed in all of the wells completed in the HJ Horizon located on the south side of the fault. The pump well, PW-101, had the most drawdown at 63.5 feet. Drawdown in the closest observation wells (HJMP-109 and MP-104) to PW-101 was 41.7 and 48.1 feet, respectively. Drawdown ranged from 4.8 to 34.1 feet in the perimeter observation wells located on the south side of the fault (M-101 to M113, M-127 and M-128).

Drawdown ranged from 0.1 to 2.0 feet in 21 monitor wells located on the north side of the fault. The largest drawdown occurred in wells closest to the fault. Based on the minimal drawdown in the monitor wells located on the north side of the fault, it appears that the fault is a partial barrier to groundwater flow within MU1, although there does appear to be some leakage. Results of testing also indicate that the splinter fault south of the main Lost Creek fault acts as a minor barrier to flow compared to the main fault.

Drawdown responses were observed in the overlying and underlying observation wells located on the north and south sides of the fault during the south pump test. The drawdown ranged from 0.0 to 1.9 feet in the overlying aquifer, and 0.1 to 5.7 feet in the underlying aquifer. There does appear to be a limited degree of communication between the HJ Horizon and the overlying and underlying aquifers; however the responses on both sides of the fault are generally an order of magnitude less than the observed responses within the HJ Horizon.

2.2.4 HJ Horizon Aquifer Properties

Drawdown data collected from monitor wells equipped with In-Situ Level TROLL data-logging pressure transducers were analyzed to determine aquifer properties, including transmissivity and storativity, primarily using the Theis method (Theis, 1935).

2.2.4.1 North Pump Test

Transmissivity results from the drawdown data for the PW-102 pump test of the HJ Horizon ranged from 50.9 to 104.0 square feet per day (ft^2/day), with an average transmissivity value of 77.9 ft^2/day. Transmissivity values calculated from the recovery data ranged from 52.2 to 57.5 ft^2/day, with an average transmissivity value of 55.4 ft^2/day. The transmissivity values appear to increase slightly toward the east on the north side of the fault. Hydraulic conductivity ranged from 0.42 to 0.87 feet per day (ft/day), with an average of 0.65 ft/day. Storativity of the HJ Horizon aquifer ranged from 5.4×10^{-5} to 1.9×10^{-4}, with an average storativity of 9.3×10^{-5}. The groundwater velocities on the north side of the fault ranged from 2.9 to 5.6 feet per year (ft/year), with an average of 4.4 ft/year.

The radius of influence (ROI), based on the drawdown responses observed in the monitor ring wells during the north pump test, was estimated from a distance drawdown plot (**Appendix F** of **Attachment MU1 2-1**) to be between 3,100 and 3,300 feet. The ROI is not symmetrical with respect to the pump well due to the presence of the fault. The minimum ROI is greater than 2,600 feet.

2.2.4.2 South Pump Test

Transmissivity results from the drawdown data for the PW-101 pump test of the HJ Horizon ranged from 69.4 to 129.0 ft^2/day with an average transmissivity value of 92.6 ft^2/day. Transmissivity values calculated from the recovery data ranged from 58.3 to 108 ft^2/day, with an average transmissivity value of 70.5 ft^2/day. The transmissivity values on the south side of the fault appear to increase closer to the fault, in the northeast portion of the test area.. Hydraulic conductivity ranged from 0.58 to 1.08 ft/day, with an average of 0.77 ft/day. Storativity of the HJ Horizon aquifer ranged from 3.6×10^{-5} to 4.2×10^{-4}, with an average storativity of 1.1×10^{-4}. The groundwater velocities on the south side of the fault ranged from 6.6 to 12.1 ft/year, with an average of 8.8 ft/year.

The ROI, based on the observed drawdown in the monitor ring wells during the south pump test, was estimated to be between 3,200 and 3,500 feet calculated from distance drawdown plots (**Appendix F** of **Attachment MU1 2-1**). The ROI, as with the north pump test, is truncated by the fault. The minimum ROI is greater than 2,900 feet.

3.0 Surface Conditions

3.1 Mine Unit Layout

The layout of MU1, including roads, pipelines, and header houses, is shown on **Figure MU1 1-3**. The MU1 monitor well ring will encompass about 210 acres, and the pattern area will cover about 37 acres within that ring. The ring extends about 5,600 feet east to west and about 2,000 feet north to south. The topography within the ring is flat, with a maximum elevation change of about 30 feet across the mine unit. Minor ephemeral drainages cross the mine unit from northeast to southwest and northwest to southeast. The types of soil and vegetation within MU1 are discussed below, along with the areas of disturbance.

3.2 Soil Conditions

The results of the Order 3 soil survey for the entire Permit Area are in Appendix D7 (Soils) of the main permit document. In accordance with WDEQ-LQD Guideline No. 1 (WDEQ-LQD, 1994), a more detailed Order 1 soil survey is needed for the portions of the Permit Area, where mining-related surface disturbance is proposed. Order 1 soil surveys were conducted for the Plant site (2008), the deep well sites and associated roads (2009), and the results are included in **Attachment OP-5a** and **Attachment OP-5b** of the main permit document. An Order 1 soil survey was also conducted at MU1 in 2008. The following section summarizes the results of that survey, which is described in more detail in **Attachment MU1 3-1.** The Order 1 soil survey fieldwork was completed in September 2008, and the soil samples were analyzed by Energy Laboratories, Inc. in Casper, Wyoming, in September and October 2008.

A reconnaissance survey was conducted in early September 2008 to select locations for backhoe excavation of soil pits and profiles and for soil sampling. Soils were examined in more detail at 28 locations, where a 3-inch diameter hand-held soil auger and a 16-inch tile spade were used to excavate soil “pits”. The pits were excavated to a depth of 60 inches, or to the C horizon In addition to the 28 pit locations, observations were also made at several of the mud pits excavated for project-related drilling in the Permit Area. Pits at the MU1 study area were also compared to pits at the Plant site, which were excavated during the same field session in September 2008 (**Attachment OP-5a** to the Operations Plan in the main permit document).

Some soil profile locations were selected to correspond with soil pit locations in order to ensure sampling was adequate to represent the spatial variability of the soils. The soil profiles were excavated by a backhoe, which allowed for more detailed observations. Each excavation was approximately 15 feet in length, five feet in depth, and four to five feet in width, oriented in an east-west direction to provide good lighting on the north soil face for descriptions and pictures.

The bottom of each profile was flat for a length of five feet, with a 45-degree slope at one end for access. The profiles were excavated and samples collected in mid-September 2008. Between three and seven horizons or sub-horizons were described and sampled at each soil profile.

Based on the soil pit and the mud pit observations, eight soil “profile” locations were selected to describe and sample. Three soil mapping units (SMUs) were identified, described and sampled in MU1: the Poposhia Loam, the Teagulf Sandy Loam, and the Pepal Sandy Loam.

