LOST CREEK ISR, LLC
Lost Creek Project

LC East Amendment
Jan 2017 Environmental Report

VOLUME 1

Section 1 Introduction – Section 3.4 Geology

LC East Amendment
Environmental Report
January 2017

NRC License SUA-1598

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1.0 INTRODUCTION

Lost Creek ISR, LLC (LC ISR, LLC) is submitting this Environmental Report (ER) to the United States (US) Nuclear Regulatory Commission (NRC) in support of an amendment to source and byproduct material license SUA-1598 to expand the Lost Creek Project (Project) in accordance with the Atomic Energy Act of 1954, as amended, 10 Code of Federal Regulations (CFR) Parts 20, 40, 51, and 70, and other applicable laws, regulations and NRC guidelines. Amendment of this license would authorize LC ISR, LLC to:

1. Expand in situ recovery (ISR) uranium mining into the KM and HJ geologic horizons of the LC East area which is immediately east of the Lost Creek license area.
2. Increase the allowable annual wellfield production rate to 1.2 million pounds of U_3O_8. Total production (site wellfield plus toll processing of resin and/or yellowcake slurry) would not exceed 2.2 million pounds per year of dried yellowcake measured as U_3O_8 (excluding contaminants).
3. Present the operations and reclamation plans for the combined Lost Creek and LC East operations.

Per the National Environmental Protection Act (NEPA) of 1969, federal agencies are obligated to evaluate the effects of major federal actions on the health and safety of the public and assess impacts to the environment. NRC and the Bureau of Land Management (BLM) are the federal agencies with jurisdiction over the Project and the Lost Creek Permit Area (Permit Area), respectively. NRC has jurisdiction under 10 CFR Part 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions. NRC is required to perform an environmental evaluation of the proposed licensing actions. As the land manager, the BLM has jurisdiction over leases related to the use of the Permit Area.

This ER is organized in accordance with the guidance contained in NUREG-1748, Environmental Review Guidance for Licensing Actions Associated with Nuclear Material Safety and Safeguards (NMSS) Programs, dated August 2003. **Section 1** provides an introduction of the Amendment request, discusses why LC ISR, LLC is requesting an amendment, and presents a Project description. **Section 2** discusses the proposed action versus alternatives, including the no-action alternative and alternatives considered but eliminated. **Section 3** describes the existing environmental conditions in the Permit Area; and **Section 4** discusses how those conditions could be impacted, if at all, by the proposed action, and the mitigation and monitoring measures that will be implemented during the Project. **Section 5** presents the Cost-Benefit Analysis. **Section 6** provides the summary of the environmental consequences from the Project. **Sections 7** and **8** contain a list of references and preparers, respectively.

1.1 Purpose and Need for the Proposed Action

The expansion of the Lost Creek Project will contribute to the advancement of the energy security goal of maintaining a reliable, economical, and domestic source of uranium. Exploratory drilling and testing have provided the delineation of the uranium ore trend and a reliable estimate on the uranium resource, grade and percent recovery.

The Project will support energy-independent and environment-friendly policies. The uranium production will assist to supply a viable domestic uranium recovery industry by applying technologies that minimize environmental disturbance and potential adverse effects to public health and safety. This Project will also help to offset the deficit in annual domestic uranium production and help to meet increasing energy demands. Following the Japanese tsunami and nuclear disaster and subsequent lower uranium prices, the annual U.S. production declined to 3.7 million pounds in 2015. We expect 2016 and 2017 numbers to show a continued decline in domestic production and employment. The United States produces less than 6% of the uranium required to power its nuclear fleet and we expect that percentage to continue to decline in the near future. Approximately 37% of uranium consumed in the U.S. is produced in Russia, Kazakhstan and Uzbekistan. The addition of the LC East area, will add over 2.6 million pounds of U_3O_8 as measured and indicated pounds and over 1.5 million pounds as inferred resources. With approval of this application, the processing facilities could also process resin and/or yellowcake slurry from other ISR sites in the region even after the Lost Creek and LC East wellfields are depleted.

Mining and other industrial activities have potential impacts. However, ISR operations will minimize surface and underground disturbance and significantly reduce potential adverse impacts to workers and the general public.

Nuclear energy production is an important strategy for curbing global climate change over the long-run. Unlike coal-fired power plants, nuclear power plants produce virtually no greenhouse gas emissions.

1.2 Proposed Action

LC ISR, LLC is applying for an amendment to the current source and byproduct material license for the Project, NRC license SUA-1598, in order to facilitate the production of U_3O_8 from the HJ and KM geologic horizons of the LC East area. The amendment also seeks to increase the annual production limit, allow toll milling, and present the operations and reclamation plans for the combined Lost Creek and LC East areas; all as detailed in **Section 1.0**. The number of KM Horizon Mine Units at LC East will be three (mine units 8, 10 and 11). The number of HJ Mine Units at LC East will be 2 (mine units 7 and 9); see **Plates 1.2-1a** and **1.2-1b**.

1.2.1 Overview

The LC East Amendment to the Lost Creek Permit Area ("Amendment") is located in the northeastern corner of Sweetwater County, south-central Wyoming. The Amendment is in an unpopulated area about 15 miles southwest of Bairoil, Wyoming, about 38 miles northwest of Rawlins, and 91 miles southwest of Casper; see **Figure 1.2-1**. The Amendment covers approximately 5,751 acres in T25N R92W sections, or portions of sections, 1-3, 10-12, 14-15, 20-23, 27-29. The main portion of the Amendment consists of 297 unpatented federal lode claims. The Amendment includes approximately 19 acres within the original Lost Creek Permit Area classified as "no right to mine acres". This acreage has since been covered by unpatented federal lode mining claims to which Lost Creek ISR controls the mineral rights. Rawlins is 38 miles southeast; Rock Springs is 80 miles southwest; Casper is 90 miles northeast; and Jeffrey City is 25 miles north. The nearest population center, located 15 miles northeast of the Permit Area, is Bairoil, a small town with less than 100 people.

The Area is characterized by low-relief, sagebrush-dominated plains, dissected by small, ephemeral drainages. Due to little variation in topography, severe winter conditions, and less than ten inches of annual precipitation, the ecological diversity in the Permit Area is limited.

The discovery of uranium deposits in the Permit Area and consequential exploratory drilling and studies have occurred over the course of four decades.

LC East is a relatively new project drawn in part from two large blocks of claims (RD and PN claims) obtained in 2012, plus some of the New Claims staked in 2011 and 2012 by a URE subsidiary.

Similar to the other projects, the earliest historical ownership within what is now the LC

East Project was by Wolf Land and Exploration starting in 1967. In 1969 Conoco entered into a joint venture with Wolf Land and Exploration, with Conoco acting as the operator. The next year Conoco took over the project and continued to explore the area as part of its Project A. In 1978 Texasgulf continued the activity as the operator of Project A in a joint venture with Conoco until 1983. PNC Exploration later acquired some of the ground in 1987 and held it until 2000.

With the resurgence of the uranium industry, High Plains Uranium, Inc. (HPU) and Energy Metals Corp. (EMC) both staked claims within the current Project boundaries in 2004. The HPU controlled claims subsequently went to EMC in 2007 when that company acquired HPU. Later that year EMC was in turn taken over by Uranium One (U1). U1 maintained the claims until they were acquired by a URE subsidiary on February 27, 2012. The land obtained from U1 represents the majority of the new LC East Project.

During 2011-2012, an additional 142 of the New Claims were staked by a URE subsidiary and subsequently joined to the LC East Project to cover prospective areas near and adjacent to the lands acquired from U1.

1.2.2 Project Description

LC ISR, LLC is proposing the construction, operation, and reclamation of facilities for ISR operations within the LC East Area. ISR involves the use of a recovery solution, otherwise known as a lixiviant, to extract the mineral from the geologic formation in which it occurs without physically removing the ore-bearing strata.

1.2.2.1 Design and Construction of Mine Units and Facilities

LC ISR, LLC will design and construct mine units in order to recover uranium resources. LC ISR, LLC is not proposing with this application to change how mine units and associated infrastructure are designed, constructed, or operated.

Mine Units

A typical uranium ISR mine unit, usually 20 to 75 acres in area, will consist of:

- a production field with injection and production well patterns,
- a monitor well ring, and
- header houses and pipelines.

Production and injection well patterns will primarily be conventional five-spot patterns, unless modified to fit the shape of the ore body. A five-spot pattern, otherwise known as a cell, is a square with four injection wells at the corners and a centrally located production well. **Figure 1.2-2** shows a typical layout of an ISR mine unit and solution flow patterns. The injection wells will be spaced 75 to 150 feet apart. Other pattern designs, such as but not limited to, line drives, half patterns, or six spots may be used as the geology and terrain dictate. All the production and injection wells will be completed so they can be used as either production wells or injection wells. This design allows changes in the solution flow patterns to improve uranium recovery and to restore the groundwater in the most efficient manner.

There are four types of monitor wells, those completed in a 'monitor ring' around the production zone, those completed in the overlying and underlying aquifers, if any, and those completed within the pattern areas. The wells in the monitor ring will be spaced about 500 feet apart, depending on the hydrogeology of the production zone, and will be located approximately 500 feet outside the pattern area. Monitor wells will also be completed in the aquifers directly overlying and underlying the production zone. These wells will be distributed uniformly across the mine unit area, with approximately one overlying, one underlying, and one production zone monitor well in each four acres of the production field.

Injection wells and production wells will be connected to their respective injection or production manifold in a building commonly called a header house. The manifolds route solutions in pipelines to and from the ion exchange circuit in the Plant. Flow meters, control valves, and pressure gauges will be installed in the individual well lines to monitor and control the individual well flow rates.

Each mine unit will have its own construction, operation, and reclamation schedule. One or more mine units may be in production at any one time with additional mine units in various stages of construction and/or reclamation. A mine unit will be dedicated to only one production zone and will typically have a flow rate of about 6,000 gallons per minute (gpm). The size and location of the mining units will be defined based on the final delineation of the ore deposits, performance of the area and development requirements. **Plates 1.2-1a and b** show the ore trends within the Lost Creek and Amendment Areas. Based on current geological and hydrogeological data, approximately six mine units will be developed in the Lost Creek Area and five in the LC East Amendment Area during the life of the Project.

Mine unit piping will be high-density polyethylene (HDPE), polyvinyl chloride (PVC), and/or steel. The individual well lines and the trunk lines to the Plant will be installed below ground to prevent freezing. Ancillary equipment needed will include truck mounted pulling units, trailer mounted hose reels, electrical generators, backhoes, mechanical integrity test (MIT) trucks, motor graders, all terrain forklifts, cementing trailers and light duty 4-wheel drive vehicles. The wells will be installed by contract well drillers who will use truck mounted rotary drilling rigs and water trucks.

Well Construction

The injection, production, and monitor wells will be drilled to the base of the target completion interval with a truck-mounted rotary drilling unit using native mud and a small amount of commercial drilling-fluid additive for viscosity and filtrate control. Following geophysical logging (spontaneous potential, single point resistivity, gamma ray, and occasionally Prompt Fission Neutron (PFN)), the upper portion of the hole will be reamed to accommodate casing. Casing will be set and cemented to isolate the completion interval from overlying aquifers. The cement will be placed by pumping it down the casing and forcing it out the bottom of the casing and back up the casing drill hole annulus.

The PVC well casing will have a standard dimension ratio (SDR) of 17, available in 20-foot joints. The typical casing will be a nominal 4.5-inch diameter with a minimum wall thickness of 0.291 inches and an internal pressure rating of 160 pound-force per square inch gauge (psig).

One casing centralizer will be located at each 40-foot interval to ensure the casing is centered in the drill hole and to ensure an effective cement seal.

The volume of cement used is the calculated volume required to fill the annulus and return cement to the surface. In most cases, the cement returns to the surface, at least initially. However, in some cases, the drilling may result in a larger annulus volume than anticipated and cement may not return to the surface. In these cases, the upper portion of the annulus will be cemented from the surface. In the majority of cases, where the cement fails to return to surface, the reason will be a washout or a casing failure. In the event of a casing problem, the well will not pass the MIT. In all cases, wells are required to pass an MIT test before operations approval. This will ensure that there is sufficient integrity to allow the use of the well in handling lixiviant.

After the cement has set, the cement plug within the casing will be drilled out and the well will be flushed with water to remove any cement fines from the target zone. An under reaming tool is then used to cut a larger diameter hole across the completion zone. The well is then developed, typically by air lifting, for a period of time adequate to remove any remaining drilling mud and/or cuttings. If sand production or hole stability problems are expected, a wire-wrapped screen or similar equipment may be installed across the completion interval. The typical injection well and production well completions are illustrated in **Figure 1.2-3** and **Figure 1.2-4**, respectively. Further well development may be achieved by swabbing the well, jetting or additional airlifting or pumping. The screened interval may be gravel packed to control fines migration.

Well Casing Integrity

Prior to operating a well, the well casing will undergo an MIT. During the MIT, the well casing is plugged, pressurized, and the pressure monitored for a set period of time. The bottom of the casing adjacent to or below the confining layer above the injection zone is sealed with a plug, down-hole packer, or other suitable device. The top of the casing is then sealed in a similar manner or with a threaded cap. A pressure gauge is installed to monitor the pressure inside of the casing. Once the well casing is plugged and a pressure gauge is installed, the pressure inside of the well casing is increased to a specified test pressure and will maintain 95 percent of that pressure for ten minutes to pass the test.

If a well casing does not pass an MIT, the casing will be repaired and retested. If a repaired well casing passes an MIT, the well will be used for its intended service. Also, if the well defect occurs at depth, the well may be plugged back and re-completed for use in a shallower zone provided it passes a subsequent MIT. If an acceptable MIT cannot be obtained after repairs, the well will be plugged. A new well casing integrity test will also be conducted after any well repair using a down hole drill bit or under reaming tool.

Monitor wells will be drilled and constructed in the same manner as production and injection wells and all three types of wells must pass MIT. All methods for demonstrating casing integrity must be approved by the Wyoming Department of Environmental Quality (WDEQ) prior to use on the Project.

Process Plant

The Plant, in operation since 2013, located within the Lost Creek license area, houses three distinct process circuits: the ion exchange circuit (also called the resin-loading circuit), the elution circuit, and the precipitation/filtration circuit. The ion exchange circuit is located adjacent to the other two circuits.

Based on operations to date, the facility is capable of processing 6,027 pounds U_3O_8 per day (2.2 million pounds per year) with normal operations at 90 percent of the design. The uranium concentration of the lixiviant solution is anticipated to range between 30 and 100 milligrams per liter (mg/L) of uranium oxide (U_3O_8), averaging 40 to 50 mg/L. Standard commercially available ion exchange resins function well under these conditions.

1.2.2.2 ISR Operations

The Project will use ISR technology to extract uranium from permeable, uranium-bearing sandstones located at depths ranging from 300 to 700 feet below the surface. The processes used for uranium ISR are well understood and well-established industrial practices. **Figures 1.2-5a, b** and **c** are schematics of a typical uranium ISR operation.

Mine Units

The mining horizons at LC East will include the HJ and KM. Within the LC East Amendment area, the depth to the top of the HJ Horizon ranges from 375 feet in the south to outcropping in the northern limits of the project. Likewise, the depths to the top of the KM Horizon vary from 500 feet to 100 feet, respectively.

The uranium ISR process starts at the mine units by first introducing lixiviant into the ore zone through the injection wells. The lixiviant is composed of native groundwater, bicarbonate, carbon dioxide and oxygen or an equivalent oxidizing agent. Carbon dioxide is to be added either at the Plant and/or at the header houses. Oxygen will be added to the barren lixiviant at the mine unit header houses. The combined carbonate/bicarbonate concentration in the injected solution will be maintained at less than five grams per liter (g/L), and the hydrogen peroxide and/or oxygen concentration will be less than one g/L. These limits help reduce the possibility of "gas lock" in the formation, which reduces mining efficiency.

When the lixiviant is injected into the ore zone, the dissolved oxidant reacts with the uranium mineral and brings the uranium to the U^{+6} oxidation state. The uranium then complexes with some of the carbonates in the lixiviant to form an uranyl dicarbonate ion $[UO_2(CO_3)_2]^{-2}$ and/or an uranyl tricarbonate ion $[UO_2(CO_3)_3]^{-4}$, both of which are soluble and stable in solution. A small portion of the radium content will also be mobilized along with the uranium. Depending on site conditions, other metals such as arsenic, molybdenum, selenium, and/or vanadium, may also be mobilized. The resultant uranium-bearing solution will be recovered from the production wells to the surface. The injection and production rates will be balanced to control the movement of fluids in the aquifer.

In each mine unit, more uranium-bearing solution will be extracted than lixiviant injected which creates a localized hydrological cone of depression or pressure sink. The anticipated overproduction or bleed will be a nominal 0.5 percent to 1.5 percent of the production rate. Under this pressure gradient, the groundwater in the surrounding area will move toward the mine unit, minimizing any chance of excursion.

Small groups of injection and production wells will be connected by buried pipelines to a header house. The uranium-bearing solution will be conveyed between the mine unit and the ion exchange facility through buried pipelines with controlled flows.

Plant

The ion exchange circuit at the existing Plant receives the uranium-bearing solution from the mine unit(s) through buried pipelines. No changes to the plant design are being proposed with this application. All required components have already been approved and installed. The following operations will occur at the Plant:

Resin Loading

The ion exchange circuit in the Plant consists of ten pressurized vessels, each containing 500 cubic feet of anionic ion exchange resin. These vessels are configured as five parallel trains for two-stage down-flow loading. Booster pumps will be located upstream and downstream of the trains.

As the pregnant (uranium rich) lixiviant enters the ion exchange circuit from the mine unit, the upstream booster pumps will pressurize the fluid to approximately 100 psig. The dissolved uranium in the pregnant lixiviant will chemically adsorb onto the ion exchange resin as the lixiviant passes through the resin beds. Any sand or silt entrained in the pregnant lixiviant will be trapped by the resin bed like a traditional sand filter. The barren lixiviant exiting the second stage will normally contain less than five mg/L uranium. A slip stream of the barren lixiviant may be treated with reverse osmosis (RO) prior to sending it back to the field for re-injection. The injection fluid will be pressurized by booster pumps prior to returning to the mine unit for re-injection. The bleed portion of the fluid will be treated and disposed of via a UIC Class I or Class V well.

Resin Elution

When resin in an ion exchange vessel is loaded and removing very little additional uranium from the incoming solution, the vessel will be isolated from the normal process flow. The resin will then be transferred to the Elution Circuit. At the Plant, the resin may be passed over vibrating screens with wash water to remove entrained sand particles and other fine debris. The resin will be gravity fed into pressurized down-flow elution vessels for uranium recovery and resin regeneration.

Loaded resin may also be brought into the facility from other uranium mining operations in the region. The resin will be off-loaded from a tanker truck and into the process during this stage of the process. Once the resin is eluted, it will be reloaded onto the tanker truck and sent back to the appropriate mine for re-use.

Once placed in the elution vessel, the resin will be contacted with an eluate composed of approximately 90 g/L sodium chloride and 20 g/L sodium carbonate (soda ash). The eluted resin will be rinsed with fresh water and returned to the bulk tank trailer or an empty ion exchange vessel. The resin will then be transported back to the ion exchange facility and placed in an ion exchange vessel for additional uranium recovery.

Using a three-staged elution circuit, 45,000 gallons of eluate will contact 500 cubic feet of resin, generating approximately 15,000 gallons of rich eluate containing ten to 20 g/L U_3O_8. Likewise, 15,000 gallons of fresh eluate will be required per elution. The fresh eluate will be prepared by mixing the proper quantities of a saturated sodium chloride (salt) solution, a saturated soda ash solution and water. The saturated salt solution will be generated in commercially available saturators (brine generators).

Precipitation

In the elution circuit, the uranyl dicarbonate ions will be removed from the loaded resin and converted to uranyl tricarbonate by a relatively small volume of strong sodium chloride/soda ash solution. The resultant rich eluate will contain sufficient uranium for economic precipitation.

From the elution circuit, the uranium-rich eluate will be sent to an agitator tank for batch precipitation. To initiate the precipitation cycle, hydrochloric or sulfuric acid will be added to the eluate to breakdown the uranyl carbonate present in the solution. Hydrogen peroxide will then be added to the eluate to effect precipitation of the uranium as uranyl peroxide. Caustic soda solution will then be added to elevate the pH, which promotes growth of uranyl peroxide crystals and makes the slurry safer to handle in the subsequent process steps.

Product Filtering

After precipitation, the precipitated uranium will be washed, to remove excess chlorides and other soluble contaminants, and then de-watered and filtered to form the yellowcake slurry. This slurry will then be stored in holding tanks or in transport tanks parked in a secure area in the Plant. The holding and transport tanks will be used solely for yellowcake slurry. On-site inventory of U_3O_8 in the slurry form will typically be less than 100,000 pounds. However, in periods of inclement weather or other interruptions to product shipments, there will be capacity for up to 200,000 pounds of slurry within the Plant. The yellowcake slurry or dried yellowcake will be shipped by exclusive-use, authorized transport to a facility licensed by NRC for processing.

Yellowcake slurry from other mines may be introduced into the process at this stage. The slurry would be delivered to the site in DOT approved tankers. The slurry would be filtered if necessary or could be pumped directly to slurry storage or to a dryer.

1.2.2.3 Instrumentation and Control

For control and monitoring purposes, two separate control systems will be provided during ISR operations. Each system will be designed and instrumented to accommodate the steady state or batch flow that is characteristic of particular process flow streams or unit operations. In particular, this distinction is highlighted as follows.

1. Steady State:
    a. Mine Unit/Resin Loading Circuit
    b. Mine Unit Process Water Disposal
2. Batch:
    a. Bleed Treatment
    b. Resin Elution
    c. Precipitation
    d. Product Filtering
    e. Process Water Disposal

Since the mine unit resin loading circuit operates at a steady state, modest deviations from the normal operating flow rates and pressure profiles (plus or minus ten percent or greater) will be indicative of major operating upsets. An automatic Emergency Shut Down (ESD) system, consisting of pressure and flow rate switches, will be provided for this circuit.

In the event of an automatic shutdown, an alarm will notify the operator of the situation. Once the major upset (broken piping, leaking vessels, etc.) is identified and corrective action taken, only then can the circuit be manually restarted. This type of control system provides the best protection against fluid spills to the environment and product losses. The back-up for the automatic ESD system is provided by local displays of the same flow rates and pressures that the ESD system monitors.

The Elution, Precipitation, and Product Filtering Circuits will operate in a batch nature. These circuits are controlled by Programmable Logic Controllers (PLCs), which sequence the opening and closing of appropriate valves once the processes are manually initiated. In addition, the PLC will provide closed-loop feedback control for the elution and precipitation circuits. All automatic valves will be equipped with manual control override. Local indication of pressures, levels, flow rates, and pH will be provided for the complete manual control of these circuits if required.

Process water treatment and disposal circuits will operate under semi-continuous, steady-state conditions, which require control systems that integrate components of both steady-state and batch operations.

The control systems will employ state-of-the-art hardware with proven as well as demonstrated process logic. Like all elements of the designs, instrumentation and control designs are based on modern practices with proven techniques.

1.2.2.4 Restoration, Decommissioning, and Reclamation

Technical, economic, and operational criteria can be reviewed to determine if uranium recovery is complete in a given header house and/or mine unit. When the mineral is sufficiently recovered, the lixiviant injection ceases and groundwater restoration commences. If a mined unit is adjacent to another unit being produced, restoration of a portion of the unit may be deferred to minimize interference with the operating unit. However, LC ISR, LLC intends that concurrent restoration and mining will be conducted (e.g., each mine unit will be restored following mining).

The primary goal of groundwater restoration will be to return the water quality parameters to pre-operational conditions. After completion of groundwater restoration, which will be approved by WDEQ and NRC, all cased wells will be permanently plugged and capped. The well casing will be cut off below plow depth and the site revegetated.

Byproduct material, as defined and amended in the Atomic Energy Act of 1954, will be disposed of at an off-site NRC-licensed disposal facility or in a UIC Class I well.

Prior to the commencement of surface reclamation, affected areas and buildings will be decontaminated, and facilities and ancillary equipment will be decommissioned and removed. Vegetation will be reestablished with the approved seed mixtures.

1.2.3 Schedule

Prior to Project start up, amendments to the WDEQ Permit to Mine, NRC Source Material License, and other federal, state and local permits and approvals must be approved.

The projected mining schedule assumes a wellfield production rate of approximately 1,000,000 pounds of U_3O_8 per year. The actual development schedule and production rates will be adjusted in response to actual mine unit conditions (e.g., flows, recovery rates, etc.) and the market demand for uranium. **Figure 1.2-6** provides a current estimated schedule of operational activities at Lost Creek. Additional resources areas are known to exist within the Permit Area, but are not currently drilled adequately to evaluate for ISR planning. These areas have the potential to extend the ultimate Project life beyond this initial period. The Plant facility may continue to be used for toll processing after wellfield production and site groundwater restoration has been terminated

1.3 Applicable Regulatory Requirements, Permits, and Required Consultations

Prior to commencing ISR operations at LC East, LC ISR, LLC must obtain an amendment to the License to Mine and a Permit to Mine from WDEQ-LQD. This amendment will include an aquifer exemption for the utilization of UIC Class III wells. The NRC Source and Byproduct Material License and the Air Quality Permit must also be amended.. The Storm Water Discharge Permit has already been amended to address drilling activity at LC East. See **Table 1.3-1** for a list of regulatory requirements.

This amendment request includes the installation of up to three additional Class I disposal wells at LC East. The existing UIC permit will need to be amended prior to the installation of any Class I wells at LC East, however, in situ mining may progress without the permit amendment.

There have been no changes to the list of agencies with regulatory authority or oversight laws since the original ER.

A Class I file search was conducted through the Wyoming State Historic Preservation Office (SHPO) Cultural Records Office prior to the Class III archaeological survey with follow-up research at the BLM Rawlins Field Office. A fieldwork authorization was obtained from BLM prior to the onset of field investigations. Consultation with Native American groups will be conducted by BLM. A Class III Archeological survey was performed with the results provided to both the Rawlins BLM Field Office and the NRC.

Individual and Block permits will be sought from the Wyoming State Engineer's Office on an as needed basis. The Wyoming State Engineer recently determined that permits are not required for monitor wells.

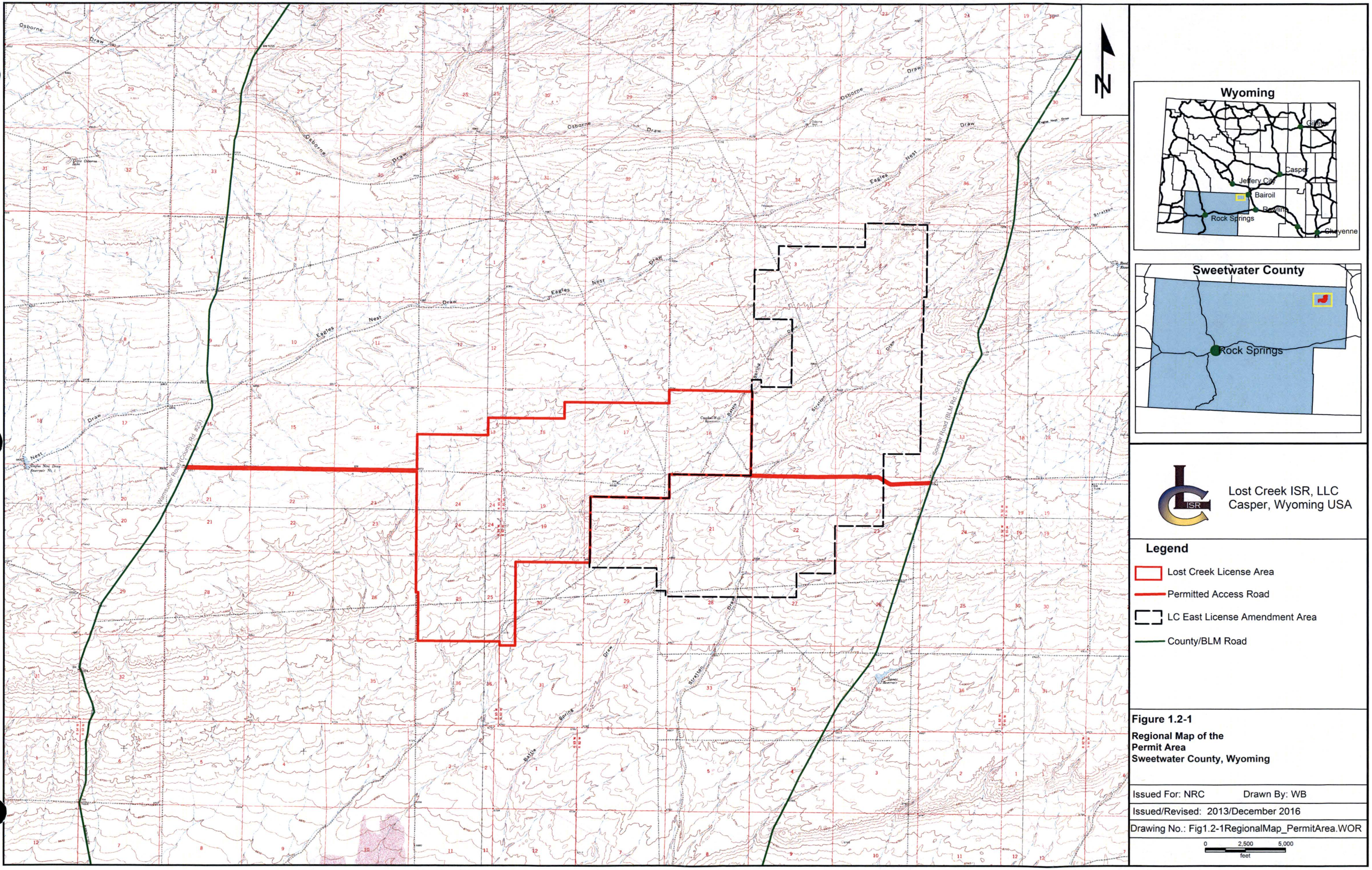

Figure 1.2-1

Regional Map of the Permit Area Sweetwater County, Wyoming

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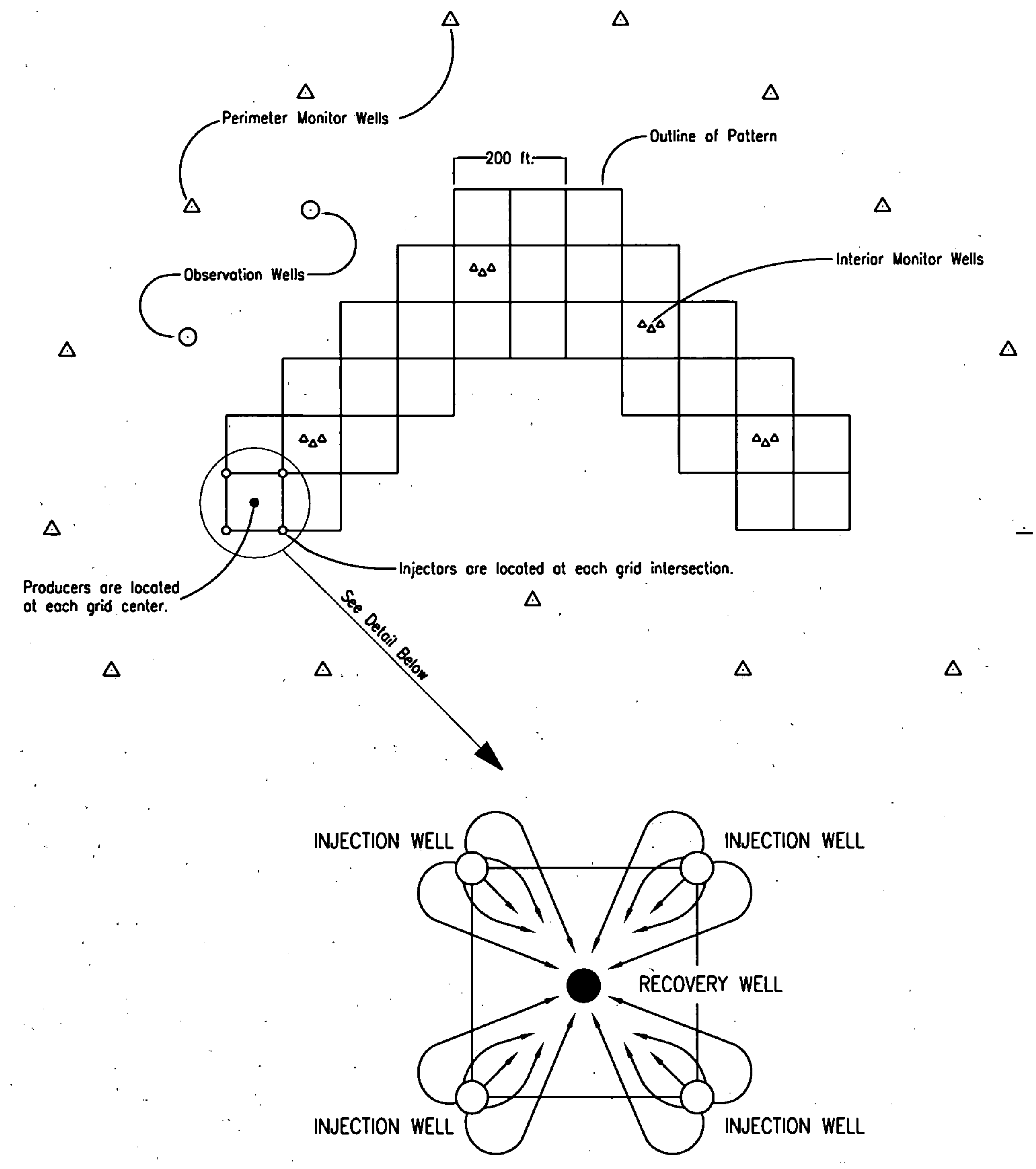

TYPICAL WELLFIELD PATTERN

Lost Creek ISR, LLC
Littleton, Colorado USA

FIGURE 1.2-2
Solution Flow Patterns

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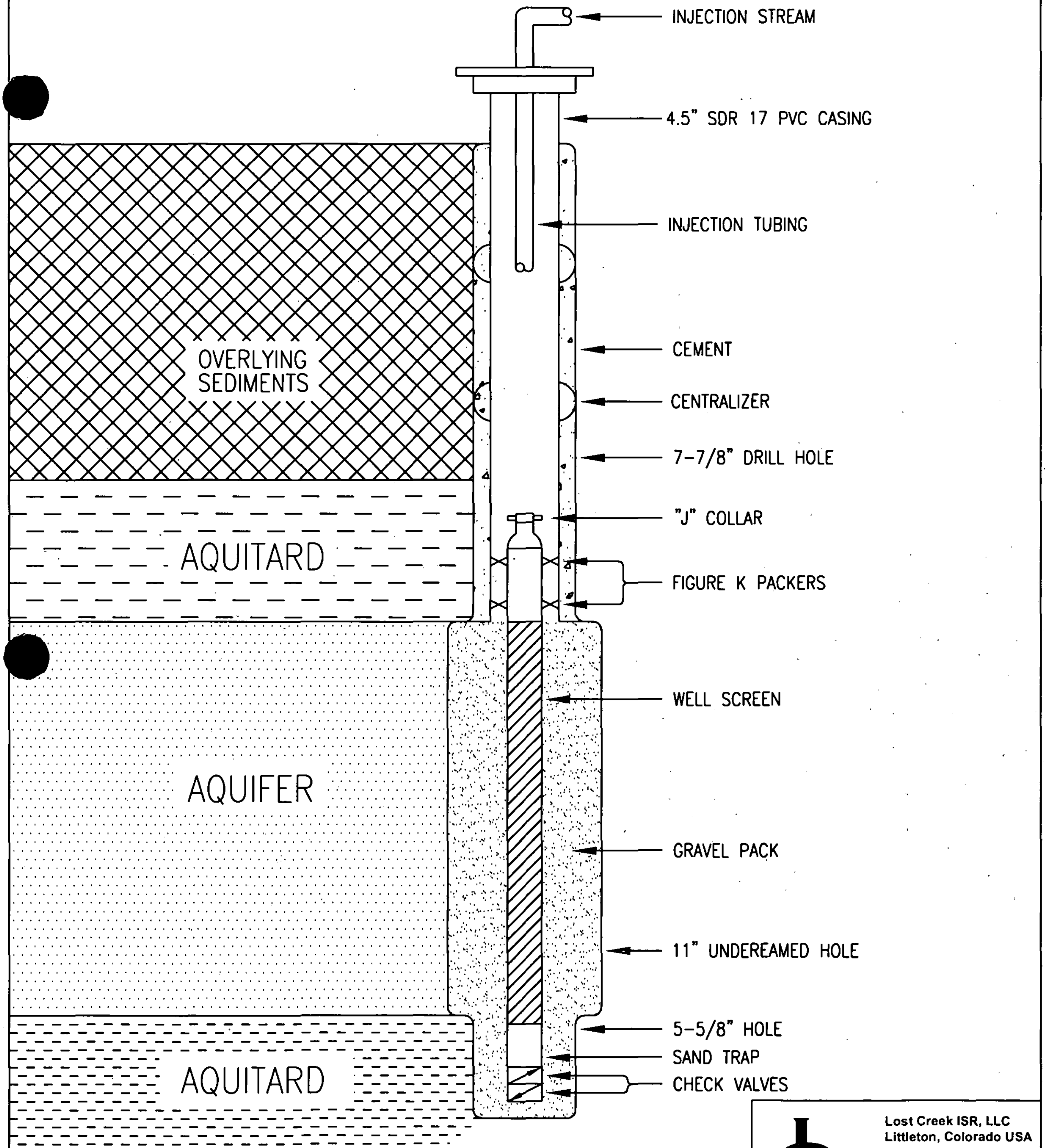

