NRC007
Submitted: 8/25/2014

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-1910, Vol. 1

Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities

Chapters 1 through 4

Final Report

Office of Federal and State Materials and
Environmental Management Programs

Wyoming Department of Environmental Quality
Land Quality Division

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Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities

Chapters 1 through 4

Final Report

Manuscript Completed: May 2009
Date Published: May 2009

Prepared by:

U.S. Nuclear Regulatory Commission
Office of Federal and State Materials and Environmental Management Programs

Wyoming Department of Environmental Quality
Land Quality Division

ABSTRACT

The Atomic Energy Act of 1954 and the Uranium Mill Tailings Radiation Control Act of 1978 authorize the U.S. Nuclear Regulatory Commission (NRC) to issue licenses for the possession and use of source material and byproduct material. These statutes require NRC to license facilities that meet NRC regulatory requirements that were developed to protect public health and safety from radiological hazards. *In-situ* leach (ISL) uranium recovery facilities must meet NRC regulatory requirements in order to obtain a source material license to operate.

Under NRC's environmental protection regulations in the Code of Federal Regulations, Title 10, Part 51, which implement the National Environmental Policy Act (NEPA), issuance of a license to possess and use source material for uranium milling requires an environmental impact statement (EIS) or a supplement to an EIS. NRC has prepared a generic environmental impact statement (GEIS) to help fulfill this requirement. The GEIS assesses the potential environmental impacts associated with the construction, operation, aquifer restoration, and decommissioning of an ISL uranium recovery facility in four specified regions in the western United States. The intent of the GEIS is to determine which impacts would be essentially the same for all ISL facilities and which ones would result in varying levels of impacts for different facilities, thus requiring further site-specific information to determine the potential impacts. As such, the GEIS provides a starting point for NRC's NEPA analyses for site-specific license applications for new ISL facilities, as well as for applications to amend or renew existing ISL licenses.

NRC developed this GEIS using (1) knowledge gained during the past 30 years licensing and regulating ISL facilities, (2) the active participation of the State of Wyoming Department of Environmental Quality as a cooperating agency, and (3) public comments received during the preparation of the GEIS. NRC's licensing experience indicates that the technology used for ISL uranium recovery is relatively standardized throughout the industry and therefore appropriate for a programmatic evaluation in a GEIS.

Based on discussions between uranium recovery companies and the NRC staff, future ISL facilities could be located in portions of Wyoming, Nebraska, South Dakota, and New Mexico. NRC is the licensing authority for ISL facilities in these states.

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CONTENTS

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

Section Page

CONTENTS (continued)

CONTENTS (continued)

Section | Page

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

Section Page

CONTENTS (*continued*)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

FIGURES

FIGURES (continued)

FIGURES (continued)

FIGURES (continued)

Figure | Page

FIGURES (continued)

Figure | Page

TABLES

TABLES (continued)

Table | Page

TABLES (continued)

TABLES (continued)

TABLES (continued)

EXECUTIVE SUMMARY

BACKGROUND

The Atomic Energy Act of 1954 and the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) authorize the U.S. Nuclear Regulatory Commission (NRC) to issue licenses for the possession and use of source material and byproduct material. The statutes require NRC to license facilities that meet NRC regulatory requirements that were developed to protect public health and safety from radiological hazards. *In-situ* leach (ISL) uranium recovery facilities must m3eet NRC regulatory requirements in order to obtain this license to operate.

NRC designed the licensing process to assure the safe operation of ISL facilities. In addition to information for a safety evaluation review, license applicants must submit an environmental report as part of their license application. Under the NRC's environmental protection regulations in the Code of Federal Regulations, Title 10, Part 51 (10 CFR Part 51), which implement the National Environmental Policy Act (NEPA), issuance of a license to possess and use source material for uranium milling requires an environmental impact statement (EIS) or a supplement to an EIS.

> **Generic Environmental Impact Statement (GEIS)**
>
> A GEIS is an environmental impact statement that assesses the scope of the environmental effects that would be associated with an action (such as issuing a license for an ISL facility) at numerous sites. The Commission directed the NRC staff to prepare the GEIS to cover as many of the potential uranium recovery sites as possible.
>
> **Supplemental Environmental Impact Statement (SEIS)**
>
> A supplemental EIS updates or supplements an existing EIS (such as the GEIS). The Commission directed the NRC staff to issue site-specific supplements to the GEIS for each new license application.