> **Poposhia Loam**: This soil formed in calcareous loamy alluvium. This deep, well-drained soil occurs in narrow swales and comprises a small proportion of the study area. Typically, the surface layer is about a six-inch-thick dark brown sandy loam. The next layer is about an 18-inch-thick dark yellowish brown clay loam or sandy clay loam. The substratum is a brown or yellowish brown loam or coarse sandy loam to a depth of 60 inches or more. Its slopes range from zero to one percent.
>
> **Teagulf Sandy Loam**: This soil formed in calcareous loamy or sandy alluvium, and is influenced by sandstone, siltstone, and mudstone or shale bedrock. Comprising a small proportion of the study area, this shallow, well-drained soil occurs on side slopes and upland ridges of slightly dissected plains. Its slopes range from three to seven percent. Typically, the surface layer is about a three-inch-thick brown or dark yellowish brown loam. The next layer is about a seven-inch-thick dark yellowish brown sandy clay loam or heavy sandy loam. The substratum is a brown or yellowish brown loamy coarse sand or coarse sand to a depth of 60 inches or more. Substrata, consisting of silt loam or sandy clay loam, also occur but are less prevalent.
>
> **Pepal Sandy Loam**: This soil formed in calcareous loamy alluvium. This moderately deep, well-drained soil occurs on gently (one- to three-percent slopes) undulating uplands and comprises a large proportion of the study area. Typically, the surface layer is about a four-inch-thick dark brown or brown coarse sandy loam. The next layer is about a 15-inch-thick dark yellowish brown clay loam or sandy clay loam. The substratum is a dark yellowish brown loamy coarse sand or coarse sandy loam to a depth of 60 inches or more.

After examining the eight soil profile descriptions, samples from four of the eight soil profiles were selected for laboratory analysis Based on the laboratory results and the field observations, the topsoil of all three SMUs provides a favorable medium for plant growth, though the depth of topsoil varies between units. The Poposhia Loam provides about 19 to 24 inches of topsoil material favorable for plant growth. The Teagulf Sandy Loam provides about six to 12 inches of topsoil material favorable for plant growth. The Pepal Sandy Loam provides 14 to 18 inches of topsoil material favorable for plant growth.

3.3 Vegetation Conditions

The results of the vegetation studies conducted throughout the Permit Area are discussed in Appendix D8 (Vegetation) of the main permit document. Within MU1 (as well as the entire Permit Area) two vegetation types, dominated by big sagebrush, were identified and mapped (**Figure MU1 3-2**). The Upland Big Sagebrush Shrubland type dominates the flat upland areas and the gentle slopes, and covers about 80% of MU1. The Lowland Big Sagebrush Shrubland type occurs in deeper soils along the gently sloped, south-facing ephemeral dry washes, and covers about 20% of MU1.

During the vegetation studies, special consideration was given to the identified potential species of special concern and micro-environments capable of supporting these species; however, no species of special concern were observed within the Permit Area. Within the Permit Area, only one listed restricted noxious weed species, tansy mustard, was observed with scattered individuals observed in the Lowland Big Sagebrush Shrubland. No areas dominated by weedy species were observed within the Permit Area. Selenium indicator species were not observed on-site, and none of the soils of the Permit Area are considered seleniferous.

3.4 Disturbance Calculations

Figures MU1 3-1 and **3-2** show the MU1 layout overlain on the soil and vegetation maps, respectively. **Tables MU1 3-1** and **3-2** include the topsoil salvage and vegetation disturbance calculations, respectively. Standard areas in the calculations, e.g., the footprint of the header houses and road widths, were based on the dimensions in **Figures OP-3c**, **OP-6a**, and **OP-6b**. Road and pipeline lengths were measured from **Figure MU1 1-3**.

3.4.1 Soils

For **Table MU1 3-1**, the topsoil salvage was calculated on the basis of the areas from which the topsoil would be removed: (1) long term, i.e., for the life of the mine unit (e.g., from roadways and header house locations); and (2) short-term, i.e., for a few weeks or months (e.g., from pipeline routes). All three of the major soil units surveyed in the Permit Area occur within MU1. About 7.6 acres of the Pepal Sandy Loam, which covers the most area within MU1, will be stripped. Based on a topsoil stripping depth of 24 inches, about 14,300 cubic yards will be stockpiled long term (for the life of the mine unit), and about 10,200 cubic yards will be stockpiled short term (for a few days to a few months). About 1.7 acres of the Teagulf Sandy Loam will be stripped. Up to about 1,400 cubic yards will be stockpiled long term, and up to about 4,200 cubic yards will be stockpiled short term. About 1.0 acre of the Poposhia Loam will be stripped; resulting in about 1,200 cubic yards stockpiled long term and about 1,900 cubic yards stockpiled short term. The stripping depths for the Teagulf Sandy Loam and Poposhia Loam will generally be less than 24 inches (Section 3.2 above), but for a conservative estimate of the volume of topsoil to be stockpiled, a depth of 24 inches was used in the calculations.

3.4.2 Vegetation

For **Table MU1 3-2**, the vegetation disturbance was calculated on the basis of: (1) the areas from which vegetation will be removed, which essentially correspond to the areas from which topsoil will be removed; and (2) the areas in which vegetation will be trodden (e.g., driven over during facility installation), but not removed. As noted in the table, about 32 acres of vegetation in the Upland Big Sagebrush community will be removed, and about 10 acres may be trodden. Much less disturbance of the Lowland Big Sagebrush community is anticipated; about 9 acres will be removed, and about 6 acres may be trodden.

Table MU1 3-2 also includes estimates of the existing disturbance within MU1. This disturbance includes: two-track roads which pre-dated the LC ISR, LLC activities but which LC ISR, LLC is currently using; the LC ISR, LLC field trailer site; and the reclaimed areas around the MU1 monitor ring wells.

4.0 Baseline Ground Water Quality

This section presents the results of baseline ground water quality sampling for MU1 in the Permit Area. The baseline groundwater quality of MU1 is characterized to facilitate the detection of potential excursions during operations and to establish restoration goals.

4.1 Sampling Protocols

Chapter 11, Non-Coal In-Situ Mining, of the Non-Coal Rules and Regulations (2005a) and Guideline No. 4, In-Situ Mining, of WDEQ-LQD (2000) provide the recommended frequency, density, parameters, and quality assurance/quality control (QA/QC) for baseline monitoring. The baseline monitoring methodology applied to MU1 is discussed below.

Following well completion, each monitor well is subject to a mechanical integrity test (MIT). With a successful MIT, each well may be employed in its intended service. In contrast, when a monitor well fails an MIT, down-hole casing repairs with follow-up MIT generally suffice. However, when a monitor well fails an MIT and repair is infeasible, the well is properly abandoned. A replacement well may then be selected or drilled. (For example, wells M-120 and

MU-108 failed their MITs, were properly abandoned, and replaced by wells M-120A and KPW-2.)

Once a monitor well passes the MIT, water quality sampling may be conducted by following the procedures below.

- The static water level is measured to the nearest 0.1 foot below ground level.
- With this static water level and the known total well depth, the casing volume is calculated.
- The groundwater is pumped from the well, using a downhole submersible pump, to remove stagnant water that may chemically differ from the water in the formation. For sampling purposes, 220 volt single phase 1 to 3 horsepower pumps were used. The resulting flow rates, depending on the size of the pump and the yield of the well, ranged from 2 to 25 gpm.
- Field parameters are measured and recorded until three consecutive samples collected at least 0.5 casing volumes apart show less than 10% variability. A minimum of three casing volumes were pumped prior to sample collection during the baseline sampling of the MU1 monitor wells.
- The field parameters include:
    - pH to the nearest 0.2 standard units (SU);
    - temperature to the nearest 0.2 degrees Celsius (°C); and
    - specific conductance to within 20 micromhos per centimeter (µmhos/cm), corrected to 25 °C.
- Once the field parameters are stable, water samples are collected in a clean plastic or glass container, properly labeled and stored on ice in coolers.
- Upon returning from the field, the water samples may be kept in a refrigerator until transferred to coolers with ice and delivered to the laboratory with a completed chain-of-custody form within one day of collection or as soon as possible to meet required holding times.