Lost Creek ISR, LLC
Littleton, Colorado USA

FIGURE 1.2-3
Injection Well Construction

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Issued / Revised: December 2016
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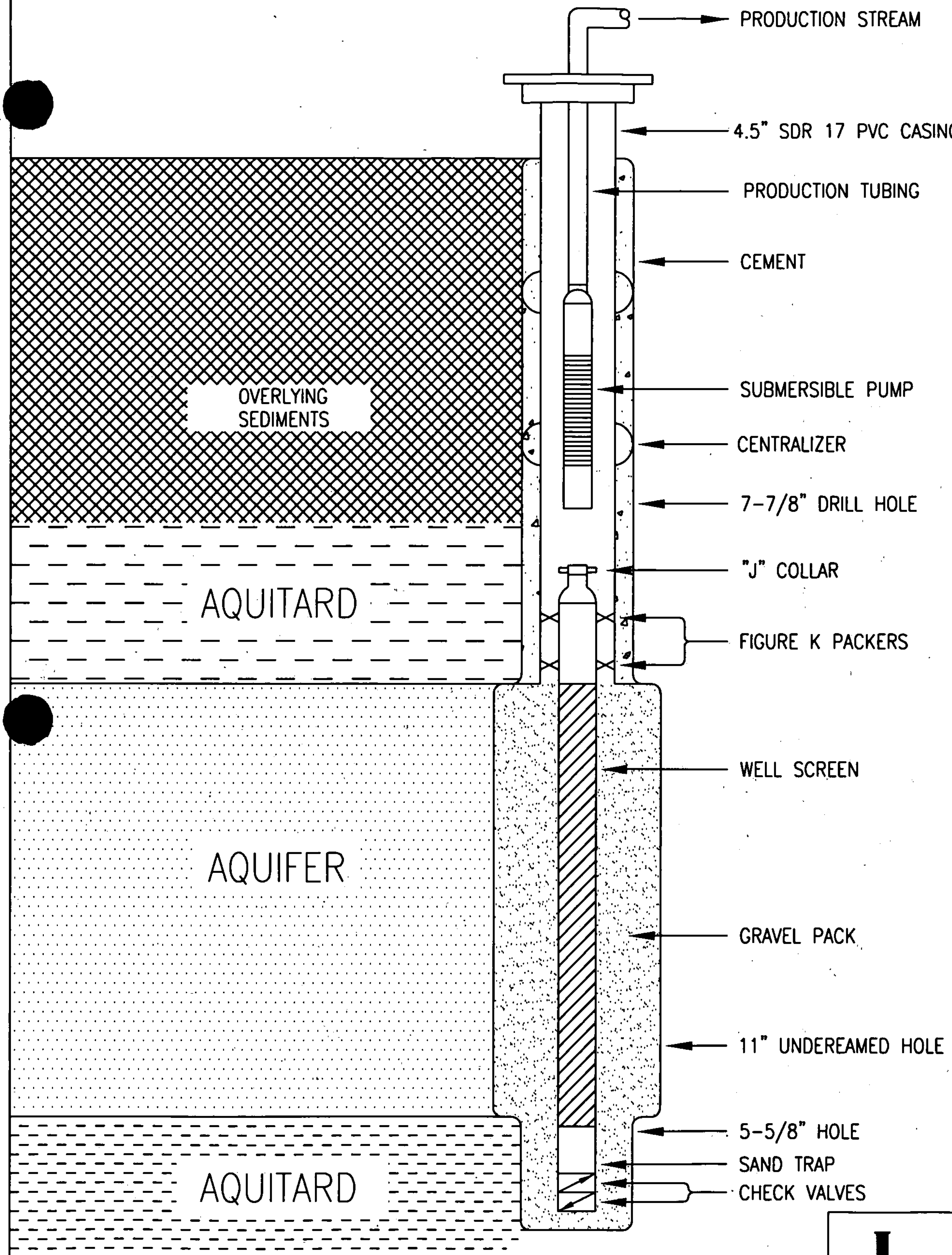

Lost Creek ISR, LLC
Littleton, Colorado USA

FIGURE 1.2-4
Production Well Construction

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Issued / Revised: December 2016	
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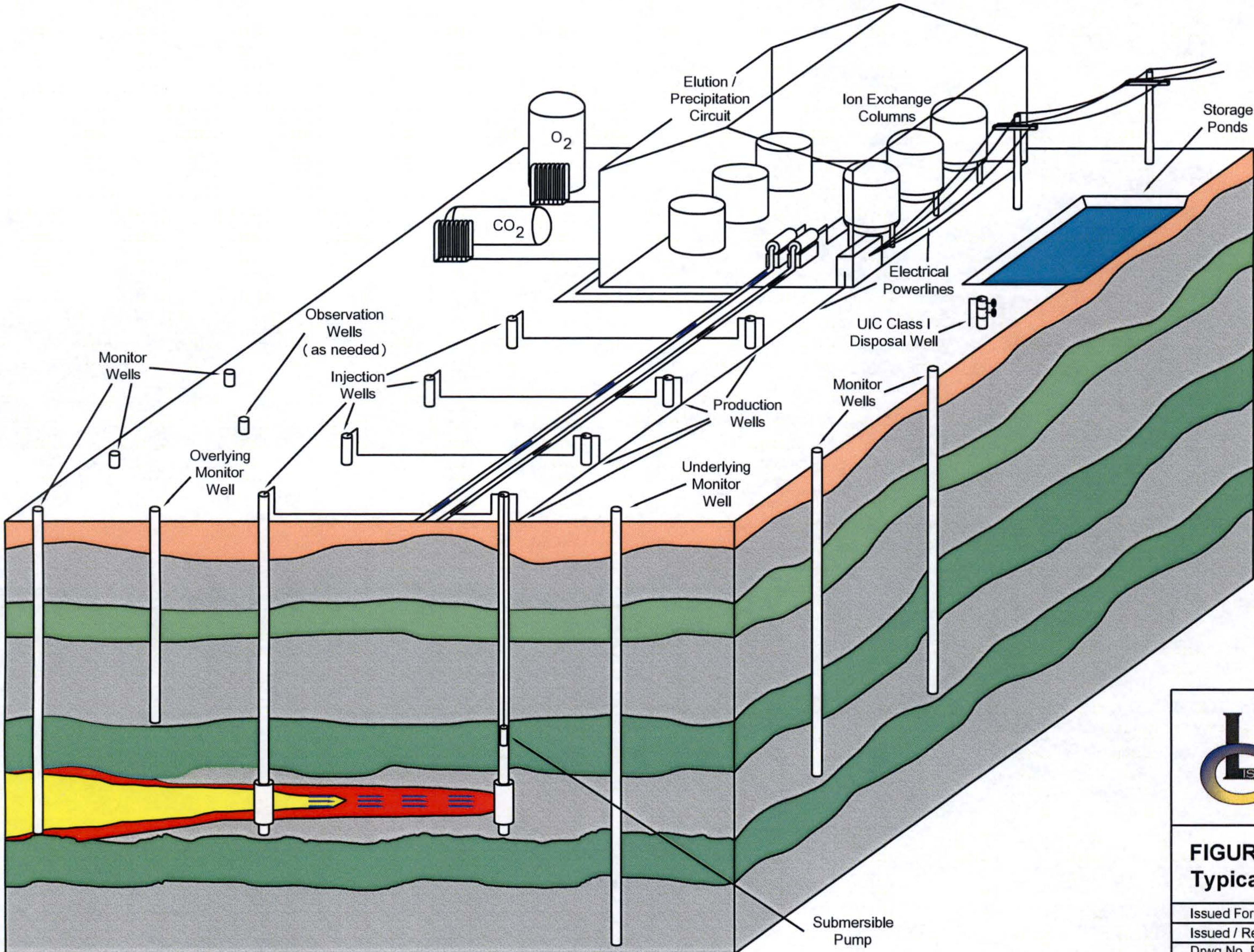

Lost Creek ISR, LLC
Littleton, Colorado USA

FIGURE 1.2-5a
Typical ISR Operation

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Issued / Revised: December 2016	
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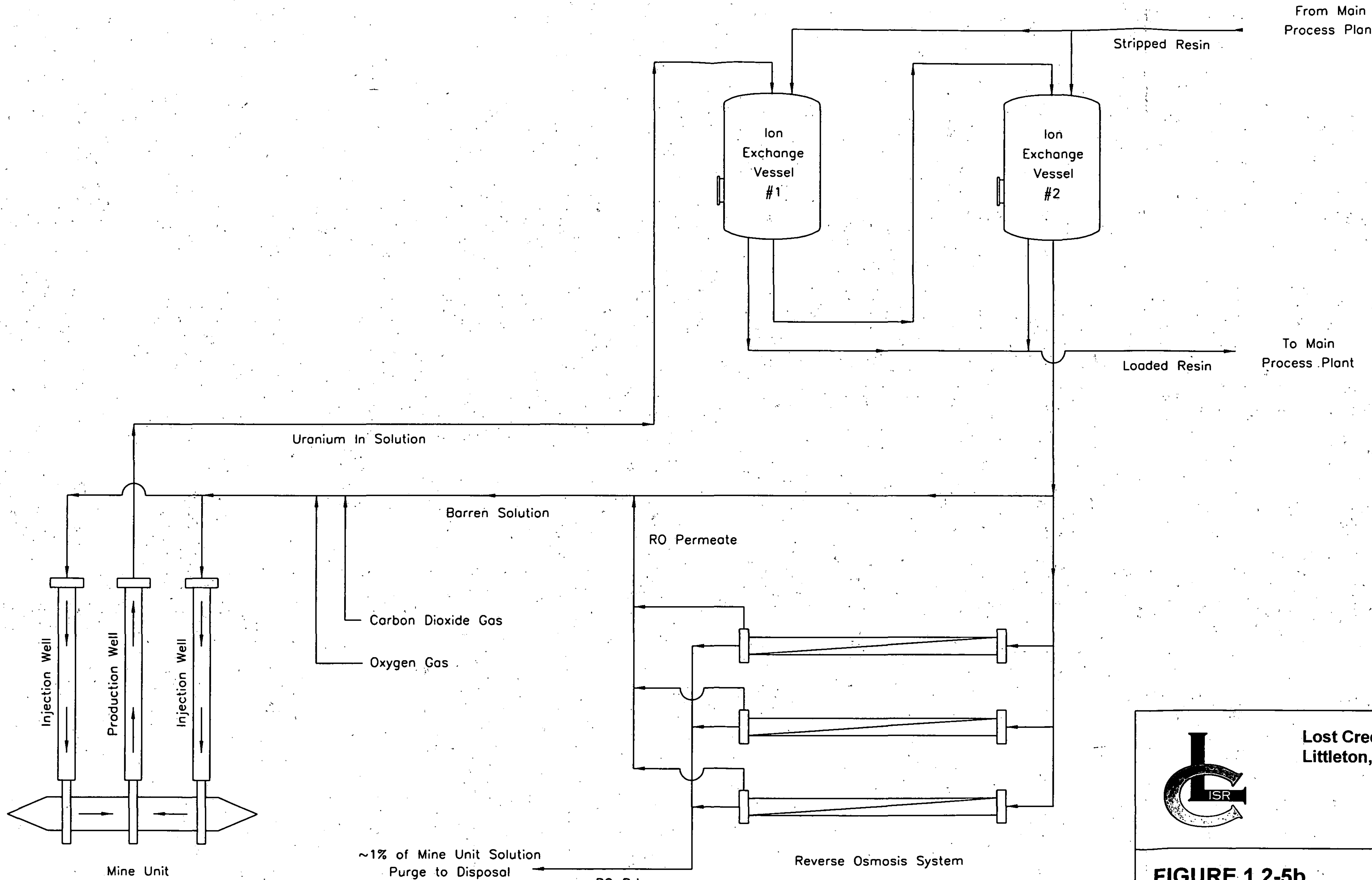

Lost Creek ISR, LLC
Littleton, Colorado USA

FIGURE 1.2-5b
Ion Exchange Process Flow

Issued For: NCR ER 1.0 Drawn By: SMH
Issued / Revised: December 2016
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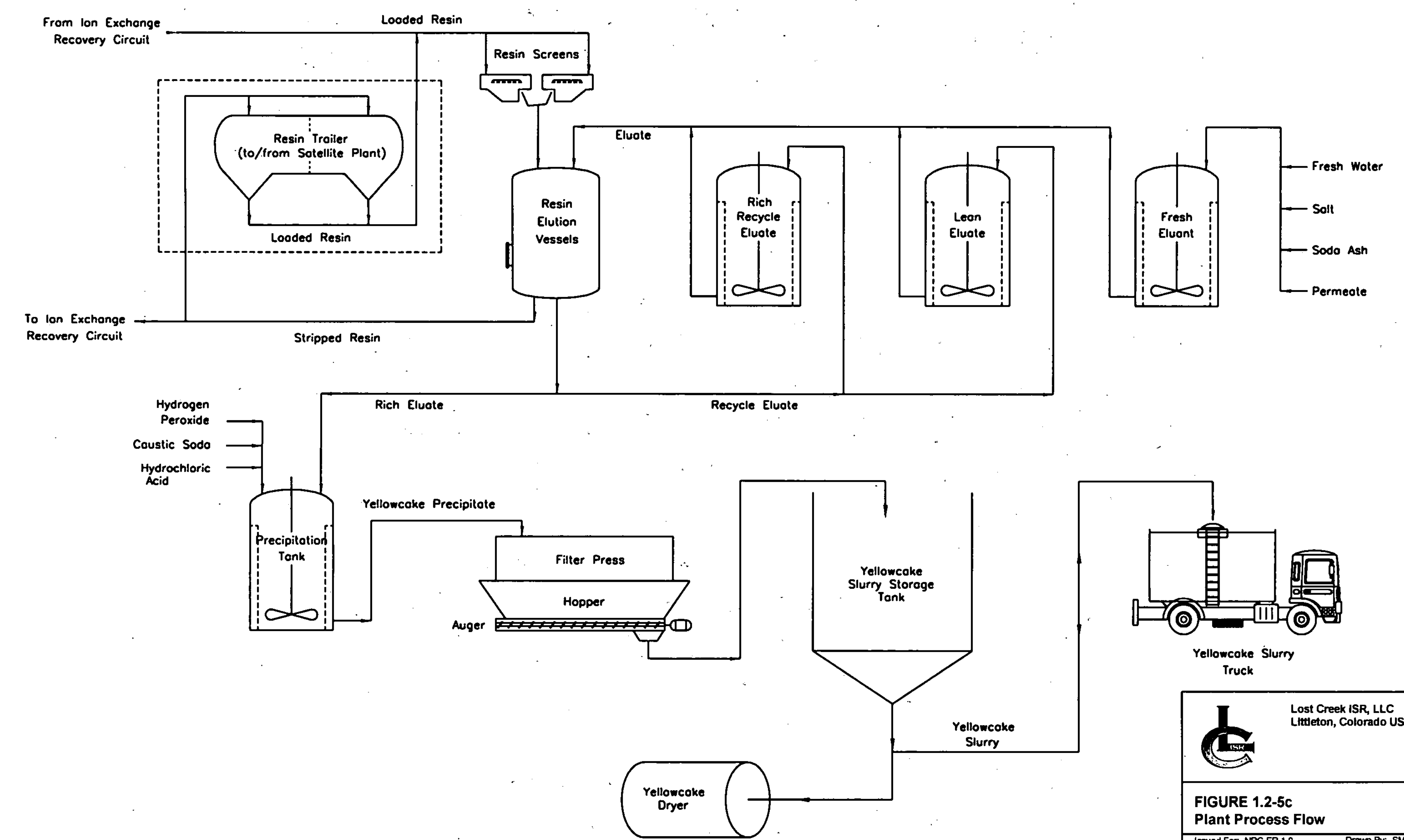

Lost Creek ISR, LLC
Littleton, Colorado USA

FIGURE 1.2-5c
Plant Process Flow

Issued For: NRC ER 1.0 Drawn By: SMH
Issued / Revised: December 2016
Dwg No. Fig1.2-5c_Plant_Process_Flow.dwg
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Figure 1.2-6 Lost Creek Project Development, Production and Restoration Schedule

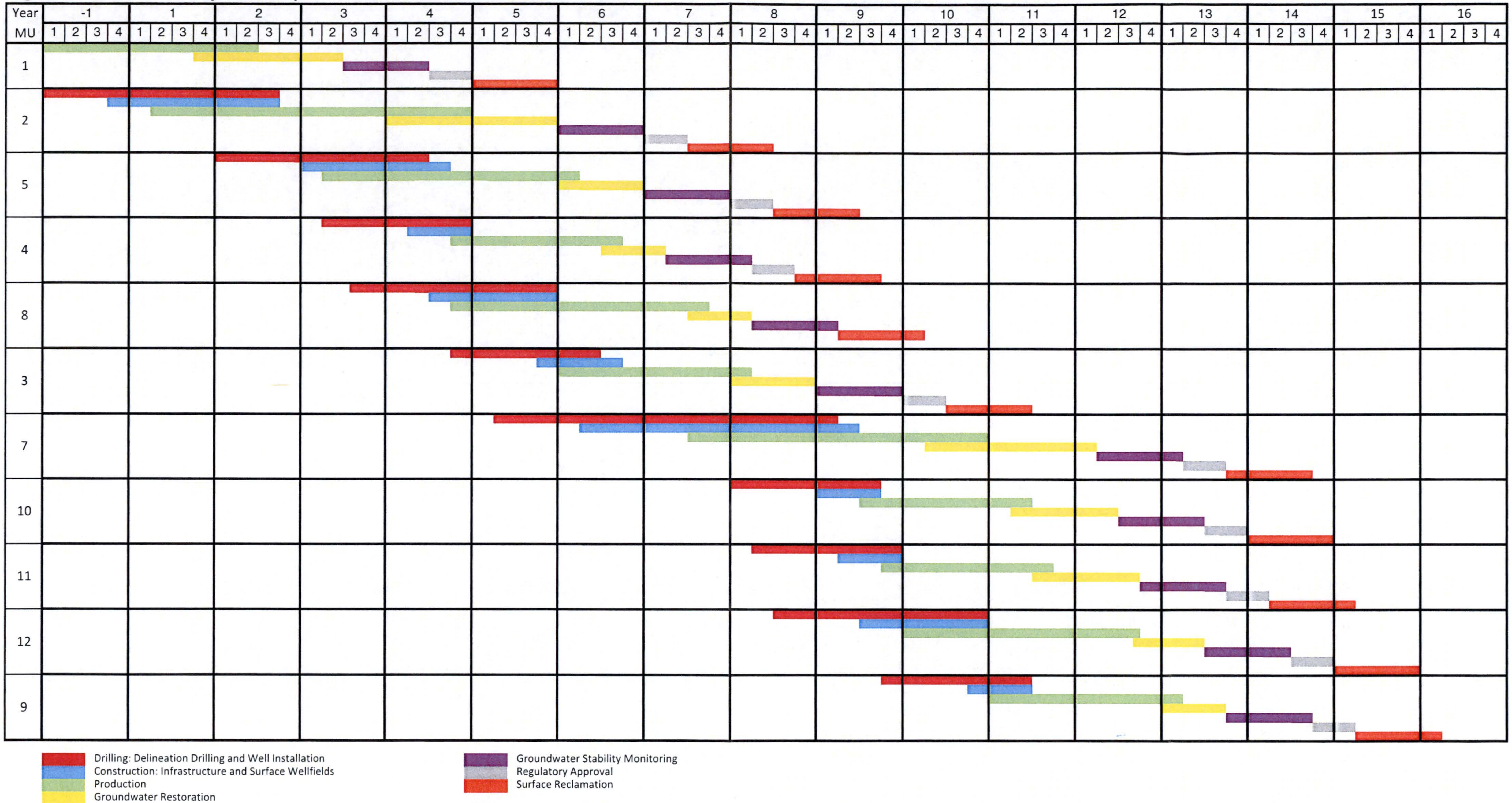

Table 1.3-1 List of Regulatory Requirements

PERMIT OR LICENSE	REGULATORY AUTHORITY	STATUS
Source and Byproduct Material License	NRC	License SUA-1598 granted. Amendments for KM Horizon and LC East being sought
Permit to Mine	WDEQ & BLM	Permit 788 for Lost Creek granted. Amendments for KM Horizon and LC East being sought
Mineral Exploration Permit	WDEQ	Obtained for all projects
License to Mine	WDEQ	Obtained for Lost Creek. Amendments being sought for KM Horizon and LC East
Underground Injection Control Permit Class I (deep disposal wells)	WDEQ	Permit for 5 wells at Lost Creek granted. May seek approval for up to three additional wells at LC East if necessary.
Aquifer Exemption Permit for Class I injection wells	WDEQ & EPA	Exemption granted for Lost Creek. WDEQ will seek exemptions for KM and LC East Amendments
Permit to Construct Additional Ponds	WDEQ & WSEO	Future Application as Needed
Permit to Appropriate Groundwater for Mine Units	WSEO	Being Prepared
Permit To Construct Sanitary Leach Field	WDEQ	Permit issued
Air Quality Permit (Fugitive Dust)	WDEQ	Permit issued but revision will be necessary for KM and LC East Amendments
Stormwater Discharge Permit	WDEQ	Permit issued for Lost Creek and LC East
County Development Permits	Sweetwater County Planning Commission	Being Prepared

Section 2
Alternatives

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2.0 ALTERNATIVES

2.1 No-Action Alternative

Under this alternative, no expansion would be conducted. There would be no uranium produced from the expansion area and no favorable or unfavorable impacts from this alternative.

2.2 Alternatives Considered but Eliminated

Underground and open pit mining represent the two currently available alternatives to ISR of the uranium resources in the Permit Area. Use of evaporation ponds for process water disposal was considered as an alternative to the UIC Class I wells.

2.2.1 Open Pit Mining

Open pit mining requires the removal of all material covering the orebody (overburden) and then the ore itself. The ore would then be transported to a conventional mill for further processing and extraction through grinding, leaching, purifying, concentrating, and drying.

From an economic point of view, open pit mining of the relatively low grade and moderate depth of the orebodies would require a much larger investment than ISR, especially in the early phase, when a significant investment would be required for acquisition of heavy equipment to perform the earthwork to expose the orebody. The overall size of the operation facilities would be larger because of greater manpower and material handling requirements.

Waste rock piles from excavation of the overburden and the mine pit would make permanent changes to the topography, with a disturbed area approximately three times the area of the orebody mined, in order to maintain slope stability. Potential personnel injury rates and potential radiological exposures at the mining site would also be higher with open pit mining than what would be experienced with ISR.

A mill tailings pond would be required to contain the millions of tons of waste produced from the uranium mill. This tonnage would represent a large volume of radioactive tailings slurry covering a large area of ground surface. Conventional mill operation would involve higher risks of spillage and radiological exposure to both personnel and the environment than those associated with the proposed ISR operations.

Open pit mining at the Permit Area would also require substantial dewatering of the pit to depress the potentiometric surface of all aquifers. Large quantities of groundwater would be discharged to the surface. Some of this groundwater contains naturally elevated radium-226 (Ra-226), radon and uranium, which would have to be treated before discharge and the residue disposed of as radioactive solid waste.

2.2.2 Underground Mining

Underground mining of the uranium resources at the Permit Area would involve sinking of shafts to the vicinity of the orebodies, horizontally driving crosscuts and drifts to the orebodies at different levels, physically removing the ore and transporting the mined ore to the conventional mill for further processing. Processes for milling and uranium extraction from underground mined ores would be the same as those for ores mined from the open pit.

When one considers the alternative of underground mining, the economic and environmental disadvantage closely parallel those of an open pit mine. These, as stated above, include large amounts of initial investment, permanent changes to the topography (though in a smaller scale than open pit mining because less amounts of waste rock are being generated), generation of a significant amount of mine tailings, increased risks of injury and potential exposure to radioactive materials during mining and milling, and surface discharge of groundwater from mine dewatering with elevated radionuclide concentrations.

One major concern for underground uranium mining is the potential exposure of miners to radon gas if the gas is not continuously vented to the atmosphere. Subsequent land surface subsidence could also occur after the completion of underground mining.

Economic costs and environmental impacts associated with open pit and underground mining clearly show that ISR is the more viable uranium extraction technique to use. The initial investment is lower; the tailings problem is completely eliminated; radiation exposure and environmental impacts are minimized; and the groundwater resource is preserved. In addition, because of the reduced costs, lower grade ores can be recovered through ISR than can be recovered from open pit and underground mines.

2.2.3 Evaporation Ponds for Process Water Disposal

Using evaporation pond(s) and/or UIC Class I well(s) for process water disposal are the most common practices for uranium ISR operations. The evaporation pond alternative was considered for the Project but eliminated for the following reasons.

- Productivity and efficiency: Due to the severe winter weather conditions at the Permit Area, evaporation ponds would be frozen and covered with snow for several months, making any evaporation close to impossible.
- Area of land surface disturbance: The size of the evaporation pond(s) would have to be large enough to accommodate the extremely low evaporation rate during the winter and to support the constant year-round production rate of the Project. A preliminary feasibility study indicates that the evaporation ponds would be approximately 21 acres in total area to sustain the proposed production rate.
- Clean-up and reclamation: The solid wastes that precipitate from the process water are radioactive and extensive efforts are needed during the reclamation phase to clean up and dispose of these solid wastes.

UIC Class I wells will be drilled and used (together with Storage Ponds) for process water disposal at the Permit Area instead, as described in the sections that follow. Treated water can also be disposed of in the existing Class V UIC wells. These methods have proven effective at Lost Creek over the past several years.

2.3 Proposed Action

The Project will use ISR technology to extract uranium from permeable, uranium-bearing sandstones located at depths ranging from approximately 300 to 700 feet. Once extracted, the uranium will be recovered by means of ion exchange, which uses commercially available anionic resin. Periodically, the ion exchange resin will become saturated with uranium. Uranium will be removed from the ion exchange resin by conventional elution processing at the Lost Creek Plant or sent to another plant for toll processing. The ion exchange resin, now stripped of uranium, will be returned to recover additional uranium. The uranium removed during the elution processing step will be precipitated, washed to remove impurities and filtered for on-sight drying or shipment as slurry to another facility. The detailed operation plan is presented in **Section 1.2** of this report.

Uranium may also be brought to the site via DOT approved tankers in the form of loaded ion exchange resin or yellowcake slurry. Up to 1.2 million pounds of U_3O_8 will be produced from the site's wellfields and up to 2.2 million pounds of U_3O_8 will be processed in the plant per year. The sum of wellfield production, slurry from off-site sources and resin from off-site sources will not exceed 2.2 million pounds of U_3O_8 per year.

2.4 Reasonable Alternatives

Since the majority of the facility, including plant complex, holding ponds, main access roads and power lines are already installed as part of the Lost Creek licensed action, very few significant reasonable alternatives are available for consideration. The mining techniques employed successfully within the Lost Creek area will also be utilized within the LC East Area and KM Amendment Areas. However, the use of portable pits is considered as a potentially reasonable alternative in this application but is not the recommended alternative.

Portable pits are a tub system that is used to drill cuttings during the drilling process instead of collecting the cuttings in an excavated drill pit. The volume of cuttings generated during drilling is larger than a portable pit can hold so the cuttings must be mucked out of the portable pit several times during the drilling process. The cuttings would be loaded onto a truck or wagon and shipped to an on-site disposal pit. By doing so, several large disposal pits would be built on-site instead of potentially thousands of small pits. While there are some advantages to using portable pits there are also several significant problems that it generates. These issues are further explored in this application.

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FIGURES

TABLES

3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The LC East Area is located in the northeastern corner of Sweetwater County, Wyoming near Carbon County, Wyoming. The Permit Area is about 15 miles southwest of Bairoil, Wyoming, about 38 miles northwest of Rawlins, and about 90 miles southwest of Casper. The Permit Area consists of 297 unpatented federal lode claims totaling 5,751 acres. The general location of the Permit Area is shown in **Figure 1.2-1**.

The regional landscape consists of rolling plains with some draws, rock outcroppings, ridges, bluffs and some isolated mountainous areas. Vegetation is primarily sagebrush and rabbit brush. The area is sparsely populated, and the closest residence is approximately 15 miles from the Permit Area boundary. The weather is dry and windy, with short, hot summers and cold winters. There is no perennial surface water, although there are a few ephemeral drainages that can convey surface water during spring snowmelt and following intense rainstorms.

3.1 Land Use

The land within the LC East Area is entirely publicly owned and managed by the Rawlins BLM Field Office (**Figure 3.1-1**). The Lost Creek License Area is likewise all public land with 85% managed by the BLM and 15% managed by the State of Wyoming. The primary land use in the study area is rangeland for cattle, but the area is also used for dispersed recreation such as hunting, off-highway vehicle (OHV) use, and antler collecting. The main access road into Lost Creek passes through the LC East Amendment Area. Regional land uses include grazing, industry, wildlife habitat, hunting, dispersed recreation, OHV use, oil and gas extraction, gas and carbon dioxide (CO_2) pipelines, and transmission lines.

3.1.1 Existing Land Uses

3.1.1.1 Rangeland and Agriculture

There is no crop production within the Area or within two miles; the only agricultural production is related to grazing. The study area includes portions of three BLM grazing allotments: Stewart Creek, Cyclone Rim, and Green Mountain (**Figure 3.1-2**). These allotments provide forage for cattle that are generally sold as food sources, as well as a small number of horses and sheep. Grazing rights are assigned by section, so all sections that are at least partly within two miles of the Permit Area are included in the grazing allotment study area. Water sources that support this grazing are discussed in **Section 3.5**.

The Stewart Creek and Cyclone Rim allotments are managed by the BLM Rawlins Field Office, and cover 22,101 acres within the study area. Together, these two allotments provide 3,027 animal unit months (AUMs) of summer and winter grazing (Calton, M. Range Specialist. BLM Rawlins Field Office. Personal communication. July, 2007.) The Green Mountain allotment is managed by the BLM Lander Field Office, and includes 9,339 acres within the study area. This acreage provides 635 AUMs of summer grazing. An AUM is an animal unit month, the common unit of measure defined as "the amount of forage to sustain one mature cow or the equivalent, based on an average daily forage consumption of 26 pounds of dry matter per day" (BLM, 2004a). The total AUMs for the Lost Creek and LC East Areas is approximately 1,366 (578 for Lost Creek and 788 for LC East), which would provide year-round forage for the equivalent of 114 cattle. For a 1,000-pound cow, the average meat yield is 550 pounds (National Sustainable Agriculture Information Service, 2007). Therefore, the annual potential total meat production associated with the Lost Creek plus LC East Area is roughly 62,700 pounds if all the cattle are slaughtered. However, some animals are generally kept for breeding, so the actual meat production is probably somewhat smaller. Most of the area will remain open to cattle grazing since only the wellfields and plant compound are fenced out in order to exclude cattle.

In 2016, one monthly AUM for cattle in the Stewart Creek Allotment was worth $2.11. The BLM calculated that cattle production would produce $65.07 per AUM of total economic impact, which includes both direct and secondary returns (BLM, 2004a). Using these figures, livestock production on rangeland within the grazing allotments of the Permit Area has a potential value of about $89,000 per year based on the current AUMs of the study area. As mentioned previously, the majority of the land within the licensed area will remain open for cattle grazing. Wildlife, except wild horses, will not be excluded from the mine units since the fencing will be wildlife friendly.

3.1.1.2 Wildlife Hunting and Viewing

WGFD hunting areas for antelope, deer, elk, and mountain lion include the Permit Area. Hunting seasons run from September through December, but hunting occurs primarily in October and November. Hunter days for the hunt areas that include the Project are shown in **Table 3.1-1**. There are no designated wildlife viewing locations in the study area.

3.1.1.3 Recreation and Special Use Areas

Considerable dispersed recreational activity takes place in the Green Mountains and Ferris Mountains, eight miles to the north and 25 miles northeast of the Permit Area, respectively. The Green Mountain Area has one developed campground with 17 campsites, water, and toilets (Rau, P. Recreation Specialist, BLM Rawlins Field Office. Personal communication. 2007.). This campground is under-used and is closed during elk calving season. There are also additional primitive camping areas available for campers with recreational vehicles (RVs) and tents. The general area is designated as an Extensive Resource Management Area (ERMA), which does not have restrictive use compared to a Special Recreation Management Area (SMRA) or Wilderness Study Area (WSA).

According to BLM's Natural Resource Recreation Settings, which are the criteria used for classification and prescriptions for BLM lands, the area is managed for Middle Country Designation. This designation does not restrict natural resource development and allows motorized and mechanized uses in most areas with some restrictions (BLM, 1987 and 2004b). A Middle Country designation falls between a Primitive classification and an Urban classification. The physical characteristics of the land area appear natural, except for primitive roads and within 0.5 miles of all improved roads, although improved roads may be visible.

3.1.1.4 Minerals and Energy

Bairoil is the residential area closest to the Permit Area, and is economically dependent on energy development in the area. Bairoil has an airport landing strip and residential and industrial units, a school, and town offices, including a police department.

Wyoming is a state with active mineral development. The types of minerals developed include oil and gas, coal and other minerals. About half the oil produced in the Resource Management Plan Planning Area (RMPPA) during 2000 and 2001 was from the Lost Soldier-Wertz Fields near Bairoil. This field complex is in a tertiary phase of oil recovery via CO_2 injection; it is expected that no future oil production enhancement can be accomplished.

There are no nuclear fuel cycle facilities within 50 miles of the Lost Creek Permit Area (NRC, 2007). However, there are several conventional uranium mills and mines and ISR projects within 50 miles of the Permit Area; the locations are shown on **Figure 3.1-3**. Other than Kennecott Uranium Company's Sweetwater Mill (NRC License No. SUA-1350; WDEQ Permit No. 481), which is currently on stand-by, and the PRI Gas Hills Project (NRC License No. SUA-1511-Amendment; WDEQ Permit No. 603), which is a new ISR project not yet constructed, all of the operations shown in **Figure 3.1-3** are in decommissioning or reclamation or have been reclaimed by the operator or the WDEQ Abandoned Mine Lands Division. The closest facility to the Project is the Sweetwater Mill, which is located about five miles south-southwest of the center of the Project, with about two miles separating the permit boundaries.

3.1.1.5 Infrastructure

The Lost Creek Mine is now constructed and provides an all-weather gravel road through the LC East Amendment Area. This road will serve as the main access to the LC East area with secondary roads leading to mine units as needed. A power line has been extended to the Plant in

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3.1.2 Planned Land Uses and Developments

Based on publicly available information, no projects are currently planned within the remote study area (Newman, M., BLM Project Manager, Personal communication, 2014). With the exception of Lost Creek ISR, LLC's projects, uranium exploration and associated mine permitting in the general vicinity has been terminated due to the decrease in prices. The Sweetwater Uranium Mine located south of Lost Creek, continues in standby mode with no public projections for restart.