NRC prepared the Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities (GEIS) to help fulfill this requirement. The GEIS was prepared to assess the potential environmental impacts associated with the construction, operation, aquifer restoration, and decommissioning of an ISL facility in four specified geographic areas. The intent of the GEIS is to determine which impacts would be essentially the same for all ISL facilities and which ones would result in varying levels of impacts for different facilities, thus requiring further site-specific information to determine the potential impacts. As such, the GEIS provides a starting point for NRC's NEPA analyses on site-specific license applications for new ISL facilities, as well as for applications to amend or renew existing ISL licenses.

PURPOSE AND NEED

Commercial uranium recovery companies have approached NRC with plans to submit a number of license applications for new uranium recovery facilities and for the restart or expansion of existing facilities in the next several years. The large majority of these potential applications would involve use of the ISL process. The companies have indicated that these new, restarted, and expanded ISL facilities would be located in Wyoming, South Dakota, Nebraska, and New Mexico.

NRC is the regulatory authority responsible for issuing a source material license for an ISL facility in those four states. 10 CFR Part 51 regulations require evaluating the environmental impacts of the ISL facility as part of the licensing process. Recognizing that the technology for ISL uranium milling is relatively standardized, that the applications may be submitted over a relatively short period of time, and that the potential ISL facilities would be located in relatively

discrete regions in the western United States, NRC decided to prepare a GEIS to avoid unnecessary duplicative efforts and to identify environmental issues of concern to focus on in site-specific environmental reviews. In this way, NRC could increase the efficiency and consistency in its site-specific environmental review of license applications for ISL facilities and so provide an option for applicants to use and licensees to continue to use the ISL process for uranium recovery.

THE PROPOSED FEDERAL ACTION AND ALTERNATIVES

In states where NRC is the regulatory authority over the licensing of uranium milling (including the ISL process), NRC has a statutory obligation to assess each site-specific license application to ensure it complies with NRC regulations before issuing a license. The proposed federal action is to grant an application to obtain, renew, or amend a source material license for an ISL facility.

Under NRC's environmental protection regulations at 10 CFR 51.20(b)(8), issuing a license to possess and use source material to a uranium milling facility is identified as a major federal action that requires the preparation of an EIS or a supplement to an EIS. NRC will prepare a SEIS for new ISL facility license applications. NRC will prepare an EA, SEIS or EIS for applications to amend or renew an existing ISL facility license.

The Proposed Federal Action

To grant applications to obtain, renew, or amend source material licenses for an ISL facility.

Purpose for the Proposed Federal Action

To provide an option for an applicant to use or a licensee to continue to use ISL technology for uranium recovery

The environmental review requirements for a material license are in 10 CFR Part 51. NRC's public health and safety requirements for ISL facilities are found in 10 CFR Parts 20 and 40. Parts 20, 40, and 51 require applicants to provide NRC with sufficient information to evaluate the impacts to public health and safety and the environment during the life-cycle of the ISL facility. NRC then prepares safety and environmental reviews that are used by NRC officials to decide whether to grant the source material license.

In reviewing an ISL license application, NRC will use the GEIS as starting point for its site-specific environmental reviews. NRC will evaluate site-specific data and information to determine whether the applicant's proposed activities and the site characteristics are consistent with those evaluated in the GEIS. NRC will then determine which sections of the GEIS can be incorporated by reference and which impact conclusions can be adopted in the site-specific environmental review, and whether additional data or analysis is needed to determine the environmental impacts to a specific resource area. Additionally, the GEIS provides guidance in the evaluation for certain impact analyses (e.g., cumulative impacts, environmental justice) for which the GEIS did not make impact conclusions. No decision on whether to license an ISL facility will be made based on the GEIS alone. The licensing decision will be based, in part, on a site-specific environmental analysis that makes use of the GEIS.