At the Permit Area, baseline water quality data were collected at:

- the monitor ring wells outside the area of uranium recovery (M wells),
- the monitor wells completed in the aquifer overlying the production zone aquifer (MO wells),
- the monitor wells completed in the aquifer underlying the production zone aquifer (MU wells), and
- the monitor wells completed in the production zone aquifer within the planned area of uranium recovery, also known as the pattern monitor wells (MP wells),

Figure MU1 4-1 shows the locations of the monitor wells. **Table MU1 4-1a** lists the monitor wells in MU1. As noted on the table, two wells (M-120A and KPW-2) replace the wells originally installed at those locations due to problems with the original wells. The MIT results for the monitor wells are included in **Table MU1 4-1b**. The completion logs, geophysical logs and lithologic logs for all the MU1 monitor wells are included in **Appendix A** of **Attachment MU1 2-1**. Some of these logs were originally submitted in **Attachment D6-3** of the main permit document. For easier reference, those logs are also included in **Appendix A** of **Attachment MU1 2-1**. In addition, seven of the wells that were used previously as regional monitor wells were recompleted to be used as monitor wells in MU1. The procedure involved retrieving the screen and packer assembly from the well and then back plugging the well to the desired depth with neat cement. A new screen and packer assembly was installed to monitor the interval of interest. The recompletion details for these seven wells are included in **Appendix A** of **Attachment MU1 2-1**.

LC ISR, LLC, with input and approval from WDEQ-LQD, has recompleted many of the monitor wells on the ring to ensure sufficient monitoring for excursions. The methods for recompleting the wells are shown in **Figures MU1 4-2a, 2b and 2c**. **Figure MU1 4-2a** illustrates an example of cutting a new window in the existing casing to allow for monitoring of additional sands. **Figure MU1 4-2b** illustrates deepening of the hole to allow monitoring of additional sand intervals below the casing. In this example, additional windows could also be cut inside the casing. **Figure MU1 4-2c** illustrates opening up additional window(s) outside the casing. Each of the three recompletion techniques involves placing a screen through the interval being monitored and a blank or casing across the intervals being isolated from monitoring.

Each monitor well has been sampled four times with at least two weeks between each sampling event as shown in **Table MU1 4-2a**. The associated QA/QC sampling is listed in **Table MU1 4-2b**, and the water levels collected during these sampling events are shown in **Table MU1 4-3 (Attachment MU1 4-3** provides the electronic version of the water level data in two formats, the preferred format of WDEQ-LQD and that of **Table MU1 4-3**). All of the wells were sampled in April, May, and June 2009, with the following exceptions. Due to an error, the fourth round of well MO-111 sampling was conducted after sampling of the other monitor wells. Well M-120 was piloted on July 24, 2008 and was intended to be used as a perimeter monitor well. After the well was completed, it was not immediately tested for integrity. The well was monitored during the MU1 pump tests for water levels and these results are reported in **Attachment MU1 2-1**. Following the pump tests and prior to baseline groundwater quality sampling, the well was tested for integrity and failed on February 6, 2009. Since Well M-120 failed integrity, Well M-120A was installed as a replacement well approximately 18 feet away on March 20, 2009. The original groundwater quality data collected from wells MP-109 and M-120A indicated these wells had not been fully developed and the water sampled from the wells did not represent formation groundwater. Therefore, the wells were redeveloped and resampled. Well MO-114 was added to the monitor program to ensure adequate monitoring near the Lost Creek Fault and associated splinter fault and was sampled the requisite four times.

Table MU1 4-4 presents the parameters analyzed at the laboratory, which include the water quality constituents, the uranium mine constituents, and the additional trace metals listed in WDEQ-LQD's Parts IV and V of Appendix 1, Guideline No. 8, Hydrology (2005b). To facilitate accurate and precise water quality data, QA/QC procedures were implemented for field measurements, sampling and laboratory analyses. Instruments for analyzing field parameters were calibrated in accordance with the manufacturer's specifications and were able to report pH to the nearest 0.2 SU, temperature to the nearest 0.2 °C, and specific conductance to the nearest 20 µmhos/cm, corrected to 25 °C.

As recommended in WDEQ-LQD's Part III of Appendix 1, Guideline No. 8, Hydrology (2005b), duplicate and field blank samples were prepared during each sampling event to identify potential data errors resultant from improper sampling or analytical methods, poor sample preservation, or collection of non-representative samples. At a randomly selected well, duplicate samples were collected by filling two separate bottle sets, preserved, stored and transported in an identical manner to verify precision. One duplicate sample was collected for each sampling event or every 20 samples. A field blank sample was prepared by filling a clean bottle set with distilled water in the field and preserving it in the same manner as other samples in order to verify the analytical recognition of zero values, any positive bias from contaminated sample bottles or preservatives, and any contamination from atmospheric sources (e.g., airborne dust). One field blank sample of distilled water was prepared for each sampling event or every 20 samples. **MU1 Table 4-2b** shows the MU1 QA/QC samples in relation to their respective sampling events.

All laboratory analysis methods are approved by the American Water Works Association, with methodologies provided by the US Environmental Protection Agency (EPA) and the American Public Health Association as shown in **Table MU1 4-4**. In addition, the laboratory conducted its own QA/QC procedures of laboratory samples.

4.2 Sampling Results

This section discusses the water level and water quality data. The water quality data is separated into QA/QC and groundwater samples.

The groundwater level data, collected during each sampling event in accordance with **Attachment OP-8** of the main permit document, is included in **Table MU1 4-3** and **Attachment MU1 4-3**. The anomalous water level readings for wells M-103, M-116, MO-112, MO-113 and MP-104 appear to be due to sampler error as opposed to significant changes in water levels. Also, samplers failed to take water level measurements for MP-109 on December 1, 2009 and December 16, 2009 and also for KPW2 on June 6, 2009.

4.2.1 QA/QC Results

Once the laboratory results were received, they were reviewed by the Environment, Health and Safety Manager, the Radiation Safety Officer or a trained designee. The review included analyzing cation-anion balances, comparing the measured and calculated total dissolved solids (TDS) values, analyzing the QA/QC samples, comparing and contrasting the results with state and federal water quality criteria, and identifying potential outliers.

Table MU1 4-5 shows the WDEQ Water Quality Division's (WDEQ-WQD's) class-of-use criteria (WDEQ-WQD, 2005) and the EPA's maximum contaminant level (MCL) drinking water criteria (EPA, 2009a). The three referenced WDEQ-WQD water use classes are domestic (Class I), agriculture (Class II), and livestock (Class III). The EPA MCL drinking water criteria are enforceable primary standards and the highest contaminant level allowed in drinking water. Unless a matrix caused interference with the laboratory analyses, the laboratory detection limits are those listed in **Table MU1 4-4**.

As shown in **Table MU1 4-6**, the cation-anion balances are less than an absolute value of 5 (except 12 values less than an absolute value of 7), which is an acceptable balance (Eaton et al., 2005). **Table MU1 4-7** compares the measured TDS to the calculated TDS, which are reasonably comparable. **Table MU1 4-8** presents the laboratory results of the field blank analyses. The detected parameter concentrations/ radiation or abnormal values of the field blank samples are minimal, with the exception of gross alpha and dissolved radium-228 radiation. In many of the analyses, the precision of the gross alpha activity exceeds the WDEQ-WQD criterion; therefore, the precision of the laboratory analysis may alone account for many of the exceedances. However, the presence of these parameters in the field blank samples may suggest that potential data errors occurred from improper sampling or analytical methods. Certain gross alpha and dissolved radium-228 values may erroneously exceed WDEQ-WQD water quality criteria if the field blank samples are representative of the other samples. Overall, even when subtracting the detected radiation levels in blanks from those of the monitor well samples, the monitor well samples generally have elevated radiation levels that exceed the WDEQ-WQD water quality criteria.

Table MU1 4-9 shows the laboratory results of the duplicate samples. Some of the dissolved potassium, total sulfate, specific conductance, dissolved arsenic, and dissolved uranium concentrations as well as gross alpha, gross beta, and dissolved radium-226 radiation values differ, although none are considered anomalies.