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Bureau of Land Management (US). 2004a. Jack Morrow Hills coordinated activity plan and proposed Green River RMP amendment, final EIS. Available from: http://www.blm.gov/wy/st/en/field_offices/Rock_Springs/jmhcap/2004final.html

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National Sustainable Agriculture Information Service (US). 2007. Sustainable Farming Association's Locally produced meat fact sheet series [Internet]. Available from: http://attra.ncat.org/attra-pub/altmeat.html#producing

Nuclear Regulatory Commission (US). 2007. Fuel Cycle Facilities. 2007 June 25. Available from: http://www.nrc.gov/info-finder/materials/fuel-cycle/

Section 3.1

Land Use

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Bureau of Land Management (US). 2004a. Jack Morrow Hills coordinated activity plan and proposed Green River RMP amendment, final EIS. Available from: http://www.blm.gov/wy/st/en/field_offices/Rock_Springs/jmhcap/2004final.html

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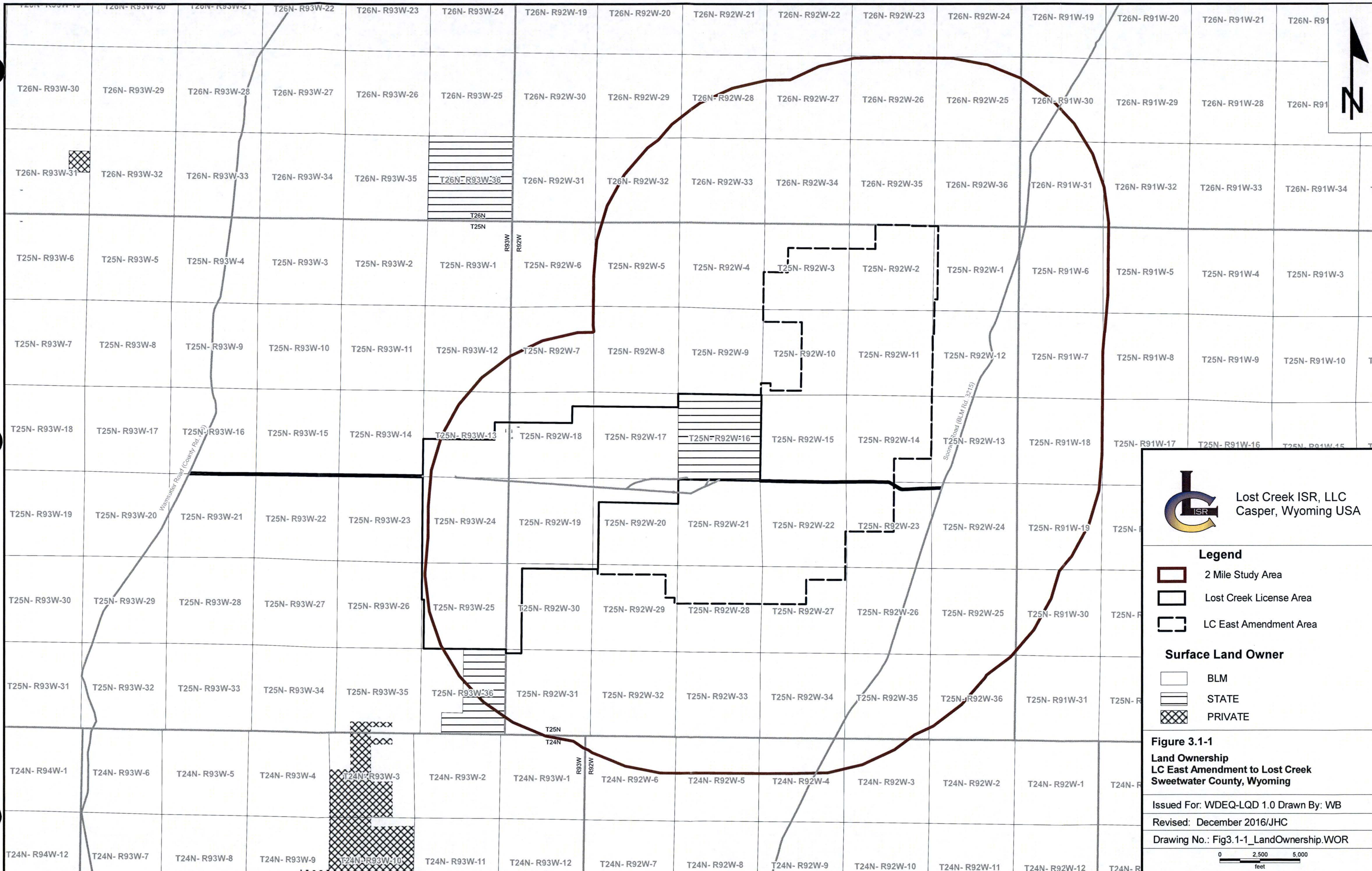
Nuclear Regulatory Commission (US). 2007. Fuel Cycle Facilities. 2007 June 25. Available from: http://www.nrc.gov/info-finder/materials/fuel-cycle/



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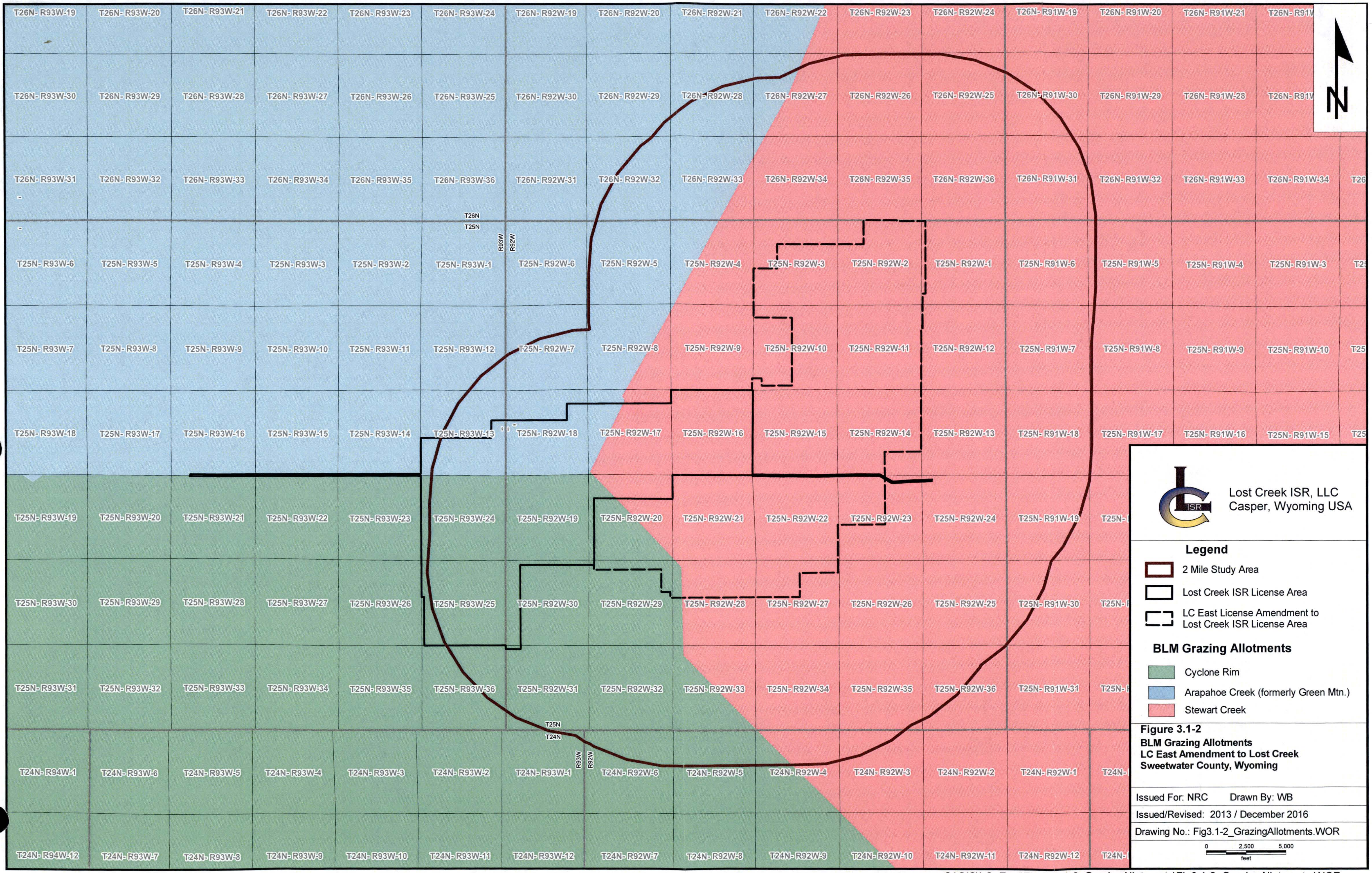

Figure 3.1-2
BLM Grazing Allotments
LC East Amendment to Lost Creek
Sweetwater County, Wyoming

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Issued/Revised: 2013 / December 2016
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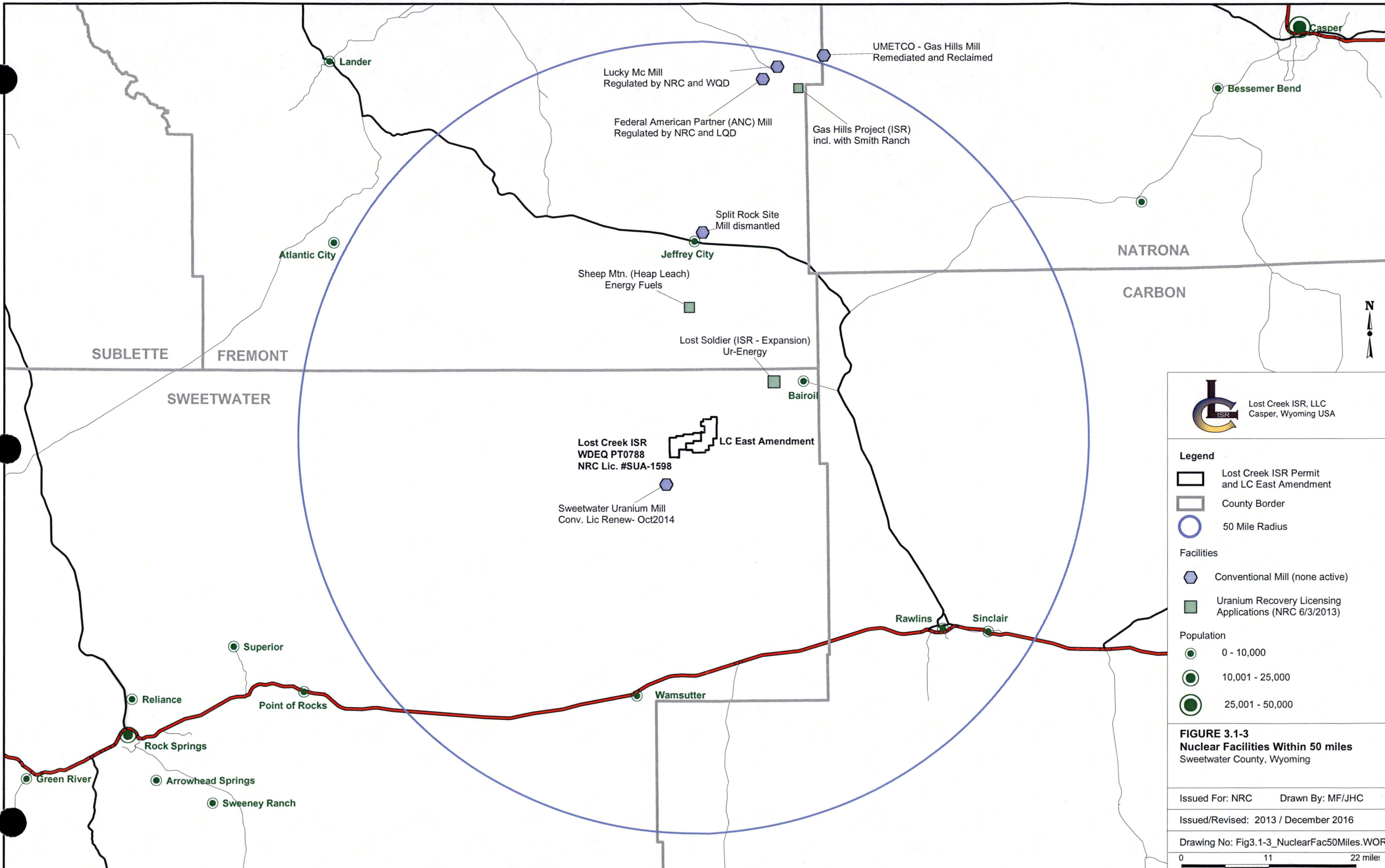

FIGURE 3.1-3
Nuclear Facilities Within 50 miles
Sweetwater County, Wyoming

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Table 3.1-1 Hunting Statistics for Hunt Areas that Include the Permit Area*

Game	Hunter Days	Active Licenses	Total Harvest	Hunter Success (percent)	Outfitters	Hunting Area
Antelope	1,141	476	494	103.8	N/A[1]	Chain Lakes
Deer (Mule & White Tailed)	732	185	53	31.4	N/A	Chain Lakes
Elk	664	120	89	74.2	N/A	Shamrock Hills
Mountain Lion	N/A	N/A	0	N/A	N/A	Red Desert

*(Wyoming Game and Fish Department, 2011 Annual Report of Big and Trophy Game Harvest)
[1] N/A = No Data

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Transportation

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3.2 Transportation

This section provides a description of the regional and on-site transportation network that is relevant to the Project. Most transportation will use the public road network; but goods may be transported by rail to and from Wamsutter. The road network will be used for: 1) shipments of construction materials, process chemicals, office supplies, and related materials from suppliers to the Plant; 2) shipment of product including loaded resin, yellowcake slurry and dry yellowcake; 3) shipments of waste material to be disposed of off-site; and 4) movement of personnel to and from the site and within the Permit Area.

3.2.1 Regional Transportation Corridors

The transportation system serving the Project relies almost exclusively on public roads and highways. Automobiles and trucks are the primary mode of transportation. The regional transportation network relevant to the Project consists of primary, secondary, and local roads (**Figure 3.2-1**). The Permit Area is served by an Interstate Highway (I-80); a US Highway (US 287); Wyoming State routes (SR 220 and 73 to Bairoil); local Carbon, Sweetwater, and Fremont County roads; and BLM roads. Transportation to the Permit Area will be predominantly from I-80 at Rawlins, Wyoming, north about 15 miles on US 287, west approximately 32 miles on Mineral Exploration Road (Sweetwater County Road 63) then six miles north on Sooner Road (BLM Road 3215) to the Permit Area access road. These roads are paved with the exception of Sooner Road and the site access road. Some of the heavier transports of materials and equipment may use the unpaved Wamsutter-Crooks Gap Road (CR 23N) to the west of the Permit Area, that connects Wamsutter and Jeffrey City. In addition to the designated routes, there are a number of four-wheel-drive routes that traverse the area for recreation and grazing access, as well as various other uses, including oil, gas, and mineral exploration.

The primary interstate and US highways are well maintained. The other county and BLM roads providing access to the Permit Area are generally maintained biannually and in fair condition, depending on the season and how recently maintenance occurred. Lost Creek ISR, LLC has an agreement in place with the BLM to maintain Sooner Road (routine blading and snow removal) as well as an agreement with Sweetwater County to remove snow from the Wamsutter-Crooks Gap Road if necessary. These roads are infrequently plowed in the winter. Ranchers, agency personnel and some hunters, fishermen, and other recreationists use these roads (Rau P. Recreation Specialist, BLM Rawlins Field Office. Personal communication. 2007).

Table 3.2-1 describes these roads, with daily and peak traffic counts for the roads that are regularly monitored. Traffic counts are not available for the county roads. These roads receive little traffic for most of the year, but use peaks in the summer and fall, when hunting and dispersed recreation is greatest.

Traffic safety data are summarized in **Table 3.2-2**. An Operator's or Owner's Traffic Accident Report is required by the Wyoming Department of Transportation (WYDOT) if any party is injured or if there is property damage of $1,000 or more (Carpenter, T. Senior Data Analyst, WYDOT. Personal communication. March, 1997). The accident rate was calculated by dividing the mean number of truck accidents per year (2002 to 2006) by the product of the road segment length, the average number of trucks per day, and the number of days per year (365). From 2002 to 2006, no accidents involving large trucks occurred on the segment of interest of WY-73, so the accident rate was calculated using all traffic. During this period, there were an average of 230 cars per day, and a total of three accidents. Traffic counts were not available for the county and BLM roads listed in **Table 3.2-2**, so the accident rate for these segments could not be calculated directly. Where no data were available, the truck accident rate was estimated as 2.2 x 10^{-6} accidents per mile (Harwood and Russell, 1990), a widely cited value for two-lane rural roads. Most traffic accidents do not cause injuries or fatalities. From 2002 to 2005, an average of 15,867 accidents occurred in Wyoming, annually. Of these accidents, 0.9 percent was fatal, 25 percent caused injuries, and 74 percent caused property damage only (WYDOT, 2007).

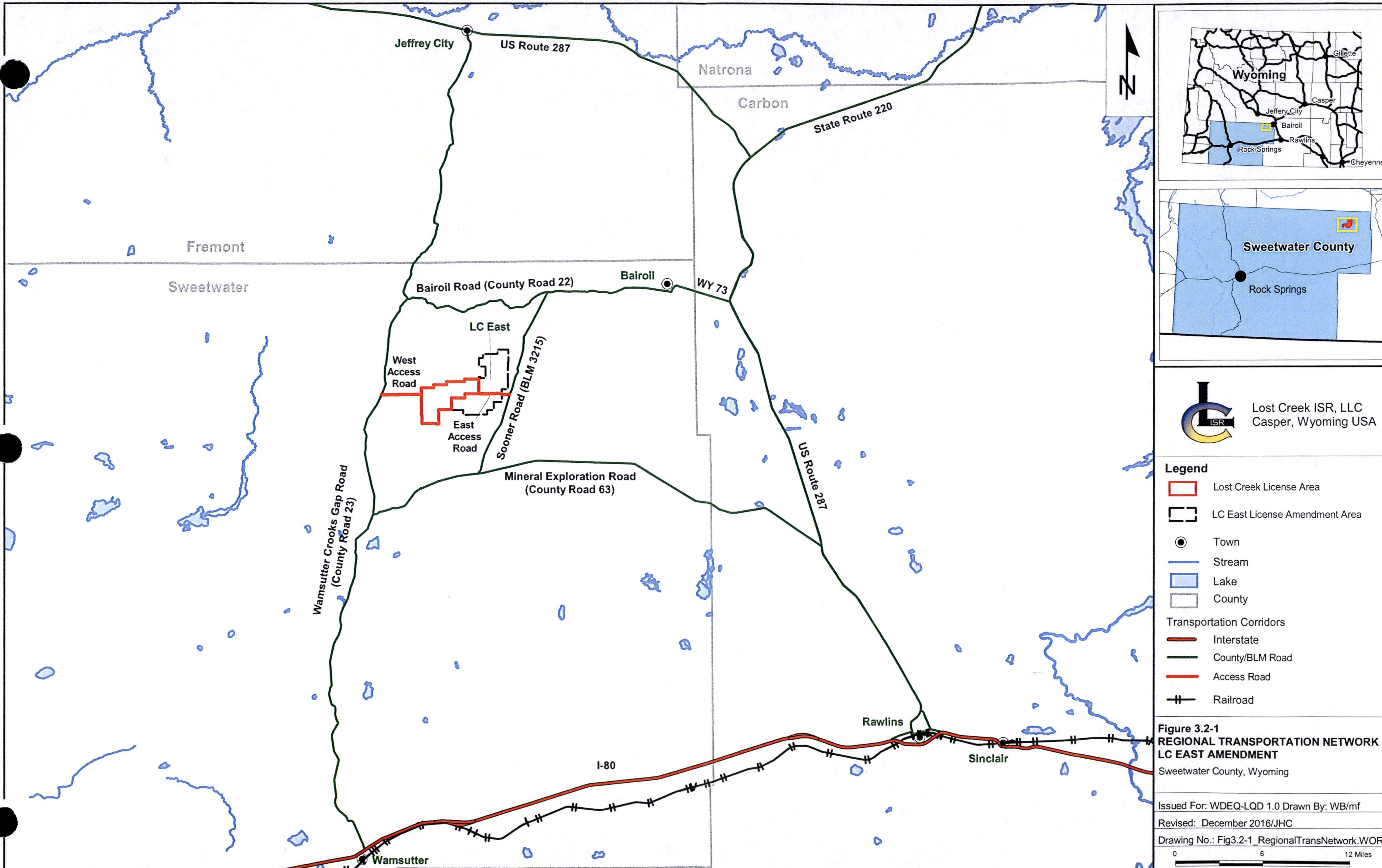
3.2.2 On-site Transportation Corridors

A main access road connecting the BLM Sooner Road and Wamsutter-Crooks Gap Road was constructed as part of the licensed activity at Lost Creek. This east-west running gravel road also runs through the LC East amendment area and will serve as the main access road to the amendment area. Secondary roads leading to individual mine units will feed off of the main access road as shown in **Plates 1.2-1a and 1b**.

3.2.3 References

Harwood DW, Russell ER. 1990. Present practices of highway transportation of hazardous materials. Department of Transportation (US). FHWA-RD-89-013.

Wyoming Department of Transportation. 2007. Statewide accident statistics, 2002-2005 [Internet]. Available from: http://www.dot.state.wy.us/



Lost Creek ISR, LLC
Casper, Wyoming USA

Figure 3.2-1
REGIONAL TRANSPORTATION NETWORK
LC EAST AMENDMENT
Sweetwater County, Wyoming

Issued For: WDEQ-LQD 1.0 Drawn By: WB/mf

Revised: December 2016/JHC

Drawing No.: Fig3.2-1_RegionalTransNetwork.WOR

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Table 3.2-1 Local and Regional Roads *

Road/Counties	Road Surface	Lanes	Speed Limit	Average Daily Traffic	Peak Hourly Traffic	Peak Time
I-80 Carbon Sweetwater	paved	4	75	12,430 13,840	549 644	4 to 5 p.m. – Aug. 4 to 5 p.m. – Aug
US-287 Carbon Fremont	paved	2	65	1,820 1,870	460 259 North 308 South	2 to 3 p.m. – Aug 3 to 4 p.m. – July 3 to 4 p.m. – July
WY-73 Carbon	paved	2	65	230	NA	NA
County Rd 22 (Bairoil Rd)	native surface	2	Not posted	NA [1]	NA	NA
County Rd 23N (Wamsutter-Crooks Gap Rd)	native surface	2	Not posted	NA	NA	NA
County Rd 63 (Mineral Exploration Rd)	paved/ native surface	2	Not posted	NA	NA	NA
BLM Rd 2315 (Sooner Rd)	native surface	2	Not posted	NA	NA	NA

* (Sandidge. M. Transportation Technician 3, WYDOT Planning Traffic Surveys. Personal communication. March, 2007)

[1] NA = No Data

Table 3.2-2 Traffic Safety Data *

Road	Length (mi)	Trucks/Day	Annual Truck Accidents	Period of Record	Accident Rate (accidents/mile)
I80 (Carbon and SW County) milepost 57.04 to 280.9	223.9	6627	408.8	2002 to 2006	7.5E-07
US 287 (Rawlins to Muddy Gap)	43.1	490	6	2002 to 2006	7.8E-07
WY 73 (287 to Bairoil) milepost 0 to 4.65 [1]	4.7	30	0	2002 to 2006	1.5E-06
County Road 22, Bairoil Rd [2]	NA [3]	NA	0.6	2002 to 2006	2.2 E-06
County Road 23 Wamsutter-Crooks Gap Rd [2]	NA	NA	0.8	2002 to 2006	2.2 E-06
County Road 63/BLM 3206, Mineral Exploration Rd [2]	NA	NA	0.6	2002 to 2006	2.2 E-06
BLM Road 3215, Sooner Rd [2]	NA	NA	NA	2002 to 2006	2.2 E-06

* (WYDOT, 2007a)

[1] No Truck Accidents; Accident rate calculated from all vehicles

[2] Generic Accident Rate (Harwood and Russell, 1990)

[3] NA = No Data

Section 3.3

Soils

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3.3 Soils

NUREG-1748 suggests a single section in the Environmental Report to include information on both soils and geology. However, for ISR operations, the data requirements and environmental concerns for soils and geology differ significantly. In particular, specific soil data are needed to support the proposed topsoil protection practices, surface reclamation, and vegetation reestablishment, while geology data is needed to understand the distribution of the ore reserve. Therefore, the topics of soil and geology are separated in this Environmental Report.

This report presents baseline information on the soils occurring within the Lost Creek ISR, LLC, Lost Creek East (LCE) Amendment Area. This will be an amendment to WDEQ Permit to Mine No. 788. NRC license is Number SUA-1598. Baseline soils inventories were used to delineate the soils resources within the LCE Amendment Area, as well as determine topsoil salvage depths and ultimately replacement depths over the entire amendment area. The project area is located approximately 50 miles northwest of Rawlins in Sweetwater County, Wyoming, in all or portions of Sections 1, 2, 3, 10, 11, 14, 15, 20, 21, 22, 23, 27, 28 and 29 of T25N, R92W.

3.3.1 METHODS

3.3.1.1 Review of Existing Literature

The soils in this portion of Sweetwater County have not yet been mapped to an Order 3 scale by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) (Martin 2013). However, in a 2007 Lost Creek ISR, LLC, Environmental Report, adjacent to the LCE Amendment Area, soils were mapped to an Order 2 scale as Typic Torriorthent, loamy and fine loamy, and fine loamy over sandy, mixed mesic. Existing information regarding soils in mapped portions of Sweetwater County is available in both electronic and hard copy formats from the NRCS. The NRCS has also centralized dissemination of typical soil series descriptions. This information is available on the internet at www.nrcs.usda.gov.

3.3.1.2 Project Participants

BKS Environmental Associates, Inc. (BKS) of Rock Springs, Wyoming, performed the 2012 soil survey fieldwork, mapping, and compiled the resulting report. Aerial imagery, for all maps used for this project, was obtained from USDA. Drafting of the final soils map was completed by BKS. All soil samples were taken to Energy Labs, Inc. in Gillette, Wyoming.

3.3.1.3 Soil Survey

Field mapping was conducted according to techniques and procedures outlined in the National Cooperative Soil Survey. Wyoming Department of Environmental Quality (WDEQ) Land Quality Division (LQD) Guideline 1 (August 1994 Revision) was used as a guide during all phases of the study.

An Order 2 soil survey was conducted in October of 2012. Actual soil boundaries were identified in the field by exposing soil profiles to determine the nature and extent of soil series within the LCE Amendment Area. The soil boundaries were delineated on a 2001 NAIP orthophoto with a relative scale of 1 inch = 500 feet. Refer to Table 3.3-1 for Soil Map Unit Acreages and Total LCE Amendment Area Acreage.

A total of 5,724.34 acres were included in the final soil mapping of the LCE Amendment Area. Overall, there were 25 verification points in addition to 18 sample points which had profiles written for them. The eighteen sampled locations were sent to the laboratory for analysis, which resulted in a total of 63 soil samples. Refer to Table 3.3-3 for Soil Sample Locations within the LCE Amendment Area.

3.3.1.4 Field Sampling

Sampling of soil series identified within the LCE Amendment Area generally followed WDEQ-LQD Guideline 1 recommendations of three sampled pedons for series encompassing greater than 160 acres, two sampled pedons for series encompassing between 40 and 160 acres, and one sampled pedon for series encompassing less than 40 acres. Please see Table 3.3-2 in the for the Soil Series Sample Summary within the LCE Amendment Area.

All soil samples were collected with a Giddings truck mounted auger or hand auger to paralithic contact or a maximum depth of 60", whichever was shallower. Sampled profiles were described in the field, to the extent possible, by the physical and chemical nature of each profile horizon. Backhoe pits were not utilized for soil sampling. Refer to Appendix 3.3-5 for Site Photographs.

Sample locations were identified on a base map, and global positioning system (GPS) points were collected with a hand-held Garmin GPS unit. Soil samples were placed in clean, labeled, polyethylene plastic bags, and sealed to limit sample contamination. Samples were kept as cool as possible, but not stored on ice. Samples were delivered to Energy Labs in Gillette, Wyoming.

3.3.1.5 Laboratory Analysis

Samples were placed into lined aluminum pans to air dry. Coarse fragments were measured with a 10 mesh screen prior to grinding. The entire sample was hand ground to pass a 10 mesh screen. An approximate 20 ounce subsample was obtained through splitting with a series of riffle splitters and subsequently analyzed. A second subsample was maintained in storage at Energy Labs. Approximately five percent of the samples were run for duplicate analysis.

Actual laboratory analysis followed the methodology outlined in WDEQ-LQD Guideline 1. In general, samples were processed as soon as possible after receipt. All analytical data is found in Appendix 3.3-3 Soil Laboratory Analysis.

3.3.2 RESULTS AND DISCUSSION

3.3.2.1 Soil Survey - General

The soils occurring within the LCE Amendment Area are typical of the semi-arid grasslands of the western United States. Due to prevailing climate and vegetation conditions, organic matter is accumulated slowly and is confined primarily to the surface horizon(s), resulting in light-coloration throughout the profile.

General topography of the area includes upland ridges, flat or gently sloping depressional areas, valley bottoms, and rolling hills. The soils occurring throughout the LCE Amendment Area were generally sandy loam textured. The soils varied in depth to paralithic material, ranging from 6 inches to greater than 60 inches. The majority of the soils were formed in slopewash alluvium weathered from sandstone and shale as well as siltstone.

3.3.2.2 Soil Mapping Unit Interpretation

The primary purpose of the 2012 baseline soils inventory was to characterize the soils within the LCE Amendment Area in terms of topsoil salvage depths and related physical and chemical properties. Refer to Appendices 3.3-1 and 3.3-2 for Soil Map Unit Descriptions and Soil Series Descriptions, respectively. Map units and series descriptions were based on existing NRCS format but tailored to fit actual findings within the LCE Amendment Area.

3.3.2.3 Analytical Results

Analyzed parameters, as defined in WDEQ-LQD Guideline 1, are in Appendix 3.3-3, Soil Laboratory Analysis. Laboratory soil texture analysis did not include percent fine sands. Field observations of fine sands within individual profiles, as well as sample site topographic position, were used in conjunction with laboratory analytical results to determine series designation for soils with fine sands. Where textures were not typical for the series (e.g., according to field observations or laboratory analysis), it was noted in the "Variation from Typical Series" section of the soil series descriptions.

3.3.2.4 Evaluation of Soil Suitability as a Plant Growth Medium

Approximate salvage depths of each map unit series are presented in Table 3.3-6 and ranged from zero to 2.2 feet. Within the LCE Amendment Area, suitability of soil as a plant growth medium was generally limited by the physical factor of paralithic contact. Chemical limiting factors included saturation percentage, pH and calcium carbonate (as determined in the field). According to WDEQ-LQD Guideline 1, marginal material was found in 11 of the 18 sampled profiles. While a frequently occurring marginal parameter in samples was low saturation percentage, it should be noted that this value frequently was not significantly less (1 to 3%) than more suitable levels present in other samples. When combined with other (i.e. suitable) soils, these marginal quality soils will become "suitable" from a plant growth medium perspective. Unsuitable material was found in none of the 18 sampled profiles. Marginal and unsuitable parameter information for the sampled profiles is identified in Table 3.3-4. A summary of trends in marginal and unsuitable parameters as it relates to soil series is found in Table 3.3-5.

3.3.2.5 Topsoil Volume Calculations

Based on the 2012 baseline soils inventory, associated field observations, and subsequent chemical analysis, the weighted average depth of salvageable topsoil over the entire LCE Amendment Area was determined to be 1.6 feet. Refer to Table 3.3-6 for approximate soil salvage depths.

3.3.2.6 Soil Erosion Properties and Impacts

Based on the soil mapping unit descriptions, the hazard for wind erosion ranges from moderate to severe and water erosion within the LCE Amendment Area varies from slight to moderate. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the generally sandy loam texture of the surface horizons throughout a majority of the LCE Amendment Area, the soils are slightly more susceptible to erosion from wind than water. See Table 3.3-7 for a Summary of Wind and Water Erosion Hazards within the LCE Amendment Area.

3.3.2.7 Prime Farmland Assessment

The LCE Amendment Area was assessed for prime farmland by Jason Martin, the NRCS MLRS Leader, Rock Springs, Wyoming. Because this area has not yet been mapped by NRCS, there is no designation of Prime Farmland, though this does not necessarily mean that such does not exist within the project area. Refer to Appendix 3.3-4 for the NRCS Letter of Non-Determination.

3.3.3 Geotechnical Investigations

No geotechnical work has been performed at LC East since no significant buildings or roads will be constructed.

3.3.4 Historical Surface Disturbances

The historical disturbance at LC East is consistent with what was described in the original ER. There remains minor evidence of historic uranium exploration drilling as well as numerous two track roads through the area used in the past by uranium exploration drilling crews, ranchers and other public land users. See the original ER for additional description.

3.3.5 References

Lost Creek ISR, LLC. Lost Creek Project South-Central Wyoming. Environmental Report, Volume 1 of 3. October 2007, revised March 2008.

Martin, Jason, MLRA Leader. United States Department of Agriculture Natural Resources Conservation Service. E-mail correspondence, 2012-2013.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions. [Online WWW]. Available URL: "http://soils.usda.gov/technical/classification/osd/index.html." USDA-NRCS, Lincoln, NE.

U.S. Department of Agriculture, Natural Resource Conservation Service. 1993. Soil Survey of Sweetwater County, Wyoming.

U.S. Department of Agriculture. 1975. Soil Taxonomy. U.S. Dept. of Agric. Handbook 436, 754 pp. Government Printing Office.

U.S. Department of Agriculture. 1993. Soil Survey Manual. U.S. Dept. of Agric. Handbook 18, 437 pp. Government Printing Office.

Wyoming Department of Environmental Quality, Land Quality Division. 1994. Guideline 1, Topsoil and Overburden.

Table 3.3-1: Total LCE Amendment Study Area Acreage.

Map Symbol	Map Unit Description	Study Area Acreage	% Study Area Acreage
Ay	Almy sandy loam	2,614.96	45.68
Br	Bluerim sandy loam	1,975.59	34.51
By	Byrnie sandy loam	223.86	3.91
Cm	Carmody sandy loam	261.61	4.57
Cl	Clowers sandy loam	423.99	7.41
D	Disturbed land	13.93	0.24
Go	Goslin loamy sand	26.08	0.46
Tg	Teagulf sandy loam	184.32	3.22
	Total	**5,724.34**	**100.00**

Table 3.3-2: Soil Series Sample Summary.

Soil Series	Number of Profiles to be Sampled for Chemical Analysis
Almy	3
Bluerim	3
Byrnie	3
Carmody	3
Clowers	3
Goslin	1
Teagulf	2
Total	**18**

Table 3.3-3: Soil Sample Locations.

Soil Sample Number[1]	Map Unit Symbol	Soil Series
1	Tg	Teagulf
2	Br	Bluerim
6	Br	Bluerim
10	Cl	Clowers
12	Br	Bluerim
13	By	Byrnie
15	By	Byrnie
17	Tg	Teagulf
18	Br	Byrnie
101	Cm	Carmody
102	Cl	Clowers
103	Ay	Almy
104	Ay	Almy
105	Cm	Carmody
106	Go	Goslin
107	Ay	Almy
111	Cm	Carmody
113	Cl	Clowers

[1]Soil Sample Numbers correspond to those samples that were sent for lab analysis.
[2]Soil Sample Waypoint Numbers do not necessarily correspond to soil sample numbers, as several waypoints were taken with photographs of soil and landscape features that were not associated with lab analyses.

Table 3.3-4: Marginal and Unsuitable Parameters within Sampled Profiles.

Soil Sample Number	Soils Series	Depth (in)	Marginal[1]	Unsuitable[1]
2	Bluerim	12-22	Saturation %	--
6	Bluerim	12-47	Saturation %	--
12	Bluerim	20-26	Saturation %	--
102	Clowers	14-24	Saturation %	--
103	Almy	20-46	Saturation %	--
104	Almy	10-45	Saturation %	--
		32-45	pH	
105	Carmody	12-35	Saturation %	--
106	Goslin	0-46	Saturation %	--
107	Almy	14-60	Saturation %	--
111	Carmody	0-12	Saturation %	--
113	Clowers	12-20	Saturation %	--

[1]Marginal and unsuitable parameters determined by comparing lab analysis with Table I-2 (Criteria to establish topsoil suitability) from WDEQ LQD Guideline 1.

Table 3.3-5: Trends in Marginal and Unsuitable Parameters for Soil Series.

Soils Series	Unsuitable/Marginal Parameter[1]
Almy	Saturation %, pH
Bluerim	Saturation %
Carmody	Saturation %
Clowers	Saturation %
Goslin	Saturation %

[1]Marginal and unsuitable parameters determined by comparing lab analysis with Table I-2 (Criteria to establish topsoil suitability) from WDEQ LQD Guideline 1.

Table 3.3-6: Approximate Soil Salvage Depths.

Map Symbol	Map Unit Description	Study Area Acreage[1]	Salvage Depth[2] (feet)	Total Volume of Topsoil[3]
Ay	Almy sandy loam	2,615.0	1.8	4707.0
Br	Bluerim sandy loam	1,975.6	1.4	2765.8
By	Byrnie sandy loam	223.9	0.6	134.3
Cm	Carmody sandy loam	261.6	0.8	209.3
Cl	Clowers sandy loam	424.0	2.2	932.8
D	Disturbed land	13.9	--	--
Go	Goslin loamy sand	26.1	0.0	0.0
Tg	Teagulf sandy loam	184.3	1.6	294.9
Average Salvage Depth of Amendment Area		**---**	**1.6**[4]	**---**
Total		**5,724.4**	**---**	**9,044.1**

[1]Found in Table 3.3-1 of this report.
[2]Found in Appendix 3.3-1 of this report, under Topsoil Suitability.
[3]Calculated by multiplying permit acreage by salvage depth in feet, as shown in Table II-1 (Topsoil Volume Summary) of WDEQ LQD Guideline 1. Note that this calculation assumes total acreage to be disturbed, whereas ISR mine will not require all acres be disturbed.
[4]Calculated as the average of the weighted average salvage depths found in Appendix 3.3-1.

Table 3.3-7: Wind and Water Erosion Hazards.

Map Unit Symbol	Soil Series	Water Erosion Hazard[1]	Wind Erosion Hazard[2]
Ay	Almy sandy loam	Moderate	Moderate
Br	Bluerim sandy loam	Moderate	Moderate
By	Byrnie sandy loam	Moderate	Moderate
Cm	Carmody sandy loam	Slight	Moderate
Cl	Clowers sandy loam	Moderate	Moderate
D	Disturbed land	Not rated	Not rated
Go	Goslin loamy sand	Moderate	Severe
Tg	Teagulf sandy loam	Moderate	Moderate

[1]Based on Kw factor of A horizon from the NRCS Soil Data Mart {http://soildatamart.nrcs.usda.gov/}
[2]Based on Wind Erodibility Group from the NRCS Soil Data Mart {http://soildatamart.nrcs.usda.gov/}.

APPENDIC 3.3-1
SOIL MAP UNIT DESCRIPTIONS

Almy sandy loam[1]—Ay

This map unit consists of well drained soils that are very deep to fine red sandstone or shale. These soils formed in alluvium on alluvial fan aprons and fan piedmonts from fine interbedded sandstone or shale. Slopes range from 0 to 15 percent. Elevation ranges from 5,400 feet to 7,800 feet.

The following are the climatic conditions in which Almy soils generally form: the average annual precipitation is approximately 12 inches but ranges from 9 to 14 inches with over half falling in April, May, and June. The mean annual air temperature ranges from 42 to 46 degrees F. The frost-free season ranges from 60 to 110 days.

Permeability within the Almy soil is moderate or moderately slow; runoff is low on the gentler slopes and medium on the steeper slopes. The hazard of water and wind erosion is moderate.