Uranium milling techniques are designed to recover the uranium from uranium-bearing ores. Various physical and chemical processes may be used, and selection of the uranium milling technique depends on the physical and chemical characteristics of the ore deposit and the attendant cost considerations. Generally, the ISL process is used to recover uranium from low-grade ores or deeper deposits that are not economically recoverable by conventional mining and milling techniques. In the ISL process, a leaching agent, such as oxygen with sodium carbonate, is added to native groundwater and injected through wells into the subsurface ore body to mobilize the uranium. The leach solution containing the mobilized uranium is pumped from there to the surface processing plant, and then ion exchange separates the uranium from the solution. After additional purification and drying, the resultant product, a mixture of uranium oxides also known as "yellowcake," is placed in 55-gallon drums prior to shipment offsite for further processing.

A range of alternatives was evaluated for inclusion in the GEIS. As defined in the GEIS, the proposed federal action is NRC's determination to grant an application to obtain, renew, or amend a source material license for an ISL facility. Under the no-action alternative, NRC would deny the applicant's or licensee's request. As a result, the new license applicant may choose to resubmit the application to use an alternate uranium recovery method or decide to obtain the yellowcake from other sources. A licensee whose renewal application is denied would have to commence shutting down operations in a timely manner. Denials of license amendments would require the licensee to continue operating under its previously approved license conditions.

Alternative methods for milling uranium were considered as possible alternatives to the ISL process. As stated previously, not all uranium deposits are suitable for ISL extraction. For example, if the uranium mineralization is above the saturated zone (i.e., all of the pore spaces in the ore-bearing rock are not filled with water), ISL techniques may not be appropriate. Likewise, if the ore is not located in a porous and permeable rock unit, it will not be accessible to the leach solution used in the ISL process. Because ISL techniques may not be appropriate in these circumstances, conventional mining (underground or open-pit/surface mining) and milling techniques (conventional milling and heap leaching) are viable alternative technologies.

Inasmuch as the suitability and practicality of using alternative milling methodologies depends on site-specific conditions, a generic discussion of alternative milling methodologies is not appropriate. Accordingly, this GEIS does not contain a detailed analysis of alternative milling methodologies. A detailed analysis of alternative milling methodologies that can be applied at a specific site will be addressed in NRC's site-specific environmental review for individual ISL license applications.

ANALYTICAL APPROACH

The GEIS serves to increase efficiency and eliminate repetitive discussions in NRC's environmental review process by identifying and evaluating environmental impacts that are generic and common to ISL uranium recovery facilities. Information from the GEIS can be summarized and incorporated by reference into the subsequent site-specific environmental review documents. The GEIS also identifies resource areas that need site-specific information to more fully determine the environmental impact to particular resource areas. The site-specific environmental impact analysis also will include any new or significant information necessary to evaluate the ISL facility license application.

For the GEIS, NRC identified the potential environmental impacts associated with the ISL process and the resource areas that could be affected. The general methodology for doing so was to (1) describe the ISL process activity or activities that could affect the resource, (2) identify the resource(s) that can be affected, (3) evaluate past licensing actions and associated environmental review documents and other available information, (4) assess the nature and magnitude of the potential environmental impacts to the resource(s), (5) characterize the significance of the potential impacts, and (6) identify site conditions and mitigation measures that may affect the significance. For some types of impacts analyses (e.g., cumulative impacts, environmental justice evaluations), NRC recognized the difficulty in making determinations in the GEIS, given the location-specific nature of these analyses. For these categories, NRC collected information and conducted initial evaluations, which are documented in the GEIS. The purpose of this information gathering and initial evaluation is intended to provide background data and guidance for the site-specific analyses for these types of impact evaluations.

NRC developed this GEIS based on its experience in licensing and regulating ISL facilities gained during the past 30 years. In the GEIS, NRC does not consider specific facilities, but rather provides an assessment of potential environmental impacts associated with ISL facilities that might be located

in four regions of the western United States. These regions are used as a framework for discussions in this GEIS and were identified based on several considerations, including

- Past and existing uranium milling sites are located within States where NRC has regulatory authority over uranium recovery;
- Potential new sites are identified based on NRC's understanding of where the uranium recovery industry has plans to develop uranium deposits using ISL technology; and
- Locations of previously identified uranium deposits within portions of Wyoming, Nebraska, South Dakota, and New Mexico.