4.2.2 Groundwater Quality Results

The groundwater quality analytical results are included in **Attachment MU1 4-1**. The results are tabulated by well (one page per well) and grouped by well. The electronic water-quality results received from the laboratory are included as **Attachment MU1 4-2**. **Attachment MU1 4-3** provides the electronic version of the water quality data in two formats, the preferred format of WDEQ-LQD and that of **Attachment MU1 4-1**.

The table for each well includes: the water quality results from each of the four sampling events; the minimum, mean, maximum, and standard deviation for each parameter (without outliers); and exceedances of state and federal water quality criteria. The results that exceed WDEQ-WQD's and EPA's criteria are discussed in detail below.

4.2.2.1 Monitor Ring Wells (M-Wells)

The M-well laboratory results are discussed in the following and presented in **Attachment MU1 4-1** and **Attachment MU1 4-3**.

General Parameters. The pH of the M-well samples ranges from 7.58 to 9.15 SU. The pH values meet the WDEQ-WQD agriculture criteria of 4.5 to 9.0 SU, except those of wells M-101, M-114, and M-115. TDS concentrations (502 to 629 milligrams per liter [mg/L]) from wells M-102 through M-106 exceed the WDEQ-WQD domestic use criterion of 500 mg/L. Samples from wells M-101 through M-107 have total sulfate concentrations exceeding the domestic criterion of 200 mg/L. The total sulfate concentrations of samples from wells M-102 through M-104 also exceed the domestic use criterion of 250 mg/L.

Metals. Wells M-117 and M-126 have samples with dissolved and total manganese concentrations exceeding the WDEQ-WQD domestic criterion (0.05 mg/L). Samples from wells M-103 and M-104 have concentrations exceeding the selenium WDEQ-WQD agriculture criterion (0.02 mg/L). The four samples collected from well M-106 have total iron concentrations (0.68 to 2.71 mg/L) exceeding the WDEQ-WQD domestic criterion (0.3 mg/L).

Uranium and Radionuclides. Twenty-two of the 28 M-wells have dissolved uranium concentrations (0.037 to 0.61 mg/L) exceeding the EPA MCL 0.03 mg/L criterion. All of the M-wells have gross alpha radiation exceeding the WDEQ-WQD criterion (15 picoCuries per liter [pCi/L]). Twenty of the 28 wells have Ra-226 plus Ra-228 values exceeding the WDEQ-WQD criterion (5 pCi/L).

4.2.2.2 'Overlying' Monitor Wells (MO-Wells)

The MO-well laboratory results are discussed in the following and presented in **Attachment MU1 4-1** and **Attachment MU1 4-3**.

General Parameters. The pH of the MO-well samples ranges from slightly basic (7.65 SU) to basic (9.69 SU). Ten samples from wells MO-106, MO-110, MO-111, and MO-112 exceed the WDEQ-WQD livestock pH criteria of 6.5 to 8.5 SU. One sample from well MO-101 has a total sulfate concentration (204.0 mg/L) that exceeds the WDEQ-WQD agriculture criterion (200.0 mg/L).

Metals. One sample from well MO-111 has a dissolved arsenic concentration (0.011 mg/L) that exceeds the EPA MCL criterion (0.010 mg/L). The dissolved selenium concentrations range from 0.001 to 0.047 mg/L. Nearly half of the samples have dissolved selenium concentrations that exceed the WDEQ-WQD agriculture criterion of 0.020 mg/L.

Uranium and Radionuclides. The uranium concentrations (0.13 to 0.92 mg/L) of every MO-well sampled exceed the EPA MCL criterion of 0.03 mg/L. All of the gross alpha values (137 to 1,060 pCi/L) exceed the WDEQ-WQD criterion of 15 pCi/L. Forty-five of the 56 samples exceed the WDEQ-WQD Ra-226 plus Ra-228 criterion (5 pCi/L).

4.2.2.3 'Underlying' Monitor Wells (MU-Wells)

The MU-well laboratory results are discussed in the following and presented in **Attachment MU1 4-1** and **Attachment MU1 4-3**.

General Parameters. The pH of the MU-well samples is basic, ranging from 7.89 to 10.20 SU. More than half of the sample values exceed the WDEQ-WQD livestock pH criteria of 6.5 to 8.5 SU.

Metals. Wells MU-109, MU-110, MU-112 and MU-113 have samples with dissolved arsenic concentrations (0.011 to 0.022 mg/L) exceeding the EPA MCL criterion (0.010 mg/L). Seven samples from wells MU-103 through MU-105 have total iron concentrations (0.45 to 3.91 mg/L) exceeding the WDEQ-WQD domestic criterion (0.3 mg/L).

Uranium and Radionuclides. Samples from wells MU-104, MU-105, MU-106, MU-110 and MU-111 have dissolved uranium concentrations (0.031 to 0.111 mg/L) that exceed the EPA MCL criterion of 0.03 mg/L. All of the MU well samples have gross alpha values (16.6 to 828 pCi/L) that exceed the WDEQ-WQD criterion of 15 pCi/L. Forty-eight (48) of the 52 samples exceed the WDEQ-WQD Ra-226 plus Ra-228 criterion of 5 pCi/L.

4.2.2.4 Pattern Monitor Wells (MP-Wells)

The MP-well laboratory results are discussed in the following and presented in **Attachment MU1 4-1** and **Attachment MU1 4-3**.

General Parameters. The pH of the MP well samples ranges from slightly basic (7.69 SU) to basic (10.70 SU). With the exception of wells MP-109 and MP-112, the pH results meet the WDEQ-WQD agriculture criteria of 4.5 to 9.0 SU. One-third of the samples exceed the WDEQ-WQD pH livestock criteria of 6.5 to 8.5 SU.

Metals. The dissolved arsenic EPA MCL (0.010 mg/L) is exceeded in eight samples (0.016 to 0.027 mg/L) from wells MP-103, MP-105 and MP-112. The selenium concentration (0.023 mg/L) of one MP-111 well sample exceeds the WDEQ-WQD agriculture criterion of 0.02 mg/L. The total iron concentrations of the MP-107 well samples also exceed the WDEQ-WQD domestic or agriculture criteria of 0.3 mg/L and 5.0 mg/L, respectively. In addition, the total manganese concentrations of only the MP-107 well samples exceed the WDEQ-WQD domestic or agriculture of 0.05 mg/L and 0.2 mg/L, respectively.

Uranium and Radionuclides. With the exception of well MP-106 samples, all of the well samples have uranium concentrations above the EPA MCL of 0.03 mg/L. All of the samples have gross alpha activity that exceeds the WDEQ-WQD criterion of 15 pCi/L. All of the samples, with the exception of two samples from well MP-107, have radium isotopic activity above the WDEQ-WQD criterion of 5 pCi/L of Ra-226 plus Ra-228.

4.3 Outliers

The water quality data of the monitor wells were evaluated to identify and remove potential outliers (anomalously high or low values relative to other values) that might otherwise strongly influence the general characterization of the wells. The outliers were identified in accordance with the process described in Section OP 3.6.4.1 of the main permit document, which is based on Attachment I of the WDEQ-LQD Guideline No. 4 (2000).

Well outliers were identified from the combined quarterly water quality sampling results of each type of monitor well (M, MO, MU, and MP). As noted in WDEQ-LQD Guideline No. 4, “there are no hard and fast rules regarding the initial selection of potential outliers” (2000). The water quality data was visually screened for anomalous values or groups of values, which were then subjectively evaluated as especially high or low relative to other values. Each potential outlier was compared to its tolerance interval, which was calculated excluding the potential outlier from the dataset. Each potential outlier was considered an outlier if its value was not within the calculated tolerance limit, unless it only marginally differed from the tolerance interval, was one of only a few detected samples, or was similar to multiple samples. **Table MU1 4-10** presents an example of outlier calculations. After evaluating the well data, the outliers were determined and are shown in **Table MU1 4-11**.