Topsoil Suitability

This map unit is a suitable source of topsoil to 21.48 inches based on an average of 2012 sample points. According to WDEQ-LQD Guideline 1, the following marginal parameters were found:

Soil Sample 103

- Saturation percentage, 20 to 46 inches

Soil Sample 104

- Saturation percentage, 10 to 45 inches
- pH, 32 to 45 inches

The 21.48-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Almy series.

[1]Map unit description based on 12/1999 NRCS information.

Bluerim sandy loam[2] – Br

The Bluerim map unit consists of moderately deep, well drained soils that formed in material weathered from calcareous sandy shale interbedded with arkosic sandstone. Slopes range from 3 to 20 percent. The Bluerim soil occurs on upland hillsides at elevations between 6,000 to 7,800 feet.

The following are the climatic conditions in which Bluerim soils generally form: the mean annual temperature is 34 to 45 degrees F. Precipitation is 10 to 14 inches. The growing season is 80 to 120 days but frost may occur in any month.

Permeability within the Bluerim soil is moderate. Runoff is moderately slow. The hazard of water and wind erosion is moderate.

Topsoil Suitability

This map unit is a suitable source of topsoil to 16.5 inches based on an average of 2012 sample points. According to WDEQ-LQD Guideline 1, the following marginal parameter was found:

Soil Sample 2
- Saturation percentage, 12 to 22 inches

Soil Sample 6
- Saturation percentage, 12 to 47 inches

Soil Sample 12
- Saturation percentage, 20 to 26 inches

Additionally, calcium carbonate was observed to be a limiting factor in the field in some samples.

The 16.5-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Bluerim series.

[2]Map unit description based on 02/1999 NRCS information.

Byrnie sandy loam[3] – By

The Byrnie map unit consists very shallow and shallow, well drained soils that formed in slope alluvium over residuum derived from reddish colored sandstone. Slopes range from 2 to 60 percent. Byrnie soils are on are on gently sloping to very steep hills and ridges at elevations between 6,000 and 7,800 feet.

The following are the climatic conditions in which Byrnie soils generally form: average annual precipitation is about 12 inches but ranges 10 to 15 inches, with peak periods of precipitation occurring in the spring and early summer months. Mean annual air temperature is 40 to 45 degrees F. Frost-free period is 85 to 100 days.

Permeability within the Byrnie soil is moderately rapid. Runoff is medium to very rapid. The hazard of water or wind erosion is moderate.

Topsoil Suitability

This map unit is a suitable source of topsoil to 7.56 inches based on an average of 2012 sample points. According to WDEQ-LQD Guideline 1, no marginal or unsuitable parameters were found. However, calcium carbonate content was observed to be a limiting factor in the field.

The 7.56-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Byrnie series.

[3]Map unit description based on 05/1999 NRCS information.

Carmody sandy loam[4] – Cm

This map unit consists of well to somewhat excessively drained soils that are moderately deep to siltstone. Slopes range from 2 to 45 percent. The Carmody soil formed in material weathered from calcareous siltstone or fine grained sandstone and are on uplands of the cold intermountain basins at elevations between 5,300 to 7,800 feet.

The following are the climatic conditions in which Carmody soils generally form: the mean annual precipitation ranges from 10 to 17 inches of which about half falls as snow or rain in April, May, and early June. The mean annual temperature is 39 to 45 degrees F., and the mean summer temperature is 58 to 65 degrees F. The frost-free season is 75 to 120 days depending upon aspect, elevation, and local air drainage.

Permeability within the Carmody soil is moderate or moderately rapid. Surface runoff is moderate to rapid. The hazard of water erosion is slight and the hazard of wind erosion is moderate.

Topsoil Suitability

This map unit is a suitable source of topsoil to 9 inches based on an average of 2012 sample points. According to WDEQ-LQD Guideline 1, the following marginal parameters were found:

Soil Sample 105
- Saturation percentage, 12 to 35 inches

Soil Sample 111
- Saturation percentage, 0 to 12 inches

The 9-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Carmody series.

[4]Map unit description based on 03/2003 NRCS information.

Clowers[5] sandy loam- Cl

This map unit consists of deep, well and moderately well drained soils formed in mixed, calcareous alluvium. Slopes are typically 0 to 3 percent but may range up to 6 percent. Clowers soils formed in stratified, calcareous alluvium from mixed sources on alluvial flood plains and terraces at elevations from 6,300 to 7,400 feet.

The following are the climatic conditions in which Clowers soils generally form: the mean annual precipitation is about 8 inches and ranges from 5 to 9 inches with about half falling as rain or snow in April, May, and early June. The mean annual temperature is about 40 degrees F. and ranges from 38 to 44 degrees F. The frost-free season is estimated to range from 60 to 90 days depending upon elevation, aspect, and air drainage.

Permeability within the Clowers soil is moderate; runoff is slow through medium. The hazard of water and wind erosion is moderate.

Topsoil Suitability

This map unit is a suitable source of topsoil to 26.40 inches based on an average of 2012 sample points. According to WDEQ-LQD Guideline 1, the following marginal parameters were found:

Soil Sample 102

- Saturation percentage, 14 to 24 inches

Soil Sample 113

- Saturation percentage, 12 to 20 inches

The 26.40-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Clowers map unit.

[5]Map unit description based on 03/2003 NRCS information.

Goslin[6] loamy sand- Go

This map unit consists of deep, well drained soils that formed in coarse textured alluvium derived from red sandstone. Slopes are 3 to 25 percent. Goslin soils formed in coarse textured alluvium derived from red sandstone on fan aprons, fan pediments, and alluvial terraces at elevations from 6,300 to 7,500 feet.

The following are the climatic conditions in which Goslin soils generally form: the mean annual precipitation is 9 to 14 inches with about half falling as snow or rain in April, May, and early June. The mean annual temperature is about 42 to 46 degrees F. The frost-free period is 60 to 90 days.

Permeability within the Goslin soil is moderately rapid. Surface runoff is moderate to medium to rapid, depending on slope. The hazard of water erosion is moderate, and the hazard of wind erosion is severe.

Topsoil Suitability

This map unit is an unsuitable source of topsoil based on 2012 sample points. According to WDEQ-LQD Guideline 1, the following marginal parameters were found:

Soil Sample 106

- Saturation percentage, 0 to 46

Additionally, calcium carbonate and high sand content were observed in the field to be limiting factors as well.

The 0-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Goslin map unit.

[6]Map unit description based on 03/2003 NRCS information.

Teagulf[7] sandy loam- Tg

This map unit consists of moderately deep, well drained soils that formed in modified residuum and slopewash alluvium from calcareous sedimentary rocks. Slopes are 0 to 8 percent. Teagulf soils formed in modified residuum and slopewash alluvium from sedimentary rocks on nearly level and gently sloping erosional upland plains and alluvial fans at elevations from 6,000 to 7,300 feet.

The following are the climatic conditions in which Teagulf soils generally form: average annual precipitation is 6 to 9 inches. The mean annual air temperature is 38 degrees to 45 degrees F., and the mean summer air temperature is 61 degrees to 66 degrees F. The frost-free season is about 80 to 110 days.

Permeability within the Teagulf soil is moderately rapid. Surface runoff is slow to medium. The hazard of water and wind erosion is moderate.

Topsoil Suitability

This map unit is a suitable source of topsoil to 18.72 inches based on 2012 sample points. According to WDEQ-LQD Guideline 1, no marginal or unsuitable parameters were found.

The 18.72-inch salvage depth was used in Table 3.3-6 Approximate Soil Salvage Depths to calculate topsoil salvage volumes for the Teagulf map unit.

[7]Map unit description based on 12/1999 NRCS information.

APPENDIX 3.3-2
SOIL SERIES DESCRIPTIONS

ALMY SERIES

SOIL MAPPING UNIT: Ay

SOIL SAMPLE LOCATION: 103

The Almy series consists of very deep, well drained soils that formed in alluvium on alluvial fan aprons and fan piedmonts. Permeability is moderate. Slopes are 0 to 15 percent. The mean annual precipitation is about 12 inches, and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Almy fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inches; brownish (5YR 5/3) fine sandy loam, dark reddish gray (5YR 4/2) moist; moderate thin platy structure; soft, very friable, slightly sticky and slightly plastic; common fine tubular pores; slightly acid (pH 6.7); clear wavy boundary.

Bt—1 to 10 inches; brownish (5YR 5/3) sandy loam, dark reddish gray (5YR 4/2) moist, moderate thin platy structure parting to moderate fine subangular blocky; slightly hard, friable, sticky and plastic; common fine and medium roots; common fine tubular pores; common distinct clay films on faces of peds and lining pores; slightly acid (pH 6.7); clear wavy boundary.

Bw--10 to 20 inches; brown gray (5YR 5/3) sandy loam, dark reddish gray (5YR 4/2) moist; weak medium prismatic structure parting to moderate fine subangular blocky; hard, friable, very sticky and plastic; common fine and medium roots; common fine tubular pores; continuous clay films on faces of peds and lining pores; slightly alkaline (pH 7.2); clear wavy boundary.

BC/C1—20 to 26 inches; gray (5YR 5/1) sandy loam; gray brown (5YR 4/1) moist; moderate medium and fine subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and medium roots; few fine tubular pores; non-effervescent; slightly alkaline (pH 7.4); gradual wavy boundary.

C--26 to 46 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots to 40 inches; moderately alkaline (pH 7.7).

TYPE LOCATION: Sweetwater County, WY. Refer to waypoint 103 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
Depth to an accumulation of secondary calcium carbonates is 10 to 20 inches. The mean annual soil temperature is 42 to 46 degrees F. Rock fragments in the particle size control section range from 0 to 15 percent gravel. The moisture control section is usually dry. It is usually moist in April, May, and early June, and dry for 60 consecutive days during the 90 day period following the summer solstice.

The A horizon has hue of 10YR through 5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4 dry and moist. Reaction is neutral through moderately alkaline.

The Bt horizon has hue of 2.5YR or 5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 6 dry and moist. It is typically a clay loam but may be loam or sandy clay loam with 18 to 35 percent clay and less than 35 percent fine sandy or coarser. Reaction is mildly through strongly alkaline. EC is less than 8 mmhos.

The Bk horizon has hue of 7.5YR or 5YR, value of 4 through 7 dry, 3 through 6 moist, and chroma of 2 through 6 dry and moist. Texture is loam, sandy clay loam, or clay loam. Some pedons have sandy loam textures in the lower Bk. EC is less than 8 mmhos. Calcium carbonate ranges from 4 to 12 percent.

The C horizon has hue of 7.5YR or 5YR, value of 4 through 7 dry, 4 through 6 moist, and chroma of 2 through 6 dry and moist. Texture is loam or fine sandy loam. Calcium carbonate ranges from 2 to 10 percent. EC is less than 8 mmhos throughout. Reaction is moderately through very strongly alkaline.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 20 inches and marginal to 26 inches, with the following marginal parameter:

- Saturation percentage, 20 to 46 inches

GEOGRAPHIC SETTING (according to official soil series description): Almy soils are on nearly level to moderately sloping alluvial fan aprons and fan piedmonts. Parent materials are weathered from interbedded, red, fine sandstone and shale. Slopes are both simple and complex and range from 0 to 15 percent. Elevation ranges from 5,400 feet to 7,800 feet. The mean annual precipitation is about 12 inches but ranges from 9 to 14 inches with over half falling in April, May, and June. The mean annual air temperature ranges from 42 to 46 degrees F. The frost-free season ranges from 60 to 110 days.

VARIATION FROM TYPICAL SERIES: Less alkaline and somewhat less clay than typical.

ALMY SERIES

SOIL MAPPING UNIT: Ay

SOIL SAMPLE LOCATION: 104

The Almy series consists of very deep, well drained soils that formed in alluvium on alluvial fan aprons and fan piedmonts. Permeability is moderate. Slopes are 0 to 15 percent. The mean annual precipitation is about 12 inches, and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Almy fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inches; light brown (5YR 5/3) fine sandy loam, dark reddish gray (5YR 4/2) moist; moderate thin platy structure; soft, very friable, slightly sticky and slightly plastic; common fine tubular pores; neutral (pH 6.9); clear wavy boundary.

Bt--1 to 10 inches; light brown (5YR 5/3) sandy loam, dark reddish gray (5YR 4/2) moist, moderate thin platy structure parting to moderate fine subangular blocky; slightly hard, friable, sticky and plastic; common fine and medium roots; common fine tubular pores; common distinct clay films on faces of peds and lining pores; neutral (pH 6.9); clear wavy boundary.

Bw--10 to 14 inches; reddish brown (5YR 5/3) sandy loam, dark reddish gray (5YR 4/2) moist; weak medium prismatic structure parting to moderate fine subangular blocky; hard, friable, very sticky and plastic; common fine and medium roots; common fine tubular pores; continuous clay films on faces of peds and lining pores; slightly alkaline (pH 7.3); clear wavy boundary.

BC/C1--14 to 18 inches; white gray (5YR 7/1) sandy loam; light gray (5YR 6/1) moist; moderate medium and fine subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and medium roots; few fine tubular pores; non-effervescent, slightly alkaline (pH 7.3); gradual wavy boundary.

C2--18 to 32 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots to 40 inches; moderately effervescent, calcium carbonate disseminated; moderately alkaline (pH 7.8).

C3--32 to 45 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots to 40 inches; moderately effervescent, calcium carbonate disseminated; strongly alkaline (pH 8.3).

TYPE LOCATION: Sweetwater County, WY. Refer to waypoint 104 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Depth to an accumulation of secondary calcium carbonates is 10 to 20 inches. The mean annual soil temperature is 42 to 46 degrees F. Rock fragments in the particle size control section range from 0 to 15 percent gravel. The moisture control section is usually dry. It is usually moist in April, May, and early June, and dry for 60 consecutive days during the 90 day period following the summer solstice.

The A horizon has hue of 10YR through 5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4 dry and moist. Reaction is neutral through moderately alkaline.

The Bt horizon has hue of 2.5YR or 5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 6 dry and moist. It is typically a clay loam but may be loam or sandy clay loam with 18 to 35 percent clay and less than 35 percent fine sandy or coarser. Reaction is mildly through strongly alkaline. EC is less than 8 mmhos.

The Bk horizon has hue of 7.5YR or 5YR, value of 4 through 7 dry, 3 through 6 moist, and chroma of 2 through 6 dry and moist. Texture is loam, sandy clay loam, or clay loam. Some pedons have sandy loam textures in the lower Bk. EC is less than 8 mmhos. Calcium carbonate ranges from 4 to 12 percent.

The C horizon has hue of 7.5YR or 5YR, value of 4 through 7 dry, 4 through 6 moist, and chroma of 2 through 6 dry and moist. Texture is loam or fine sandy loam. Calcium carbonate ranges from 2 to 10 percent. EC is less than 8 mmhos throughout. Reaction is moderately through very strongly alkaline.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 10 inches and marginal to 18 inches, with the following marginal parameters:

- Saturation percentage, 10 to 45 inches
- pH, 32 to 45 inches

GEOGRAPHIC SETTING (according to official soil series description): Almy soils are on nearly level to moderately sloping alluvial fan aprons and fan piedmonts. Parent materials are weathered from interbedded, red, fine sandstone and shale. Slopes are both simple and complex and range from 0 to 15 percent. Elevation ranges from 5,400 feet to 7,800 feet. The mean annual precipitation is about 12 inches but ranges from 9 to 14 inches with over half falling in April, May, and June. The mean annual air temperature ranges from 42 to 46 degrees F. The frost-free season ranges from 60 to 110 days.

VARIATION FROM TYPICAL SERIES: Less alkaline and somewhat less clay than typical.

ALMY SERIES

SOIL MAPPING UNIT: Ay

SOIL SAMPLE LOCATION: 107

The Almy series consists of very deep, well drained soils that formed in alluvium on alluvial fan aprons and fan piedmonts. Permeability is moderate. Slopes are 0 to 15 percent. The mean annual precipitation is about 12 inches, and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Almy fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 3 inches; reddish brown (5YR 5/3) fine sandy loam, dark reddish gray (5YR 4/2) moist; moderate thin platy structure; soft, very friable, slightly sticky and slightly plastic; common fine tubular pores; slightly acid (pH 6.3); clear wavy boundary.

Bt--3 to 14 inches; reddish brown (5YR 5/3) loam, dark reddish gray (5YR 4/2) moist, moderate thin platy structure parting to moderate fine subangular blocky; slightly hard, friable, sticky and plastic; common fine and medium roots; common fine tubular pores; common distinct clay films on faces of peds and lining pores; slightly acid (pH 6.7); clear wavy boundary.

Bw--14 to 26 inches; reddish brown (5YR 5/3) sandy loam, dark reddish gray (5YR 4/2) moist; weak medium prismatic structure parting to moderate fine subangular blocky; hard, friable, very sticky and plastic; common fine and medium roots; common fine tubular pores; continuous clay films on faces of peds and lining pores; slightly acid (pH 6.6); clear wavy boundary.

C1--26 to 34 inches; reddish brown (5YR 5/3) sandy loam; reddish brown (5YR 4/3) moist; moderate medium and fine subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and medium roots; few fine tubular pores; neutral (pH 7.0); gradual wavy boundary. (5 to 25 inches thick)

C2--34 to 42 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots to 40 inches; neutral (pH 6.9).

C2--42 to 60 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots to 40 inches; neutral (pH 7.1).

TYPE LOCATION: Sweetwater County, WY. Refer to waypoint 107 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
Depth to an accumulation of secondary calcium carbonates is 10 to 20 inches. The mean annual

soil temperature is 42 to 46 degrees F. Rock fragments in the particle size control section range from 0 to 15 percent gravel. The moisture control section is usually dry. It is usually moist in April, May, and early June, and dry for 60 consecutive days during the 90 day period following the summer solstice.

The A horizon has hue of 10YR through 5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4 dry and moist. Reaction is neutral through moderately alkaline.

The Bt horizon has hue of 2.5YR or 5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 6 dry and moist. It is typically a clay loam but may be loam or sandy clay loam with 18 to 35 percent clay and less than 35 percent fine sandy or coarser. Reaction is mildly through strongly alkaline. EC is less than 8 mmhos.

The Bk horizon has hue of 7.5YR or 5YR, value of 4 through 7 dry, 3 through 6 moist, and chroma of 2 through 6 dry and moist. Texture is loam, sandy clay loam, or clay loam. Some pedons have sandy loam textures in the lower Bk. EC is less than 8 mmhos. Calcium carbonate ranges from 4 to 12 percent.

The C horizon has hue of 7.5YR or 5YR, value of 4 through 7 dry, 4 through 6 moist, and chroma of 2 through 6 dry and moist. Texture is loam or fine sandy loam. Calcium carbonate ranges from 2 to 10 percent. EC is less than 8 mmhos throughout. Reaction is moderately through very strongly alkaline.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 26 inches, with the following marginal parameter:

- Saturation percentage, 20 to 46 inches

GEOGRAPHIC SETTING (according to official soil series description): Almy soils are on nearly level to moderately sloping alluvial fan aprons and fan piedmonts. Parent materials are weathered from interbedded, red, fine sandstone and shale. Slopes are both simple and complex and range from 0 to 15 percent. Elevation ranges from 5,400 feet to 7,800 feet. The mean annual precipitation is about 12 inches but ranges from 9 to 14 inches with over half falling in April, May, and June. The mean annual air temperature ranges from 42 to 46 degrees F. The frost-free season ranges from 60 to 110 days.

VARIATION FROM TYPICAL SERIES: Less alkaline and somewhat less clay than typical.

BLUERIM SERIES

SOIL MAPPING UNIT: Br

SOIL SAMPLE LOCATION: 2

The Bluerim series consists of moderately deep, well drained soils that formed in material weathered from calcareous sandy shale interbedded with arkosic sandstone. Bluerim soils are on upland hillsides and have slopes of 3 to 20 percent. The mean annual precipitation is about 11 inches, and the mean annual temperature is about 39 degrees F.

TYPICAL PEDON: Bluerim sandy soil-rangeland. The surface is covered with 15 percent very fine pebbles. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inches; red brown (10YR 5/3) sandy loam, very dark brown (10YR 3/3) moist; moderate medium and fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; neutral (pH 6.9); clear smooth boundary.

Bt--1 to 12 inches; red brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; neutral (pH 6.9); clear smooth boundary.

C1--12 to 14 inches; grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; weak medium angular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; few medium roots; few thin clay films on faces of some peds; 10 percent very fine pebbles; neutral (pH 7.0); clear smooth boundary.

C2--14 to 22 inches; light olive brown (2.5Y 5/4) sandy loam, olive brown (2.5Y 4/4) moist; massive; soft, very friable, slightly sticky and nonplastic; 10 percent very fine pebbles; slightly calcareous, lime in a few masses and seams; neutral (pH 7.0); gradual wavy boundary.

Cr--22 to 60* inches; soft, olive, calcareous sandy shale with seams and nests of lime.

*Verified to 36 inches, varying colored layers of coarse olive and red calcareous weathered sandstone.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 2 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): The mean annual soil temperature ranges from 35 to 47 degrees F., and the mean summer soil temperature ranges from 59 to 62 degrees F. Depth to bedded sandy shale is 20 to 40 inches. The soils commonly are noncalcareous. Calcium carbonate accumulation in the lower part of the C horizon is weak and discontinuous. Very fine pebbles range from 0 to 15 percent throughout.

The A1 horizon has hue of 2.5Y or 10YR, value of 4 or 5 dry, 3 or 4 moist, and chroma of 2 through 4 dry and moist. EC is less than 2 mmhos. Reaction is neutral or mildly alkaline.

The Bt2 horizon has hue of 2.5Y through 7.5YR, value of 4 through 6 dry, 4 or 5 moist, and chroma of 3 or 4 dry and moist. Texture is sandy clay loam with 20 to 27 percent clay. EC is less than 2 mmhos. Reaction is neutral or mildly alkaline.

The C horizon has hue of 5Y through 10YR, value of 4 through 7 dry, 5 or 6 moist, and chroma of 2 through 4. It is sandy loam or sandy clay loam. EC is less than 4 mmhos. Reaction ranges from mildly alkaline through strongly alkaline. Visible accumulation of calcium carbonate is discontinuous.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 12 inches, with the following marginal parameter:

- Saturation percentage, 12 to 22 inches

GEOGRAPHIC SETTING (according to official soil series description): Bluerim soils are on upland hillsides. Slopes are 3 to 20 percent. The soils formed in residuum weathered from calcareous sandy shales interbedded with arkosic sandstone. Elevation is 6,000 to 7,800 feet. The mean annual temperature is 34 to 45 degrees F. Precipitation is 10 to 14 inches. The growing season is 80 to 120 days but frost may occur in any month.

VARIATION FROM TYPICAL SERIES: Slightly less alkaline than typical. Fewer B horizons than typical.

BLUERIM SERIES

SOIL MAPPING UNIT: Br

SOIL SAMPLE LOCATION: 6

The Bluerim series consists of moderately deep, well drained soils that formed in material weathered from calcareous sandy shale interbedded with arkosic sandstone. Bluerim soils are on upland hillsides and have slopes of 3 to 20 percent. The mean annual precipitation is about 11 inches, and the mean annual temperature is about 39 degrees F.

TYPICAL PEDON: Bluerim sandy soil-rangeland. The surface is covered with 15 percent very fine pebbles. (Colors are for dry soil unless otherwise stated.)

A--0 to 2 inches; brown (10YR 5/3) sandy loam, very dark brown (10YR 3/3) moist; moderate medium and fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; mildly acid (pH 6.0); clear smooth boundary.

Bw--2 to 12 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; mildly acid (pH 6.0); clear smooth boundary.

C1--12 to 24 inches; yellow (2.5Y 8/3) sandy loam, yellow brown (2.5Y 7/3) moist; massive; soft, very friable, slightly sticky and nonplastic; 10 percent very fine pebbles; slightly acid (pH 6.5); gradual wavy boundary.

C2--24 to 40 inches; light olive brown (2.5Y 5/4) loamy sand, olive brown (2.5Y 4/4) moist; massive; soft, very friable, slightly sticky and nonplastic; 10 percent very fine pebbles; slightly calcareous, lime in a few masses and seams; slightly alkaline (pH 7.2); coarse, stratified horizon, yellow to 30 inches, pale olive to 36 inches, white to 40 inches.

Cr--40* to 60 inches; soft, olive, calcareous sandy shale with seams and nests of lime.

* Verified to 47 inches, with paralithic material encountered at 40 inches: very coarse yellow weathered sandstone.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 6 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): The mean annual soil temperature ranges from 35 to 47 degrees F., and the mean summer soil temperature ranges from 59 to 62 degrees F. Depth to bedded sandy shale is 20 to 40 inches. The soils commonly are noncalcareous. Calcium carbonate accumulation in the lower part of the C horizon is weak and discontinuous. Very fine pebbles range from 0 to 15 percent throughout.

The A1 horizon has hue of 2.5Y or 10YR, value of 4 or 5 dry, 3 or 4 moist, and chroma of 2 through 4 dry and moist. EC is less than 2 mmhos. Reaction is neutral or mildly alkaline.

The Bt2 horizon has hue of 2.5Y through 7.5YR, value of 4 through 6 dry, 4 or 5 moist, and chroma of 3 or 4 dry and moist. Texture is sandy clay loam with 20 to 27 percent clay. EC is less than 2 mmhos. Reaction is neutral or mildly alkaline.

The C horizon has hue of 5Y through 10YR, value of 4 through 7 dry, 5 or 6 moist, and chroma of 2 through 4. It is sandy loam or sandy clay loam. EC is less than 4 mmhos. Reaction ranges from mildly alkaline through strongly alkaline. Visible accumulation of calcium carbonate is discontinuous.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 12 inches, with the following marginal parameter:

- Saturation percentage, 12 to 47 inches

GEOGRAPHIC SETTING (according to official soil series description): Bluerim soils are on upland hillsides. Slopes are 3 to 20 percent. The soils formed in residuum weathered from calcareous sandy shales interbedded with arkosic sandstone. Elevation is 6,000 to 7,800 feet. The mean annual temperature is 34 to 45 degrees F. Precipitation is 10 to 14 inches. The growing season is 80 to 120 days but frost may occur in any month.

VARIATION FROM TYPICAL SERIES: Fewer B horizons than typical. Less alkaline C horizons than typical.

BLUERIM SERIES

SOIL MAPPING UNIT: Br

SOIL SAMPLE LOCATION: 12

The Bluerim series consists of moderately deep, well drained soils that formed in material weathered from calcareous sandy shale interbedded with arkosic sandstone. Bluerim soils are on upland hillsides and have slopes of 3 to 20 percent. The mean annual precipitation is about 11 inches, and the mean annual temperature is about 39 degrees F.

TYPICAL PEDON: Bluerim sandy soil-rangeland. The surface is covered with 15 percent very fine pebbles. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inches; brown (10YR 5/3) sandy loam, very dark brown (10YR 3/3) moist; moderate medium and fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; slightly alkaline (pH 7.2); clear smooth boundary.

Bw--1 to 9 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; slightly alkaline (pH 7.2); clear smooth boundary.

BC--9 to 12 inches; light orange yellow (10YR 7/4) sandy loam, dark orange yellow (10YR 6/4) moist; moderate medium angular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few medium roots; continuous thin clay films on faces of peds; 10 percent very fine pebbles; mildly alkaline (pH 7.5); abrupt smooth boundary.

C1--12 to 20 inches; light orange yellow (10YR 7/4) sandy loam, dark orange yellow (10YR 6/4) moist; massive; soft, very friable, slightly sticky and nonplastic; 10 percent very fine pebbles; slightly calcareous; mildly alkaline (pH 7.5); gradual wavy boundary.

C2--20 to 26 inches; light olive brown (2.5Y 5/4) sandy loam, olive brown (2.5Y 4/4) moist; massive; soft, very friable, slightly sticky and nonplastic; 10 percent very fine pebbles; slightly calcareous; moderately alkaline (pH 7.8); gradual wavy boundary.

Cr—26* to 60 inches; soft, olive, calcareous sandy shale with seams and nests of lime.

* 26 to 36 inches verified as fine weathered, pale tan sandstone.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 12 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): The mean annual soil temperature ranges from 35 to 47 degrees F., and the mean summer soil temperature ranges from 59 to 62 degrees F. Depth to bedded sandy shale is 20 to 40 inches. The soils commonly are noncalcareous. Calcium carbonate accumulation in the lower part of the C horizon is weak and discontinuous. Very fine pebbles range from 0 to 15 percent throughout.

The A1 horizon has hue of 2.5Y or 10YR, value of 4 or 5 dry, 3 or 4 moist, and chroma of 2 through 4 dry and moist. EC is less than 2 mmhos. Reaction is neutral or mildly alkaline.

The Bt2 horizon has hue of 2.5Y through 7.5YR, value of 4 through 6 dry, 4 or 5 moist, and chroma of 3 or 4 dry and moist. Texture is sandy clay loam with 20 to 27 percent clay. EC is less than 2 mmhos. Reaction is neutral or mildly alkaline.

The C horizon has hue of 5Y through 10YR, value of 4 through 7 dry, 5 or 6 moist, and chroma of 2 through 4. It is sandy loam or sandy clay loam. EC is less than 4 mmhos. Reaction ranges from mildly alkaline through strongly alkaline. Visible accumulation of calcium carbonate is discontinuous.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 20 inches, with the following marginal parameter:

- Saturation percentage, 20 to 26 inches

GEOGRAPHIC SETTING (according to official soil series description): Bluerim soils are on upland hillsides. Slopes are 3 to 20 percent. The soils formed in residuum weathered from calcareous sandy shales interbedded with arkosic sandstone. Elevation is 6,000 to 7,800 feet. The mean annual temperature is 34 to 45 degrees F. Precipitation is 10 to 14 inches. The growing season is 80 to 120 days but frost may occur in any month.

VARIATION FROM TYPICAL SERIES: Less developed B horizons than typical.

BYRNIE SERIES

SOIL MAPPING UNIT: By

SOIL SAMPLE LOCATION: 13

The Byrnie series consists of very shallow and shallow, well drained soils that formed in slope alluvium over residuum derived from reddish colored sandstone. These soils are on gently sloping to very steep hills and ridges. Slopes are 2 to 60 percent. The mean annual precipitation is about 12 inches and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Byrnie fine sandy loam - rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 2 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; moderate fine granular structure; soft, very friable, nonplastic, nonsticky; common very fine and fine roots; common fine and very fine tubular pores; neutral (pH 7.0); clear smooth boundary.

Bw--2 to 5 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; neutral (pH 7.0); clear smooth boundary.

Bt--5 to 13 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; mildly alkaline (pH 7.5); clear smooth boundary.

C--13 to 17 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; soft, very friable, nonplastic, nonsticky; slightly alkaline (pH 7.2); clear wavy boundary. (2 to 19 inches thick.)

Cr--17 inches; soft calcareous reddish brown sandstone, with calcareous fragments.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 13 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Mean annual soil temperature: 40 to 45 degrees F.
Depth to the paralithic contact: 4 to 20 inches to weathered sandstone
The profile is usually calcareous throughout but may be leached in some pedons in the A horizon.

A horizon:
Hue: 2.5YR through 7.5YR

Value: 5 through 7 dry, 4 through 6 moist
Chroma: 3 through 6 dry or moist
Texture: sandy loam, fine sandy loam or very fine sandy loam
Rock fragments: 0 to 35 percent gravel and cobble
Reaction: slightly alkaline to strongly alkaline

C horizon:
Hue: 2.5YR to 7.5YR
Value: 4 through 6 dry, 4 or 5 moist
Chroma: 4 through 6 dry or moist
Texture: sandy loam or fine sandy loam
Rock fragments: 0 to 35 percent gravel or cobble
Allogenic calcium carbonate equivalent: 5 to 20 percent
Reaction: slightly alkaline through strongly alkaline
Some pedons have a weak Bk horizon.

TAXONOMIC CLASS: Loamy, mixed, superactive, calcareous, frigid, shallow Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 13 inches, with no marginal or unsuitable values in the profile.

GEOGRAPHIC SETTING (according to official soil series description): Parent material: slope alluvium over residuum derived from reddish colored sandstone
Landform: gently sloping to very steep hills and ridges
Slopes: 2 to 60 percent
Elevation: 6000 to 7800 feet
Mean annual precipitation: at the type location it is about 12 inches but ranges 10 to 15 inches with peak periods of precipitation occurring in the spring and early summer months
Mean annual air temperature: 40 to 45 degrees F.
Frost-free period: 85 to 100 days

VARIATION FROM TYPICAL SERIES: Bt and Bw horizons not typical of series.

BYRNIE SERIES

SOIL MAPPING UNIT: By

SOIL SAMPLE LOCATION: 15

The Byrnie series consists of very shallow and shallow, well drained soils that formed in slope alluvium over residuum derived from reddish colored sandstone. These soils are on gently sloping to very steep hills and ridges. Slopes are 2 to 60 percent. The mean annual precipitation is about 12 inches and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Byrnie fine sandy loam - rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 2 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; moderate fine granular structure; soft, very friable, nonplastic, nonsticky; common very fine and fine roots; common fine and very fine tubular pores; mildly acid (pH 6.6); clear smooth boundary.

Bt--2 to 12 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; mildly acid (pH 6.6); clear smooth boundary.

C--12 to 16 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; soft, very friable, nonplastic, nonsticky; slightly alkaline (pH 7.2); clear wavy boundary.

Cr--16 inches; soft calcareous reddish brown sandstone containing crystalline fragments.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 15 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Mean annual soil temperature: 40 to 45 degrees F.
Depth to the paralithic contact: 4 to 20 inches to weathered sandstone
The profile is usually calcareous throughout but may be leached in some pedons in the A horizon.

A horizon:
Hue: 2.5YR through 7.5YR
Value: 5 through 7 dry, 4 through 6 moist
Chroma: 3 through 6 dry or moist
Texture: sandy loam, fine sandy loam or very fine sandy loam
Rock fragments: 0 to 35 percent gravel and cobble
Reaction: slightly alkaline to strongly alkaline

C horizon:
Hue: 2.5YR to 7.5YR
Value: 4 through 6 dry, 4 or 5 moist
Chroma: 4 through 6 dry or moist
Texture: sandy loam or fine sandy loam
Rock fragments: 0 to 35 percent gravel or cobble
Allogenic calcium carbonate equivalent: 5 to 20 percent
Reaction: slightly alkaline through strongly alkaline
Some pedons have a weak Bk horizon.

TAXONOMIC CLASS: Loamy, mixed, superactive, calcareous, frigid, shallow Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 12 inches, with no marginal or unsuitable values in the profile.

GEOGRAPHIC SETTING (according to official soil series description): Parent material: slope alluvium over residuum derived from reddish colored sandstone
Landform: gently sloping to very steep hills and ridges
Slopes: 2 to 60 percent
Elevation: 6000 to 7800 feet
Mean annual precipitation: at the type location it is about 12 inches but ranges 10 to 15 inches with peak periods of precipitation occurring in the spring and early summer months
Mean annual air temperature: 40 to 45 degrees F.
Frost-free period: 85 to 100 days

VARIATION FROM TYPICAL SERIES: Somewhat less alkaline than typical. Bt horizon not typical of series.

BYRNIE SERIES

SOIL MAPPING UNIT: Br

SOIL SAMPLE LOCATION: 18

The Byrnie series consists of very shallow and shallow, well drained soils that formed in slope alluvium over residuum derived from reddish colored sandstone. These soils are on gently sloping to very steep hills and ridges. Slopes are 2 to 60 percent. The mean annual precipitation is about 12 inches and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Byrnie fine sandy loam - rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 3 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; moderate fine granular structure; soft, very friable, nonplastic, nonsticky; common very fine and fine roots; common fine and very fine tubular pores; slightly alkaline (pH 7.2); clear smooth boundary. (1 to 4 inches thick.)

Bw--3 to 10 inches; reddish brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; 10 percent very fine pebbles; slightly alkaline (pH 7.2); clear smooth boundary.

C1--10 to 15 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; soft, very friable, nonplastic, nonsticky; slightly alkaline (pH 7.3); clear wavy boundary.

C2--15 to 18 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; massive; soft, very friable, nonplastic, nonsticky; slightly alkaline (pH 7.3); clear wavy boundary.

Cr--18 inches; soft calcareous pale yellow to gray sandstone with coarse fragments.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 18 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Mean annual soil temperature: 40 to 45 degrees F.
Depth to the paralithic contact: 4 to 20 inches to weathered sandstone
The profile is usually calcareous throughout but may be leached in some pedons in the A horizon.

A horizon:
Hue: 2.5YR through 7.5YR
Value: 5 through 7 dry, 4 through 6 moist

Chroma: 3 through 6 dry or moist
Texture: sandy loam, fine sandy loam or very fine sandy loam
Rock fragments: 0 to 35 percent gravel and cobble
Reaction: slightly alkaline to strongly alkaline

C horizon:
Hue: 2.5YR to 7.5YR
Value: 4 through 6 dry, 4 or 5 moist
Chroma: 4 through 6 dry or moist
Texture: sandy loam or fine sandy loam
Rock fragments: 0 to 35 percent gravel or cobble
Allogenic calcium carbonate equivalent: 5 to 20 percent
Reaction: slightly alkaline through strongly alkaline
Some pedons have a weak Bk horizon.

TAXONOMIC CLASS: Loamy, mixed, superactive, calcareous, frigid, shallow Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 10 inches, with no marginal or unsuitable values in the profile.

