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6.0 GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

A variety of restoration and reclamation activities will be phased in throughout the project life as mine units are depleted of uranium. Final facility decommissioning and reclamation will occur once the Plant is no longer in use. **Figure 1.7-2** includes a schedule of activities for the Project, including the restoration and reclamation activities. This schedule is an alternate schedule pursuant to 10 CFR 40.42. While LC ISR, LLC believes the groundwater restoration and surface reclamation can be completed within 24 months for each mine unit, the associated regulatory reviews and approvals will lengthen the schedule beyond 24 months. LC ISR, LLC understands that any revision to the alternate schedule must be requested through a license amendment application.

For each mine unit, LC ISR, LLC will submit a decommissioning plan as part of the mine unit package. For the processing and support facilities that will not be removed until the end of the Project, LC ISR, LLC will submit a decommissioning plan for those facilities at least 12 months prior to removal of those facilities. The decommissioning plans will include a quality assurance program as discussed in TR Section 5.2.

Reclamation of each mine unit and associated header houses involves:

1) groundwater restoration,
2) radiological decontamination,
3) equipment removal/decommissioning (e.g. well abandonment), and
4) surface reclamation (e.g., well site reseeding).

Groundwater restoration may start once uranium recovery is complete at that header house, and restoration of a header house may occur contemporaneously with operation of another header house in the same mine unit. To ensure maximum ore recovery and avoid interference between header houses, contemporaneous production and restoration of adjacent header houses and/or mine units will be carefully evaluated. Once groundwater restoration is complete, decontamination and other reclamation activities will start. Decontamination of equipment and other surface reclamation activities will start when all of a mine unit is restored.

Reclamation of the Plant and support facilities involves similar activities, including:

1) radiological decontamination,
2) equipment removal/decommissioning (e.g., building demolition), and
3) surface reclamation (e.g., road removal, topsoil replacement, and reseeding).

The following sections describe the criteria used to determine when production is complete, the status of the mine unit at the end of operations, the subsequent restoration and reclamation activities, and the criteria used to determine when restoration and reclamation have been successful.

6.1 Completion of Production Operations

Technical, economic, and operational criteria can be reviewed to determine if uranium recovery is complete in a given header house and/or mine unit. The technical criteria comprise the percentage recovery of the estimated ore reserves, the uranium concentration in the production fluid, and the header house flow rates. Typically, the technical criteria for considering production operations complete are:

- a uranium recovery of at least 80 percent;
- a production fluid uranium concentration reduced to a level not significantly greater than the injection fluid; and,
- in some instances, a reduced groundwater flow rate.

The economic criteria comprise the corporate financial objectives, the price of uranium, and the annual production targets. When production targets are no longer being met, and operational changes will not improve the possibility of meeting those targets, then ISR operations may be considered complete.

The Plant ion exchange and processing capacity may also factor into determining if ISR operations have been completed in a given header house or mine unit. If there is unused ion-exchange-recovery and waste-management capacity that can be filled by continued operation of an area, which is essentially depleted but will continue to supply a low-concentration production fluid, it may be economic to continue operation of that header house. Such an extension allows for the recovery of uranium for a period of a few months after the header house operations might normally be considered complete. In addition, such an extension allows for higher percent recovery of uranium, which may facilitate subsequent groundwater restoration. This extension will end when there is no longer sufficient capacity for low-concentration production fluid or the quantity of uranium recovered is insufficient to cover operating costs.

The decision to take a mine unit (out of production and place it into restoration will be based solely on the considerations outlined above. As long as a mine unit is economic and there are not technical issues preventing production, the mine unit will remain in production status. Pursuant to 10 CFR 40.42(d), if an area must be temporarily shut down for any reason, decommissioning will commence within 24 months unless NRC grants an exemption.

For each mine unit, LC ISR, LLC will inform NRC of the transition from production to restoration. Four conditions would trigger NRC notification of decommissioning (restoration) activities: the license has expired, a determination to permanently cease principal activities, no principal activities have been conducted for 24 months under the license, or no principal activities have been conducted in a specific wellfield. Cessation of injection marks the end of principal activities.

A hydrologic bleed sufficient to control mining or restoration solutions will be maintained during all phases, including any hiatus in production, until active restoration is complete. The anticipated water quality in the production zone before restoration is included in Table 6.1-1.

6.2 Plans and Schedules for Groundwater Quality Restoration

The objective of restoration and reclamation is to return the affected groundwater and land surface to the uses for which they were suitable before commencement of the Project operations. To achieve this objective LC ISR, LLC will use Best Practicable Technology (BPT) to return the groundwater in the pattern area to the quality described in 10 CFR Part 40 Appendix A Criterion 5B(5) or to baseline if baseline is higher. If LC ISR, LLC determines that despite the implementation of BPT that the groundwater cannot be returned to background, an Alternate Concentration Limit will be requested. The proposed methods for groundwater restoration are described in this section. Before discussing restoration methodologies, the chemistry of the system is briefly reviewed.

6.2.1 Conditions in the Mineralized Zone Before and After Operations

The uranium deposits underlying the Permit Area are similar to those found at other ISR operations in the US. They are primarily roll front deposits in fluvial sandstones, and the uranium was deposited when oxidized groundwater containing the uranium entered reducing conditions in the subsurface aquifers. The reducing agents were probably organic matter and pyrite and, to a lesser degree, hydrogen sulfide.

ISR operations essentially reverse the natural processes that deposited the uranium. Injection wells introduce lixiviant into the mineralized zone to oxidize the reduced uranium and to complex it with bicarbonates. Pumping from production wells draws the solution through the mineralized zone, oxidizing additional ore between the injection and production wells.

In turn, groundwater restoration essentially reverses the effects of the oxidation during ISR operations and re-establishes the reducing conditions that were present prior to production, to the extent possible. Groundwater sweep removes much of the groundwater oxidized during operations. During the RO phase, residual uranium and other metals mobilized under the oxidized conditions are removed, and the treated water reinjected. As necessary to accomplish restoration, specific reductants such as hydrogen sulfide may be added. Biorestoration may also be applied, if site conditions are suitable for this restoration technology.