4.4 Baseline

It is assumed that the baseline concentrations are normally distributed. The 95% confidence interval, which is approximated by the baseline mean plus or minus three standard deviations, will be used to establish that the actual population mean is represented by the baseline mean. For the M, MO, and MU wells, the baseline mean is established on a well-by-well basis. For the MP wells, the baseline mean is established for the wells as a group (WDEQ 2007).

5.0 Operations Plan

Section OP 3.0 of the main permit document describes the mine unit processes, instrumentation, and control for the Project as a whole. The following sections describe specific operational considerations for MU1.

5.1 Mine Unit Operations

5.1.1 Operating Parameters and Procedures

MU1 will be subdivided into 12 operational areas referred to as header houses. **Figure MU1 1-3** shows the proposed locations and associated infrastructure for the 12 header houses. Each header house will be designed to accommodate the meter runs and distribution manifolds for approximately 20 production and 40 injection wells. The MU1 production wells are expected to have an average flow rate between 30 to 35 gpm. The injection wells are expected to have an average flow rate between 15 to 20 gpm, depending on the production and bleed flow rates. With the Plant operating at a nominal flow rate of 6,000 gpm, approximately 180 production wells and 360 injection wells will be in operation at any given point in time. Also, the hydrologic information obtained from the MU1 pump tests did not alter the assumptions used to develop the Lost Creek Project water balance. (The water balance for the Project is discussed in Section OP 3.6.3 and illustrated on **Figures OP-5a** through **OP-5f** of the main permit document.)

During the initial start up of mine unit operations, a single header house will be brought on line with an approximate production flow rate of 640 gpm flowing to the Plant through the main production pipeline. The main production and injection pipelines will be designed to accommodate the nominal operating flow rate of 6,000 gpm. Additional header houses will be brought on line at an approximate schedule of one per month until the maximum flow capacity through the Plant is realized. By this time, there should be eight to ten partially or fully on line header houses, depending on the realized average flow rates from the production wells. Header house construction and well installations will continue even though the nominal flow rate to the Plant has been achieved.

The start of each header house will be done in accordance with a prescribed standard operating procedure. The procedure will include a set checklist to ensure that pre start up inspections have been performed and documented. As part of the start-up procedure, LC ISR, LLC will monitor the water levels in the overlying and underlying monitor wells nearest to the header house as the house is brought on line.

The nominal flow rate of 6,000 gpm for the Plant is determined by the anticipated flow rate capacity of the ion exchange columns. The ten ion exchange columns are designed for an average throughput of 1,200 gpm with a maximum of 1,500 gpm. The flow through the ion exchange columns will be in series with five columns in the lead position and five columns in the trail position. This means that five lead columns will receive the mine unit flow directly from the production pipeline and the five trail columns will receive the flow exiting the lead columns. The flow from the trail columns is returned to the mine unit by the main injection pipeline. Therefore, the nominal flow rate through the Plant is five times 1,200 gpm, or 6,000 gpm. A bleed stream of the production flow into the Plant will be sent to the waste water disposal system prior to the re-injection of the leaching solution. Also, the carbonate component of the injection fluid will be added to the leaching solution downstream of the ion exchange columns and prior to exiting the Plant. The oxidant will be added to the leaching solution in the header houses prior to injection. The chemical constituents will be added at concentrations as specified in **Section OP 3.0** of the main permit document. An antiscalant may be added if needed.

New production wells will be brought on line to replace production wells that are shut in when it is determined that the recovery of uranium from these wells is no longer technically or economically warranted. This process will ensure that the nominal flow rate to the Plant will be maintained for maximum production and will continue in MU1 until the twelfth header house is fully on line. Groundwater restoration and surface reclamation will commence directly following the determination of the completion of uranium recovery (mining) in MU1 in accordance with the Reclamation Plan of the main permit document.

The initial proposed project schedule for the Lost Creek Project was based on the results of the regional pump tests performed in 2007. Since the MU1 pump tests provided comparable results to these previous pump tests, the proposed project schedule has not changed. A detailed discussion of the mine and reclamation plans for each proposed wellfield is provided in **Section OP 2.1** and a timeline is presented in **Figure OP-4a** of the main permit document.

5.1.2 Process Instrumentation

Instrumentation systems will be an essential component to monitoring and maintaining the proper mine unit flow balance and provide notice to operators in the case of mine unit upset conditions. Mine Unit Operators will use the data and information provided by the instrumentation systems to maintain proper header house and pattern flow balances as specified in **Section OP 3.6** of the main permit document.

5.1.3 Operational Monitor Well Sampling and Data Review

The MU1 monitor wells listed in **Table MU1 4-1a** were installed as described in **Section OP 3.2** of the main permit document. **MU1 Section 4.0** describes the baseline sampling program for these wells and the UCL and baseline restoration criteria calculation methods. This section presents the operational well sampling procedure and the review of the monitor well sample data.

Excursion monitoring includes sampling of the monitor ring wells (M wells), which are completed in the same horizon as the pattern area (HJ Horizon) and monitor wells screened in the overlying (MO wells) and underlying (MU wells) aquifers on the schedule outlined in **Section OP 3.6.4.2** of the main permit document. Prior to the start of well sampling, water levels will be measured for each monitor well. The groundwater collected from the wells will be analyzed for the excursion parameters (chloride, specific conductance and alkalinity) and their concentrations will be compared to the calculated UCL concentrations for those parameters for each type of monitor well. Data retention times are also included in **Section OP 3.6.4.2**.

During mine unit operations, the primary purpose of the monitoring well sampling program is to prevent and detect excursions. Therefore, a thorough review of the monitor well sampling data will be performed by an LC ISR, LLC employee trained for this task as the results of the sample analyses become available. The prevention of horizontal excursions in the perimeter monitor well ring is possible by reviewing the water quality data in concert with the water level data. The data reviewer will have access to a monitor well data base that will allow that person to trend data over time for a specific monitor well or a series of wells to determine whether a potential excursion exists and alert the mine unit operations staff to make the necessary flow changes to prevent the excursion.

Sudden increases in water levels in the overlying or underlying aquifers, however, may be an indication of casing failure in a production, injection or monitor well. Isolation and shutdown of individual wells can be used to determine the well causing the water level increases. MIT's of production and injection wells in the area of a suspected failure may also be performed to locate the failed well.

In the event that an excursion is detected, then verified by confirmation samples, excursion control would be initiated in accordance with the procedures in **Section OP 3.6.4** of the main permit document.

5.1.4 Perimeter Monitor Well Location Design

The primary objective for an in situ recovery project groundwater monitoring program is the protection of existing groundwater supplies. Appendix D5 and Appendix D6 of the main permit document contain general baseline geologic and hydrologic information pertaining to the overall project area. Prior to mine unit development it is necessary to collect and assemble detailed information on geologic and hydrologic conditions to define the ore zones, plan the mine unit and develop the groundwater monitoring program.

As part of the groundwater monitoring program, perimeter monitor wells have been installed within the Production Zone, outside of the production pattern area in a "ring" around the mine area. These wells were used to obtain baseline water quality data and will be used to detect mining zone excursions during mine unit operations. The UCLs determined for these wells from the baseline water quality data (Section 4.5) are used to determine the presence of an excursion.