GEOGRAPHIC SETTING (according to official soil series description): Parent material: slope alluvium over residuum derived from reddish colored sandstone
Landform: gently sloping to very steep hills and ridges
Slopes: 2 to 60 percent
Elevation: 6000 to 7800 feet
Mean annual precipitation: at the type location it is about 12 inches but ranges 10 to 15 inches with peak periods of precipitation occurring in the spring and early summer months
Mean annual air temperature: 40 to 45 degrees F.
Frost-free period: 85 to 100 days

VARIATION FROM TYPICAL SERIES: Bw horizon not typical of series.

CARMODY SERIES

SOIL MAPPING UNIT: Cm

SOIL SAMPLE LOCATION: 101

The Carmody series consists of well to somewhat excessively drained soils that are moderately deep to siltstone. These soils formed in material weathered from calcareous siltstone or fine grained sandstone. Carmody soils are on uplands of the cold intermountain basins. Slopes are 2 to 45 percent. The mean annual precipitation is about 14 inches, and the mean annual temperature is about 44 degrees F.

TYPICAL PEDON: Carmody very fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 3 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine and very fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; mildly acid (pH 6.6); gradual wavy boundary.

AC/C1--3 to 10 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; slightly alkaline (pH 7.2); abrupt wavy boundary. (16 to 30 inches thick)

C2--10 to 24 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; strongly effervescent, lime disseminated; mildly alkaline (pH 7.6); abrupt wavy boundary. (16 to 30 inches thick)

Cr—24* to 60 inches; light brownish gray to white, calcareous siltstone containing fine grained sand.

* Verified to paralithic material from 24 to 48 inches.

TYPE LOCATION: Sweetwater, WY. Refer to Waypoint 101 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Depth to a paralithic contact is 20 to 40 inches. Depth to uniformly calcareous material is 0 to 10 inches. The mean annual soil temperature ranges from about 40 to 47 degrees F., and the mean summer soil temperature ranges from about 59 to 63 degrees F. The control section is very fine sandy loam or fine sandy loam, averaging 10 to 18 percent clay and more than 15 percent fine sand or coarser. Flat fragments or fine pebbles range from 0 to 15 percent. Thin, discontinuous horizons of carbonate accumulation occur immediately above the paralithic contact in some pedons.

The A horizon has hue of 2.5Y or 10YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4. EC is less than 2 mmhos. Reaction is mildly or moderately alkaline.

The C horizon has hue of 2.5Y or 10YR, value of 4 through 7 dry, 3 through 5 moist, and chroma of 2 through 6. EC is less than 2 mmhos. Reaction is moderately or strongly alkaline.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, calcareous, frigid Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 3 inches, with no marginal or unsuitable values in the profile. Calcium carbonate was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description): Carmody soils are on plateaus and hillslopes in intermountain basins. Slopes are 2 to 45 percent. The soils formed in calcareous material weathered from semi-consolidated fine grained sandstone or siltstone. The mean annual precipitation ranges from 10 to 17 inches of which about half falls as snow or rain in April, May, and early June. Elevation is 5,300 to 7,500 feet. The mean annual temperature is 39 to 45 degrees F., and the mean summer temperature is 58 to 65 degrees F. The frost-free season is 75 to 120 days depending upon aspect, elevation, and local air drainage.

VARIATION FROM TYPICAL SERIES: Less alkaline than typical in top of profile.

CARMODY SERIES

SOIL MAPPING UNIT: Cm

SOIL SAMPLE LOCATION: 105

The Carmody series consists of well to somewhat excessively drained soils that are moderately deep to siltstone. These soils formed in material weathered from calcareous siltstone or fine grained sandstone. Carmody soils are on uplands of the cold intermountain basins. Slopes are 2 to 45 percent. The mean annual precipitation is about 14 inches, and the mean annual temperature is about 44 degrees F.

TYPICAL PEDON: Carmody very fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine and very fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; neutral (pH 6.8); gradual wavy boundary.

AC--1 to 12 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; neutral (pH 6.8); abrupt wavy boundary.

C1--12 to 30 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; slightly alkaline (pH 7.3); abrupt wavy boundary.

C2 --30 to 35 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; violently effervescent, lime disseminated; moderately alkaline (pH 7.6); abrupt wavy boundary.

Cr—35* to 60 inches; light brownish gray to white, calcareous siltstone containing fine grained sand.

*Verified 35 to 36 inches, pink sandstone.

TYPE LOCATION: Sweetwater, WY. Refer to Waypoint 105 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Depth to a paralithic contact is 20 to 40 inches. Depth to uniformly calcareous material is 0 to 10 inches. The mean annual soil temperature ranges from about 40 to 47 degrees F., and the mean summer soil temperature ranges from about 59 to 63 degrees F. The control section is very fine sandy loam or fine sandy loam, averaging 10 to 18 percent clay and more than 15 percent fine sand or coarser. Flat fragments or fine pebbles range from 0 to 15 percent. Thin, discontinuous horizons of carbonate accumulation occur immediately above the paralithic contact in some pedons.

The A horizon has hue of 2.5Y or 10YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4. EC is less than 2 mmhos. Reaction is mildly or moderately alkaline.

The C horizon has hue of 2.5Y or 10YR, value of 4 through 7 dry, 3 through 5 moist, and chroma of 2 through 6. EC is less than 2 mmhos. Reaction is moderately or strongly alkaline.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, calcareous, frigid Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 12 inches, with the following marginal parameters:

- Saturation percentage, 12 to 35 inches.

Additionally, calcium carbonate content was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description): Carmody soils are on plateaus and hillslopes in intermountain basins. Slopes are 2 to 45 percent. The soils formed in calcareous material weathered from semi-consolidated fine grained sandstone or siltstone. The mean annual precipitation ranges from 10 to 17 inches of which about half falls as snow or rain in April, May, and early June. Elevation is 5,300 to 7,500 feet. The mean annual temperature is 39 to 45 degrees F., and the mean summer temperature is 58 to 65 degrees F. The frost-free season is 75 to 120 days depending upon aspect, elevation, and local air drainage.

VARIATION FROM TYPICAL SERIES: Less alkaline than typical in top of profile.

CARMODY SERIES

SOIL MAPPING UNIT: Cm

SOIL SAMPLE LOCATION: 111

The Carmody series consists of well to somewhat excessively drained soils that are moderately deep to siltstone. These soils formed in material weathered from calcareous siltstone or fine grained sandstone. Carmody soils are on uplands of the cold intermountain basins. Slopes are 2 to 45 percent. The mean annual precipitation is about 14 inches, and the mean annual temperature is about 44 degrees F.

TYPICAL PEDON: Carmody very fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 4 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine and very fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium roots; slightly acid (pH 6.7); gradual wavy boundary.

AC--4 to 12 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; slightly acid (pH 6.6); abrupt wavy boundary.

C--12 to 24 inches; light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate medium and coarse prismatic structure; slightly hard, friable, slightly sticky; few fine and many medium roots; moderately effervescent; mildly alkaline (pH 7.4); abrupt wavy boundary.

Cr—24* to 60 inches; light brownish gray to white, calcareous siltstone containing fine grained sand.

*Verified 24 to 36 inches, olive sandstone.

TYPE LOCATION: Sweetwater, WY. Refer to Waypoint 111 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description): Depth to a paralithic contact is 20 to 40 inches. Depth to uniformly calcareous material is 0 to 10 inches. The mean annual soil temperature ranges from about 40 to 47 degrees F., and the mean summer soil temperature ranges from about 59 to 63 degrees F. The control section is very fine sandy loam or fine sandy loam, averaging 10 to 18 percent clay and more than 15 percent fine sand or coarser. Flat fragments or fine pebbles range from 0 to 15 percent. Thin, discontinuous horizons of carbonate accumulation occur immediately above the paralithic contact in some pedons.

The A horizon has hue of 2.5Y or 10YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4. EC is less than 2 mmhos. Reaction is mildly or moderately alkaline.

The C horizon has hue of 2.5Y or 10YR, value of 4 through 7 dry, 3 through 5 moist, and chroma of 2 through 6. EC is less than 2 mmhos. Reaction is moderately or strongly alkaline.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, calcareous, frigid Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is marginal to a depth of 12 inches, with the following marginal parameters:

- Saturation percentage, 0 to 12 inches

Additionally, calcium carbonate content was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description): Carmody soils are on plateaus and hillslopes in intermountain basins. Slopes are 2 to 45 percent. The soils formed in calcareous material weathered from semi-consolidated fine grained sandstone or siltstone. The mean annual precipitation ranges from 10 to 17 inches of which about half falls as snow or rain in April, May, and early June. Elevation is 5,300 to 7,500 feet. The mean annual temperature is 39 to 45 degrees F., and the mean summer temperature is 58 to 65 degrees F. The frost-free season is 75 to 120 days depending upon aspect, elevation, and local air drainage.

VARIATION FROM TYPICAL SERIES: Less alkaline than typical in top of profile.

CLOWERS SERIES

SOIL MAPPING UNIT: Cl

SOIL SAMPLE LOCATION: 10

The Clowers series consists of deep, well and moderately well drained soils formed in mixed, calcareous alluvium. Clowers soils are on alluvial flood plains and terraces. Slopes are typically 0 to 3 percent but range up to 6 percent. The mean annual precipitation is about 8 inches, and the mean annual temperature is about 40 degrees F.

TYPICAL PEDON: Clowers loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 5 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse platy structure parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; common medium and fine roots; 2 percent semi-rounded pebbles; mildly acid (pH 6.4); clear smooth boundary.

Bt1--5 to 12 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; neutral (pH 6.8); clear smooth boundary.

Bt2--12 to 28 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; neutral (pH 6.9); clear smooth boundary.

Btk--28 to 32 inches; light brownish gray (2.5Y 6/2) sandy clay loam, dark grayish brown (2.5Y 4/2) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; strongly effervescent, lime disseminated; mildly alkaline (pH 7.4); clear smooth boundary.

Ck1--32 to 36 inches; light brownish gray (2.5Y 6/2) sandy clay loam stratified with thin lenses of very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine and few medium roots; violently effervescent, lime disseminated; mildly alkaline (pH 7.4); gradual wavy boundary.

C2--36 to 42 inches; light brownish gray (2.5Y 6/2) sandy loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; few fine roots; violently effervescent, lime disseminated and as few fine soft masses in various strata; 5 percent rounded pebbles; moderately alkaline (pH 7.5).

C3--42 to 56 inches; light brownish gray (2.5Y 6/2) sandy clay loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent, lime disseminated and as few fine soft masses in various strata; 5 percent rounded pebbles; moderately alkaline (pH 7.6).

C4--56 to 60 inches; light brownish gray (2.5Y 6/2) sandy clay loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent, lime disseminated and as few fine soft masses in various strata; 5 percent rounded pebbles; moderately alkaline (pH 7.6).

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 10 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
These soils are typically calcareous at the surface but are leached up to 8 inches in some pedons. Depth to bedrock exceeds 60 inches. The mean annual soil temperature is about 41 to 47 degrees F., and the mean summer soil temperature is about 59 to 63 degrees F. The soil is stratified with individual strata whose textures range from sandy loam to clay loam. The particle size control, though stratified, averages 18 to 35 percent clay, 20 to 55 percent silt, and 20 to 55 percent sand with more than 15 but less than 35 percent fine or coarser sand. Bulk texture is loam or clay loam. Coarse fragments are variable within various strata but when averaged range from 0 to 15 percent pebbles within the control section. Calcium carbonate equivalent ranges from 2 to 10 percent throughout with only minor segregation. Gypsum crystals are common in some strata. ESP ranges from 0 to 15 percent with the highest concentration located in thin strata at depths of 20 to 40 inches or more..

The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 3 through 5 moist, and chroma of 1 through 4. EC ranges from 0 to 14 mmhos. Reaction is moderately or strongly alkaline.

The C horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 4. Strata of sandy loam, sandy clay loam, loam, silt loam, silty clay loam, and clay loam are common and range from thin lenses to strata 10 inches thick. EC ranges from 0 to 14 mmhos in the upper part and from 0 to 8 in the lower part. Reaction is moderately or strongly alkaline.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, frigid Typic Torrifluvents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 28 inches, with no marginal or unsuitable values in the profile. However, calcium carbonate was observed to be a limiting factor in the field.

GEOGRAPHIC SETTING (according to official soil series description):
Clowers soils are on nearly level or gently sloping alluvial flood plains, drainageways, and terraces. These soils formed in stratified, calcareous alluvium from mixed sources. Elevation ranges from 6,300 to 7,400 feet. The mean annual precipitation is about 8 inches and ranges from 5 to 9 inches. About half falls as rain or snow in April, May, and early June. The mean annual temperature is about 40 degrees F. and ranges from 38 to 44 degrees F. The frost-free season is estimated to range from 60 to 90 days depending upon elevation, aspect, and air drainage.

VARIATION FROM TYPICAL SERIES: Somewhat less alkaline in top 34 inches of profile. Bt and Btk horizons not typical.

CLOWERS SERIES

SOIL MAPPING UNIT: Cl

SOIL SAMPLE LOCATION: 102

The Clowers series consists of deep, well and moderately well drained soils formed in mixed, calcareous alluvium. Clowers soils are on alluvial flood plains and terraces. Slopes are typically 0 to 3 percent but range up to 6 percent. The mean annual precipitation is about 8 inches, and the mean annual temperature is about 40 degrees F.

TYPICAL PEDON: Clowers loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 14 inches; light brownish gray (2.5Y 6/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse platy structure parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; common medium and fine roots; slightly effervescent, lime disseminated; 2 percent semirounded pebbles; mildly acid (pH 6.3); clear smooth boundary.

C1--14 to 24 inches; light brownish gray (2.5Y 6/2) sandy loam stratified with thin lenses of very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine and few medium roots to 22 inches; lime disseminated; neutral (pH 6.9); gradual wavy boundary.

C2--24 to 34 inches; light brownish gray (2.5Y 6/2) loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; lime disseminated; neutral (pH 7.0).

C3--34 to 46 inches; light brownish gray (2.5Y 6/2) sandy clay loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; few fine roots to 30 inches; lime disseminated; moderately alkaline (pH 7.5).

C4--46 to 57 inches; light brownish gray (2.5Y 6/2) loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; few fine roots to 30 inches; moderately effervescent, lime disseminated and as few fine soft masses in various strata; 5 percent rounded pebbles; moderately alkaline (pH 7.7).

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 102 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
These soils are typically calcareous at the surface but are leached up to 8 inches in some pedons. Depth to bedrock exceeds 60 inches. The mean annual soil temperature is about 41 to 47 degrees

F., and the mean summer soil temperature is about 59 to 63 degrees F. The soil is stratified with individual strata whose textures range from sandy loam to clay loam. The particle size control, though stratified, averages 18 to 35 percent clay, 20 to 55 percent silt, and 20 to 55 percent sand with more than 15 but less than 35 percent fine or coarser sand. Bulk texture is loam or clay loam. Coarse fragments are variable within various strata but when averaged range from 0 to 15 percent pebbles within the control section. Calcium carbonate equivalent ranges from 2 to 10 percent throughout with only minor segregation. Gypsum crystals are common in some strata. ESP ranges from 0 to 15 percent with the highest concentration located in thin strata at depths of 20 to 40 inches or more.

The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 3 through 5 moist, and chroma of 1 through 4. EC ranges from 0 to 14 mmhos. Reaction is moderately or strongly alkaline.

The C horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 4. Strata of sandy loam, sandy clay loam, loam, silt loam, silty clay loam, and clay loam are common and range from thin lenses to strata 10 inches thick. EC ranges from 0 to 14 mmhos in the upper part and from 0 to 8 in the lower part. Reaction is moderately or strongly alkaline.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, frigid Typic Torrifluvents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 14 inches and marginal from 14 to 24 inches, with the following marginal parameter:

- Saturation percentage, 14 to 24 inches.

Additionally, calcium carbonate content was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description):
Clowers soils are on nearly level or gently sloping alluvial flood plains, drainageways, and terraces. These soils formed in stratified, calcareous alluvium from mixed sources. Elevation ranges from 6,300 to 7,400 feet. The mean annual precipitation is about 8 inches and ranges from 5 to 9 inches with about half falling as rain or snow in April, May, and early June. The mean annual temperature is about 40 degrees F. and ranges from 38 to 44 degrees F. The frost-free season is estimated to range from 60 to 90 days depending upon elevation, aspect, and air drainage.

VARIATION FROM TYPICAL SERIES: Somewhat less alkaline in top 24 inches of profile.

CLOWERS SERIES

SOIL MAPPING UNIT: Cl

SOIL SAMPLE LOCATION: 113

The Clowers series consists of deep, well and moderately well drained soils formed in mixed, calcareous alluvium. Clowers soils are on alluvial flood plains and terraces. Slopes are typically 0 to 3 percent but range up to 6 percent. The mean annual precipitation is about 8 inches, and the mean annual temperature is about 40 degrees F.

TYPICAL PEDON: Clowers loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inches; light brownish gray (2.5Y 6/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse platy structure parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; common medium and fine roots; 2 percent semirounded pebbles; neutral (pH 7.0); clear smooth boundary.

Bw--1 to 12 inches; light brownish gray (2.5Y 6/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak medium prismatic structure that parts to moderate medium angular blocky; hard, friable, sticky and plastic; many fine and medium roots; continuous thin clay films on faces of all peds; neutral (pH 7.0); clear smooth boundary.

C1--12 to 20 inches; light brownish gray (2.5Y 6/2) sandy loam stratified with thin lenses of very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine and few medium roots; 2 percent rounded pebbles; mildly alkaline (pH 7.4); gradual wavy boundary.

C2--20 to 26 inches; light brownish gray (2.5Y 6/2) sandy loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; few fine roots; violently effervescent, lime disseminated and as few fine soft masses in various strata; 5 percent rounded pebbles; moderately alkaline (pH 7.5).

C2--26 to 46 inches; light brownish gray (2.5Y 6/2) sandy loam stratified with lenses of very fine sandy loam, clay loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive with much of the original stratified layers in place; slightly hard, very friable, slightly sticky and slightly plastic; few fine roots to 30 inches; strongly effervescent, lime disseminated and as few fine soft masses in various strata; 5 percent rounded pebbles; moderately alkaline (pH 7.8).

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 113 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
These soils are typically calcareous at the surface but are leached up to 8 inches in some pedons.

Depth to bedrock exceeds 60 inches. The mean annual soil temperature is about 41 to 47 degrees F., and the mean summer soil temperature is about 59 to 63 degrees F. The soil is stratified with individual strata whose textures range from sandy loam to clay loam. The particle size control, though stratified, averages 18 to 35 percent clay, 20 to 55 percent silt, and 20 to 55 percent sand with more than 15 but less than 35 percent fine or coarser sand. Bulk texture is loam or clay loam. Coarse fragments are variable within various strata but when averaged range from 0 to 15 percent pebbles within the control section. Calcium carbonate equivalent ranges from 2 to 10 percent throughout with only minor segregation. Gypsum crystals are common in some strata. ESP ranges from 0 to 15 percent with the highest concentration located in thin strata at depths of 20 to 40 inches or more.

The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 3 through 5 moist, and chroma of 1 through 4. EC ranges from 0 to 14 mmhos. Reaction is moderately or strongly alkaline.

The C horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 4. Strata of sandy loam, sandy clay loam, loam, silt loam, silty clay loam, and clay loam are common and range from thin lenses to strata 10 inches thick. EC ranges from 0 to 14 mmhos in the upper part and from 0 to 8 in the lower part. Reaction is moderately or strongly alkaline.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, frigid Typic Torrifluvents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 12 inches, with the following marginal parameter:

- Saturation percentage, 12 to 20 inches.

Additionally, calcium carbonate content was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description):
Clowers soils are on nearly level or gently sloping alluvial flood plains, drainageways, and terraces. These soils formed in stratified, calcareous alluvium from mixed sources. Elevation ranges from 6,300 to 7,400 feet. The mean annual precipitation is about 8 inches and ranges from 5 to 9 inches with about half falling as rain or snow in April, May, and early June. The mean annual temperature is about 40 degrees F. and ranges from 38 to 44 degrees F. The frost-free season is estimated to range from 60 to 90 days depending upon elevation, aspect, and air drainage.

VARIATION FROM TYPICAL SERIES: Slightly less alkaline in top 12 inches of profile. Bw horizon atypical.

GOSLIN SERIES

SOIL MAPPING UNIT: Go

SOIL SAMPLE LOCATION: 106

The Goslin series consists of deep, well drained soils that formed in coarse textured alluvium derived from red sandstone. The Goslin soils are on fan aprons, fan pediments, and alluvial terraces. Slopes are 3 to 25 percent. The mean annual precipitation is about 12 inches, and the mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Goslin fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 6 inches; yellowish brown (10YR 5/4) fine loamy sand, dark brown (7.5YR 4/4) moist; weak coarse platy structure; soft, very friable, slightly sticky and nonplastic; many fine, medium, and coarse roots; moderately alkaline (pH 7.4); abrupt wavy boundary.

C1--6 to 14 inches; light brown (7.5YR 5/4) fine loamy sand, dark brown (7.5YR 4/4) moist; very weak coarse subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; many fine, medium, and coarse roots to 14 inches; moderately alkaline (pH 7.5); gradual wavy boundary.

C2--14 to 34 inches; white (5YR 7/2) fine loamy sand, pale brown (5YR 5/2) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; strongly alkaline (pH 7.8).

C2--34 to 46 inches; white (5YR 7/2) fine loamy sand, pale brown (5YR 5/2) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; strongly alkaline (pH 7.9).

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 106 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
The mean annual soil temperature is 44 to 46 degrees F., and the mean summer soil temperature is 59 to 63 degrees F. The particle-size control section is sandy loam or fine sandy loam modified with 0 to 35 percent coarse fragments. Clay ranges from 8 to 18 percent. It is moderately alkaline or strongly alkaline throughout. EC ranges from 0 to 4 mmhos.

The A horizon has hue of 10YR through 2.5YR, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4. A surface covering of gravel lag is common in some pedons.

The C horizon has hue of 7.5YR through 2.5YR, value of 5 through 7 dry, 4 or 5 moist, and chroma of 2 through 4. Carbonates range from 5 to 20 percent with less than one-fourth as pedogenetic accumulation.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, calcareous, frigid Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 0 inches, with the following marginal parameter:

- Saturation percentage, 0 to 46 inches.

Additionally, calcium carbonate content was observed in the field to be a limiting factor, as was sand content.

GEOGRAPHIC SETTING (according to official soil series description):
Goslin soils are on fan aprons, fan pediments, and alluvial terraces. They formed in coarse textured alluvium derived from red sandstone. Slopes are 3 to 25 percent. Elevations range from 6,300 to 7,500 feet. The mean annual precipitation is 9 to 14 inches with about half falling as snow or rain in April, May, and early June. The mean annual temperature is about 42 to 46 degrees F. The frost-free period is 60 to 90 days.

VARIATION FROM TYPICAL SERIES: Somewhat less alkaline than typical.

TEAGULF SERIES

SOIL MAPPING UNIT: Tg

SOIL SAMPLE LOCATION: 1

The Teagulf series consists of moderately deep, well drained soils that formed in modified residuum and slopewash alluvium from calcareous sedimentary rocks. Teagulf soils are on erosional upland plains and alluvial fans. Slopes are 0 to 8 percent. The mean annual precipitation is about 8 inches. The mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Teagulf fine sandy loam - rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 2 inches; light brownish gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; neutral (pH 7.1); clear wavy boundary.

Bt--2 to 17 inches; light brownish gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak coarse prismatic structure; slightly hard, friable; slightly sticky, nonplastic; common fine roots; moderately alkaline (pH 7.6); clear wavy boundary.

C1k--17 to 28 inches; light olive brown (2.5Y 5/4) fine sandy loam, olive brown (2.5Y 4/4) moist; massive; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; violently effervescent, lime is segregated in soft masses; moderately alkaline (pH 7.6).

C2--28 to 36 inches; light olive brown (2.5Y 5/4) fine sandy loam, olive brown (2.5Y 4/4) moist; massive; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; moderately effervescent, lime is segregated in soft masses; moderately alkaline (pH 7.6).

Cr--36 inches; soft sandstone.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 1 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
The mean annual soil temperature is 43 degrees to 47 degrees F. The mean summer soil temperature is 63 degrees to 68 degrees F. Coarse fragment content is typically less than 5 percent but ranges in some pedons from 0 to 15 percent and consists of gravel and channers. Depth to horizons of continuous carbonate accumulation is 7 to 20 inches. Depth to bedrock is typically 28 to 35 inches but may range from 20 to 40 inches.

The A horizon has hue of 10YR or 2.5Y; values of 5 through 7 dry, 4 or 5 moist; and chroma of 2 through 4 dry and moist. Textures are fine sandy loam, sandy loam, or loamy fine sand. Reaction is mildly or moderately alkaline. Effervescence ranges from none to strong. Salinity is 0 to 2 mmhos/cm.

The B horizon has hue of 10YR or 2.5Y; values of 5 through 7 dry, 4 or 5 moist; and chroma of 2 through 6 dry and moist. Textures are fine sandy loam or sandy loam. Reaction is mildly or moderately alkaline. Structure is weak prismatic or weak subangular blocky. Effervescence is slight to strong. Salinity is 0 to 2 mmhos/cm.

The Ck horizon has hues of 10YR or 2.5Y; values of 6 or 8 dry, 4 to 6 moist; and chroma of 2 through 6 dry and moist. Textures are fine sandy loam or sandy loam. Reaction is moderately or strongly alkaline. Effervescence is strong or violent. Salinity is 0 to 4 mmhos/cm. Carbonate equivalent ranges from 8 to 25 percent.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, frigid Typic Haplocalcids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 17 inches, with no marginal or unsuitable parameters within the profile. However, calcium carbonate content was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description):
Teagulf soils are on nearly level and gently sloping erosional upland plains and alluvial fans. The soils formed in modified residuum and slopewash alluvium from sedimentary rocks. Slopes are 0 to 8 percent. Elevations range from 6,000 to 7,300 feet. Average annual precipitation is 6 to 9 inches. The mean annual air temperature is 38 degrees to 45 degrees F., and the mean summer air temperature is 61 degrees to 66 degrees F. The frost-free season is about 80 to 110 days..

VARIATION FROM TYPICAL SERIES: A horizon somewhat less alkaline than typical. Lower calcium carbonate content than typical in Ck horizon.

TEAGULF SERIES

SOIL MAPPING UNIT: Br

SOIL SAMPLE LOCATION: 17

The Teagulf series consists of moderately deep, well drained soils that formed in modified residuum and slopewash alluvium from calcareous sedimentary rocks. Teagulf soils are on erosional upland plains and alluvial fans. Slopes are 0 to 8 percent. The mean annual precipitation is about 8 inches. The mean annual temperature is about 43 degrees F.

TYPICAL PEDON: Teagulf fine sandy loam - rangeland. (Colors are for dry soil unless otherwise stated.)

A1--0 to 1 inches; light brownish gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; neutral (pH 6.8); clear wavy boundary.

Bw--1 to 6 inches; light brownish gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak coarse prismatic structure; slightly hard, friable; slightly sticky, nonplastic; common fine roots; slightly effervescent, lime segregated in lower part; neutral (pH 6.8); clear wavy boundary.

C1--6 to 16 inches; pale yellow brown (2.5Y 7/4) fine sandy loam, yellow brown (2.5Y 6/4) moist; massive; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; mildly alkaline (pH 7.3).

C2k--16 to 20 inches; pale yellow white (2.5Y 8/2) fine sandy loam, pale yellow brown (2.5Y 6/2) moist; massive; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; violently effervescent, lime is segregated in soft masses; moderately alkaline (pH 7.5).

Cr—20 to 36 inches; soft sandstone.

TYPE LOCATION: Sweetwater County, WY. Refer to Waypoint 17 on the map included in this report.

RANGE IN CHARACTERISTICS (according to official soil series description):
The mean annual soil temperature is 43 degrees to 47 degrees F. The mean summer soil temperature is 63 degrees to 68 degrees F. Coarse fragment content is typically less than 5 percent but ranges in some pedons from 0 to 15 percent and consists of gravel and channers. Depth to horizons of continuous carbonate accumulation is 7 to 20 inches. Depth to bedrock is typically 28 to 35 inches but may range from 20 to 40 inches.

The A horizon has hue of 10YR or 2.5Y; values of 5 through 7 dry, 4 or 5 moist; and chroma of 2 through 4 dry and moist. Textures are fine sandy loam, sandy loam, or loamy fine sand.

Reaction is mildly or moderately alkaline. Effervescence ranges from none to strong. Salinity is 0 to 2 mmhos/cm.

The B horizon has hue of 10YR or 2.5Y; values of 5 through 7 dry, 4 or 5 moist; and chroma of 2 through 6 dry and moist. Textures are fine sandy loam or sandy loam. Reaction is mildly or moderately alkaline. Structure is weak prismatic or weak subangular blocky. Effervescence is slight to strong. Salinity is 0 to 2 mmhos/cm.

The Ck horizon has hues of 10YR or 2.5Y; values of 6 or 8 dry, 4 to 6 moist; and chroma of 2 through 6 dry and moist. Textures are fine sandy loam or sandy loam. Reaction is moderately or strongly alkaline. Effervescence is strong or violent. Salinity is 0 to 4 mmhos/cm. Carbonate equivalent ranges from 8 to 25 percent.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, frigid Typic Haplocalcids

SUITABILITY FOR TOPSOIL (according to WDEQ-LQD Guideline 1, 1994): This soil is suitable to a depth of 16 inches, with no marginal or unsuitable parameters. However, calcium carbonate content was observed in the field to be a limiting factor.

GEOGRAPHIC SETTING (according to official soil series description):
Teagulf soils are on nearly level and gently sloping erosional upland plains and alluvial fans. The soils formed in modified residuum and slopewash alluvium from sedimentary rocks. Slopes are 0 to 8 percent. Elevations range from 6,000 to 7,300 feet. Average annual precipitation is 6 to 9 inches. The mean annual air temperature is 38 degrees to 45 degrees F., and the mean summer air temperature is 61 degrees to 66 degrees F. The frost-free season is about 80 to 110 days.

VARIATION FROM TYPICAL SERIES: Somewhat less alkaline than typical. Lower calcium carbonate content than typical in Ck horizon.

APPENDIX 3.3-3
SOIL LABORATORY ANALYSIS

LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

Client: Lidstone and Associates **Report Date:** 12/18/12
Project: Lost Creek East Uranium **Date Received:** 11/12/12
Workorder: G12110266

	Analysis	SAT	OM-WB	Coarse Fragments	Sand	Silt	Clay	Texture	pH-SatPst	COND	Ca-SatPst	Mg-SatPst	Na-SatPst	SAR-sat paste
	Units	wt%	%	%	%	%	%	%	s.u.	mmhos/cm	meq/L	meq/L	meq/L	unitless
Sample ID	Client Sample ID	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
G12110266-001	1, 0-17 in.	27	0.5	< 2	64	20	16	SL	7.1	1.0	6.04	2.47	0.73	0.4
G12110266-002	1, 17-28 in.	32	0.4	< 2	66	18	16	SL	7.6	0.8	4.22	1.94	2.21	1.3
G12110266-003	1, 28-36 in.	26	0.2	< 2	74	18	8	SL	7.6	1.6	6.73	2.98	5.67	2.7
G12110266-004	2, 0-12 in.	27	0.7	3	62	24	14	SL	6.9	1.0	6.33	2.59	0.48	0.2
G12110266-005	2, 12-22 in.	18	< 0.2	6	78	6	16	SL	7.0	1.4	8.02	3.33	0.56	0.2
G12110266-006	6, 0-12 in.	27	0.8	5	58	28	14	SL	6.0	0.3	1.46	0.59	0.19	0.2
G12110266-007	6, 12-24 in.	23	0.3	6	76	16	8	SL	6.5	0.2	1.17	0.47	0.31	0.3
G12110266-008	6, 24-47 in.	21	< 0.2	12	82	12	6	LS	7.2	0.5	2.60	0.85	1.02	0.8
G12110266-009	10, 0-5 in.	31	1.5	4	44	38	18	L	6.4	0.4	2.10	0.91	0.27	0.2
G12110266-010	10, 5-12 in.	33	0.9	2	42	38	20	L	6.8	0.3	1.86	0.76	0.36	0.3
G12110266-011	10, 12-28 in.	40	0.6	5	32	44	24	L	6.9	0.4	2.62	1.01	0.58	0.4
G12110266-012	10, 28-36 in.	33	0.7	8	52	26	22	SCL	7.4	0.8	4.59	1.42	0.63	0.4
G12110266-013	10, 36-42 in.	29	0.3	12	66	18	16	SL	7.5	0.5	3.27	0.90	0.66	0.5
G12110266-014	10, 42-60 in.	34	0.3	12	54	26	20	SCL	7.6	0.6	3.77	1.11	1.03	0.7
G12110266-015	12, 0-9 in.	26	0.6	< 2	68	18	14	SL	7.2	0.5	3.24	1.31	0.38	0.2
G12110266-016	12, 9-20 in.	25	0.3	< 2	74	14	12	SL	7.5	0.4	2.31	1.00	0.48	0.4
G12110266-017	12, 20-26 in.	23	< 0.2	2	78	14	8	SL	7.8	0.7	2.26	1.20	2.47	1.9
G12110266-018	13, 0-5 in.	26	1.0	7	62	26	12	SL	7.0	0.6	3.19	1.40	0.51	0.3
G12110266-019	13, 5-13 in.	27	0.7	9	62	22	16	SL	7.5	0.6	3.54	1.44	0.98	0.6
G12110266-020	13, 13-17 in.	27	0.8	9	64	24	12	SL	7.2	0.7	4.02	1.67	0.95	0.6
G12110266-021	15, 0-12 in.	26	0.6	3	62	22	16	SL	6.6	0.6	2.93	1.22	0.35	0.2
G12110266-022	15, 12-16 in.	26	0.3	12	68	18	14	SL	7.2	0.6	3.15	1.30	0.53	0.4
G12110266-023	17, 0-6 in.	28	0.6	7	68	16	16	SL	6.8	0.7	4.22	1.77	0.45	0.3
G12110266-024	17, 6-16 in.	27	0.4	4	72	12	16	SL	7.3	0.5	3.14	1.38	0.43	0.3
G12110266-025	17, 16-20 in.	26	0.3	7	74	12	14	SL	7.5	0.5	3.10	1.41	0.55	0.4
G12110266-026	18, 0-10 in.	28	0.5	3	65	17	18	SL	7.2	0.5	3.08	1.12	0.50	0.4
G12110266-027	18, 10-18 in.	31	0.3	15	68	16	16	SL	7.3	0.8	3.34	1.36	2.20	1.4
G12110266-028	101, 0-3 in.	27	0.4	< 2	70	14	16	SL	6.6	0.2	1.17	0.46	0.24	0.3
G12110266-029	101, 3-10 in.	30	0.3	< 2	68	20	12	SL	7.2	0.5	2.68	0.84	0.32	0.2
G12110266-030	101, 10-24 in.	30	0.4	< 2	68	18	14	SL	7.6	0.5	2.71	0.90	0.84	0.6
G12110266-031	102, 0-14 in.	28	1.1	4	60	26	14	SL	6.3	0.4	2.77	1.17	0.24	0.2
G12110266-032	102, 14-24 in.	24	0.3	8	54	30	16	SL	6.9	0.3	1.95	0.89	0.29	0.2
G12110266-033	102, 24-34 in.	32	0.4	4	52	28	20	L	7.0	0.3	1.63	0.71	0.36	0.3
G12110266-034	102, 34-46 in.	34	0.3	< 2	54	26	20	SCL	7.5	0.4	2.69	1.15	0.55	0.4
G12110266-035	102, 46-57 in.	35	0.4	< 2	56	26	18	SL	7.7	0.6	4.07	2.08	0.72	0.4
G12110266-036	103, 0-10 in.	27	0.6	4	68	20	12	SL	6.7	0.4	2.43	1.05	0.27	0.2
G12110266-037	103, 10-20 in.	25	0.3	3	68	16	16	SL	7.2	0.5	3.03	1.28	0.39	0.3
G12110266-038	103, 20-26 in.	24	0.5	7	72	16	12	SL	7.4	0.5	3.41	1.48	0.43	0.3
G12110266-039	103, 26-46 in.	24	< 0.2	11	78	12	10	SL	7.7	0.7	3.46	1.97	1.39	0.8
G12110266-040	104, 0-10 in.	25	0.6	8	66	20	14	SL	6.9	0.4	2.29	0.98	0.35	0.3
G12110266-041	104, 10-18 in.	22	0.5	14	72	16	12	SL	7.3	0.5	3.35	1.48	0.56	0.4
G12110266-042	104, 18-32 in.	21	0.3	19	68	22	10	SL	7.8	0.5	3.02	1.67	1.01	0.7

LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

Client: Lidstone and Associates
Project: Lost Creek East Uranium
Workorder: G12110266