6.2.2 Restoration Requirements

LC ISR, LLC commits to return the groundwater to baseline water quality in accordance with NRC regulations. However, if after the application of Best Practicable Technology (BPT), the water quality has not been returned to baseline quality, LC ISR, LLC may seek an alternate restoration standard pursuant to NRC regulations. During all stages of operations, approved standby modes and active restoration, a hydrologic bleed will be maintained on the mine unit such that mining solutions are maintained within the exempted aquifer. The hydrologic bleed will be stopped during stabilization.

Prior to operation of each mine unit, groundwater baseline quality will be determined on the basis of the water quality data collected in accordance with WDEQ regulations and NRC guidance found in NUREG 1569 Section 3.1.3 and 10 CFR 40.31(g). For the wells in the perimeter monitor ring and for wells in overlying and underlying aquifers, the baseline will be determined on a well-by-well basis. For the pattern area, baseline water quality data from monitor wells in the pattern area will be averaged to determine the overall baseline water quality.

Baseline water quality data will be collected from the monitor wells in the perimeter ring, in the pattern area, and in the overlying and underlying aquifers before ISR operations in each mine unit, in accordance with the Testing Proposal which will be submitted to WDEQ-LQD for review and approval. A minimum of four samples will be collected from each well, at least 14 days apart. Each of the four samples will be analyzed for the parameters required per WDEQ-LQD Guidelines 4 and 8, as listed in **Table 6.2-1** with the exception of silver for which LC ISR, LLC is seeking an exemption.

6.2.3 Groundwater Restoration Methods

The following sections discuss the active phases that will be used under the groundwater restoration program. Following completion of groundwater restoration, stability monitoring will commence to demonstrate that the chemical constituents of the groundwater in the mine unit are in equilibrium with their immediate surroundings.

Restoration activities are designed to: optimize restoration equipment used in treating groundwater; minimize the number of pore volumes circulated during the restoration stage; and minimize net consumptive use of groundwater resources. LC ISR, LLC will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary.

Restoration consists of three phases:

- groundwater sweep,
- groundwater treatment, and
- recirculation.

A reductant may be added at anytime during the restoration process to lower the oxidation potential of the production zone. Reductants have been used successfully in some mine units in Wyoming, but have been relatively ineffective in others, in part because the minerals present in one mine unit may respond differently than other minerals present in another mine unit. (For example, the solubility of manganese increases with decreasing oxidation conditions.) Therefore, the use of reductants will be evaluated on a case by case basis. A sulfide or sulfite compound may be added to the injection stream in concentrations sufficient to reduce the mobilized species. Prior to use of a reductant, a safety plan for that reductant will be developed, approved by the SERP, and implemented. Biological reductants may be evaluated as experimental technology if warranted, depending on-site conditions; however, no biorestoration will be conducted without prior NRC approval. Additional descriptions of the active phases of groundwater restoration are presented below.

The progress of groundwater restoration is often measured on the basis of the number of ‘pore volumes’ treated in each phase. One pore volume is equivalent to:

- the volume of water within the pattern area (thickness of the ore sand times the pattern area times the effective porosity of the sand); plus
- the volume of water at the edge the pattern area affected by the horizontal ‘flare’ from the injection wells along the edge of the pattern area; plus
- the volume of water above and below the injection interval affected by the vertical ‘flare’ from the injection wells throughout the pattern.

The thickness of the ore sand and pattern area are readily measurable, and the effective porosity was determined from core samples collected from numerous drill holes within the Permit Area. The extent of the horizontal and vertical flare can be estimated from hydrogeologic data for each mine unit. For preliminary purposes, LC ISR, LLC has estimated the horizontal flare and vertical flare are both 20 percent of the volume in the pattern area, based on information from other Wyoming operations.

LC ISR, LLC uses six pore volumes as an estimate for restoration because it is an industry standard that has been accepted by NRC in the past and continues to be used by many licensees (including Christensen Ranch and Smith Ranch). Attachment 6.2-1 provides a comparison of the anticipated restoration conditions at the Lost Creek Project with those at the Christensen Ranch and Irigaray ISR Projects, with emphasis on the number of pore volumes. As LC ISR, LLC gains experience at restoring mine units at Lost Creek, it may become necessary to adjust the number of pore volumes needed to restore a mine unit. If a pore volume adjustment becomes necessary, , LC ISR, LLC will update the annual surety and restoration schedule as part of an amendment request.

Pump tests have shown that aquifer properties at Lost Creek are higher than at many other in situ facilities, which will allow for sustained operational pumping rates that are more amenable to ISR. This should enable LC ISR, LLC to produce and restore the mine unit more quickly than at other facilities. Also, LC ISR, LLC has committed to the WDEQ to install all significant restoration equipment (pipelines and reverse osmosis systems) before mining starts and to initiate groundwater restoration without unnecessary delay upon completion of mining. Finally, and perhaps most importantly, LC ISR, LLC will treat approximately 200 gallons per minute of production water with reverse osmosis before piping that water back out to the field. This practice will result in several pore volumes of groundwater treatment during production and will reduce the number of pore volumes of treatment needed during restoration.

As stated in Section 3.2.2, the ore sub-rolls within the HJ Horizon will be mined at the same time as is standard industry practice. Likewise, restoration of the sub-rolls will occur at the same time. The use of bioreductants may result in a reduced number of pore volumes required for restoration. However, LC ISR, LLC will not propose a reduced number of pore volumes for bonding purposes until technical justification is provided.

6.2.3.1 Groundwater Sweep

During groundwater sweep, water is pumped from the mine unit, without re-injection, causing an influx of baseline quality water from the perimeter of the mine unit, which

‘sweeps’ the affected portion of the aquifer. The perimeter baseline quality water has lower ion concentrations, which helps strip cations (e.g., sodium cations) that were mobilized by the lixiviant but subsequently attached to the clays in the pattern area during ISR operations. These remaining cations can be readily removed from the clays and affect groundwater quality; hence the need to remove them. The affected water near the edge patterns of the mine unit is also drawn back into the pattern area, making the later restoration phases more efficient.