The MU1 perimeter monitor well ring was installed in the fall of 2008 with each well located approximately, but no greater than, 500 feet from the outside edge of the mine unit as defined by mapped individual pattern areas. Also, the distance between each of the monitor ring wells is approximately, but no greater than, 500 feet apart. These distances are based on the MU1 aquifer characteristics to ensure the monitor well ring is adequate to detect horizontal excursions. Also, the completion interval of each monitor well targets the production zone(s) adjacent to that well within an 800 foot radius and on the same side of the Fault. Trend wells will be used to detect changes in water quality for those production completion horizons outside the 800 foot radius and not monitored by the exterior monitor wells (see **Figure MU1 5-6**).

As discussed in LQD Guideline #4 the distance between the mine unit and the perimeter monitor wells should be such that the monitor wells are within the zone of control of the production wells which would be used to control excursions. Based on the MU1 aquifer pump tests results, it is apparent that the radius of influence of a single pumping well greatly exceeds 500 feet. In fact, the MU1 aquifer pump tests indicated a response in the HJ Horizon of a minimum distance of 2,600 feet (North Test) within 2 days. Therefore, an excursion detected at the perimeter monitor well ring placed within 500 feet of the mine unit will be readily controlled by adjusting extraction and injection rates in nearby well patterns as described in Section OP 3.6.4 of the main permit document.

On November 12, 2010 LC ISR, LLC provided WDEQ-LQD with a numerical model prepared by Petrotek (2010). The original text of the numerical model summary was clarified and has been inserted into this document as Attachment MU1 5-1. As part of the analysis the production and restoration model used in previous simulations was modified to evaluate if an excursion could be detected using the current monitor ring well spacing at MU1. A hypothetical excursion was simulated by reducing the pumping rate at an extraction well in one well pattern on each side of the Lost Creek Fault, along the west edge of MU1. The west edge of MU1 was selected for the excursion simulation because the natural hydraulic gradient is toward the west-southwest. Wellfield fluids in the western portion of MU1 should have the greatest probability of moving outside the hydraulic control of the wellfield if an "out of balance" event occurs. The production rate in each of the two extraction wells was reduced to approximately 25 percent of the original operating rate to simulate an "out of balance" situation. The two extraction wells had previously been simulated as producing at a rate of 32 gpm, or 6,160.4 cubic feet per day. No change was made to the injection well rates or locations in or around the neighboring well patterns for this simulation. All other extraction and injection wells were simulated at the same rates presented in the production simulation previously described. The change in production for this simulation is a reduction of 64 gpm resulting in a net "under-production" of 4 gpm for MU1. Particles were placed at the injection wells in the well patterns with the reduced rate extraction wells. The particles show the flowpath of injectate from the injection wells. Particles travel away from the wellfield and toward the monitor well ring. This hypothetical simulated excursion represents the loss of lixiviant during the production phase of ISR. The simulation shows that some particles from both well patterns that are "out of balance" will reach (and be detected by) monitor wells in the monitor ring. The 500-foot spacing between MU1 monitor ring wells is adequate for detection of the simulated excursion.

Recovery of the excursion was also simulated by the numerical model. For the recovery simulation, particles were placed at the monitor well where the excursion was "detected". The model was run for an additional 30 days under the "out of balance" conditions. This allowed for the excursion to continue to migrate away from the wellfield during the time it would take to conduct resampling, and develop a response to the excursion. A line of particles was then placed at the downdip limit reached by the particles during the 30-day interval, representing the maximum distance that the excursion traveled beyond the monitor well. The simulation was resumed with rates at the two extraction wells increased to the original 32 gpm production rate. Select injection wells in the two well patterns were shut-in. For the south well pattern, injection was reduced by 32 gpm and extraction increased by 32 gpm resulting in a net change of 64 gpm. For the north well pattern, the injection was reduced by 40 gpm and extraction increased by 32 gpm for a net change of 72 gpm. Results of the simulation show that the excursion moves back inside the well ring within less than 30 days. Hydrographs of the two monitor wells where the excursions were detected show the rapid response to the excursion recovery action. Within less than one day after beginning excursion recovery there is over 10 feet of drawdown at both monitor wells. These results are consistent with the response of the aquifer during the north and south hydrologic tests.

The approximate 500-foot spacing between perimeter monitor wells is a standard practice within the ISR industry in Wyoming and has proven to be effective in detecting mining zone excursions. Also, **Figures 6-17** and **6-18** in **Attachment MU1 2-1** indicate a relatively uniform drawdown pattern in the perimeter monitor wells in relation to the distance from the pumped well. This indicates that channeling within the HJ Horizon, if present within MU1, does not significantly control or influence groundwater movement during periods of pumping stress. Each of the monitor ring wells, with the exception of well M-114 (which straddles the fault) showed approximately five feet or more of drawdown by the end of the 2 to 3-day tests. Even if paleochannels are present at MU1 that traverse between two monitor wells, the uniform hydraulic response of the HJ Horizon to the pumping wells indicates that any paleochannel would also be hydraulically connected to the pumping wells. Otherwise, there would have been a 'shortcircuit' in the system that would have either prevented a response in wells separated from the pumping well by the paleochannel, or resulted in a drastic steepening of the drawdown contours between the paleochannel and the outer monitor wells. The north hydrologic test included monitoring of 32 HJ Horizon wells on the north side of the Fault and the south hydrologic test included monitoring of 29 HJ Horizon wells on the south side of the Fault. This density of monitoring should be sufficient to identify if areas of MU1 are hydraulically isolated within the HJ Horizon. The Hydrologic Tests did not indicate such an occurrence. Based on results of the hydrologic testing that has been performed, any paleochannels that exist within MU1, are in hydraulic communication with the Production Zone aquifer and will be adequately monitored.

Each perimeter monitor well has been screened to discretely monitor the mining zones closest to the monitor well ring as was previously discussed with the WDEQ-LQD in Lander on June 25, 2008 prior to design and installation of the wells. The results of the attached MU1 pump tests confirm that the various sand units within the HJ Horizon are hydraulically well connected. As a result, these sands respond as a single hydrostratigraphic unit. Therefore, monitor well completions across the entire HJ Horizon would most likely result in the collection of samples that are more diluted with respect to any mining fluids which could potentially decrease the likelihood of detecting an excursion. Following the originally approved installation and testing of the MU1 monitoring system, the WDEQ-LQD requested a revised monitor well completion program. The revised program (shown in **Figure MU1 5-6**) incorporates an 800 foot capture radius for each monitor well. In other words, each monitor well completion is based on those pattern completion horizons within an 800 foot radius from that monitor well on the same side of the Lost Creek Fault. In addition, two trend wells were installed to allow for those patterns not accounted for within the capture radius of the exterior monitor wells. The monitor wells originally completed in 2008 were modified to the completions shown in **Figure MU1 5-6** in 2010

Wells TW1-1, TW 2-1 and OW1-1 were also added to the monitoring system to improve detection capabilities in situations where there were no completion zones being monitored within

800 feet of the production pattern. Water levels will be collected from these wells on the same frequency as the monitor well ring wells.

5.2 UCL Calculations

With the characterization of the baseline MU1 groundwater quality, the UCL parameters and limits were selected and calculated to facilitate the detection of potential excursions during Project operations. Among other factors, UCL parameters were selected considering their potential to react through sorption, oxidation, reduction, and precipitation. Common, reliable UCL parameters of in-situ uranium mining are specific conductance, chloride, TDS, sulfate, bicarbonate or total alkalinity, sodium, and calcium.