Report Date: 12/18/12
Date Received: 11/12/12

	Analysis	SAT	OM-WB	Coarse Fragments	Sand	Silt	Clay	Texture	pH-SatPst	COND	Ca-SatPst	Mg-SatPst	Na-SatPst	SAR-sat paste
	Units	wt%	%	%	%	%	%	%	s_u_	mmhos/cm	meq/L	meq/L	meq/L	unitless
Sample ID	Client Sample ID	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
G12110266-043	104, 32-43 in.	21	< 0.2	18	70	16	14	SL	8.3	1.0	1.86	1.32	6.90	5.5
G12110266-044	105, 0-12 in.	25	0.7	4	74	14	12	SL	6.8	0.4	2.86	1.08	0.28	0.2
G12110266-045	105, 12-30 in.	23	0.3	14	76	12	12	SL	7.3	0.5	2.98	1.22	0.59	0.4
G12110266-046	105, 30-35 in.	24	0.3	8	80	10	10	SL	7.6	0.7	4.50	1.93	0.68	0.4
G12110266-047	106, 0-6 in.	23	0.8	< 2	80	12	8	LS	7.4	0.5	3.82	1.32	0.28	0.2
G12110266-048	106, 6-14 in.	21	0.5	< 2	84	8	8	LS	7.5	0.4	3.01	1.09	0.32	0.2
G12110266-049	106, 14-34 in.	21	< 0.2	< 2	86	6	8	LS	7.8	0.4	2.28	0.82	0.41	0.3
G12110266-050	106, 34-46 in.	19	0.2	< 2	88	6	6	LS	7.9	0.4	2.57	1.05	0.57	0.4
G12110266-051	107, 0-3 in.	26	1.3	< 2	80	6	14	SL	6.3	0.2	1.51	0.66	0.16	0.2
G12110266-052	107, 3-14 in.	28	0.9	< 2	52	34	14	L	6.7	0.4	2.85	1.17	0.25	0.2
G12110266-053	107, 14-26 in.	21	0.5	< 2	68	20	12	SL	6.6	0.2	1.06	0.50	0.23	0.3
G12110266-054	107, 26-34 in.	20	0.3	< 2	76	14	10	SL	7.0	0.1	0.72	0.34	0.24	0.3
G12110266-055	107, 34-42 in.	24	0.3	3	74	16	10	SL	6.9	0.2	1.31	0.59	0.32	0.3
G12110266-056	107, 42-60 in.	22	0.2	< 2	78	14	8	SL	7.1	0.2	1.19	0.55	0.35	0.4
G12110266-057	111, 0-4 in.	23	0.8	4	70	14	16	SL	6.7	0.4	2.45	1.02	0.36	0.3
G12110266-058	111, 4-12 in.	24	0.8	12	66	20	14	SL	6.6	0.4	2.14	0.89	0.75	0.6
G12110266-059	111, 12-24 in.	40	0.5	< 2	42	38	20	L	7.4	0.8	2.42	0.80	2.72	2.1
G12110266-060	113, 0-12 in.	26	0.8	3	64	22	14	SL	7.0	0.6	3.98	1.48	0.38	0.2
G12110266-061	113, 12-20 in.	22	0.8	4	68	18	14	SL	7.4	0.5	3.82	1.39	0.37	0.2
G12110266-062	113, 20-26 in.	25	0.7	4	74	14	12	SL	7.5	1.1	6.73	2.75	0.70	0.3
G12110266-063	113, 26-46 in.	25	0.4	12	78	8	14	SL	7.8	1.2	3.44	2.04	4.45	2.7

LABORATORY ANALYTICAL REPORT
Prepared by Gillette, WY Branch

Client: Lidstone and Associates
Project: Lost Creek East Uranium
Workorder: G12110266

Report Date: 12/18/12
Date Received: 11/12/12

Sample ID	Client Sample ID	B	Selenium
	Units	mg/kg	mg/kg
		Results	Results
G12110266-001	1, 0-17 in.	0.1	< 0.1
G12110266-002	1, 17-28 in.	0.2	< 0.1
G12110266-003	1, 28-36 in.	0.2	< 0.1
G12110266-004	2, 0-12 in.	0.1	< 0.1
G12110266-005	2, 12-22 in.	< 0.1	< 0.1
G12110266-006	6, 0-12 in.	< 0.1	< 0.1
G12110266-007	6, 12-24 in.	< 0.1	< 0.1
G12110266-008	6, 24-47 in.	< 0.1	< 0.1
G12110266-009	10, 0-5 in.	0.2	< 0.1
G12110266-010	10, 5-12 in.	0.3	< 0.1
G12110266-011	10, 12-28 in.	0.2	< 0.1
G12110266-012	10, 28-36 in.	0.2	< 0.1
G12110266-013	10, 36-42 in.	0.1	< 0.1
G12110266-014	10, 42-60 in.	0.1	< 0.1
G12110266-015	12, 0-9 in.	0.2	< 0.1
G12110266-016	12, 9-20 in.	0.2	< 0.1
G12110266-017	12, 20-26 in.	0.2	< 0.1
G12110266-018	13, 0-5 in.	0.3	< 0.1
G12110266-019	13, 5-13 in.	0.5	< 0.1
G12110266-020	13, 13-17 in.	0.3	< 0.1
G12110266-021	15, 0-12 in.	0.1	< 0.1
G12110266-022	15, 12-16 in.	< 0.1	< 0.1
G12110266-023	17, 0-6 in.	0.1	< 0.1
G12110266-024	17, 6-16 in.	< 0.1	< 0.1
G12110266-025	17, 16-20 in.	< 0.1	< 0.1
G12110266-026	18, 0-10 in.	< 0.1	< 0.1
G12110266-027	18, 10-18 in.	0.1	< 0.1
G12110266-028	101, 0-3 in.	< 0.1	< 0.1
G12110266-029	101, 3-10 in.	< 0.1	< 0.1
G12110266-030	101, 10-24 in.	0.1	< 0.1
G12110266-031	102, 0-14 in.	0.2	< 0.1
G12110266-032	102, 14-24 in.	0.2	< 0.1
G12110266-033	102, 24-34 in.	0.3	< 0.1
G12110266-034	102, 34-46 in.	0.2	< 0.1
G12110266-035	102, 46-57 in.	0.2	< 0.1
G12110266-036	103, 0-10 in.	< 0.1	< 0.1
G12110266-037	103, 10-20 in.	< 0.1	< 0.1
G12110266-038	103, 20-26 in.	< 0.1	< 0.1
G12110266-039	103, 26-46 in.	< 0.1	< 0.1
G12110266-040	104, 0-10 in.	0.1	< 0.1
G12110266-041	104, 10-18 in.	0.1	< 0.1
G12110266-042	104, 18-32 in.	< 0.1	< 0.1

LABORATORY ANALYTICAL REPORT
Prepared by Gillette, WY Branch

Client:	Lidstone and Associates	**Report Date:**	12/18/12
Project:	Lost Creek East Uranium	**Date Received:**	11/12/12
Workorder:	G12110266		

	Analysis	B	Selenium
	Units	mg/kg	mg/kg
Sample ID	Client Sample ID	Results	Results
G12110266-043	104, 32-45 in.	0.1	< 0.1
G12110266-044	105, 0-12 in.	0.1	< 0.1
G12110266-045	105, 12-30 in.	< 0.1	< 0.1
G12110266-046	105, 30-35 in.	< 0.1	< 0.1
G12110266-047	106, 0-6 in.	0.2	< 0.1
G12110266-048	106, 6-14 in.	0.2	< 0.1
G12110266-049	106, 14-34 in.	< 0.1	< 0.1
G12110266-050	106, 34-46 in.	< 0.1	< 0.1
G12110266-051	107, 0-3 in.	< 0.1	< 0.1
G12110266-052	107, 3-14 in.	< 0.1	< 0.1
G12110266-053	107, 14-26 in.	< 0.1	< 0.1
G12110266-054	107, 26-34 in.	< 0.1	< 0.1
G12110266-055	107, 34-42 in.	< 0.1	< 0.1
G12110266-056	107, 42-60 in.	< 0.1	< 0.1
G12110266-057	111, 0-4 in.	< 0.1	< 0.1
G12110266-058	111, 4-12 in.	< 0.1	< 0.1
G12110266-059	111, 12-24 in.	< 0.1	< 0.1
G12110266-060	113, 0-12 in.	0.1	< 0.1
G12110266-061	113, 12-20 in.	0.2	< 0.1
G12110266-062	113, 20-26 in.	0.2	< 0.1
G12110266-063	113, 26-46 in.	0.1	< 0.1

APPENDIX 3.3-4

PRIME FARMLAND DESIGNATION

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
79 Winston Drive, Suite 235
Rock Springs, WY 82901

Lisa Cox
BKS Environmental Associates, Inc.
724 Dewar Drive
Rock Springs, Wyoming 82901

March 8, 2013

RE: Prime Farmland Designation for Lost Creek Project

Dear Ms. Cox:

Recently you requested soil survey information for the Lost Creek project. Your project area is located approximately 50 miles northwest of Rawlins, Wyoming and is located in Sweetwater County, Wyoming. It includes all of or portions of sections 1,2,3,10,11,14,15,20,21,22,23,27,28, and 29 of Township 25N, Range 92W.

I regret to inform you that there is currently no soil mapping completed in the area described. As such, we have not designated any of that land as Prime Farmland. Please keep in mind that this does not necessarily mean the area does not contain any Prime Farmland, but that at this time we simply have not assessed its suitability due to lack of documentation.

Please contact the Rock Springs MLRA Soil Survey Office at (307) 362-3062 if you have any further questions regarding this matter.

Sincerely,

Jason Martin
MLRA Soil Survey Leader, Rock Springs, WY

APPENDIX 3.3-5
PHOTOGRAPHS

Photo 1. Profile view of Sample Point #1

Photo 2. General view of Sample Point #1

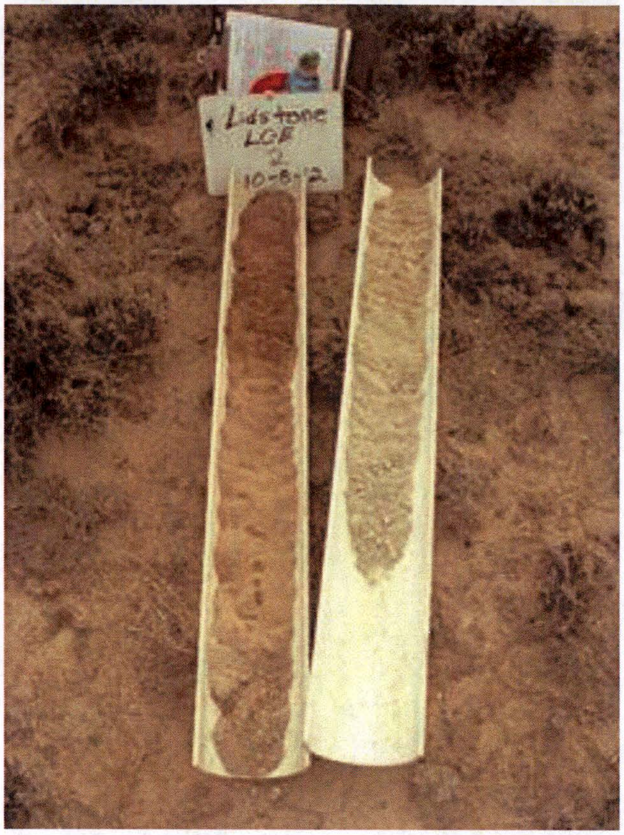

Photo 3. Profile view of Sample Point #2

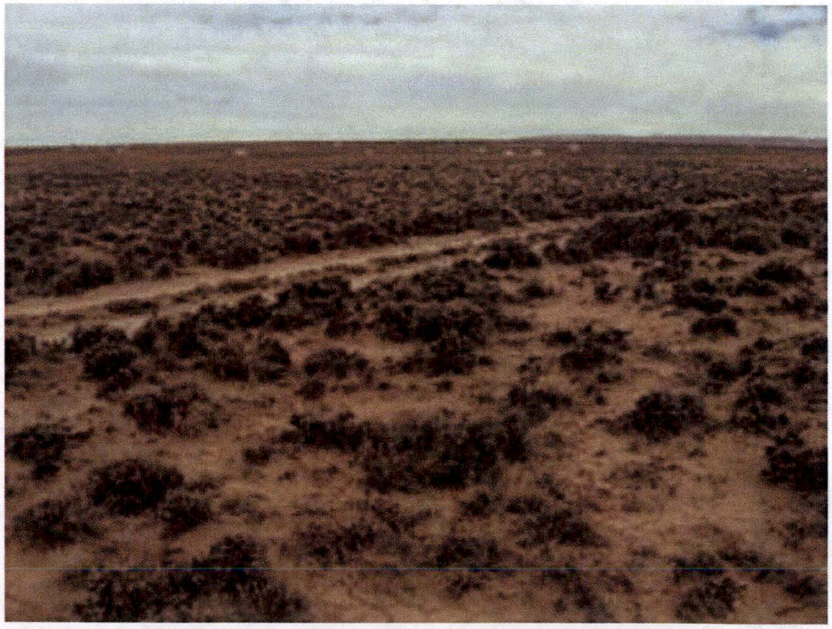

Photo 4. General view of Sample Point #2

Photo 5. Profile view of Sample Point #6

Photo 6. General view of Sample Point #6

Photo 7. Profile view of Sample Point # 10

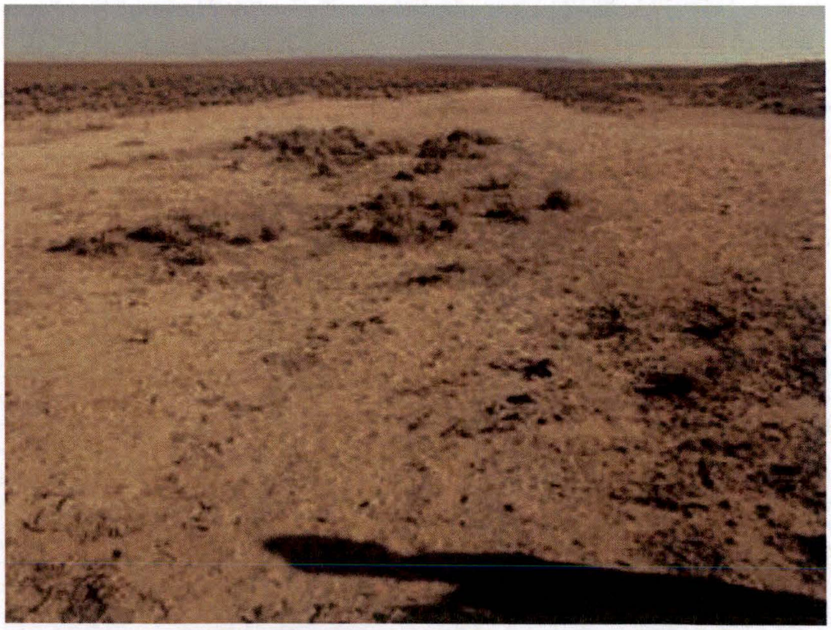

Photo 8. General view of Sample Point #10

Photo 9. Profile view of Sample Point #12

Photo 10. General view of Sample Point #12

Photo 11. Profile view of Sample Point #13

Photo 12. General view of Sample Point #11

Photo 13. Profile view of Sample Point #15

Photo 14. General view of Sample Point #15

Photo. 15. Profile view of Sample Point #17

Photo 16. General view of Sample Point #17

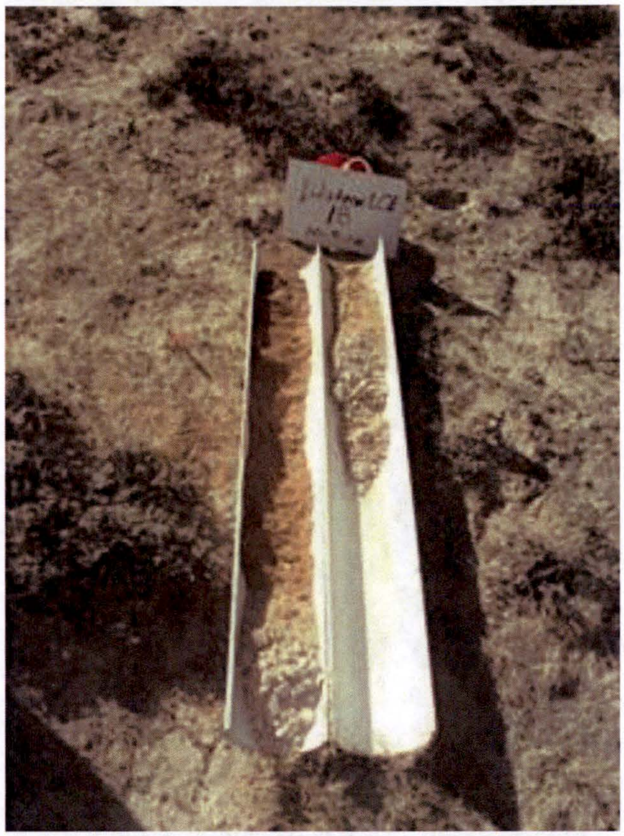

Photo 17. Profile view of Sample Point #18

Photo 18. General view of Sample Point #18

Photo 19. Profile view of Sample Point #101

Photo 20. General view of Sample Point #101

Photo 21. Profile view of Sample Point #102

Photo 22. General view of Sample Point #102

Photo 23. Profile view of Sample Point #103

Photo 24. General view of Sample Point #103

Photo 25. Profile view of Sample Point #104

Photo 26. General view of Sample Point #104

Photo 27. Profile view of Sample Point #105

Photo 28. General view of Sample Point #105

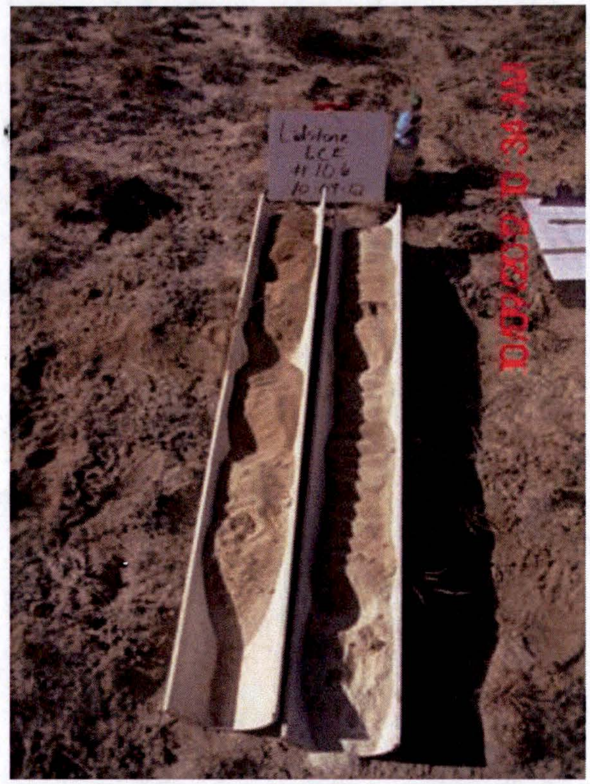

Photo 29. Profile view of Sample Point #106

Photo 30. General view of Sample Point #106

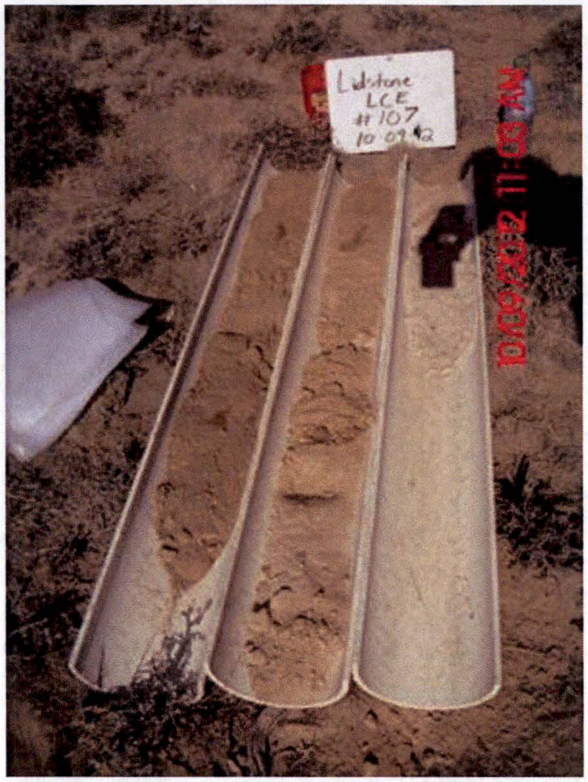

Photo 31. Profile view of Sample Point #107

Photo 32. General view of Sample Point #107

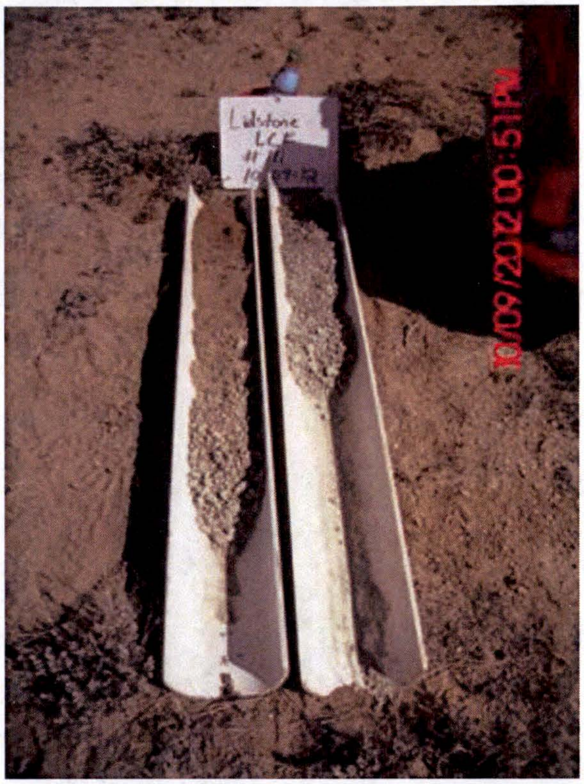

Photo 33. Profile view of Sample Point #111

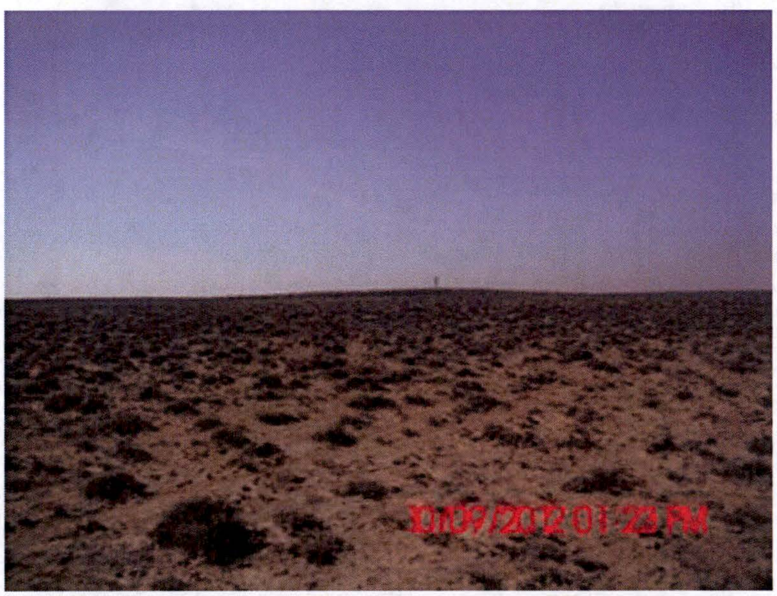

Photo 34. General view of Sample Point #111

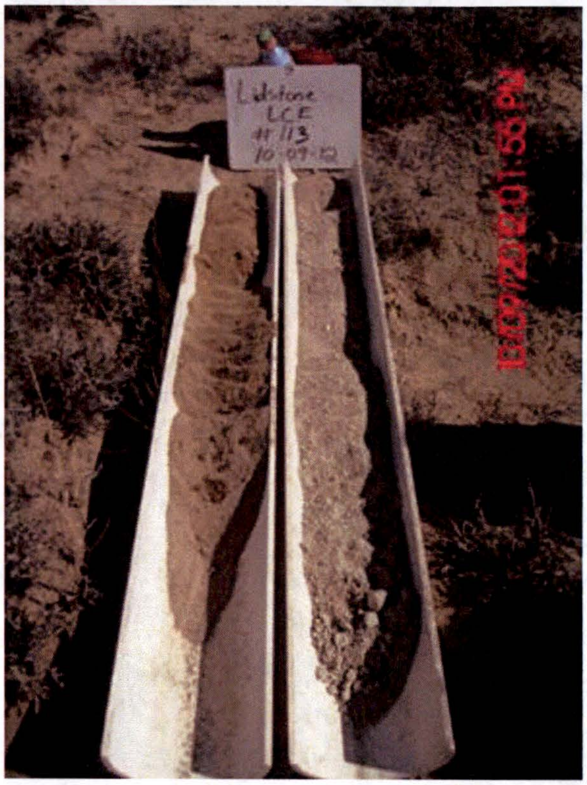

Photo 35. Profile view of Sample Point #113

Photo 36. General view of Sample Point #113

Appendix 3.3-6
MAPS

Section 3.4

Geology

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FIGURES

TABLES

PLATES

3.4 Geology

3.4.1 Regional Geology

The Lost Creek Property, including the LC East Amendment Area, is situated in the northeastern part of the Great Divide Basin (Basin) which is underlain by up to 25,000 feet of Paleozoic to Quaternary sediments. The Basin is an oval-shaped structural depression, encompassing some 3,500 square miles in south-central Wyoming. It represents the northeastern portions of the greater Green River Basin, which occupies much of southwestern Wyoming. The Basin lies within a unique divergence of the Continental Divide and is bounded by structural uplifts or fault displaced Precambrian rocks, resulting in internal drainage and an independent hydrogeologic system. It is bounded on the north by the Wind River Range and Granite Mountains, on the east by the Rawlins Uplift, on the south by the Wamsutter Arch and on the west by the Rock Springs Uplift. Geologic development of the Basin began in the Late Cretaceous and continued through much of the Early Eocene.

Rock outcrops in the Basin are dominated by the Battle Spring Formation of Eocene age. Due to the soft nature of the formation, this occurs largely as sub-crop beneath the soil. The dominant lithology in the Battle Spring Formation is coarse arkosic sandstone, separated by abundant but intermittent beds of mudstone, claystone and siltstone. Deposition occurred as alluvial-fluvial fan deposits within a south-southwest flowing paleo-drainage. The sedimentary source is considered to be the Granite Mountains, approximately 20 to 30 miles to the north. Maximum thickness of the Battle Spring Formation sediments within the Basin is 6,200 feet.

Uranium deposits in the Great Divide Basin, including the Lost Creek and LC East deposits, are found principally in the Battle Spring Formation.

3.4.1.1 Stratigraphy

The earliest sedimentation during development of the Basin was the Paleocene (Early Tertiary) Fort Union Formation, which was unconformably deposited upon the Lance Formation of Late Cretaceous age. The Fort Union Formation consists mostly of lacustrine shales, siltstones, and thin sandstones, which locally contain lignite and coal beds. The thickness of the Fort Union Formation varies from place to place in the Basin.

The Fort Union Formation is unconformably overlain by sediments of Eocene age, which consist of about 6,200 feet of basin fill. In the northern and northeastern portions of the Basin the Eocene is represented by thick, medium to coarse-grained arkosic sandstones and conglomerates of the Battle Spring Formation. The Battle Spring Formation represents a large alluvial fan complex relatively close to the sediment source in the ancestral Granite Mountains to the north. In the southern and southwestern portions of the Basin the Battle Spring Formation undergoes a facies transition into intertonguing units of the Wasatch and Green River Formations which represent distal fluvial and lacustrine depositional environments, respectively. The lithology of these units is predominately sandstone, claystone, siltstone, limestone, conglomerate and include thin lignite beds. Pliocene pediment deposits and recent alluvium cover large areas of the surface in the Basin.

The LC East Amendment Area is located near the north-central part of the Basin. Here the Basin fill consists of the Eocene Battle Spring and Wasatch Formations plus the Paleocene Fort Union Formation. The upper portions of the stratigraphic section consist of Battle Spring Formation underlain by a tongue of the Wasatch Formation. The combined thickness of the Battle Spring and Wasatch formations under the Permit Area is approximately 6,200 feet. The Battle Spring/Wasatch formations are unconformably underlain by the Fort Union Formation which is approximately 4,650 feet thick beneath the Permit Area. The Fort Union Formation, in turn, is unconformably underlain by numerous Cretaceous, Jurassic, Triassic, Paleozoic, and Precambrian basement lithologic units.

Approximately six to eight miles southwest of the LC East Amendment Area, the Battle Spring Formation interfingers with the Wasatch and Green River Formations of equivalent age (Eocene) within a belt roughly 15 miles wide. The Wasatch and Green River Formations collectively represent low-energy fluvial, lacustrine and paludal depositional environments which are time-equivalents of the alluvial fan deposits of the Battle Spring Formation. **Figure 3.4-1** schematically illustrates the stratigraphic relationships of Tertiary sediments within the Great Divide Basin, and the specific LC East stratigraphy.

3.4.1.2 Structure

The present geomorphological features of the Basin were generated by geologic events of the Laramide Orogeny. During this upheaval, in the Late Cretaceous and Early Tertiary, bounding structures surrounding the Basin were formed or rejuvenated. The Wind River Mountains and Granite Mountains were thrust upward on the north side of the Basin. The Rawlins Uplift formed to the east; the Wamsutter Arch formed to the south; and the Rock Springs Uplift formed to the west. All of these highs formed a ring around the Basin, transforming the Basin into a bowl-shaped geological structure with internal drainage only.

The Great Divide Basin is asymmetrical in shape, with its major axis trending west-northwest. Strata in some locations along the basin margin may dip as much as 25 degrees. Dips gradually become gentler toward the center of the Basin, and in the LC

East Amendment area they are approximately one to three degrees westerly and southwesterly.

Gentle folding during late Eocene accompanied late-stage regional thrusting resulting in several broad anticlinal and synclinal folds within the Basin. A few anticlines are oil-bearing (at levels much deeper than the uranium-bearing formations). Noteworthy among these is the Lost Soldier anticline at the northeastern edge of the Basin, approximately 15 miles northeast of the LC East Amendment area. The Battle Spring and Fort Union formations, as well as older units, crop out on the southwest flank of the anticline with dips of 20 to 25 degrees.

Deep-seated regional thrust faulting associated with the Wind River uplift occurred at depth in the north-central portions of the Great Divide Basin. The horizontal component of displacement is possibly greater than nine miles. However, displacement along these faults did not extend to the surface, such that the upper portions of the Battle Spring Formation are largely undisturbed. Shallow normal faulting is also common throughout the central Great Divide Basin, having a preferential orientation that is generally east-west. These are relatively local and appear to be the result of late stage events in the structural history of the Basin. They are believed to be the result of a regional extension event and possibly also of isostatic unloading within the basin due to regional erosion. They may be associated with the Chicken Springs fault system as shown on published geological maps but are not considered to be currently active. Displacements are generally less than 100 feet and most commonly are less than 50 feet.

3.4.2 Site Geology

Outcrop within the entire LC East Amendment area is represented solely by the upper portions of the Battle Spring Formation, which is the host to uranium mineralization. The depositional environment of the Battle Spring Formation is that of a major alluvial fan system extending from the ancestral Granite Mountains to the north. The Formation consists of abundant thin to thick beds of medium to coarse sandstones separated by a multitude of thin to medium thick layers of mudstone, claystone and siltstone. The sandstone facies represent fluvial channel fill depositional environments, whereas the shaley units represent channel margin and overbank depositional environments. The anastomosing nature of the fluvial channels has resulted in complex stratigraphy which tends to be erratic and lacking long range continuity. Detailed geological correlation has partitioned the stratigraphy into multiple named "Horizons" dominated by sandstone and separated by named shale intervals. Stratigraphic nomenclature is described in more detail in the following Sections and illustrated on **Figure 3.4-2**.

The lithology of the Battle Spring Formation within the LC East Amendment area consists of approximately 60% to 80% weakly consolidated, medium to coarse, commonly conglomeratic, clean arkosic sands in units from five to 50 feet thick; separated by 20% to 40% interbedded mudstone, claystone, siltstone, and fine sandstone, generally less than 25 feet thick (**Figure 3.4-2**). This lithological assemblage remains relatively consistent throughout the entire vertical section of interest within the Battle Spring Formation, such that the lithology of the shallowest units is virtually identical to that of the deepest units of interest. Economic uranium mineralization is mainly associated with medium to coarse-grained sand facies.

Like at Lost Creek, the most significant mineral resources in the LC East Amendment occur within two major stratigraphic horizons: the HJ and the KM Horizons. The HJ Horizon is currently being developed under the Lost Creek Permit. The KM Horizon underlies the HJ Horizon and contains additional economic mineralization which will be targeted for production in both the Lost Creek and LC East areas. To date, a total of over 18 individual roll fronts have been identified in the HJ and KM Horizons within a composite stratigraphic interval of approximately 225 feet.

Mineralization also occurs within the FG Horizon. It is secondary to that of the HJ and KM and will require significant drilling and assessment to determine economic viability. Mineral discoveries have also been made in the L, M, and N Horizons, which are collectively referred to as the Deep Horizons. Economic assessment of the FG and Deep Horizons will require additional exploration efforts and they are not the focus of current permitting activity.

The combined HJ and KM mineral trend within the LC East Amendment area is referred to as the East Mineral Trend (EMT). It extends in a general southwest to northeast orientation for approximately five miles (**Plates 3.4-1** and **3.4-2**). The composite width of the EMT varies considerably from 200 to 1,500 feet. The EMT represents a separate mineral trend from the Main Mineral Trend (MMT), which is currently being mined in the Lost Creek Permit area. However, it is considered to be the product of the same regional mineralizing event and therefore virtually contemporaneous and similar in most respects.

Mineralization within the LC East Amendment area occurs as roll front type uranium deposits. It is similar in character to that in the Lost Creek Permit area in virtually all respects. The geometry of mineralization is dominated by the classic roll front "C" shape or crescent configuration at the alteration interface. Thickness of mineralization within each roll front may vary from 5 to 25 feet thick. Typical thickness is from 10 to 15 feet. Mineral intercepts of over 25 feet in total thickness are common where multiple roll fronts occur stacked on top of each other. Average grade is approximately 0.055% eU_3O_8. Mineralization on individual roll fronts within the deposit is typically 25 to 75 feet wide and is very sinuous. Roll fronts in both the HJ and KM Horizons are stacked vertically and commonly overlie each other in a complex, erratic, anastomosing pattern in plan-view.

Depth to the top of any given unit can vary from one end of the EMT to the other by up to 400 feet due to regional dip of one to three degrees, and to displacement by normal faulting. Within the LC East Amendment area, the depth to the top of the HJ Horizon ranges from 375 feet in the south to outcropping in the northern limits of the project. Likewise, the depths to the top of the KM Horizon vary from 500 feet to 100 feet, respectively.

3.4.2.1 Stratigraphy

The upper portion of the Battle Spring Formation is host to the uranium mineralization in the LC East Amendment area. Being the product of an alluvial fan depositional environment, the Battle Spring Formation can be described as a very thick sequence composed predominantly of numerous channel sands typically from five to 50 feet thick interfingered with innumerable shales typically two to 25 feet thick which represent channel margin and overbank environments. Lateral extent of both of these lithologies can range from 100 feet to miles. Where multiple sand channels are stacked on top of each other, the cumulative sand thickness and width can be considerable. The erratic nature of these narrow channels results in stratigraphy which can be highly variable. The outcome can be very complex, where interfingering or abrupt facies changes may result in drastic changes in shale or sand thickness over short distances. This is well illustrated in the thickness isopach maps of the various units of interest (**Plates 3.4-3** thru **3.4-7**) where discernable patterns of deposition are virtually absent; and also in the Geologic Cross-sections (**Plates 3.4-8** thru **3.4-17**).

Sedimentary and depositional conditions throughout the entire Battle Spring interval of interest remained quite consistent and uniform. Consequently, from a lithological and stratigraphic perspective there is little difference between deeper units and those near the surface. Distinctive characteristics of given stratigraphic intervals are subtle and generally are not consistent regionally, consequently partitioning into meaningful stratigraphic units remains largely arbitrary. Vertical boundaries have been defined at shale units showing the greatest regional continuity, or lacking that, at pre-established thickness intervals.

In the LC East Amendment area, the top 1,200 feet of the Battle Spring Formation represents the interval of interest. Within this interval the stratigraphy has been sub-divided into several thick stratigraphic "Horizons" (e.g. HJ or KM). Horizons are dominated by sands and separated from each other by **"Named Shales"** of regional extent. Each horizon, however, is in actuality the composite of numerous "sands" which are in turn separated by numerous **"Unnamed Shales"** within the horizon. Unnamed shales may be quite areally extensive, or may be only of local extent. Note also that the term "shale" is used herein rather loosely, as it commonly may include considerable amounts of siltstone or fine grained sand in addition to the typical mudstone and claystone.

Horizons of primary interest are further subdivided into "Sub-Horizons" (e.g., LFG, UHJ, and UKM). Criteria for establishing sub-horizons are based largely on a combination of continuity of sand packages and continuity of associated mineral horizons. Vertical boundaries between sub-horizons are established somewhat arbitrarily and may or may not coincide with the presence of an intervening shale.

The resulting system of stratigraphic nomenclature is illustrated in the Stratigraphic Column within **Figure 3.4-2**. This nomenclature is internal to Ur-Energy and is not recognized officially by the geological community. The foundation for this system has been carried over, with some modification, from that established by Conoco Minerals during its early exploration activities in the region and subsequently adopted by Texasgulf during its tenure with the property. Nomenclature terms from surface downward to the KM Horizon were inherited from previous operators; below that the terms were derived by Ur-Energy.

Note that in the last few years Ur-Energy has abandoned the use of the term "Sand" in favor of the term "Horizon" to describe the major stratigraphic units. It is believed that the term "Sand" can be misleading in recognition of the fact that any substantial stratigraphic interval consists not only of sand facies but also contains a considerable number of interbedded shales which yields hydrogeological characteristics significantly different than an interval consisting only of sand. Also note that the boundaries between horizons (i.e. Named Shales) have been established on a relatively arbitrary basis and don't necessarily reflect patterns or breaks in sedimentary or depositional characteristics. As a result, the system of nomenclature as illustrated on **Figure 3.4-2** should be viewed essentially and simply as a cataloguing tool for stratigraphic organization.