The sweep water is treated or passed through the ion exchange circuit to capture uranium and then pumped to the UIC Class I wells. The number of pore volumes of groundwater sweep is dependent on the capacity of the wastewater disposal system and the effectiveness of the groundwater sweep in lowering the TDS. Past experience at other ISR operations in Wyoming and elsewhere indicates that this phase is more effective in capturing affected water near the edge of the mine unit than it is in lowering TDS levels and that the majority of benefits from groundwater sweep are realized in one pore volume. Typically, one pore volume or less is recovered before moving to the groundwater treatment phase.

6.2.3.2 Groundwater Treatment

Following the groundwater sweep phase, water will be pumped from the mine unit to treatment equipment and then re-injected into the mine unit. Ion exchange and RO circuits are used during this phase as shown on the generalized restoration flow diagram on **Figure 6.2-1**.

All water recovered from restoration will be passed through the ion exchange circuit to capture any remaining uranium. The ion exchange columns exchange the majority of the soluble uranium for chloride or sulfate. Once the solubilized uranium is removed, a small amount of reductant may be metered into the water being re-injected to reduce any pre-oxidized minerals. The concentration of reductant injected (if used) into the formation is determined by the concentration and type of trace elements encountered. The goal of reductant addition is to reduce those minerals that are solubilized by carbonate complexes in order to prevent the buildup of dissolved solids, which would increase the time for restoration to be completed.

A portion of the restoration recovery water can be sent to the RO unit. The use of an RO unit: 1) reduces TDS in the impacted groundwater; 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits; 3) concentrates the dissolved constituents in a smaller volume of brine to facilitate waste management and disposal; and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration.

As previously mentioned, the water is pumped through the ion exchange circuit prior to RO. The RO unit contains membranes that pass about 60 to 75 percent of the water through, leaving the dissolved salts in the water that will not pass the membranes. **Table 6.2-2** shows typical RO manufacturers' specification data for removal of ion constituents. The clean water, called "permeate," will be re-injected, sent to storage for use in the ISR process, or to the wastewater disposal system. The 25 to 40 percent of water that is rejected, called "brine," contains the majority of dissolved salts in the groundwater recovered from the mine unit and is sent for disposal in the waste system. Make-up water may be added to the mine unit injection stream to control the amount of "bleed" in the restoration areas.

If reductant is added to the injection stream during the groundwater treatment stage, it will scavenge oxygen and reduce the oxidation-reduction potential (Eh) of the aquifer. During ISR operations, certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered, thereby decreasing the solubility of these elements. As warranted, hydrogen sulfide, sodium sulfide (Na_2S), or a similar compound may be added as a reductant. LC ISR, LLC is more likely to use sodium sulfide as a reductant due to the chemical safety issues associated with proper handling of hydrogen sulfide. A comprehensive safety plan regarding reductant use will be implemented.

The number of pore volumes treated and re-injected during the groundwater treatment phase will depend on the efficiency of the RO in removing TDS and the effectiveness of the reductant, if used, in lowering the uranium and trace element concentrations. LC ISR, LLC will monitor the quality of selected wells throughout restoration to determine the effectiveness of the treatment/re-injection phase of groundwater restoration and to determine if additional or alternate techniques are necessary. Restoration at other ISR facilities within Wyoming has shown that the rate of TDS reduction drops off rapidly after five to seven pore volumes of RO treatment and re-injection.

6.2.3.3 Recirculation

At the completion of the groundwater treatment phase in a mine unit, recirculation will be initiated. Recirculation consists of pumping from the mine unit and re-injecting the recovered solution to recirculate solutions and homogenize the groundwater conditions. It is anticipated that one pore volume of groundwater will be recirculated.

The sequence of the activities will be determined by LC ISR, LLC based on operating experience and the wastewater system capacity. Not all phases of the restoration phases will be used if deemed unnecessary.

Once the active restoration activities are completed, LC ISR, LLC will collect groundwater samples to determine if the restoration requirements have been met. If so, LC ISR, LLC will start the stabilization monitoring phase and will 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 standards, LC ISR, LLC will either re-initiate certain of the restoration phases or submit documentation to the agencies that BPT has been used in restoration. The documentation will include an evaluation of the water quality data and a narrative of the restoration techniques used.

6.2.4 Stabilization Phase

Upon completion of active restoration a groundwater stabilization monitoring program will begin in which some or all of the production monitor wells used to evaluate restoration success will be sampled. The wells and sampling parameters used to evaluate stability will be based on the overall conditions at the end of restoration with agency approval.

The stability monitoring data collected from the production monitor wells will be representative of the entire HJ Horizon since the HJ Horizon is a single confined aquifer overlain by the Lost Creek Shale and underlain by the Sage Brush Shale. While the HJ Horizon contains several interbedded low permeability units, these units are localized in areal extent and do not divide the HJ Horizon into separate, confined aquifers. The interbedded low permeability units caused the oxidation/reduction chemical boundary to divide and coalesce, resulting in ‘sub-rolls’, i.e., ore deposition at different levels within the Horizon, hence the terms UHJ for the uppermost ore within the HJ Horizon. The water quality throughout the HJ is significantly consistent regardless of the vertical position. The ore sub-rolls in the HJ Horizon will be mined and restored as a single horizon as has been and is the practice at virtually all in situ recovery mines. The ore zone monitor wells will be completed to target discrete ore levels within the Horizon at a density and spacing prescribed by WDEQ and NRC regulations.