Using these criteria, four geographic regions were identified (Figure ES–1). For the purpose of this GEIS, these regions are

- Wyoming West Uranium Milling Region
- Wyoming East Uranium Milling Region
- Nebraska-South Dakota-Wyoming Uranium Milling Region
- Northwestern New Mexico Uranium Milling Region

The foundation of the environmental impact assessment in the GEIS is based on (1) the historical operations of NRC-licensed ISL facilities and (2) the affected environment in each of the four regions. The structure of the GEIS is presented in Figure ES–2.

Chapter 2 of the GEIS provides a description of the ISL process, addressing construction, operation, aquifer restoration, and decommissioning of an ISL facility. This section also discusses financial assurance, whereby the licensee or applicant establishes a bond or other financial mechanism prior to operations to ensure that sufficient funds are available to complete aquifer restoration, decommissioning, and reclamation activities.

Chapter 3 of the GEIS describes the affected environment in each uranium milling region using the environmental resource areas and topics identified through public scoping comments on the GEIS and from NRC guidance to its staff in NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated With NMSS Programs," issued in 2003.

Chapter 4 of the GEIS provides an evaluation of the potential environmental impacts of constructing, operating, aquifer restoration, and decommissioning at an ISL facility in each of the four uranium milling regions. In essence, this involves placing an ISL facility with the characteristics described in Chapter 2 of the GEIS within each of the four regional areas described in Chapter 3 and describing and evaluating the potential impacts in each region separately. The potential environmental impacts are evaluated for the different stages in the ISL process: construction, operation, aquifer restoration, and decommissioning. Impacts are examined for the resource areas identified in the description of the affected environment. These resource areas are

- Land use
- Transportation
- Geology and soils
- Water resources
- Ecology
- Air quality
- Noise
- Historical and cultural resources
- Visual and scenic resources
- Socioeconomic
- Public and occupational health