Total alkalinity, chloride, and specific conductance were chosen as the primary lixiviant migration indicators for MU1. Since bicarbonate (a component of total alkalinity) is a major compound added to the lixiviant during mining, total alkalinity is a useful UCL parameter. Chloride is a common UCL parameter in Wyoming due to its low levels in the native groundwater and its mobility in groundwater. Chloride is elevated in the lixiviant in comparison to the native groundwater due largely to the chemistry of the ion exchange system. The lixiviant TDS concentration generally differs than that of the baseline groundwater quality and does not appreciably change with sediment interaction; therefore, specific conductance is an excellent indicator due to its direct correlation to TDS.

UCLs were established for each M, MO and MU well. As recommended in WDEQ-LQD's Guideline No. 4 (2000), the alkalinity and specific conductance UCLs were calculated by adding five standard deviations to each UCL parameter baseline mean. Each chloride UCL was calculated by adding five standard deviations to each mean chloride concentration or by adding 15 mg/L to each mean chloride concentration, whichever was larger. The outliers identified in **MU1 Section 4.3** were excluded from the UCL calculations. **Table MU1 4-12** shows the means, the standard deviations and UCLs for the M, MO, and MU wells. Those monitor wells where the completion intervals were modified per the WDEQ-LQD request in 2010 will be sampled one additional time. Those samples will analyzed for total alkalinity, chloride and conductivity and the results compared to the original results used to generate UCLs for each well. The UCLs will not be changed if the measurements are within ten percent of the original UCL. However, if the ten percent limit is exceeded, the well in question will be re-sampled for the UCL constituents as detailed in **MU1 Section 4** and a new UCL set. Trend wells will be monitored in-house for water level only.

5.2.1 Monitoring the LFG and UKM Sands across the fault

The Lost Creek Fault transects the MU1 pattern area. LC ISR, LLC recognizes that within some areas of MU1, the LFG and UKM Sands are positioned across from the HJ mining zone due to the structure of the fault. This fact is illustrated on **Plate D5-1d** of the main permit document. Therefore, LC ISR, LLC has examined these areas to ensure that a monitoring strategy to detect excursions into these juxtaposed sands is in place prior to the start of mining. Section 2.1 (Structural Geology) provides a more detailed discussion of the Lost Creek Fault.)

LC ISR, LLC has designed MU1 so none of the individual patterns cross the fault. However, there are patterns screened in the Upper HJ (UHJ) Sand that are positioned across from the LFG Sand on the down thrown side of the splinter fault of the Lost Creek Fault. **Figure MU1 5-1** shows the pattern locations, outlined in red, where this occurs. In order to monitor the LFG Sand at this location, LC ISR, LLC has recompleted well MO-114 in the LFG Sand and will use this well to monitor for mining solutions that may cross the Lost Creek Fault from the UHJ mining patterns. Well MO-114 was not included in the MU1 baseline sampling program conducted April through June 2009. However, a baseline sampling program for well MO-114 has been completed and the data has been incorporated into the database for MU1. Also indicated on **Figure MU1 5-1,** there is a set of patterns (outlined in red) north of the Lost Creek Fault screened in the UHJ Sand that are positioned across from the LFG Sand on the down thrown side of the Lost Creek Fault. Monitor well MO-113, which was sampled as part of the original baseline wells, is positioned to monitor the LFG Sand to detect potential excursions that may occur across the fault at this location. A summary of monitoring across the fault can be found in **Table MU1 5-3**.

Also indicated on **Figure MU1 5-2,** there is a set of patterns north of the Lost Creek Fault screened in the Middle HJ1 (MHJ1) Sand that are positioned across from the LFG Sand on the down thrown side of the Lost Creek Fault. Monitor wells MO-113 and MO-109 are positioned to monitor the LFG Sand to detect potential excursions that may occur across the fault at these locations.

The Middle HJ2 (MHJ2) Sand is the only sand unit that is positioned across from both the LFG and the UKM Sands. **Figures MU1 5-3a and b** show the pattern areas (outlined in red) where this occurs. The MHJ2 pattern areas north of the Lost Creek Fault (**Figure MU1 5-3a**) are positioned across from the LFG Sand on the down thrown side of the Lost Creek Fault. Monitor well MO-114 is positioned to monitor the LFG Sand to detect potential excursions that may occur across the fault from these patterns. **Figure MU1 5-3b** shows the MHJ2 pattern areas that are screened across from the UKM Sand. Monitor well MU-111 is positioned to monitor the UKM Sand to detect potential excursions that may occur north across the Lost Creek Fault from the MHJ2 pattern areas located south of the fault in the western portion of the of the mine unit.

Finally, there are patterns screened in the LHJ Sand that are positioned across from the UKM Sand as shown on **Figure MU1 5-4**. LC ISR, LLC believes there is sufficient monitoring positioned in the UKM Sand (MU wells) that leakage across the Lost Creek Fault into the UKM sand will be detected. Monitor well MU-111 is positioned to monitor the UKM Sand to detect potential excursions that may occur north across the Lost Creek Fault from the LHJ pattern areas located south of the fault in the western portion of the mine unit.

LC ISR, LLC will be overproducing in these pattern areas as part of the bleed system as discussed in **Section OP 3.6** and **Attachment OP-2**, “Engineering Controls” of the main permit document. However, in the event that leakage is detected across the fault in these locations and verified by confirmation samples, then excursion control would be initiated in accordance with the procedures in **Section OP 3.6.4** of the main permit document.

LC ISR, LLC believes that, with the addition of monitor well MO-114 the monitoring system is sufficient to discover any leakage of mining solutions that may occur across the fault into the LFG and UKM sand units due to their juxtaposition to the HJ mining zone.

5.3 Historic Drill Hole Locations

Figure MU1 5-5 shows the historic drill holes located within the proposed MU1 pattern area. Also, **Plate MU1 5-1** shows the proposed MU1 pattern area, the proposed monitor well ring and historic drill holes out to a distance 500 feet beyond the proposed monitor well ring. **Table MU1 5-1** lists the abandonment information available for the historic drill holes shown on **Figure MU1 5-5** and **Plate MU1 5-1.**

A review of the historic records suggests these holes were properly abandoned by the original operator pursuant to regulations that were in place at that time. Additionally, the two MU1 pump tests included with this submittal do not identify any improperly abandoned drill holes within the MU1 pattern areas. The pump tests do reveal minor communication between the overlying and underlying aquifers and the HJ Horizon, which is most likely caused through the displacement of the Lost Creek Fault.

However, to ensure compliance with the Safe Drinking Water Act and State Regulations, LC ISR, LLC will actively pursue a re-plugging program of historic drill holes within the MU1 pattern areas for holes which can be positively located and identified by LC ISR and/or WDEQ-LQD. Additionally, if a historic drill hole or well is later located during the mine unit installation testing, or operation, the drill hole or well will be abandoned in accordance with abandonment procedures currently in use by LC ISR, LLC.

5.4 Updated Water Rights Information

Table D6-13 of the main permit document lists the groundwater permits of the Project that had been obtained from the Wyoming State Engineer’s Office as of December 2008. As requested in the WDEQ-LQD’s August 2008 Comment #34 on Appendix D6, **Table MU1 5-2** lists the groundwater permit information updated for MU1.

6.0 Groundwater Quality Restoration and Surface Reclamation

The section on Groundwater Quality Restoration and Surface Reclamation in the main permit document describes the plans for the Project as a whole. The following sections describe specific restoration and reclamation considerations for MU1.

6.1 Groundwater Restoration

6.1.1 Calculated MU1 Pore Volume

The progress of groundwater restoration is often measured on the basis of the number of pore volumes (PVs) treated in each phase. Pore volume is a term used by the industry to define an indirect measurement of a unit volume of aquifer water affected by ISR operations. It represents the volume of water that fills the void space in a certain volume of rock or sediment. Pore volume provides a unit reference that an operator can use to describe the amount of treated water circulations needed to flow through a depleted ore body to achieve restoration standards. A more detailed discussion about pore volumes is included in **Section RP 2.3** of the main permit document.