In addition, each production monitor well will be sampled at the beginning of stabilization and once per quarter for a period of nine months and analyzed for parameters in Table 6.2-1. This will yield a total of four sample rounds. This time frame is considered appropriate in the Lost Creek setting because the intent of the restoration procedures is to return the groundwater oxidation/reduction conditions to the reduced state present before mining. Mobilization of the uranium requires its oxidation, which in this case requires injection of a bicarbonate lixiviant under pressure. The restoration procedures are designed to remove the oxidizing material introduced during mining. Once the oxidizing material is removed, then the groundwater conditions revert to the reduced state present before mining. Remobilization would again require introduction of

an oxidizing agent which cannot readily happen. In addition, the restoration monitoring is designed to provide information throughout the mine unit, i.e., both in the production zone and in the adjacent monitor ring. This allows for identification of 'hot spots' in the production zone, i.e., production wells possibly requiring well-specific treatment, which have historically been a cause for difficulties in meeting restoration standards.

Historically, slow restoration of mine units at other operations can generally be attributed to maintenance of production at the expense of restoration, inefficient monitoring, and similar operational practices which LC ISR, LLC has committed to avoid. Also LC ISR, LLC will be using reverse osmosis even during production, which will improve restoration efficiencies.

6.2.4.1 Statistical Analyses

Following the end of the stability period, LC ISR LLC will perform a linear regression analysis on each monitored constituent within the pattern monitor wells. This statistical method will assist in determining if the concentration of a given constituent exhibits a significantly increasing trend during the stability period. The regression analysis will be performed in accordance with Chapter 17 on trend analysis in the EPA guidance document, "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance" (EPA, 2009)

If a constituent exhibits a strongly increasing trend (or in the case of pH a strongly increasing or decreasing trend), the action that LC ISR, LLC will take to resolve this situation will depend on the constituent and the status of the restored groundwater system. As stated in the EPA guidance document, statistical analysis provides a "workable decision framework". However, due to the complexity of the aqueous geochemical groundwater systems involved, these statistical techniques should not be relied on as the sole determinant when evaluating the effectiveness of groundwater restoration. Therefore LC ISR, LLC will consider which constituent(s) is showing an increasing trend in concentration and base the decision on further action on the status of the mining zone groundwater geochemistry. These actions may include extending the stability period or LC ISR, LLC may return to a previous phase of active restoration to resolve the issue. The phase of active restoration that will be used will be determined by the constituent and the process required to bring it to stability.

If the analytical results continue to meet the appropriate standards for the mine unit and do not exhibit significant increasing trends, LC ISR, LLC will submit supporting documentation to the regulatory agencies that the restoration parameters have remained at or below the restoration standards and request that the mine unit be declared restored.

6.2.4.2 Identification of 'Hot Spots'

For one or two parameters, localized, elevated concentrations above the restoration criteria (**Section 5.7.8.2**) may remain in the production zone following restoration. These isolated, residual elevated concentrations, referred to as 'hot spots', could potentially impact groundwater outside of the exempted portion of the aquifer. Per guidance provided by NRC (November 2009), the primary indicator of a hot spot for a specific constituent or parameter will be the mean production zone concentration plus or minus two standard deviations. If a constituent or parameter at a production zone monitor well exceeds that criterion, the location of the well will be identified as a hot spot. Once a hot spot is identified, additional evaluation will be conducted to determine potential impacts that such a hot spot could have on water quality outside of the exempted aquifer. The additional evaluation may include collection of additional water samples, analysis of added parameters (to assess post-restoration redox conditions), trend analysis, or flow and transport modeling. Based on the results of the evaluation, additional stability monitoring or restoration would be conducted as needed to ensure the protection of water quality outside the exempted aquifer.

6.2.5 Reporting

During the restoration process LC ISR, LLC will perform daily, weekly, and monthly analyses as needed to track restoration progress. These analyses will be summarized, along with the restoration methods, and discussed in the Semiannual Radiological Effluent and Environmental Monitoring Report submitted to NRC. This information will also be included in the final report on restoration. During active restoration, the perimeter, underlying, and overlying monitor wells will continue to be sampled for excursions at least twice per month, and no less than ten days apart, for UCL parameters.

Upon completion of restoration activities and before stabilization, the wells in the monitor ring, the overlying and underlying monitor wells, and the monitor wells in the pattern area will be sampled for the parameters required per WDEQ-LQD Guidelines 4 and 8, as listed in **Table 6.2-1**. The water quality data from each well in the monitor ring and from each overlying and underlying well will be compared with the baseline water quality data for that well. The average of the water quality data from the monitor wells in the pattern area will be compared with the baseline average from the pattern area. In addition, the water quality data will be compared with the EPA MCLs, if greater than baseline concentrations, to help ensure the groundwater outside the area exempted for ISR operations will be protective of human health. If the concentrations are at or below those approved by WDEQ and NRC, LC ISR, LLC will submit supporting documentation that the restoration parameters are at or below the restoration standards.

During stabilization monitoring the monitor ring, overlying, and underlying monitor wells will be sampled for the UCL parameters once every two months.

During stabilization, quarterly samples will be collected to ensure the oxidation/reduction conditions do not fluctuate significantly. The wells and sampling parameters used to evaluate stability will be based on the overall conditions at the end of restoration with agency approval, except that the final sample will be for the parameters required per WDEQ-LQD Guidelines 4 and 8, as listed in **Table 6.2-1**. At the end of a nine-month stabilization period, LC ISR, LLC will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies with the data and description of the restoration methods. If the analytical results continue to meet the appropriate standards for the mine unit and do not exhibit significant increasing trends, LC ISR, LLC will request the mine unit be declared restored. Following agency approval, mine unit reclamation and plugging and abandonment of wells will be performed as described in **Section 6.3**.

6.3 Mine Unit Reclamation

6.3.1 Preliminary Radiological Surveys and Contamination Control

Radiological surveys will be conducted prior to dismantling or disposing of any of the mine unit facilities at which radiological materials could be concentrated in accordance with the procedures outlined in **Section 6.4.1.**

6.3.2 Well Abandonment

Once the 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. Currently, the applicable well abandonment statutes and rules include:

- Wyoming Statute 35-11-404;
- WDEQ-LQD Rules and Regulations Chapter VIII;
- WDEQ-WQD Rules and Regulations Chapter XI, Section G; and
- WSEO Rules and Regulations Part III, Chapter VI, Section 5.