Named Shales represent the shaley interval nearest the stratigraphic level established as the break between Horizons. Strictly defined they represent the shaley interval between the lowest sand assigned to the overlying Horizon and the uppermost sand assigned to the underlying Horizon. The Battle Spring interval of interest contains many more shales (unnamed) than just the Named Shales (see Type Log LCE149, **Figure 3.4-3** and Geological Cross-Sections **Plates 3.4-8** to **3.4-17**). As such, Named Shales may not be the dominant shale in any given area nor represent the only shale occurring between production sands. Named Shales may not be regionally continuous; or they may represent a series of shales which can be overlapping en-echelon or complexly interwoven with vertically adjacent sands. Because of this complexity, thickness values selected for shale isopach mapping (**Plates 3.4-3, 3.4-5** and **3.4-7**) may not represent all shales in such a series, but rather only the one that best correlates to the stratigraphic nomenclature boundary. Shale complexity is well illustrated in the Cross-Sections (**Plates 3.4-8** thru **3.4-17**)

The most notable shales are the LCS and SBS Shales which exhibit a high degree of regional continuity and confinement, although locally may display considerably complexity.

Provided below is a brief description of each named stratigraphic unit within the Lost Creek Project. The general lithologic character of the units remains relatively consistent throughout the entire property, however depths below ground surface (bgs) may vary significantly locally due to regional stratigraphic dip and displacement due to normal faulting.

A Horizon –The A Horizon is not present in the LC East Amendment area, having been removed by erosion.

BC Horizon – The BC Horizon is the horizon occurring at the surface within the majority of the Lost Creek Project; however, similar to the A Horizon, the BC Horizon has been removed by erosion over the vast majority of the LC East Amendment area. Thin remnants remain only in the northern portions of Sections 20 and 21 in areas that had been down-dropped by faulting. Maximum depth is approximately 50 to 75 feet. When present, lithologic data is often missing in drill logs because it occurs above the fluid level in the drill hole while logging. Fluid in the hole is required to generate the single point resistance and spontaneous potential (SP) curves used for lithological characterization. In general, it appears to be similar in character to the adjacent underlying DE Horizon. The upper and lower boundaries are arbitrary and poorly defined. Thickness is approximately 80 to 100 feet. The BC Horizon is dry and hosts no significant mineralization.

DE Horizon – This Horizon occurs at the surface in the southern and central portions of LC East Amendment area, but has been removed by erosion in the northern portions. In the LC East Amendment area, the top of the unit ranges in depth from surface to approximately 70 feet and is approximately 80 feet thick where the entire section is present. The DE Horizon is dry everywhere within the LC East Amendment area and carries no significant mineralization.

EF Shale (formerly the Upper No Name Shale) – The EF Shale represents the boundary between the overlying DE Horizon and the underlying FG Horizon. Hydrogeological continuity and confinement by the EF Shale is uncertain as lithologic data in drill logs is often missing, as mentioned above. It crops-out in a northwesterly strike near the common corner between Sections 10, 11, 14 and 15 and is absent to the north. Thickness varies considerably from a few feet to 30 feet. Where present, depths to the top of the EF Shale vary: from surface to 150 feet in the down-dropped northwestern portions of Section 20.

FG Horizon – The FG Horizon crops-out in the northern one-third of the LC East Amendment area. It reaches its deepest in the northern portions of Section 20 where depth to its top is approximately 150 feet. The total thickness of the FG Horizon ranges between 160 to 180 feet. Stratigraphically, the FG Horizon is subdivided into three sub-horizons: the Upper FG (UFG), Middle FG (MFG) and the Lower FG (LFG), all roughly of equal thickness. The breaks between these are not rigidly defined. Generally, they are selected based on significant shales (if present) which separate channel-fill sequences. The FG commonly consists of sands and intervening shaley units which are thinner, more erratic than what is characteristic of the underlying HJ and lower horizons; and as a whole the FG has a lower SS/Sh ratio. Locally the FG contains significant mineralization in the LC East Amendment area. However, no recovery from the FG is planned.

Lost Creek Shale (LCS) – The Lost Creek Shale separates the FG and HJ Horizons. It is a dominant shaley horizon which has been observed to be continuous throughout the LC East Amendment area. For this reason, it has been used as the datum for stratigraphic and structural correlation. Thickness ranges from 5 to 40 feet, typically being from 10 to 20 feet. Depth ranges from approximately 350 feet in the northern portions of Section 20 to outcropping in the far northern portions of the Amendment area. Its lithology is dominated by silty mudstone and dense claystone. It commonly includes siltstone, and may locally be sandy or contain thin lenticular sands. Segments of the LCS commonly interfinger with lower sands of the FG Horizon and upper sands of the HJ Horizon. This can complicate correlation and often results in dramatic changes in the thickness of the LCS within short horizontal distances. A thickness isopach map for the LCS Shale is presented as **Plate 3.4-3**.

HJ Horizon – The HJ Horizon is a major host for mineralization in the East Mineral Trend (EMT) and is the host to current production at Lost Creek. The HJ Horizon has been subdivided into four sub-horizons: Upper HJ (UHJ), Middle HJ1 (MHJ1), Middle HJ2 (MHJ2) and the Lower HJ (LHJ). The boundaries between the sub-horizons are somewhat arbitrary but selection is guided by sand channel and roll front mineral horizon continuity. Boundaries may be accompanied by a shale break. The bulk of the uranium mineralization is present in the two MHJ sub-horizons. The HJ Horizon characteristically includes noticeably thicker sands and a high SS/Sh ratio compared to most of the other horizons. The total thickness of the HJ Horizon ranges from approximately 120 to 130 feet, thinning northerly slightly to about 110 feet. Depth to the top of the HJ Horizon within the LC East Amendment area ranges from a maximum of approximately 360 feet in the northern parts of Section 20 to outcropping in the northernmost portions of the Amendment area. **Plate 3.4-4** is a thickness isopach map for the HJ Horizon.

Sagebrush Shale (SBS) – The Sagebrush Shale forms the boundary between the HJ Horizon and the underlying KM Horizon. The SBS is laterally extensive and virtually continuous throughout the LC East Amendment area. Depth to the top of the SBS within the LC East Amendment area ranges from a maximum of 510 feet in the northern parts of Section 20 to 100 feet in northernmost portions of the Amendment area. Thickness varies from 2 to 30 feet. Similar to the LCS, segments of the SBS commonly interfinger with and undergo rapid facies exchanges with lower sands of the HJ Horizon and upper sands of the KM Horizon. This can complicate correlation and often results in dramatic changes in the thickness of the SBS within short horizontal distances, as is evident in the thickness isopach map for the SBS (**Plate 3.4-5**).

KM Horizon – The KM Horizon is also a primary host to the mineralization in the EMT. Nomenclature for the KM was modified in recent years. Initially, and at the time of the original Lost Creek Mine Permit, the KM Horizon was assigned three sub-horizons: the Upper KM (UKM), the Middle KM (MKM) and the Lower KM (LKM). As additional drilling results became available over time it became apparent that the KM is better described as having only two sub-horizons, underlain by the K Shale. Consequently, the MKM designation was abandoned and replaced by the LKM such that the current nomenclature employs only the UKM and LKM.

Its general the character and lithology of the KM is similar to that of the HJ Horizon. Both the UKM and the LKM sub-horizons host mineralization. A shale unit referred to as the No Name Shale (NNS) commonly divides the two sub-horizons of the KM, but it is not always present. Depth to the top of the KM Horizon ranges from approximately 510 feet in the northern parts of Section 20 to about 100 feet in the far northern portions of the Amendment area. Thickness ranges from approximately 100 feet to 130 feet. A thickness isopach map for the KM Horizon is presented as **Plate 3.4-6**.

K Shale – The K-Shale represents the lower boundary of the KM horizon. It occurs throughout the LC East Amendment area, and generally exhibits continuity and adequate confinement. However, it may locally be absent or be represented by multiple overlapping shales. Where this occurs, confinement may not be seamless. Average thickness is 10 feet, ranging from 2 feet to 30 feet. A thickness isopach map for the K Shale is presented as **Plate 3.4-7**. Depth to the K Shale varies from approximately 610 feet in the northern portions of Section 20 to approximately 200 feet at the northern limits of the LC East Amendment area.

L, M, N, and P Horizons – These horizons are collectively referred to as the "Deep Horizons" and occur within a 300 to 350 feet interval below the K Shale. Currently they are the targets of exploration activities. Available drill data for these horizons is much sparser than for the shallower horizons. Individually, each horizon is approximately 100 feet thick. They consist of lithologies identical to that of overlying horizons. In general, like the remainder of the Battle Spring Formation, they are composed of multiple, stacked, coarse sands separated by numerous shale intervals. Stratigraphically, shales within these horizons are often relatively thick and more continuous than seen in the shallower horizons, contributing to an overall lower SS/Sh ratio. At the same time, individual sands tend to be thicker and show more regional continuity. This character becomes more dominant with depth.

L Horizon: Depth to the L Horizon varies from approximately 640 feet in Section 20 to approximately 200 feet in the far north. Commonly the L Horizon exhibits a much more shaley character with more shale interbeds, thinner sands and a much lower SS/Sh ratio than the vertically adjacent horizons.

M Horizon: The M Horizon typically exhibits thick shales with thick well developed sands. Depth to the top of the M Horizon ranges from approximately 720 feet in Section 20 to approximately 300 feet in the far north.

N and P Horizons: The character of these horizons is similar to that of the M Horizon, commonly exhibiting thick shales with well developed sands. Data is relatively limited, particularly in the southern portions of the project, as drilling generally has not penetrated these units. Depth to the top of the N Horizon ranges from 830 to 410 feet and from 930 to 520 feet for the P Horizon.

LM, MN, and NP Shales – These shales represent the lower boundaries of the L, M and N Horizons respectively. Designation of these shales as horizon boundaries was arbitrarily established on roughly 100 foot intervals below the K Shale. As such they do not present unique characteristics compared to any other shales within this stratigraphic interval. Thickness of the shales varies considerably, reaching up to 30 feet with an average of approximately 10 feet. Although these shales have regional extent, continuity is unconfirmed. In many areas drill data spacing is insufficient to confirm correlation.

3.4.2.2 Structure

Bedding within the Battle Spring Formation in the LC Amendment area is nearly flat-lying, dipping gently to the west and southwest at approximately one to three degrees. This regional pattern of strike and dip is modified locally due to horst and graben features resulting from normal faulting, as discussed below.

The dominant geologic structural features in the LC East Amendment area are a complex series of normal faults. The locations of these faults are illustrated in the Structural Contour Map (**Plate 3.4-18**); in the Geological Cross-Sections (**Plates 3.4-8** to **3.4-17**) and in the Isopach Maps; (**Plates 3.4-3** to **3.4-7**). They are believed to be the result of late stage events in the structural history of the Basin resulting from regional extension and possibly also of isostatic unloading within the basin due to regional erosion. Displacement typically exhibits maximum movement of up to 70 feet which tapers in both directions, commonly quite abruptly. Faulting occurred post-deposition and postmineralization, therefore depositional patterns were not influenced by the fault movements and the mineral horizons are offset by faulting. The fault planes are very close to vertical in orientation.

The most prominent faulting occurs in Sections 20 and 21 where a system of faults with displacements of 50 to 70 feet created a series of horsts and grabens (**Plate 3.4-18**). Secondary to these are numerous minor faults which show displacements on the order of 10 feet and which appear to be fairly localized. Collectively the fault series results in a net down-dropping in the northern portions of Sections 20 and 21 resulting in a synclinal feature when viewed in a regional sense, with a northeast-southwest oriented axis.

Pump test results indicate that the faults serve as low-flow boundaries, but are not fully sealed.

3.4.2.3 Ore Mineralogy and Geochemistry

The age of mineralization in the Battle Spring Formation is considered to be between 35 and 26 million years before present. Uranium mineralization in the Basin generally occurs either as tabular or C-shaped roll-front deposits. Oxygen-rich surface water, carrying dissolved uranium, entered various sandstones in the Basin. The water percolated down dip, oxidizing the sandstones on its way down dip. Upon reaching sites rich in organic matter, the water lost its oxidizing potential and deposited the uranium, forming the two types of mineralization mentioned above.

Tabular deposits may form at the interface between oxidizing and reducing conditions (the redox front), where oxidation, for all practical purposes, stops. Localized tabular deposits may also form up-dip from the redox front in an entirely oxidized zone, where carbonaceous materials have gathered and formed locally reducing conditions.

The C-shaped roll-front deposits normally form just at the redox front, where the water loses its oxidizing potential. The uranium precipitates and accumulates in a "C"-shaped deposit, with the concave side facing up-dip toward the oxidized sand. Uranium usually accumulates in finer-grained sandstones that carry various amounts of organic matter, which provides a reducing condition.

The alteration process not only changes the color, but also alters the mineralogy of the host sandstones. The color of unaltered, reduced sandstone is light to dark grey, with carbon trash, dark accessories, and traces of pyrite. Altered, oxidized, sandstone contains iron oxide staining (where former carbonaceous matter and pyrite were present), kaolinized feldspar, and has a pink to tan-buff, greenish-grey to bleached appearance. The presence of pyrite and carbonaceous material appear to be the major controlling factors for the precipitation of uranium mineralization. Thinning of sandstones and diminishing grain size probably slowed the advance of the uranium-bearing solutions and further enhanced the chances of precipitation.

The main uranium minerals are uraninite, a uranium oxide, and coffinite, a uranium silicate. Russell Honea (1979) and John V. Heyse (1979) studied several core samples by scanning electron microprobe (SEM), polished section and thin section. Their conclusions were that the host sands are fine- to coarse-grained, poorly sorted arkose. The uranium mineralization is of sub-microscopic size and can be seen only in SEM magnification. They are associated and at times intergrown with round pyrite particles. The uranium minerals identified are mostly uraninite and, possibly, coffinite. The uranium, besides occurring with pyrite, also occurs as a coating around sand grains and as filling of voids between grains. It also occurs as minute particles within larger clay particles.

The most recent study of the lithology and mineralogy was conducted by Hazen Research under the guidance of Dr. Nick Ferris, Ur-E geologist (Ferris, 2007, company report). He concluded that the rocks, represented by a core sample from a depth of 506 to 507 feet of Hole Number LC-64C, are composed of medium- to coarse-grained sand with interstitial clay and silt. Uranium occurrences are very fine-grained and micron-sized, and are mainly dispersed throughout some of the interstitial clays, and occur similarly in some of the interstitial pyrite as well. Because of the size of uranium mineral particles, it was not certain whether the uranium mineral was coffinite or uraninite. The sample tested, comes from the Upper KM Sand unit and may or may not be representative of the majority of the mineralization in the overlying HJ Horizon within the Permit Area.

Known mineralized intervals are found at depths ranging from near surface down to 1,150 feet below the surface in the Permit Area. It is possible that deeper mineralization may exist as well. The main mineralization horizons trend in an east-northeast direction for at least three miles, and are up to 2,000 feet wide. The thickness of individual mineralized beds at the Permit Area ranges from five to 28 feet and averages about 16 feet. The mineralization grade ranges from 0.03 percent to more than 0.20 percent equivalent uranium oxide (eU_3O_8). Four main mineralized horizons, from depths of 300 to 700 feet, have been identified. The richest mineralized zone occurs in the middle part of the HJ Horizon (MHJ Sand) and it is about 30 feet thick, 400 to 450 feet deep, and is believed to contain more than 50 percent of the total resource under the Permit Area.

Leach amenability studies, using the bottle roll method, were performed on core samples collected from the Permit Area in 2007. The analytical results of the bottle roll tests indicate leach efficiencies of 84 percent to 93 percent where bicarbonate was added to the leach solution (a standard in situ recovery practice). The testing demonstrated leach amenability to varying levels of bicarbonate and oxidant addition and accomplished the goal of defining the chemical factors for leaching the ore body and determining the maximum economic leach efficiencies.

The bottle roll tests were conducted using standard industry practice and rigorous modern laboratory controls. The tests were performed on seven uniform splits of a composite core recovered from hole LC66C. Oxidation of uranium in core that has been exposed to the atmosphere can increase the leachability of the uranium, yielding results which are not representative of the in situ deposit. Therefore, the drill core was vacuum sealed in airtight plastic sleeves immediately after recovery to protect the uranium bearing minerals from exposure to the air.

Upon completion of the coring program, the sealed core was characterized by geologists and transferred to the laboratory. A single core composite of eight feet of core was selected for leach amenability, bicarbonate and oxidant studies. The selected core composite was chosen to represent a typical production zone for the Project. The composite splits were then subjected to "bottle roll" amenability testing in which each individual sample was placed in a plastic container with a hydrogen peroxide lixiviant in a measured volume estimated to be five pore volumes of the tested interval, and then rolled mechanically for 16 hours. The lixiviant was extracted and tested for uranium content in the solution and new lixiviant was added and the process was repeated. Each sample was subjected to five additional periods of leaching, to represent the total volume of fluid that would leach uranium from the host over the life of an in situ recovery operation. These six roll sets, each being leached with five pore volumes of lixiviant, replicates a total of 30 pore volumes of lixiviant passing through the deposit, thus closely simulating an actual in situ leach operation. Once the six sets of rotation were completed, the core was analyzed to determine the amount of uranium remaining, in order to establish the efficiency of the leaching system. This allows a determination of the potential in situ leachability of the uranium-bearing sandstone and the potential rate of recovery.

A total of seven tests were conducted. The first test, LC-2001-01, showed low recovery without a bicarbonate addition, which demonstrated the requirement for bicarbonate addition to the lixiviant and the effectiveness of the sample preparation for the test. The other six samples (LC-2001-02 through -07) successfully demonstrated the ore's wide range of amenability to varying chemical conditions. The results of these tests demonstrate that uranium is easily mobilized for production and that the chemical conditions utilized in the tests will be equally effective under both low and high oxidant injection rates. The results of this testing are summarized in **Table 3.4-1**.

Mineralogy has been studied in thin section and by x-ray diffraction analysis. These analyses were conducted in 2007 by Hazen Research which included samples from the KM Horizon derived from core (core-hole LC64C). Results indicate that the uranium in the KM is virtually identical to that in the HJ Horizon, occurring primarily as the mineral coffinite (uranium silicate) in the form of micron- to submicron-size inclusions disseminated in and on interstitial clay, possibly absorbed by cation exchange; also intimately interspersed through some of the pyrite and as partial coatings on quartz and biotite. Minor amounts of uraninite (uranium oxide) and brannerite (uranium-titanium oxide) have also been identified. Clay rich fractions are predominantly smectite (montmorillonite), with minor kaolinite.

The Hazen Research analysis concluded that uranium should be recoverable by an ISR operation because of the unconsolidated nature of the sandstone and expected diffusion of the lixiviant through the smectite minerals. Leach amenability tests as discussed in the original Permit Application included one set of core samples collected from the UKM Horizon (core-hole LC46C). Recoverability has been confirmed by these leach testing results, which revealed that the character of KM mineralization is virtually identical to that in the HJ Horizon.

The nature of the uranium mineralization in the HJ and KM Horizons at the LC East Project is identical to that observed at the Lost Creek Project and therefore can be reasonably presumed to be identical in ore mineralogy and leaching amenability. No site-specific petrographic or leaching tests have been conducted for the LC East Project.

3.4.2.4 Historic Uranium Exploration Activities

The ground currently designated as the LC East Amendment area has been extensively drilled in the past and can be considered to be in the mid to late exploration phase in the northern portions and pre-development phase in the southern portions. The earliest drilling was started in 1967 by Wolf Land and Exploration who was later joined in a joint venture by Conoco in 1969. Also, in 1967 Hecla Mining drilled one exploration hole on what is currently the LC East Project. Conoco took full control of the Red Desert venture in 1970 and continued to drill the property through 1977 as part of its Project A. By that time approximately 916 exploration holes had been drilled, including 13 core holes. Abundant significant mineralization had been found and a well-defined mineral trend identified, which is currently referred to as the EMT. Much of the drilling was on 200-foot spacing and in several localities has a spacing of 100 feet or less.

In 1978, Texasgulf joint-ventured with Conoco as the operator on Project A. They continued defining the trend by drilling an additional 126 exploration holes through 1981, including three core holes of very shallow targets (less than 150 feet). Texasgulf discontinued their operations in the Great Divide Basin in 1983. Portions of the current LC East Project were later acquired by PNC Exploration in 1987. In 1990 they drilled 21 holes within the current LC East Project in conjunction with their activities on the MMT in the Lost Creek Project. PNC released their property in 2000. Since then, no additional exploration drilling activity had been conducted in LC East until activities by URE in

2012. Prior to acquisition by URE, a total of 1,064 historical exploration holes for a total of 474,582 feet of drilling had been drilled within the currently defined LC East Project, including one water well which has since been abandoned. Drilled depths average 446 feet, ranging from 40 feet to 2,257 feet. Exploration by URE has been limited to 16 widely spaced stratigraphic test holes.

Since acquisition, URE has conducted pre-development drilling activities consisting of 179 delineation holes for a total of 114,600 feet of drilling, plus the installation of 28 baseline monitors and pump test wells totalling 11,945 feet. Baseline environmental studies have also been conducted and concluded.

No uranium production has been conducted in the past within the LC East Amendment holes.

3.4.3 Seismology

The discussion of the seismology of the Permit Area and surrounding areas includes: an analysis of historic seismicity (**Figure 3.4-4**); an analysis of the Uniform Building Code (UBC); a deterministic analysis of nearby faults; an analysis of the maximum credible "floating earthquake;" and a discussion of the existing short- and long-term probabilistic seismic hazard analysis. The materials presented here are mainly based on the seismologic characterization of Sweetwater, Carbon, Fremont, and Natrona Counties by James C. Case and others from the Wyoming State Geological Survey (Case et al., 2002a, 2002b, 2002c and 2003).

Town of Bairoil Area

Bairoil is located about 15 miles northeast of the Permit Area. Historically, there have been only a few earthquakes that have occurred within 20 miles of Bairoil. On August 11, 1916, a non-damaging intensity III earthquake occurred approximately 17 miles northwest of Bairoil. On June 1, 1993, a non-damaging magnitude 3.8, intensity III earthquake occurred four miles north of Bairoil, and was felt by some residents. On December 10, 1996, a non-damaging magnitude 2.6 earthquake occurred approximately ten miles northwest of Bairoil. A few residents also felt that event.

Two recent earthquakes were recorded near Bairoil in 2000. On May 26, 2000, a magnitude 4.0 earthquake occurred, followed by another (magnitude 2.8) four days later, on May 30, 2000. Both earthquakes were located about 3.5 miles southwest of Bairoil. Most residents in Bairoil felt the first earthquake. No significant damage was associated with either seismic event (Cook, 2000).

Town of Rawlins Area

Rawlins is approximately 38 miles southeast of the Permit Area. The first recorded earthquake that was felt and reported immediately southwest of Rawlins occurred on March 28, 1896. The intensity IV earthquake shook for about two seconds. On March 10, 1917, an earthquake (intensity IV) was recorded approximately one-mile northeast of Rawlins. The earthquake was felt as a distinct shock that caused wooden buildings to noticeably vibrate. Stone buildings were not affected by the event (*Rawlins Republican*, 1917).

On September 10, 1964, a magnitude 4.1 earthquake occurred approximately 30 miles west of Rawlins. One Rawlins resident reported that the earthquake caused a crack in the basement of his home in Happy Hollow. No other damage was reported (*Daily Times*, 1964).

Small earthquakes were detected, on April 13, 1973, May 30, 1973, and June 1, 1973, approximately six miles west of Hanna. No one reported feeling these events. On July 11, 1975, Rawlins residents felt an earthquake (intensity II) event. On January 27, 1976, an earthquake (magnitude 2.3, intensity V) occurred approximately 12 miles north of Rawlins. Several people reported that they were thrown out of bed (*Daily Times*, 1976). On March 3, 1977, an earthquake (intensity V) was reported approximately 18.5 miles west-northwest of Encampment. Doors and dishes were rattled in southern Carbon County homes; but no significant damage was reported (*Laramie Daily Boomerang*, 1977).

On April 13, 1991 and April 19, 1991, magnitude 3.2 and magnitude 2.9 earthquakes, respectively, occurred near the center of the Seminoe Reservoir. A magnitude 3.1 earthquake occurred on December 18, 1991, southwest of the Seminoe Reservoir, approximately 15 miles northeast of Sinclair. No one reported feeling these Seminoe-Reservoir-area earthquakes. On August 6, 1998, a magnitude 3.6 earthquake occurred approximately 13 miles north of Rawlins. Residents in Rawlins reported hearing a sound and then feeling a jolt. On April, 1999, a magnitude 4.3 earthquake occurred approximately 29 miles north-northwest of Baggs. It was felt in Rawlins; and residents reported that pictures fell off the walls.

Town of Rock Springs Area

Rock Springs is located approximately 80 miles southwest of the Permit Area. The first recorded earthquake that was felt in Sweetwater County occurred on April 28, 1888. This intensity IV earthquake, which originated near Rock Springs, did not cause any appreciable damage. On July 25, 1910, an intensity V earthquake occurred at the same time that the Union Pacific Number One Mine in Rock Springs partially collapsed. On July 28, 1930, an intensity IV earthquake, with an epicenter near Rock Springs, was felt in Rock Springs and Reliance (*Casper Daily Tribune*, 1930). The earthquake awakened many residents; and some merchandise fell off of store shelves.

On March 21, 1942, a non-damaging, intensity III earthquake was felt in the Rock Springs area. This event was followed, on September 14, 1946, by an intensity IV earthquake. On October 25, 1947, a small earthquake with no assigned intensity or magnitude occurred southeast of Rock Springs. Two intensity IV earthquakes occurred in the Rock Springs area on September 24, 1948. The events rattled dishes in parts of Rock Springs.

A magnitude 3.9 event was recorded on January 5, 1964, approximately 23 miles south of Rock Springs. The University of Utah Seismograph Stations detected a non-damaging, magnitude 2.4 earthquake on March 19, 1968. This event was centered approximately 17 miles southeast of Rock Springs. A magnitude 3.2 event occurred on May 29, 1975, approximately 13 miles northeast of Superior. A week later, on June 6, 1975, a magnitude 3.7 earthquake was recorded in the same area. No damage was associated with any of the 1975 events.

The University of Utah Seismograph Stations recorded a non-damaging magnitude 2.7 earthquake on June 5, 1986. This event was located approximately 14 miles southwest of Green River, Wyoming.

On February 1, 1992, the University of Utah Seismograph Stations recorded a non-damaging magnitude 2.3 earthquake, approximately seven miles north of Rock Springs.

City of Lander Area

Lander is about 70 miles northwest of the Permit Area. A number of earthquakes have occurred in the Lander area. The first reported earthquake occurred on January 22, 1889, and had an intensity of III to IV. This was followed by an intensity IV event on November 21, 1895, during which houses were jarred and dishes rattled. On November 23, 1934, an intensity V earthquake was centered approximately 20 miles northwest of Lander. For a radius of ten miles around Lander, residents reported that dishes were thrown from cupboards, and that pictures fell down from the walls. Cracks were found in buildings along two business blocks; and the brick chimney of the Fremont County Courthouse was separated by two inches from the building. The earthquake was felt at Rock Springs and Green River, Wyoming (*Casper Tribune-Herald*, 1934).

There were a series of earthquakes in the Lander area in the 1950s that caused little damage. On August 17, 1950, there was an intensity IV earthquake that caused loose objects to rattle and buildings to creak. On January 12, 1954, there was an intensity II event; and on December 13, 1955, there was an intensity IV event near Lander, with no damage reported.

On June 14, 1973, a small earthquake was reported about eight miles east-northeast of Lander. The earthquake has been recently interpreted as a probable explosion. On January 31, 1992, a non-damaging magnitude 2.8 earthquake occurred approximately 20 miles northwest of Lander. This event was followed, on October 10, 1992, by a magnitude 4.0, intensity III earthquake centered approximately 22 miles east of Lander.

City of Casper Area

Casper is located about 90 miles northeast of the Permit Area. Two of the earliest recorded earthquakes in Wyoming occurred near Casper. The first was on June 25, 1894, and had an estimated intensity of V. In residences on Casper Mountain, dishes rattled and fell on the floor and people were thrown from their beds. Water in the Platte River changed from fairly clear to reddish, and became thick with mud, due to the river banks slumping into the river during the earthquake. On November 14, 1897, an even larger event was felt. An intensity VI to VII earthquake, one of the largest recorded in central and eastern Wyoming, caused considerable damage to a few buildings. As a result of the earthquake, a portion of the Grand Central Hotel was cracked from the first to the third story. Some of the ceilings in the Grand Central Hotel were also severely damaged.

On October 25, 1922, an intensity IV earthquake was reported in the Casper area. The event was felt in Casper; at Salt Creek, 50 miles north of Casper; and at Bucknum, 22 miles west of Casper. Dishes were rattled and hanging pictures were tilted near Salt Creek. No significant damage was reported in Casper (Casper Daily Tribune, 1922). On December 11, 1942, an intensity IV earthquake was recorded north of Casper. Although no damage was reported, the event was felt in Casper, Salt Creek, and Glenrock (Casper Tribune-Herald, 1941). On August 2, 1948, another intensity IV earthquake was reported in the Casper area. No damage was reported (Casper Tribune-Herald, 1948). In the 1950s, two earthquakes caused some concern among Casper residents. On January 24, 1954, an intensity IV earthquake near Alcova did not result in any reported damage (Casper Tribune-Herald, 1954). On August 19, 1959, an intensity IV earthquake was felt in Casper. Most recently, on October 19, 1996, a magnitude 4.2 earthquake was recorded approximately 15 miles north-northeast of Casper. No damage was reported.

3.4.4 Uniform Building Code

With safety in mind, the UBC provides Seismic Zone Maps to help identify which building design factors are critical to specific areas of the country. Five UBC seismic zones are recognized, ranging from Zone 0 to Zone 4. These seismic zones are, in part, defined by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years. The criteria used for defining boundaries on the Seismic Zone Map were established by the Seismology Committee of the Structural Engineers Association of California (SEAOC, 1986). The criteria they developed are as follows:

- Zone 4: ≥ 30 percent gravity (g) effective peak acceleration;
- Zone 3: 20 to ≤ 30 percent g effective peak acceleration;
- Zone 2: 10 to ≤ 20 percent g effective peak acceleration;
- Zone 1: 5 to ≤ 10 percent g effective peak acceleration; and
- Zone 0: ≤ 5 percent g effective peak acceleration.

The Seismology Committee of the Structural Engineers Association of California assumed that there was a 90 percent probability that the above values would not be exceeded in 50 years, or a 100 percent probability that the values would be exceeded in 475 years.

Figure 3.4-5 shows the delineation of UBC seismic zones in Wyoming. The Permit Area is located in Seismic Zone 1. Since effective peak accelerations (90 percent chance of non-exceedance in 50 years) can range from five to ten percent g in Zone 1, it may be reasonable to assume that an average peak acceleration of 7.5 percent g could be applied to the design of a non-critical facility located near the center of Zone 1.

3.4.5 Deterministic Analysis of Active Fault Systems

There are two active fault systems in the vicinity of the Permit Area, the Chicken Springs Fault System and the South Granite Mountain Fault System (**Figure 3.4-6**).

The Chicken Springs Fault System, located six miles east of the Permit Area, is composed of a series of east-west trending segments. In 1996, the Wyoming State Geological Survey investigated this fault system, and determined that the most recent activity on the system appears to be Holocene in age. Reconnaissance-level studies indicated that the fault system is capable of generating a magnitude 6.5 earthquake (Case et al., 2002a). A magnitude 6.5 earthquake on the Chicken Springs Fault System would generate peak horizontal accelerations of approximately 4.8 percent g at Rawlins (Case et al., 2002a). These accelerations would be roughly equivalent to an intensity V earthquake, which may cause some light damage. Bairoil, however, would be subjected to a peak horizontal acceleration of approximately 23 percent g, or an intensity VII earthquake (Case et al., 2002a). Intensity VII events have the potential to cause moderate damage.

The South Granite Mountain Fault System is located about 14 miles northeast of the Permit Area. This fault system is composed of several northwest-southeast trending normal and thrust faults in southeastern Fremont County and northwestern Carbon County. The active segments of the system have been assigned a maximum magnitude of 6.75, which could generate peak horizontal accelerations of approximately 20 percent g at Bairoil and 6.1 percent g at the Rawlins (Case et al., 2002a). These accelerations would be roughly equivalent to an intensity VII earthquake at the Bairoil and an intensity V earthquake at Rawlins. Bairoil could sustain moderate damage; whereas minor or no damage could occur at Rawlins.

3.4.6 Maximum Tectonic Province Earthquake "Floating Earthquake" Seismogenic Source

Tectonic provinces are regions with a uniform potential for the occurrence of earthquakes that are tied to buried faults with no surface expression. Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly, and, as a result, can theoretically occur anywhere within that area of uniform earthquake potential. In reality, that random distribution may not be the case, as most earthquakes are associated with specific faults. If all buried faults have not been identified, however, the distribution has to be considered random. "Floating earthquakes" are earthquakes that are considered to occur randomly in a tectonic province.

The US Geological Survey (USGS) identified tectonic provinces in a report titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" (Algermissen et al., 1982). In that report, Sweetwater County was classified as being in a tectonic province with a "floating earthquake" maximum magnitude of 6.1. Geomatrix (1988) suggested using a more extensive regional tectonic province, called the "Wyoming Foreland Structural Province," which is approximately defined by the Idaho-Wyoming Thrust Belt on the west, 104 degrees West longitude on the east, 40 degrees North latitude on the south, and 45 degrees North latitude on the north. Geomatrix (1988) estimated that the largest "floating earthquake" in the "Wyoming Foreland Structural Province" would have a magnitude in the 6.0 to 6.5 range, with an average value of magnitude 6.25.

3.4.7 Short-Term Probabilistic Seismic Hazard Analysis

The USGS publishes probabilistic acceleration maps for 500-; 1,000-; and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a ten percent probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100 percent probability of exceedance in 500 years.

The 500-year map provides accelerations that are comparable to those derived from the UBC and from the deterministic analysis on the Green Mountain Segment of the South Granite Mountain Fault System. It was often used for planning purposes for average structures. Based on the 500-year map (ten percent probability of exceedance in 50 years), the estimated peak horizontal acceleration in the Permit Area is approximately 6.5 percent g, which is comparable to the acceleration expected in Seismic Zone 1 of the

UBC (**Figure 3.4-7**). These accelerations (3.9 – 9.2 percent g) are roughly comparable to intensity V earthquakes which can result in cracked plaster and broken dishes, but minor or no construction damages (Case, 2002). All facilities, including the processing plant, pipelines and well structures, at Lost Creek will be designed and constructed to sustain an intensity V earthquake. In addition, the observations of injection, production, and pipeline pressures and associated monitor well measurements, necessary for the in situ operation, will provide short-term information about any unanticipated seismic impacts. The estimated acceleration in the Permit Area is 20 percent g on the 2,500-year map.

3.4.8 References

Algermissen ST, Perkins DM, Thenhaus PC, Hanson SL, Bender BL. 1982. Probabilistic estimates of maximum acceleration and velocity in rock in the contiguous United States. Geological Survey (US). USGS open file report No. 82-1033.

Case JC, et. al. 2002a. Basic seismological characterization for Sweetwater County, Wyoming. Wyoming State Geological Survey; September 2002.

Case JC, et. al. 2002b. Basic seismological characterization for Carbon County, Wyoming. Wyoming State Geological Survey; September 2002.

Case JC, et. al. 2002c. Basic seismological characterization for Fremont County, Wyoming. Wyoming State Geological Survey; September 2002.

Case JC, et. al. 2003. Basic seismological characterization for Natrona County, Wyoming. Wyoming State Geological Survey; January 2003.

Cook L. 2000 Jun 1. Earthquake felt in Bairoil. Office of the Wyoming State Geologist. Press release from the Wyoming State Geological Survey.

Ferris N. 2007. Lost Creek petrography and uranium mineralogy. Ur Energy (Denver, CO). Company report.

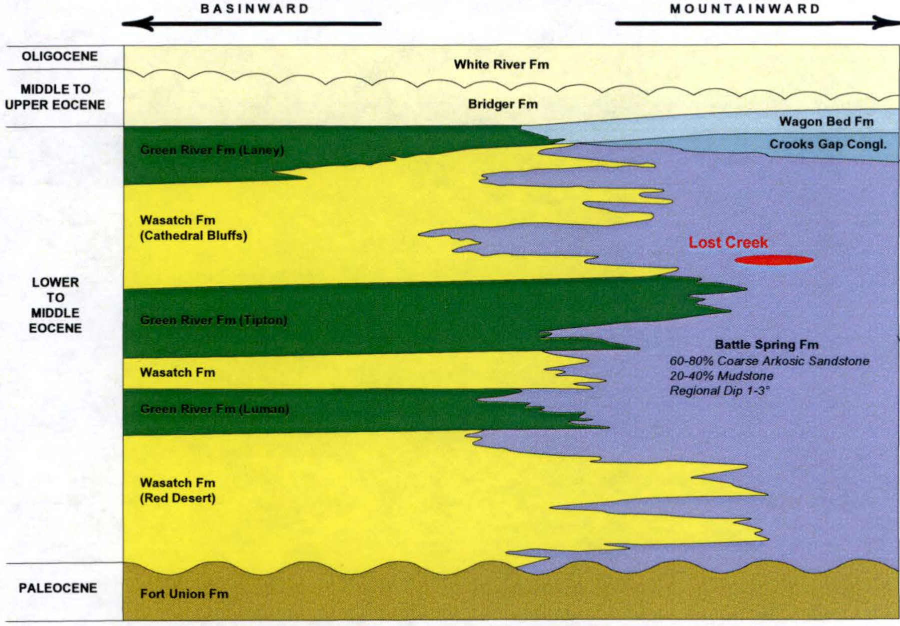
Geomatrix Consultants, Inc. 1988. Seismotectonic evaluation of the Wyoming Basin geomorphic province. Prepared for the Bureau of Reclamation (US). Contract No. 6-CS-81-07310.