One PV is equivalent to:

- PV = Area x Thickness x Horizontal Flare x Vertical Flare x Porosity x Conversion
- PV (in gallons) = A (in ft^2) x T (in ft) x 1.2 x 1.2 x 0.25 x 7.48 (gallons/ft^3)

The MU1 PV is based on the following data:

- Mine Unit Area = 2,115,594 ft^2
- Average Thickness = 12 ft

Therefore the mine unit area PV is:

- PV = 2,115,594 ft^2 x 12 feet x 1.2 x 1.2 x 0.25 x 7.48 (gallons/ft^3) = 68,362,458 gallons.

Additional data specific to MU1 is available in Worksheet 1 of **Table RP-4** of the main permit document.

Area: is the area of the patterns projected to the ground surface. It is used in the pore volume calculations, but because of the presence of 'stacked' ore, it must be adjusted in those calculations to account for pattern overlap. The surety estimate was originally based on 180 patterns at 9,000 square feet per pattern or 1,620,000 total square feet. However, the pattern overlap within the HJ Sand was not taken into account in this approach. The updated estimate includes 241 patterns, and the actual surface area is 1,611,720 square feet. However, to account for pattern overlap in the pore volume calculations, it is has been assumed that the area is larger, i.e., the area of each pattern is taken into account in the pore volume calculation, even if it is stacked with another pattern. With this approach, the total MU1 area has been revised to 2,115,594 square feet. The surety estimate and schedule will be modified on an annual basis, and the estimated areal extent will be updated as necessary.

Thickness: is estimated to be 12 feet based on preliminary estimates for pattern completions. The average completion thickness for the MP monitor wells in MU1 is 17 feet. The MP monitor well completions are considered ‘gross’ completions and are designed to capture all the ore in the immediate production horizon. The MP monitor wells also tend to be in the thickest part of the ore to insure water quality samples indicative of the ore zone. Therefore, these monitor well completion intervals are expected to be thicker than many of the actual production and injection well completions because many of the production and injection wells are located on the ‘fringes’ of the ore, where the ore thickness is less. Because of the range of ore thicknesses, LC ISR, LLC maintains that the original estimate of 12 feet ‘average’ completion thickness is valid. Further, the surety estimate will be modified on an annual basis and the estimated ore thickness will be replaced with actual ore thickness as the production and injection wells are installed.

‘Stacked Ore’ in MU1: The HJ Sand is the production zone of interest in MU1. Production is planned from four horizons (UHJ, MHJ1, MHJ2 and LHJ) within the Sand. Production patterns will be completed with separate wells in each of these horizons and produced simultaneously regardless of whether they overlie each other or not. The surety estimate accounts for horizontal flare equal to 20 percent of each pattern’s area and vertical flare equal to 20 percent of each pattern’s thickness. This is regardless of continuity with other patterns either vertically or horizontally. Therefore, every pattern is fully accounted for in the surety estimate.

6.1.2 Groundwater Restoration Methods

The number of PVs planned for each stage of groundwater restoration to meet the restoration objective and to demonstrate the application of BPT is as follows:

- Groundwater transfer: zero to two PVs (optional);
- Groundwater sweep: three-tenths (0.30) of a PV;
- RO permeate injection: six PVs; and
- Groundwater recirculation: one PV.

LC ISR, LLC will conduct an in-house water quality monitoring program throughout the progression of the groundwater restoration activities. Once the restoration requirements are believed to have been met, LC ISR, LLC will collect appropriate groundwater samples for verification, as outlined in the main permit document. If confirmed, LC ISR, LLC will initiate the stabilization monitoring phase and submit supporting documentation that the restoration parameters are at or below the restoration standards. If, at the end of restoration activities, the parameters are not at or below the primary standards, LC ISR will either re-initiate certain restoration phases or submit documentation to the agencies that BPT has been used in restoration and the aquifer has been restored to its original class of use. The documentation will include an evaluation of the water quality data and a narrative of the application of BPT.

Additional details, descriptions and discussion of the PV requirement determination of the various phases of groundwater restoration are presented in **Section RP 3.2** of the main permit document.

6.1.3 Evaluation of Groundwater Restoration Success

Upon completing groundwater restoration and notifying WDEQ, a groundwater stabilization monitoring program will begin in which the 13 MU1 pattern monitor wells will be sampled to evaluate restoration success will be sampled. Additional details of the stabilization monitoring program are discussed in **Section RP 2.4** and **Section RP 2.5** of the main permit document.

As described in **Section RP 2.2** (Restoration Requirements) of the main permit document, LC ISR, LLC will apply the Best Practicable Technology (BPT) to return the groundwater to the pre-operational class-of-use, and if possible, to approximate baseline conditions, in accordance with WDEQ statutes and regulations. Per **Section RP 2.5** of the main permit document, the criteria that will be used to evaluate restoration success are: the baseline and restoration means and associated statistics; the water treatment technology applied during restoration, and the EPA criteria. The criteria for the wells in the monitor ring (M) and the overlying (MO) and underlying (MU) aquifers are evaluated on a well-by-well basis. Additionally, **Section RP 2.5** of the main permit document outlines the procedure to follow if an M, MO or MU monitor well has been impacted by an excursion during mining. The criteria for the monitor wells in the pattern area (MP) are evaluated collectively (WDEQ-LQD & WQD, 1977).

Comparison of Baseline and Restoration Means. After the stability samples are analyzed, the minimum, mean, maximum, and standard deviation of each parameter will be calculated. For the MP wells, the calculations will be an average of the results for all the MP wells. For any M, MO, or MU well that went on excursion during mine unit operation, the calculations will be for that well.

Similar to the baseline samples, the 95% confidence interval will be used to establish that the actual population mean is represented by the restoration mean. The unpaired t-test, or similar parametric test, will be used to determine if the difference between the restoration and baseline means is statistically significant at the 95% confidence interval (see e.g., Part III of the EPA Unified Guidance [EPA 2009b]).

Application of Best Practicable Technology (BPT). If the restoration mean exceeds the baseline mean for a particular parameter, then LC ISR, LLC will provide detail on the technology applied per Section RP 2.5 of the main permit document. The WDEQ-LQD will evaluate whether the technology meets the definition of per Chapter 11, Section 5(a)(ii) of the WDEQ-LQD NonCoal Rules (2005).

EPA Criteria. Per Chapter 11, Section 5(a)(ii)(D) of the LQD NonCoal Rules and Regulations, the EPA Maximum Contaminant Limits must be taken into consideration if an MCL has been established for a particular parameter. If the baseline concentration exceeds the MCL, then the baseline becomes the criteria (see, e.g., Item 2 Fact Sheet #13 for WDEQ-VRP).

6.2 Surface Reclamation

6.2.1 Well Abandonment

Once NRC and WDEQ review and approve LC ISR, LLC's assessment that the groundwater restoration is complete in a given mine unit, all of the wells will be abandoned in accordance with applicable regulations, unless a well is needed for continued monitoring of another mine unit or retention of the well for future use has been requested and approved. A detailed description of LC ISR, LLC's well abandonment procedure has been submitted with the main permit application in **Section RP 3.1**.

6.2.2 Surface Reclamation

Once NRC and WDEQ review and approve LC ISR, LLC's assessment that the groundwater restoration is complete in a given mine unit, with the exception of any facilities, access roads, or utility corridors required for continued operation, all of the facilities associated with the 12 header houses in MU1 will be removed in accordance with **Section RP 3.2** of the main permit document. Soil replacement and reseeding will be performed in accordance with the methods described in **Section RP 4.5** of the main permit document.

7.0 References

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