The regulations will be reviewed prior to well abandonment to ensure that the following procedures are still appropriate.

1) A drill rig, tremie pipe, or similar equipment will be used to ensure proper grouting through the entire length of the well.
2) The grout properties will be: a ten-minute gel strength of at least 20 pounds per 100 square feet and a filtrate volume not to exceed 0.824 cubic inches (13.5 cubic centimeters).
3) The volume of fluid necessary to grout the entire length of the well will be calculated and recorded.
4) A mud and/or water retention pit will be constructed by removing topsoil and subsoil from the pit area near the well. The depth of topsoil removed will be based on the soil characteristics of the area; and the removed material will be stockpiled and protected from wind and water erosion.
5) The grout will be mixed in a manner to ensure the appropriate fluid properties are obtained and will be introduced into the well through the drill pipe to the bottom of the well. The grout will be pumped until the grout rises to the well collar. The water displaced from the well will be directed to the water retention pit. The amount of grout pumped into the well will be compared with the calculated volume to ensure there are no major discrepancies, which could indicate bridging or another problem with the abandonment procedure.
6) The well will be left open for at least 24 hours to allow the grout to set.
7) If the grout has settled no more than 40 feet below ground surface the top of the well will be sealed with bentonite chips, pellets, or additional grouting material will be used. If the grout has settled more than 40 feet, then additional grout will be introduced on top of settled grout through a tremie pipe.
8) Once the grout is set, the soil around the well collar will be excavated so the final plug depth is at least three feet below ground surface. The well casing above that depth will be removed.
9) A concrete plug will be set in place above the top of the casing, along with a steel plate with the permit number, well identification number, and date of plugging.
10) The excavated soil will be replaced into the hole around the abandoned well and into the mud/water retention pit and leveled with the surrounding surface or mounded slightly above it to ensure depressions are not created.
11) The disturbed area will be reseeded with the seed mixture listed in **Table 6.3-1**.
12) A written well abandonment report will be completed and sent to WSEO.

6.3.3 Facility and Road Reclamation

With the exception of any facilities, access roads, or utility corridors required for the operation of others, all of the facilities associated with a specific header house or mine unit will be removed once groundwater restoration in that header house or mine unit has been deemed complete.

The header houses and pump stations will be moved to new locations in others in the Permit Area or dismantled and disposed of in accordance with applicable regulations. Soil will be replaced at each header house or pump station in accordance with the depths and acreages salvaged during construction, as described in more detail in the Hydrologic Testing Proposal and subsequent Test Report submitted to WDEQ-LQD for review and approval prior to development of each mine unit. Soil replacement and reseeding will be done in accordance with the methods described below in **Section 6.6**.

Topsoil will be windrowed along pipeline routes; and buried piping will be excavated. Any contaminated piping will be disposed of at an NRC-licensed facility, and non-contaminated piping will be removed for salvage or for disposal in accordance with applicable regulations. Topsoil along the pipeline route will be re-spread and the disturbed area reseeded with the seed mixture listed in **Table 6.3-1**.

Unless approval for leaving a specific road is obtained for post-mine use, all roads will be reclaimed. Improved or constructed roads will be reclaimed by removal of culverts, removal of road surfacing materials, recontouring, as necessary, preparation of the seed bed, and reseeding in accordance with the procedures outlined below in **Section 6.6**.

Post-reclamation radiological surveys will be conducted in accordance with the methods described below in **Section 6.5**.

6.4 Reclamation and Decommissioning of Processing and Support Facilities

The facilities that require reclamation and decommissioning include:

1) processing and water treatment equipment, which includes tanks, filters, ion-exchange columns, pipes, pumps, and related equipment;
2) buildings and structures, processing facilities, shipping areas, and offices;
3) waste storage, treatment, and disposal facilities, including the UIC Class I wells;
4) buried pipes;

5) engineering control structures, such as dams and culverts; and
6) roads.

With the exception of any facilities, including roads, approved for post-operational use, all of the facilities associated with the Project will be removed once uranium processing operations have been completed. Approval for post-operational use must be supported by the landowners and/or lessees request, and approval from the BLM, which is the surface management agency of the Permit Area, and WDEQ. If any facility, including a road, is left post-operations, the responsibility for long-term maintenance and ultimate reclamation of the facility or road will be transferred to the accepting party.

6.4.1 Preliminary Radiological Surveys and Contamination Control

Throughout the Project, radiation levels of the affected areas and facilities will be monitored for the safety of employees and the environment; and elevated radiation levels will be addressed during the course of the Project. In addition, requirements for spill remediation and similar 'quick response' actions reduce the extent of contamination. Therefore, the need for contamination control prior to reclamation is expected to be confined to the equipment related to uranium concentration and shipping. However, radiological surveys will be conducted prior to dismantling or disposing all of the facilities in accordance with the Program developed for the Project (**Section 5.7**). Records of the surveys will be maintained in accordance with the Program specifications; and any remediation activities necessary prior to further decommissioning will be conducted in accordance with the SOPs for the Project.

Prior to decommissioning, LC ISR, LLC will perform a soil radiometric study in a manner similar to that used to determine baseline conditions (TR Section 2.9.1). In addition to the general survey of the area to be decommissioned, LC ISR, LLC will review the spill records and perform an additional survey in any impacted location. Locations impacted by a spill will be surveyed on a one-meter grid using a properly calibrated instrument capable of detecting activities exceeding the decommissioning standards. As contaminated piping is removed, a survey of the trench will be performed at least every fifteen feet to ensure no spills went undetected. Any soil which does not meet the clean-up criteria will be removed and disposed of at an NRC or Agreement State licensed facility. Soil cleanup will not be complete until the cleanup criteria in 10 CFR 40 Appendix A Criterion 6 are reached. Soil verification Analysis is discussed in Section **6.5.2**.