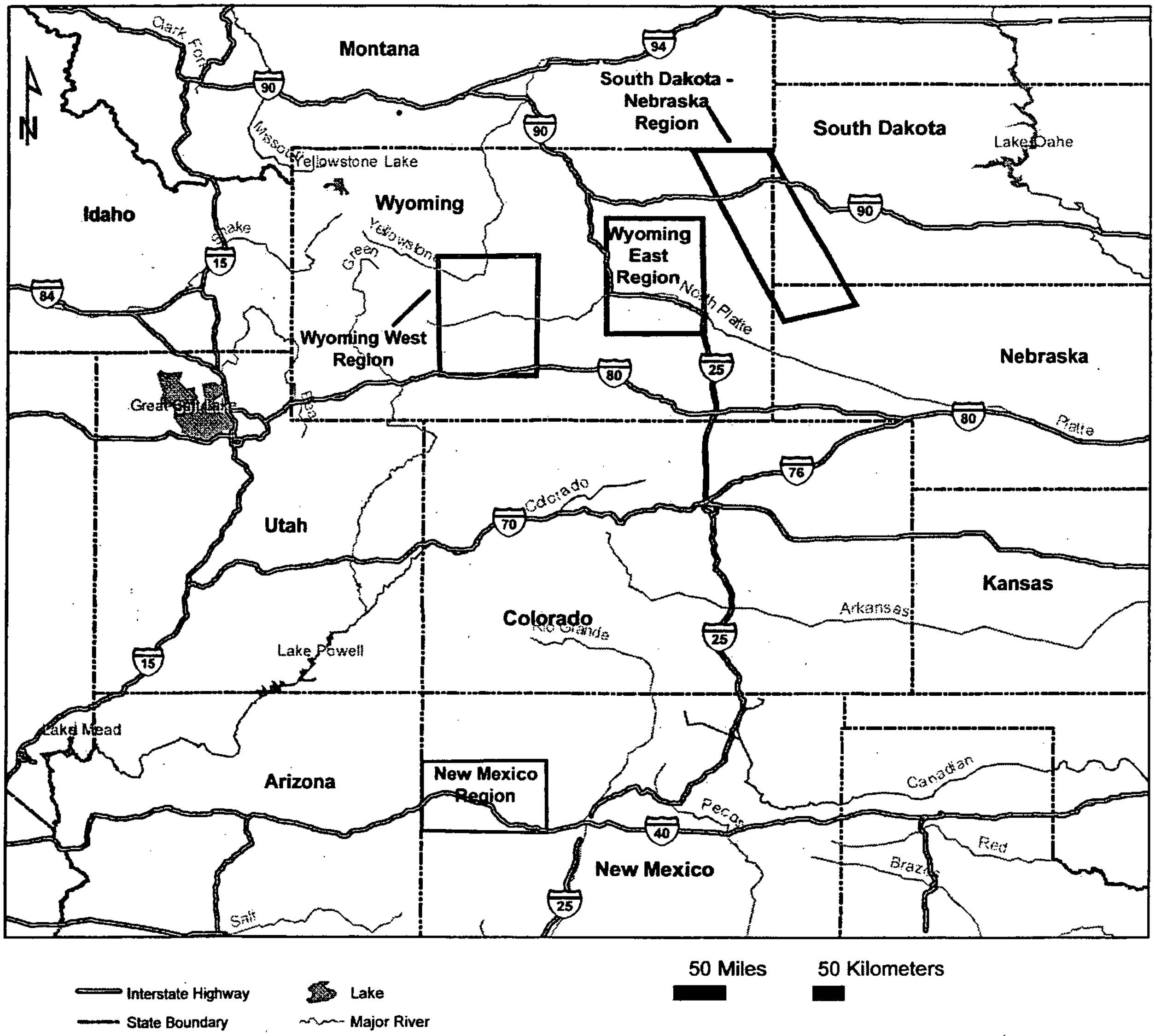

Figure ES–1. Location of Four Geographic Regions Used as a Framework for the Analyses Presented in This GEIS