Heyse J. 1979. Mineralogy and petrology of the Lost Creek Uranium Ore (Texas Gulf Sulfur property), Sweetwater County, Wyoming. Wyoming Minerals Corporation Report.

Honea R. 1979. Petrographic examination of core samples from Hole TT-152, Lost Creek Site 2, Red Desert, Wyoming. Texas Gulf Company Report.

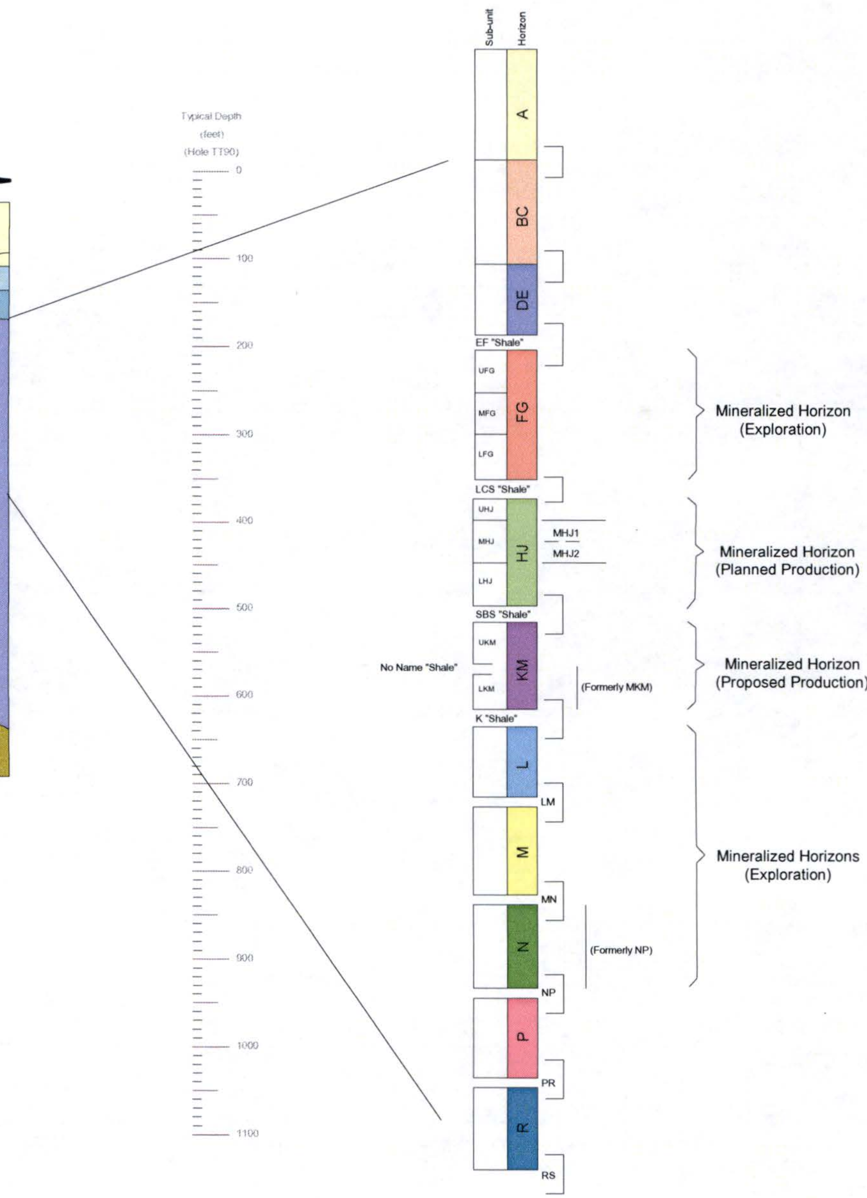
Structural Engineers Association of California (SEAOC). 1986. Building Standards, Seismology Committee of the SEAOC. 1986 September to October. Sacramento (CA).

Stratigraphic Relationships - Schematic



Diagrammatic relationships of Tertiary sedimentary units in the Great Divide Basin, Wyoming (Modified from Pippiringos & Denson, 1970)

Lost Creek Project
Stratigraphic Column



Lost Creek ISR, LLC
Casper, Wyoming, USA

Figure 3.4-1
Stratigraphic Relationships
Lost Creek Project

July 15, 2014 Drawn by: MML

Lost Creek ISR, LLC

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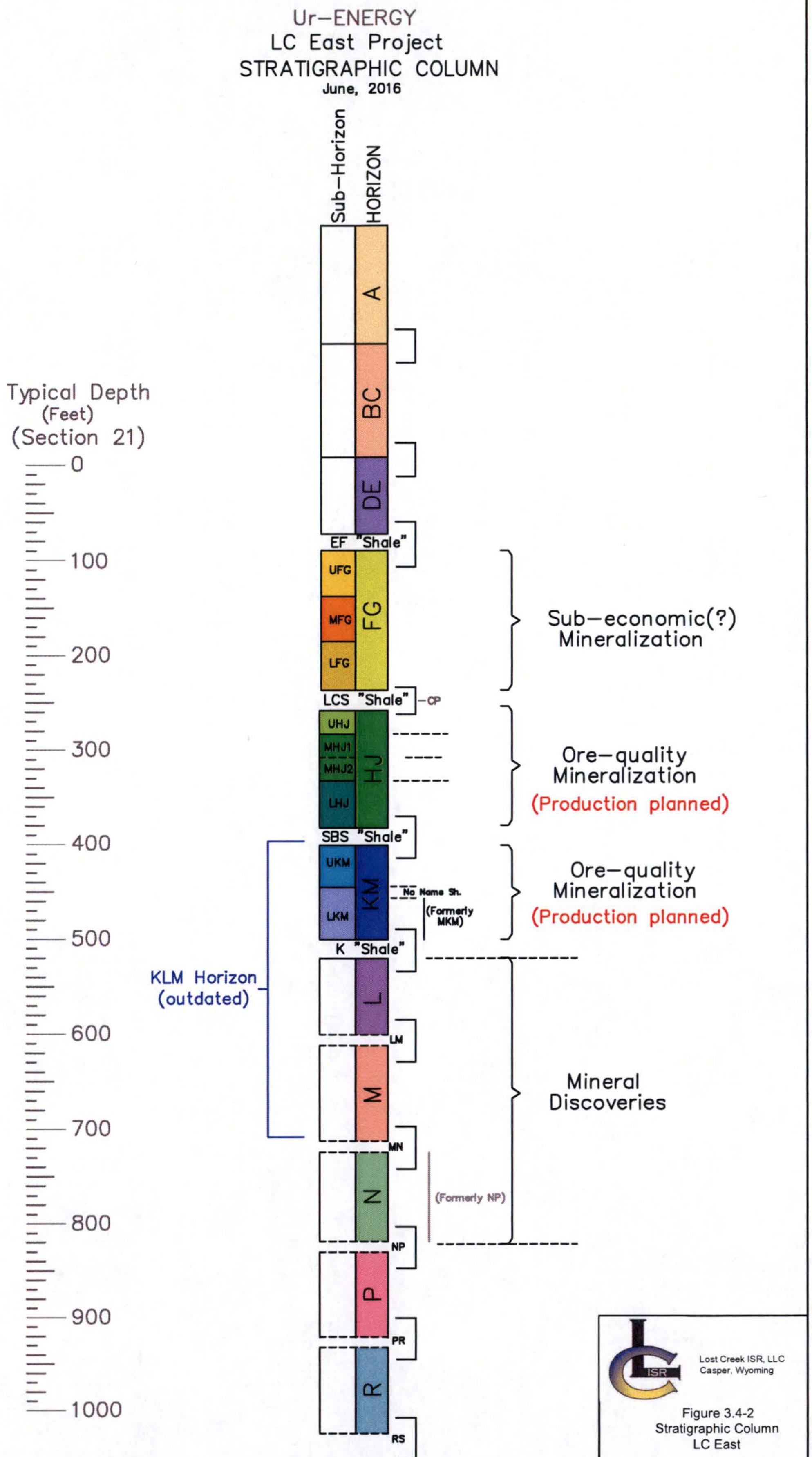

Figure 3.4-2
Stratigraphic Column
LC East

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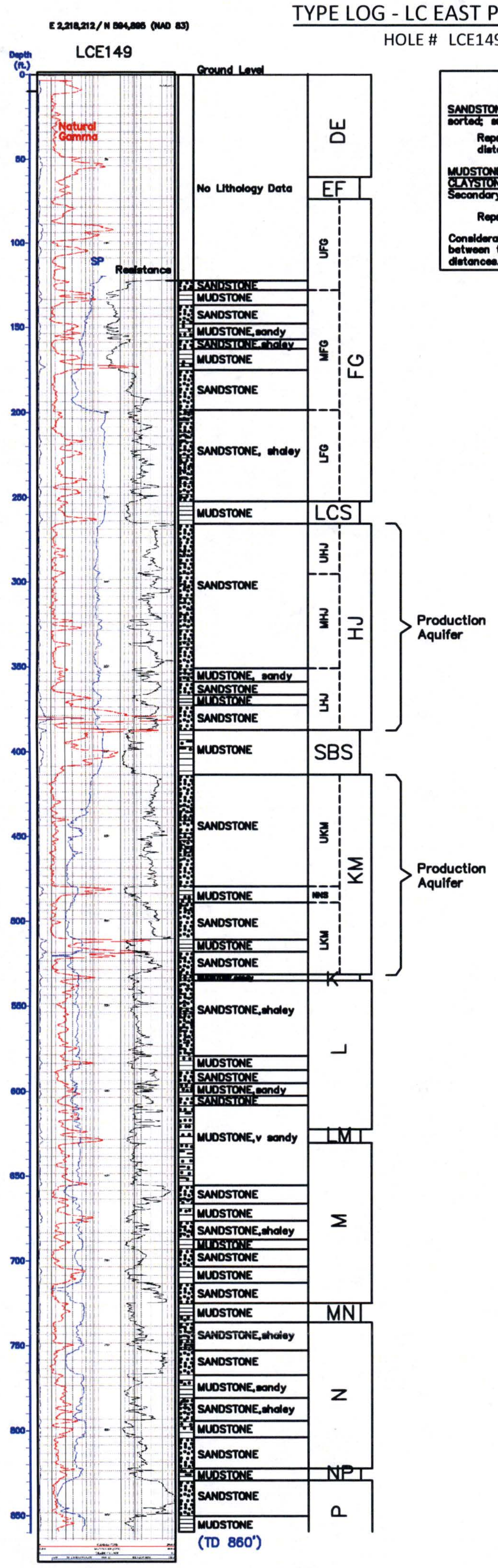
Lost Creek ISR, LLC

TYPE LOG - LC EAST PROJECT

HOLE # LCE149



Battle Spring Formation –Typical Lithology

SANDSTONE: arkosic; medium to very coarse-grained, locally fine-grain; poorly-sorted; subangular to angular; weakly to moderately consolidated, moderately firm.

Represents bed-load to mixed-load, channel-fill fluvial environments within a distal alluvial fan system.

MUDSTONE, commonly very silty and/or sandy; soft to very firm; and CLAYSTONE, moderately firm to very firm, dense, blocky.
Secondary amounts of SILTSTONE, commonly very sandy, firm to very firm.

Represents inter-channel and overbank fluvial environments.

Considerable lateral facies changes, inter-tonguing, and overlapping occurs between between the two dominant lithologies. This can be very dramatic within short distances.

DE Horizon: Multiple sandstone units interbedded with mudstones

EF:(upper No-Name Shale): Mudstone and claystone, commonly silty and/or sandy; locally with interbedded very fine-grained sands. Does not exhibit lateral continuity throughout project area. Represents a series of overlapping shaley units.

FG Horizon: Multiple sandstone units, commonly shaley, interbedded with mudstones, Commonly thinly bedded. Host to secondary amounts amounts of uranium mineralization.

LCS (Lost Creek Shale): Mudstone and claystone, commonly silty and/or sandy; locally with interbedded very fine-grained sands. Exhibits lateral continuity throughout project area. Commonly intertongues with upper portions of the HJ and lower portions of the FG.

HJ Horizon: Multiple thick sandstone units interbedded with intermittent mudstones. Primary host to uranium mineralization.

SBS (Sagebrush Shale): Mudstone and claystone, commonly silty and/or sandy; locally with interbedded very fine-grained sands. Exhibits lateral continuity throughout project area. Commonly intertongues with upper portions of the KM and lower portions of the HJ.

KM Horizon: Multiple thick sandstone units interbedded with mudstones intermittent mudstones. Primary host to uranium mineralization.

Includes NNS (No Name Shale) separating UKM from LKM. Does not exhibit regional continuity.

(Note: LKM was previously named MKM).

K (K Shale): Mudstone and claystone, commonly silty and/or sandy. May locally be absent or represented by multiple overlapping shales.

L Horizon: Multiple sandstone units, commonly shaley, interbedded with mudstones, Commonly thinly bedded. Host to exploration uranium mineralization.

LM Shale: Mudstone and claystone, commonly silty and/or sandy. Regional continuity has not been established.

M Horizon; Multiple sandstone units, interbedded with mudstones. Commonly thickly bedded. Host to exploration uranium mineralization

MN Shale: Mudstone and claystone, commonly silty and/or sandy. Regional continuity has not been established.

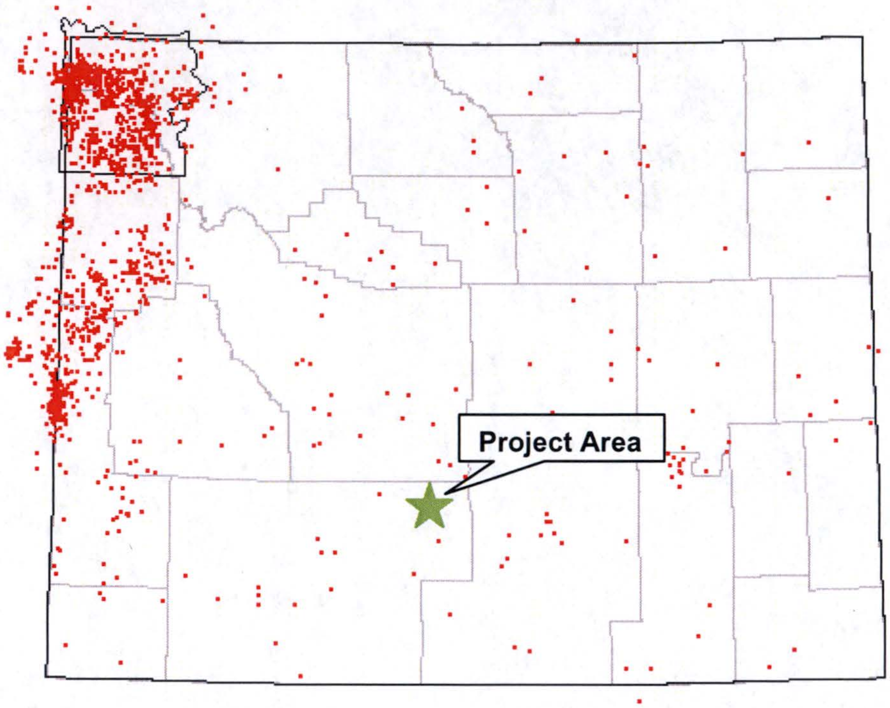
N Horizon; Multiple sandstone units, interbedded with mudstones. Commonly thickly bedded. Host to exploration uranium mineralization

NP Shale: Mudstone and claystone, commonly silty and/or sandy. Regional continuity has not been established.

P Horizon; Multiple sandstone units, interbedded with mudstones. Commonly thickly bedded.

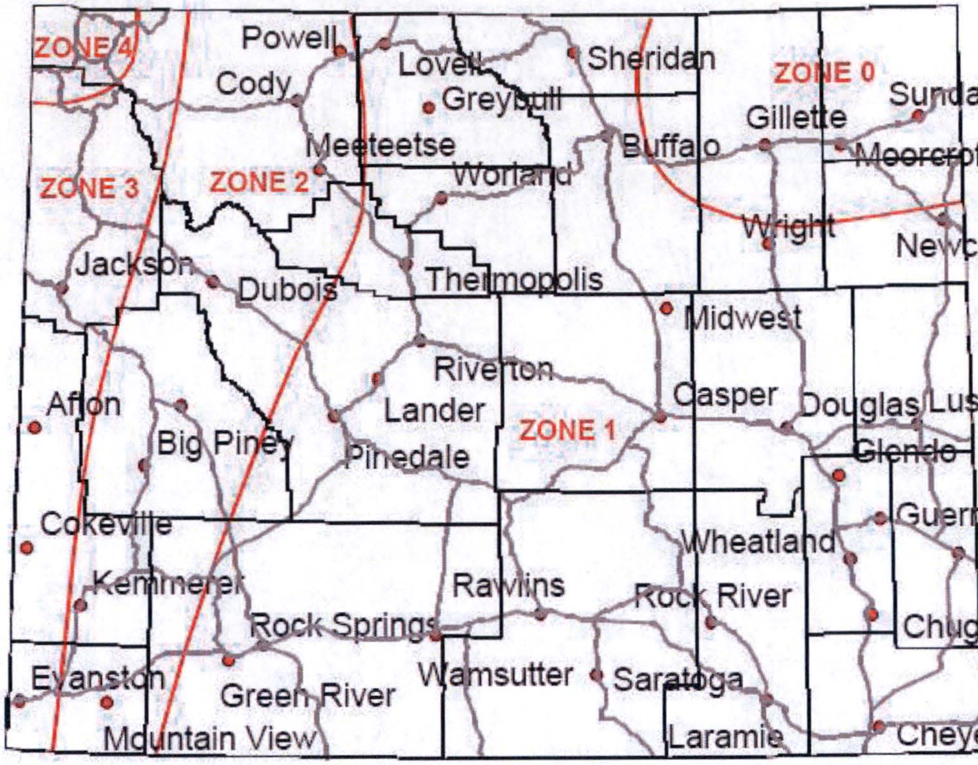
Figure 3.4-3

Figure 3.4 - 4 Historical seismic activities in Wyoming*



* Red dots are locations of epicenters for those magnitude = 2.5 or intensity = III earthquakes recorded from 1871 to present. (Bergantion et al., 2007)

Figure 3.4-5 UBC Seismic Zones in Wyoming (Case et. al., 2002)



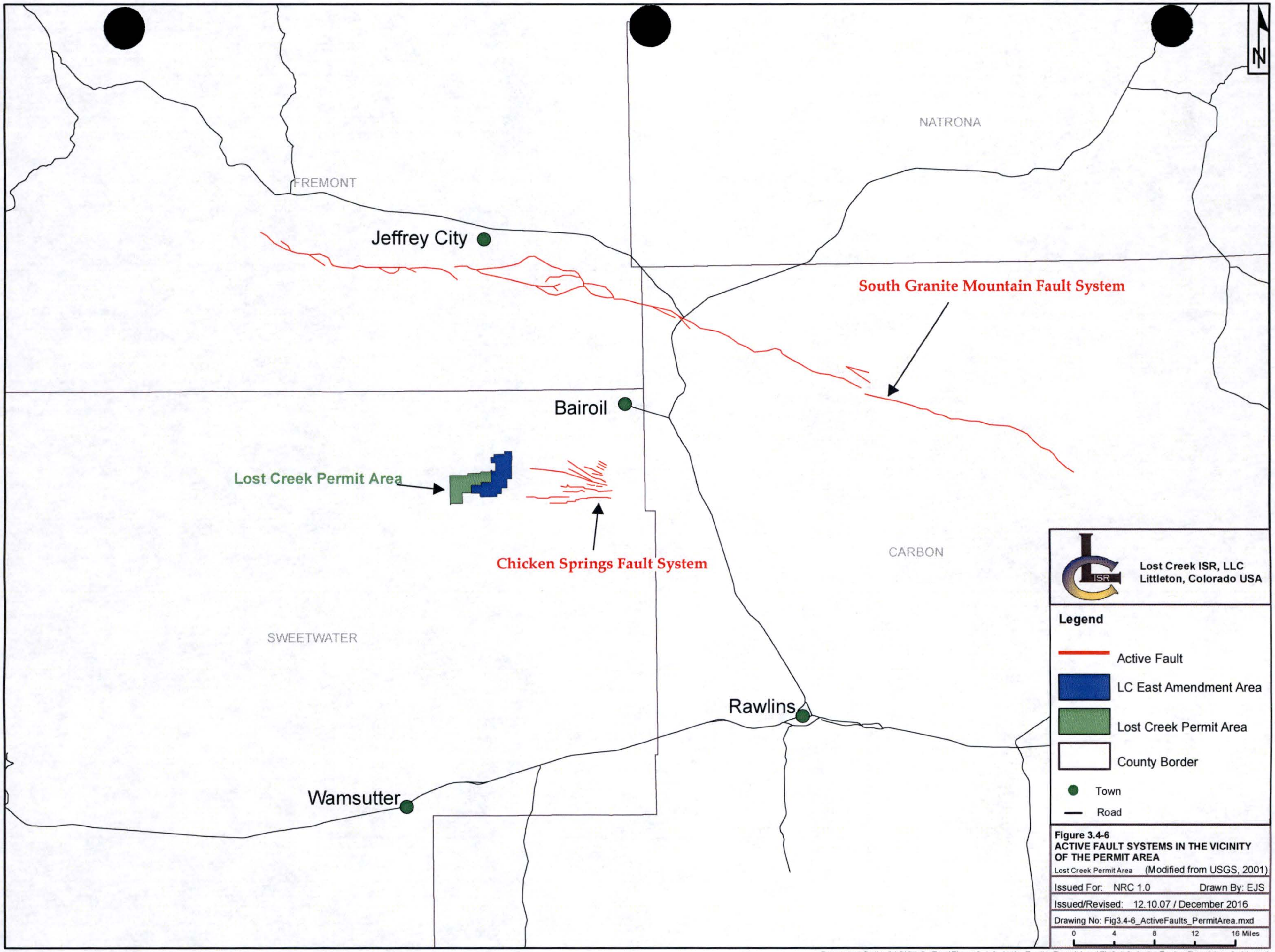


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Figure 3.4-7: 500-YEAR PROBABLISTIC ACCELERATION MAP OF WYOMING (Case et. al., 2002)

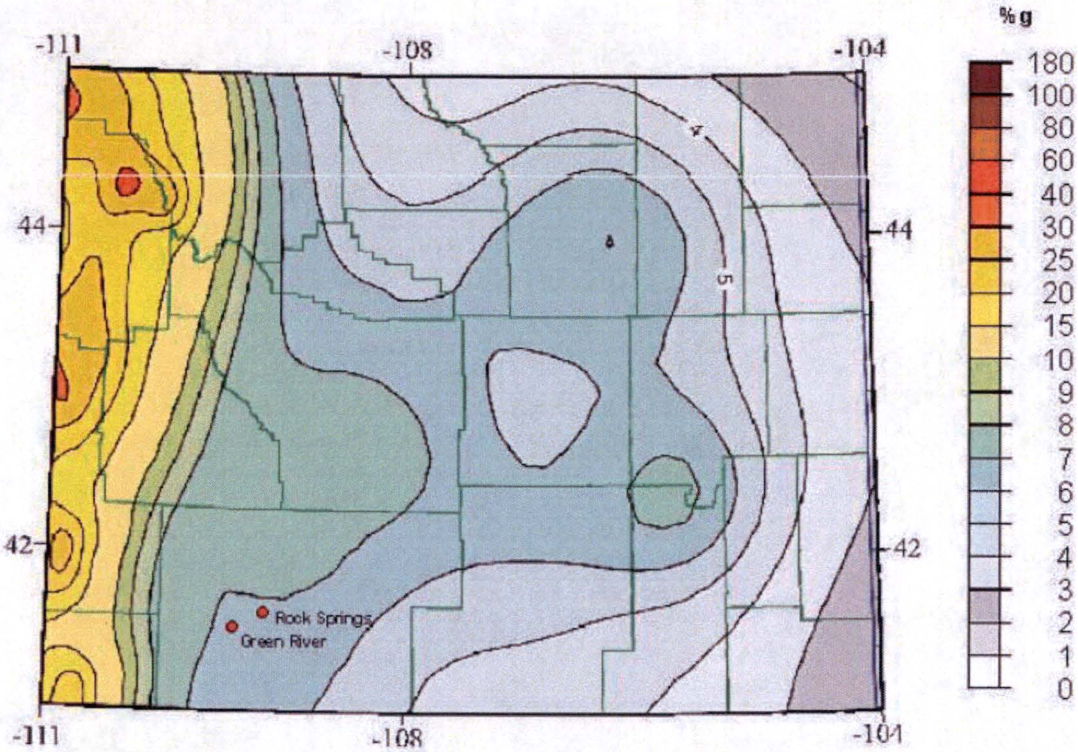

Table 3.4-1 Leach Amenability

Sample ID	Solution Base	Bicarbonate (g/L)	H_2O_2 (g/L)	Uranium Recovery (percent)
LC-2001-01	Ground Water	Natural Bicarb	0.25	20.0
LC-2001-02	Ground Water	1.0	0.25	84.1
LC-2001-03	Ground Water	1.5	0.25	86.4
LC-2001-04	Ground Water	2.0	0.25	93.3
LC-2001-05	Ground Water	2.0	0.50	87.1
LC-2001-06	Synthetic	2.0	0.25	92.6
LC-2001-07	Synthetic	2.0	0.50	88.1

Hole ID: LC-66C
Core Composition Depth Interval: 412 to 420.4 feet
Pre-Test Feed Grade: 0.0513% $_c$U

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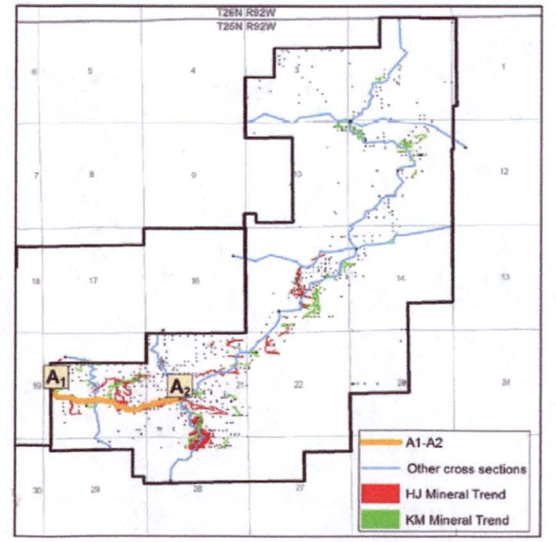

Legend

- Aquitard : clay, silt, shaly sand
  - Named shale:
  - Unnamed shale:
- Sand
- Mineralization: (generalized)

SCALE

0 100 200

Feet

(Vertical and Horizontal)

Lost Creek ISR, LLC
Casper, Wyoming, USA

PLATE 3.4-8
Cross Section A_1-A_2
(West-East)

Lost Creek Permit
LC East Amendment

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Geology by C. VanHolland
Issued/Revised: original

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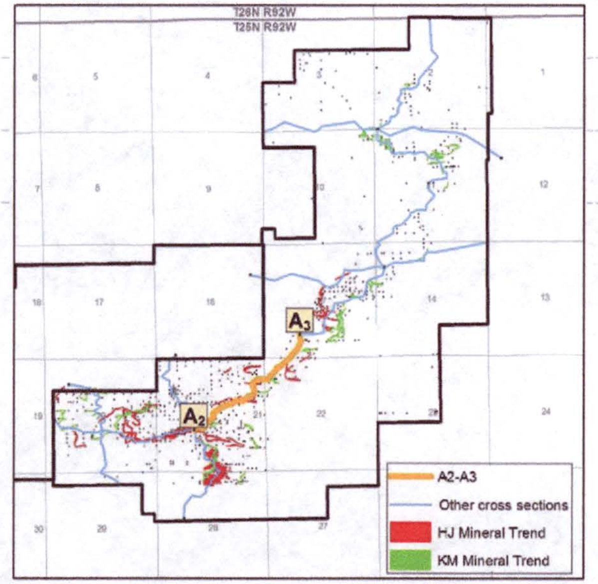

Legend

- Aquitard : clay, silt, shaly sand
  - Named shale:
  - Unnamed shale:
- Sand
- Mineralization: (generalized)

SCALE

0 100 200

Feet

(Vertical and Horizontal)

Lost Creek ISR, LLC
Casper, Wyoming, USA

PLATE 3.4-9
Cross Section A_2-A_3
(Southwest-Northeast)

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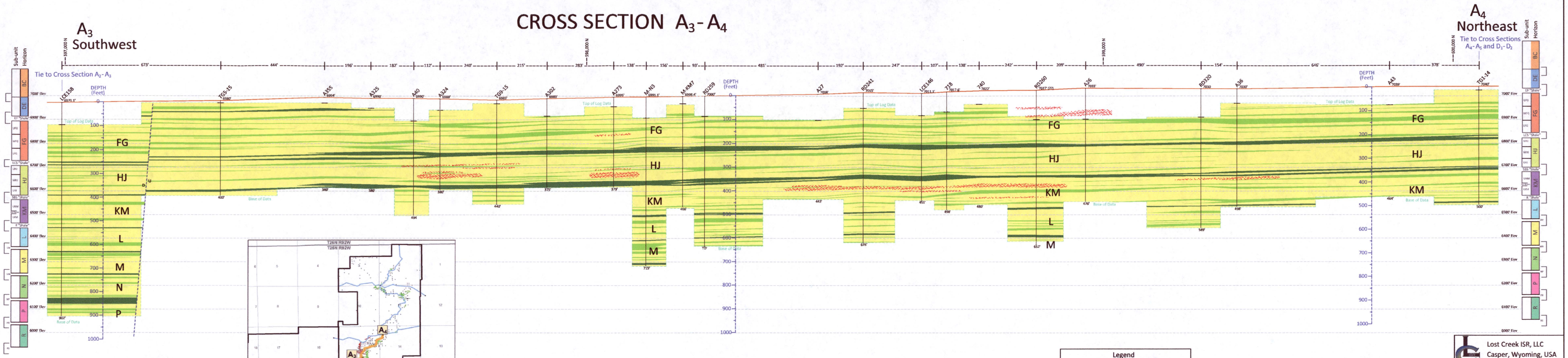

Legend

- Aquitard : clay, silt, shaly sand
  - Named shale:
  - Unnamed shale:
- Sand
- Mineralization: (generalized)

SCALE

0 100 200
Feet
(Vertical and Horizontal)

Lost Creek ISR, LLC
Casper, Wyoming, USA

PLATE 3.4-10
Cross Section A_3-A_4
(Southwest-Northeast)

Lost Creek Permit
LC East Amendment

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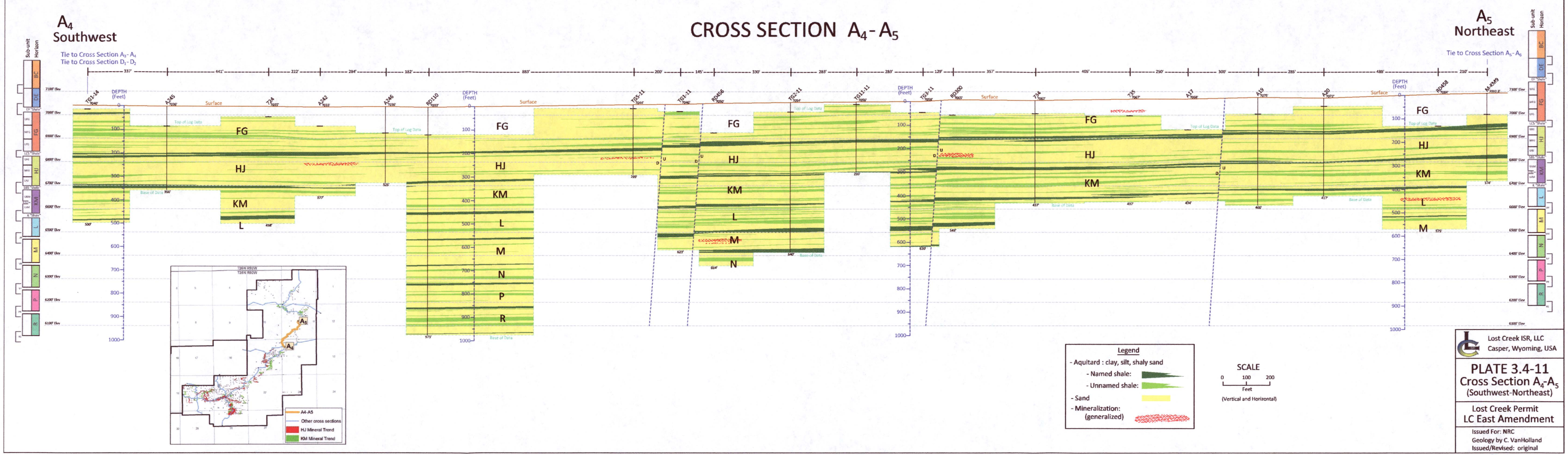

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PLATE 3.4-11
Cross Section A_4-A_5
(Southwest-Northeast)

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LC East Amendment

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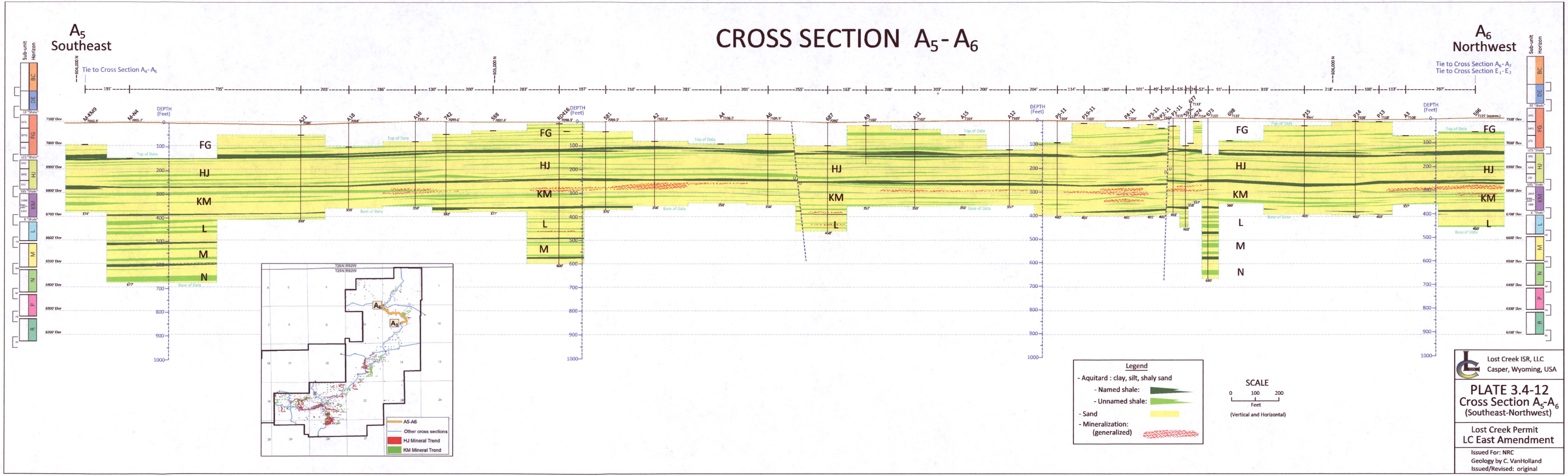

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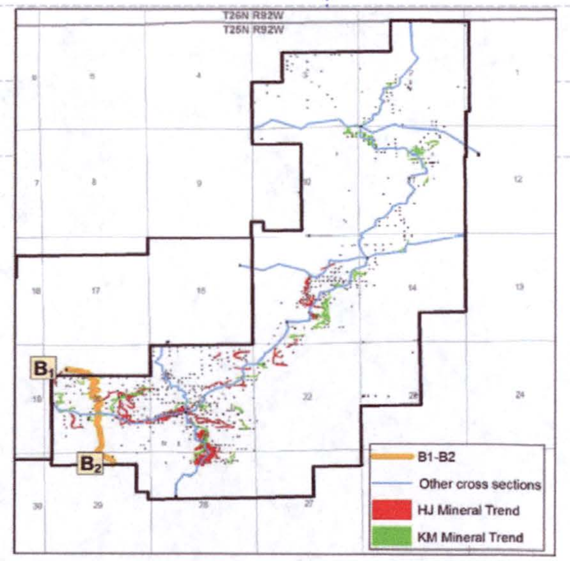

Legend

- Aquitard : clay, silt, shaly sand
  - Named shale:
  - Unnamed shale:
- Sand
- Mineralization: (generalized)

SCALE

0 100 200

Feet

(Vertical and Horizontal)

Lost Creek ISR, LLC
Casper, Wyoming, USA

PLATE 3.4-14
Cross Section B_1-B_2
(North-South)

Lost Creek Permit
LC East Amendment

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Geology by C. VanHolland
Issued/Revised: original

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