6.4.2 Removal and Disposal of Equipment and Structures

Prior to demolition of the buildings and structures, all equipment will be decontaminated, if necessary, based on preliminary radiological surveys. Particular attention will be given to equipment and structures in which radiological materials could accumulate, including piping, traps, junctions, and access points. Materials which can be decontaminated may include piping, valving, instrumentation, and various other types of equipment. Decontamination (where possible) will be accomplished by completing a preliminary radiological survey to determine the location and extent of the contamination and to identify any hazards. The preliminary review will be in the form of an alpha survey. The primary step will be to remove loose contamination from the object by use of high pressure washing. If required, secondary decontamination will consist of washing with a dilute acid or equivalent compatible solution. Upon completion of decontamination, a final alpha survey will be performed to insure that the unrestricted release limits noted below are met:

- Removable alpha contamination of 1,000 dpm/100 square cm.
- Average total alpha contamination of 5,000 dpm/100 square cm. over an area no greater than one square meter.
- Maximum total alpha contamination of 15,000 dpm/100 square cm. over an area no greater than 100 square cm.

Equipment which cannot be decontaminated to these standards will be either used on site or sent to an NRC licensed facility for disposal. Those materials meeting the above decontamination standard will be released unrestricted and shipped to the nearest public landfill (Carbon County Landfill).

Radiological materials will either be decontaminated to NRC unrestricted release standards or removed for disposal at an NRC-licensed facility. Processing and water treatment equipment, including tanks, filters, ion exchange columns, pipes, and pumps, will be prepared, including decontamination if necessary, for use at another location or dismantled and disposed of in accordance with applicable regulations. Radiologically contaminated materials will be disposed of at an NRC-licensed facility; and materials contaminated with other industrial constituents will be disposed of at an appropriately licensed facility. Decontaminated and non-contaminated materials will be removed for salvage, disposed of on-site at a designated location and depth, or disposed of at an appropriately licensed solid waste facility. Any materials disposed of on-site will be covered with a minimum of four feet of overburden and topsoil, over any other required cover. The contours of the disposal area shall blend with those of the surrounding area.

Structures will be decontaminated, if necessary, and moved to a new location, salvaged, or dismantled and disposed of on-site at a designated location and depth, or disposed at

an appropriately licensed solid waste facility. Concrete flooring, foundations, and foundation materials will be decontaminated, if necessary, broken up, and either buried in place, disposed of at a designated location and depth on-site, or disposed of at an appropriately licensed facility. Any materials disposed of on-site will be covered with a minimum of four feet of overburden and topsoil, over any other required cover. The contours of the disposal area shall blend with those of the surrounding area. All materials to be buried on site must meet material release limits established by the NRC. The RSO will have procedures in place to ensure only releasable materials are buried on site. Material release records will be maintained for all materials, originating from potentially contaminated areas, that are disposed of on site.

10 CFR Part 40, Appendix A, Criterion 2 clearly prohibits disposal of 11(e)(2) material at a site such as Lost Creek, and LC ISR, LLC is not proposing to dispose of 11(e)(2) material at the site. LC ISR, LLC may seek a permit for a "construction" landfill at the site from the Bureau of Land Management and WDEQ. This type of landfill can be used to dispose of wood, brick, plastic, and other construction material. If such a landfill is permitted, only non-contaminated items will be placed in the landfill. Any item which has been in a process area (e.g., the Plant, active header house, or active mine unit) will not be disposed of in the landfill unless it has been surveyed by the Radiation Safety Officer (RSO) or Health Physics Technician and meets the release standards outlined in Section 5.7.6.2 of the TR. If an item may be contaminated and cannot be adequately surveyed due to its shape or other factors, it will be considered contaminated and will be disposed of as 11(e)(2) material at an off-site facility licensed by the NRC or an Agreement State. If an on-site landfill is used, the RSO will ensure a stringent Standard Operating Procedure for usage and maintenance of the landfill is written and implemented with employee training.

Records of equipment decontamination, distribution, disposal, and related decommissioning activities will be maintained in accordance with the specifications of the Program (**Section 5.7**); and any necessary decontamination activities will be conducted in accordance with the SOPs for the Project.

Soil will be replaced at sites from which structures are removed in accordance with the depths and acreages salvaged prior to installation of the structures as described in **Section 3.0** (Proposed Operations). Soil replacement and reseeding will be done in accordance with the methods described below in **Section 6.6**.

6.4.3 Waste Storage, Treatment, and Disposal Facilities

Those facilities for which a separate license has been obtained, e.g., a UIC Class I Well for process water injection, will be transferred to another owner or operator in accordance

with applicable requirements or reclaimed in accordance with the separate license requirements.

Any sludge accumulation in the Storage Ponds, the pond liner, and, if necessary, the leak detection equipment will be removed, in accordance with the SOP for handling of contaminated materials, and disposed of at an NRC-licensed facility. The soil underneath the pond will be surveyed for radiological contamination, and any areas in which concentrations exceed limits for unrestricted use will be excavated and the contaminated material disposed of at an NRC-licensed facility. Confirmation surveying and sampling will be conducted in accordance with applicable requirements to ensure all contaminated material has been removed. The area will then be reclaimed in accordance with the procedures outlined above in **Section 6.4.2**.

All other waste facilities will be reclaimed in accordance with the procedures outlined above in **Section 6.4.2**.

6.4.4 Buried Piping and Engineering Control Structures

Buried piping and engineering control structures will be decontaminated and removed. All the reclamation will be done in accordance with the procedures outlined above in **Section 6.4.2**.

6.4.5 Roads

Improved or constructed roads will be reclaimed by removal of culverts, removal of road surfacing and road bed materials, and recontouring, as necessary. Unimproved roads will be recontoured, if necessary, and scarified, ripped, or disced to reduce compaction. The roads will then be reclaimed through preparation of the seed bed and reseeding, in accordance with the procedures outlined below in **Section 6.6**.