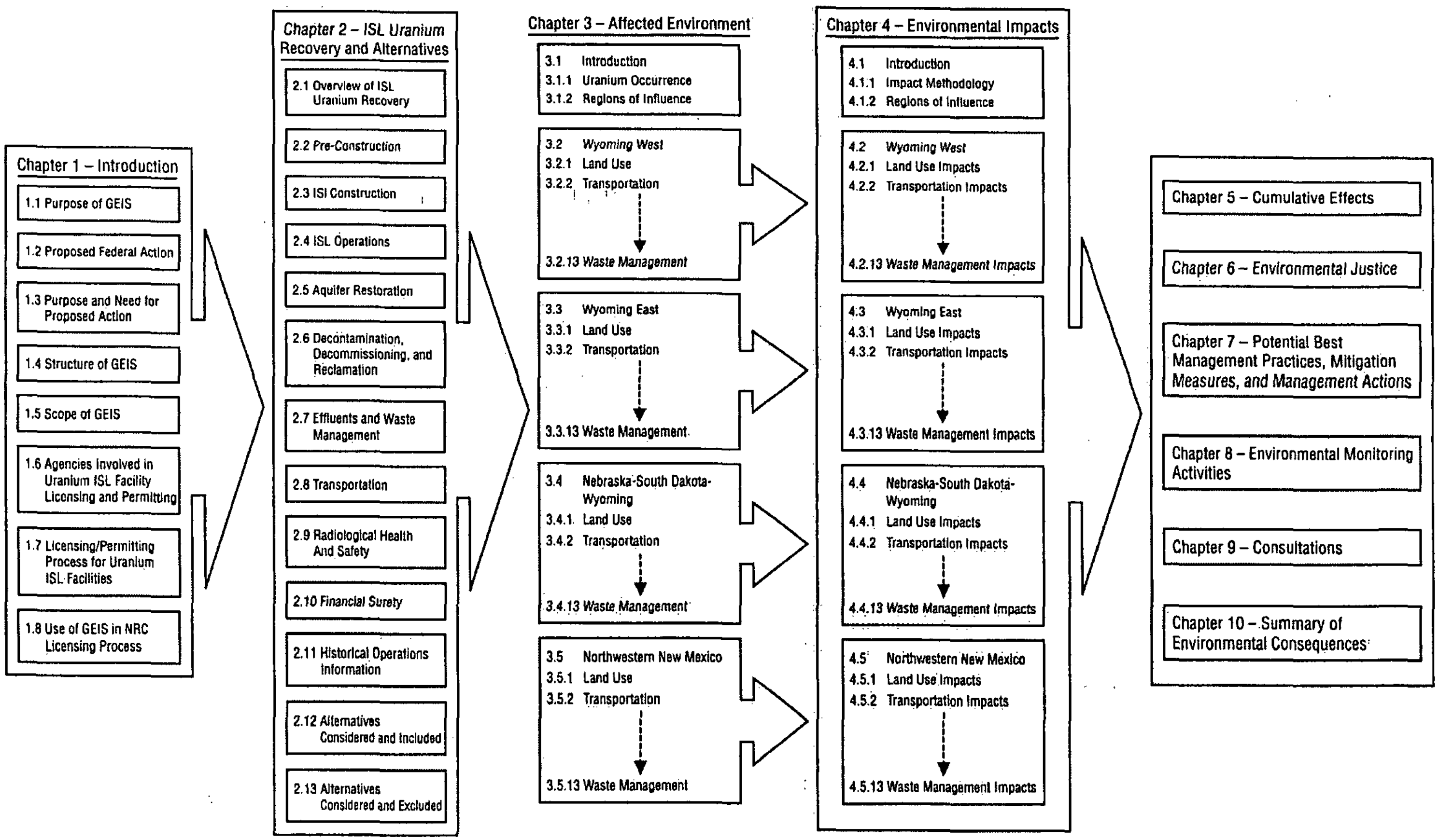

Figure ES–2. Structure of This GEIS

NRC identified a number of other issues that helped in the evaluation of the potential environmental impacts of an ISL facility. These issues include

- **Applicable Statutes, Regulations, and Agencies**. Various statutes, regulations, and implementing agencies at the federal, state, tribal, and local levels that have a role in regulating ISL facilities are identified and discussed.

- **Waste Management**. Potential impacts from the generation, handling, treatment, and final disposal of chemical, radiological, and municipal wastes are addressed.

- **Accidents**. Potential accident conditions are assessed in the GEIS. These include consideration of a range of possible accidents and estimation of their consequences, including well field leaks and spills, excursions, processing chemical spills, and ion-exchange resin and yellowcake transportation accidents.

- **Environmental Justice**. Although not required for a GEIS, to facilitate subsequent site-specific analyses, this GEIS provides a first order definition of minority and low income populations. Early consultations will be initiated with some of these populations, and the potential for disproportionately high and adverse impacts from future ISL licensing in the uranium milling regions will be evaluated in the event ISL license applications are submitted.

- **Cumulative Impacts**. The GEIS addresses cumulative impacts from proposed ISL facility construction, operation, groundwater restoration, and decommissioning on all aspects of the affected environment, by identifying past, present, and reasonably foreseeable future actions in the uranium milling regions.

- **Monitoring**. The GEIS discusses various monitoring methodologies and techniques used to detect and mitigate the spread of radiological and nonradiological contaminants beyond ISL facility boundaries.

SIGNIFICANCE LEVELS

In the GEIS, NRC has categorized the potential environmental impacts using significance levels. According to the Council on Environmental Quality, the significance of impacts is determined by examining both context and intensity (40 CFR 1508.27). Context is related to the affected region, the affected interests, and the locality, while intensity refers to the severity of the impact, which is based on a number of considerations. In this GEIS, the NRC used the significance levels identified in NUREG–1748:

- SMALL Impact: The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource considered.

- MODERATE Impact: The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource considered.

- LARGE Impact: The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource considered.

SUMMARY OF IMPACTS

Chapter 4 of the GEIS provides NRC's evaluation of the potential environmental impacts of the construction, operation, aquifer restoration, and decommissioning at an ISL facility in each of the four uranium milling regions. A summary of this evaluation by environmental resource area and phase of the ISL facility lifecycle is provided next.

Land Use Impacts

CONSTRUCTION—Land use impacts could occur from land disturbances (including alterations of ecological cultural or historic resources) and access restrictions (including limitations on other mineral extraction activities, grazing activities, or recreational activities). The potential for land use conflicts could increase in areas with higher percentages of private land ownership and Native American land ownership or in areas with a complex patchwork of land ownership. Land disturbances during construction would be temporary and limited to small areas within permitted boundaries. Well sites, staging areas, and trenches would be reseeded and restored. Unpaved access roads would remain in use until decommissioning. Competing access to mineral rights could be either delayed for the duration of the ISL project or be intermixed with ISL operations (e.g., oil and gas exploration). Changes to land use access including grazing restrictions and impacts on recreational activities would be limited due to the small size of restricted areas, temporary nature of restrictions, and availability of other land for these activities. Ecological, historical, and cultural resources could be affected, but would be protected by careful planning and surveying to help identify resources and avoid or mitigate impacts. For all land use aspects except ecological, historical, and cultural resources, the potential impacts would be SMALL. Due to the potential for unidentified resources to be altered or destroyed during excavation, drilling, and grading, the potential impacts to ecological, historical, or cultural resources would be SMALL to LARGE, depending on local conditions.