6.5 Post-Reclamation and Decommissioning Radiological Surveys

Gamma surveys will be conducted in the Permit Area, at all locations affected by the Project activities, once all of the equipment and facility removal is complete in a given area. As header houses and mine units are reclaimed, the radiological surveys will be conducted prior to reseeding; so if elevated concentrations are found, remedial actions can be taken without jeopardizing revegetation success.

6.5.1 Determination of Site Soil Cleanup Criteria

The pre-existing baseline conditions are presented in **Section 2.9** of this report. Elevated radiation levels resulting from the prior exploration activities and from naturally-occurring conditions will be used in the calculation of appropriate cleanup levels.

The Appendix A cleanup criteria for radium-226 are specified in 10 CFR 40. “Impacted areas” of the site, as defined in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), will be identified based on a “historical” site assessment and characterization survey prior to development of a decommissioning plan. Direct gamma surveys as well as soil sampling protocols will be developed in accordance with the number and extent of impacted areas. The “benchmark approach” will be used to define the cleanup criteria for other radionuclides, as described in Appendix E to NUREG 1569. Impacted soils will be excavated or treated to meet those criteria.

The cleanup criterion for uranium in soil will be determined at the time the decommissioning plan is developed in accordance with Appendix E to NUREG 1569. It is premature to develop the criterion prior to operation of the facility as situations and surrounding land uses might change, and the “benchmark dose” is sensitive to the land use scenarios used in the calculations.

6.5.2 Soil Verification Survey Methodology

A GPS-based gamma radiation survey will be performed of the area to be decommissioned (i.e., mine unit or facility area) using techniques similar to those that were used to determine baseline site conditions. A statistically defensible number of soil samples will be collected throughout the site at varying soil radium-226 concentrations (based on the gamma radiation survey). The soil samples will be analyzed for radionuclides of concern and the results will be plotted against the readings from the area survey. In this manner, a correlation between the two measurement types can be established. If the decommissioning survey reveals any location which appears to approach the decommissioning standard, the baseline background will be subtracted from that location's apparent Ra-226 concentration. If the apparent concentration thus calculated approaches the decommissioning standard, a soil sample will be collected and analyzed to determine actual radionuclide concentrations and to assist in determination of an appropriate remedial action.

The verification survey and final status survey methods will be developed on a statistically valid basis to provide 95 percent confidence that the survey units meet the cleanup guidelines, and those methods will be described in each decommissioning plan.

Several statistical approaches, including but not limited to MARSSIM, will be considered in designing the surveys.

6.5.3 Decommissioning of Non-radiological Hazardous Constituents

During decommissioning, LC ISR, LLC will decommission tanks and piping associated with chemicals which are classified as hazardous (e.g., hydrochloric acid or sulfuric acid). Any remaining bulk quantities of material will be sold to another responsible company or will be transferred to other LC ISR, LLC properties for use. The tanks will then be washed out to remove any residual chemicals, in accordance with appropriate protocols outlined below, and sold or moved to another property for use.

The piping associated with hazardous chemicals will be washed out with water, in accordance with appropriate protocols outlined below. If the piping cannot be re-used by LC ISR, LLC or sold to another company for similar use, the EHS Department shall verify the pipe does not constitute a hazardous material and the piping will be sent to an off-site licensed landfill for disposal. All of the hazardous chemicals proposed for usage at LC ISR, LLC are highly soluble and should be easy to remove from tanks and piping.

All tank and pipe cleaning shall be performed in a manner that is protective of the employees and the environment. A qualified individual in the EHS Department shall review tank and pipe decommissioning plans and operations to ensure operations are carried out in a protective manner. All potentially affected employees shall be trained in the hazards of chemicals and how to protect themselves. Equipment and fluids used for cleaning will be collected and disposed of in accordance with applicable regulations.

All sanitary waste will typically be collected and taken into Rawlins, WY or other nearby town and properly disposed of in a licensed landfill.

As discussed in Section 4.3.1 of the TR, non-radiological hazardous wastes will be stored in accordance with OSHA and EPA requirements and disposed of off-site by a licensed contractor.

6.6 Soil Replacement and Revegetation

Areas in which reclamation will be required within the Permit Area include the mine units, in particular where the header houses and roads have been removed, and the Plant area. Disturbed areas will be reclaimed to the approved post-operations land use by regrading the surface to the approximate pre-operations contour, re-establishing

drainages, replacing salvaged soil, and revegetating the areas, in accordance with the procedures outlined below.

6.6.1 Post-Operational Land Use

The post-operations land use will be livestock grazing and wildlife habitat, which is the same as the pre-operations land use. Buildings, roads, wells, or other facilities constructed as part of the Project will be removed and the disturbance reclaimed, unless prior approval in obtained from the NRC and WDEQ to leave the facilities in place to improve post-operational access or land use.

6.6.2 Surface Preparation

Disturbed surfaces will be graded to approximate pre-operational contours and drainage patterns. Seed bed preparation will be performed under appropriate soil and climatic conditions. In areas where soil was not removed but was compacted due to site operations, e.g., two-track roads used to access monitor wells, soils will be scarified, ripped, or disced as necessary to aid in revegetation. In areas where soil was removed, the disturbed areas will be scarified, ripped, or disced as necessary to ensure soil stability after replacement.

6.6.3 Soil Replacement

Soils will be replaced where excavated, whenever possible. Due to the relatively uniform soil characteristics across the site, the similarity of the topsoil and subsoil, and the relative thinness of the topsoil and subsoil, separate handling of the topsoil and subsoil is not required, as described in **Section 3.1.1** of the Operations Plan. The soil thickness will generally be uniform and approximate the disturbance thickness. The replacement will be along the contour, where necessary to prevent soil erosion. To avoid clods, soils will not be replaced when the ground is wet or frozen. The replaced topsoil will be disced to create a proper seed bed.

6.6.4 Seed Mix, Reseeding Methods, and Fencing

The permanent seed mix and seeding rates for revegetation of the Permit Area are provided in **Table 6.3-1**. This seed mix will adequately support the post-operational land uses, livestock grazing and wildlife habitat, and was approved by Mark Newman of the BLM Rawlins Office on November 17, 2006 and by Melissa Bautz of the WDEQ-LQD Lander Field Office on November 3, 2006 (e-mail communications). If any of the

approved seed is unavailable or prohibitive in cost at the time of seeding, other locally adapted and certified seed may be substituted with prior approval of BLM and WDEQ-LQD.

Two methods of seeding, pit and broadcast, will be used. Seeding will be performed as a continuous operation when conditions allow. In general, seeding will be completed during the spring or fall, whichever is the first normal period for favorable planting after the seed bed preparation.

Pit seeding will be the primary method. Areas with little gradient will be pit seeded with the rows of pits perpendicular to the direction of the prevailing wind. Where necessary to prevent erosion, pit seeding will be done along the contour. Pit seeding increases the likelihood of successful vegetation in the Permit Area by sheltering seeds from aeolian erosion and capturing moisture in the area of the seed.

Broadcast seeding will be performed on any steep slopes and drainage areas that may be disturbed in the Permit Area. The seed will be distributed uniformly over the area using a mechanical seed spreader.

Immediately after seeding, the areas will be raked or dragged along the contour. This will cover the seeds with approximately one-quarter inch of soil.

Temporary fencing may be installed to restrict access to reseeded areas until vegetation is successfully re-established. The fence specifications follow those of the BLM. Upon demonstration of successful revegetation, the fencing will be removed.

6.6.5 Revegetation Success Criteria

Revegetation shall be deemed complete no earlier than the fifth full growing season after seeding and when:

- the revegetation is self-renewing under the site conditions;
- the total vegetation cover of perennial species (excluding noxious weed species) and any species in the approved seed mix is at least equal to the total vegetation cover of perennial species (excluding noxious weed species) before operations;
- the species diversity and composition are suitable for the post-operational land use; and
- the total vegetation cover and species diversity and composition are quantitatively assessed in accordance with procedures approved by WDEQ-LQD.

Because many of the reclaimed areas are relatively small in comparison with the Permit Area and because of the similarity of the vegetation communities at the site, LC ISR, LLC will delineate a comparison area in an undisturbed portion of the site at least six months prior to evaluation of revegetation success. In addition, LC ISR, LLC will describe the quantitative methods to be used for comparing the total vegetation cover in the reclaimed and undisturbed areas and for evaluating species diversity and composition. These methods, as well as the size and location of the comparison area, will be submitted to WDEQ-LQD for review and approval at least six months prior to the fifth full growing season.

6.7 Decommissioning Health Physics and Radiation Safety

All decommissioning activities will be conducted in accordance with the same procedures used during ISR operations, as described in the Contaminant Control Program in **Section 5.7.2**.

6.8 Financial Assurance

LC ISR, LLC will establish and maintain appropriate surety arrangements with NRC and WDEQ to cover the costs of groundwater restoration, radiological decontamination, facility decommissioning, and surface reclamation. The surety will be reviewed annually and adjusted to reflect changes in cost and in the Project. The existing surety amount will be automatically extended if NRC has not approved the extension at least 30 days prior to the expiration date. However, it should be noted that per WDEQ requirements, reclamation bonds do not expire, and the bonds for in situ operations are generally held by WDEQ, with the amounts based on review and approval by NRC and WDEQ. LC ISR, LLC also commits to increase the surety arrangement within three months of NRC approval of a revised closure plan which includes an increased surety amount. Again, it should be noted that WDEQ will not approve changes to restoration/reclamation plans *until* any surety amount increase is in place. LC ISR, LLC will provide NRC with a copy of WDEQ's surety review and final surety arrangement.

The Land Quality Division of the WDEQ is the lead agency for approving and holding adequate bonding from LC ISR to cover site decommissioning. WDEQ finds the following types of bonds acceptable: Corporate surety bonds, certificates of deposit that are FDIC insured, Cash, Treasury bills or notes that can be placed on deposit with the state on a non-interest bearing basis, letters of credit, self-bonding, or any combination thereof. ISR LLC is committed to providing bonding acceptable to the state, the BLM and the NRC and will choose the best method from the options available to it. A

substantial, if not all, of the requirements will be in some form of cash, whether it is used to secure letters of credit, secure some form of self-funding, purchase securities or make a cash deposit.

The surety estimate for the Project, including surface reclamation of all the facilities and groundwater restoration of the first year of activity, is $6,772,488 based on current US dollars. Restoration costs for additional mine units will be added to the surety as the mine units are brought online. The bond calculation will be updated annually to reflect proposed installations, construction and operations for the upcoming year. A detailed description of this surety estimate is provided in **Table 6.8-1**. The table includes a summary page and a series of worksheets with itemized costs for the reclamation and restoration activities. Each worksheet covers a particular task or associated tasks, such as Building Demolition. Worksheets are provided for:

- Groundwater Restoration,
- Building Demolition (including disposal),
- Pond Reclamation (including disposal of pond materials),
- Well Abandonment,
- Mine Unit Equipment, and
- Topsoil and Revegetation;

along with two worksheets, which provide information on quantities and weights of equipment for the demolition calculations. The Surety will be updated at least 90 days prior to initiating any major construction not previously covered in the bond.

As demonstrated in the facility schedule (**Figure 1.7-2**) and restoration and reclamation plan, it is LC ISR, LLC's intent to restore groundwater and perform surface reclamation as quickly as possible after the cessation of mining in each mine unit. This practice will help minimize impacts to the environment, environmental liability, and surety costs. Under a hypothetical scenario in which restoration and surface reclamation were deferred until the end of the project, the cost of restoring the affected groundwater in all six mine units would be approximately $25 million. The cost of subsurface and surface reclamation, inclusive of groundwater restoration and removal of contaminated soil, would total approximately $39 million, again assuming no reclamation work is performed until the end of the project. These figures are highly speculative since the precise size of mine units and many other factors are not known.