OPERATION—The types of land use impacts for operational activities would be similar to construction impacts regarding access restrictions because the infrastructure would be in place. Additional land disturbances would not occur from conducting operational activities. Because access restriction and land disturbance related impacts would be similar to, or less than, those for construction, the overall potential impacts to land use from operational activities would be SMALL.

AQUIFER RESTORATION—Due to the use of the same infrastructure, land use impacts would be similar to operations during aquifer restoration, although some operational activities would diminish—SMALL.

DECOMMISSIONING—Land use impacts would be similar to those described for construction with a temporary increase in land-disturbing activities for dismantling, removing, and disposing of facilities, equipment, and excavated contaminated soils. Reclamation of land to preexisting conditions and uses would help mitigate potential impacts—SMALL to MODERATE during decommissioning, and SMALL once decommissioning is completed.

Transportation Impacts

CONSTRUCTION—Low magnitude traffic generated by ISL construction relative to local traffic counts would not significantly increase traffic or accidents on many of the roads in the region. Existing low traffic roads could be moderately impacted by the additional worker commuting traffic during periods of peak employment. This impact would be expected to be more pronounced in areas with relatively lower traffic counts. Moderate dust, noise, and incidental

wildlife or livestock kill impacts would be possible on, or near, site access roads (dust in particular for unpaved access roads)—SMALL to MODERATE.

OPERATION—Low magnitude traffic relative to local traffic counts on most roads would not significantly increase traffic or accidents. Existing low traffic roads could be moderately impacted by commuting traffic during periods of peak employment including dust, noise, and possible incidental wildlife or livestock kill impacts on or near site access roads. High consequences would be possible for a severe accident involving transportation of hazardous chemicals in a populated area. However, the probability of such accidents occurring would be low owing to the small number of shipments, comprehensive regulatory controls, and use of best management practices. For radioactive material shipments (yellowcake product, ion-exchange resins, waste materials), compliance with transportation regulations would limit radiological risk for normal operations. Low radiological risk is estimated for accident conditions. Emergency response protocols would help mitigate long-term consequences of severe accidents involving release of uranium—SMALL to MODERATE.

AQUIFER RESTORATION—The magnitude of transportation activities would be lower than for construction and operations, with the exception of workforce commuting, which could have moderate impacts on, or in the vicinity of, existing low traffic roads—SMALL to MODERATE.

DECOMMISSIONING—The types of transportation activities, and therefore the types of impacts, would be similar to those discussed for construction and operations, except the magnitude of transportation activities (e.g., number and types of waste and supply shipments, no yellowcake shipments) from decommissioning could be lower than for operations. Accident risks would be bounded by the operations yellowcake transportation risk estimates—SMALL.

Geology and Soils Impacts

CONSTRUCTION—Disturbance to soil would occur from construction (clearing, excavation, drilling, trenching, road construction); however, such disturbances would be expected to be temporary, disturbed areas would be small (approximately 15 percent of the total site area), and potential impacts would be mitigated by using best management practices. A large portion of the well fields, trenches, and access roads would be restored and reseeded after construction. Excavated soils would be stockpiled, seeded, and stored onsite until needed for reclamation fill. No impacts to subsurface geological strata would be likely—SMALL.

OPERATION—Temporary contamination or alteration of soils would be likely from operational leaks and spills and possible from transportation, use of evaporation ponds, or land application of treated waste water. However, detection and response to leaks and spills (e.g., soil cleanup), monitoring of treated waste water, and eventual survey and decommissioning of all potentially impacted soils would limit the magnitude of overall impacts to soils—SMALL.

AQUIFER RESTORATION—Impacts to geology and soils from aquifer restoration activities would be similar to impacts from operations due to use of the same infrastructure and similar activities conducted (e.g., well field operation, transfer activities, liquid effluent treatment and disposal)—SMALL.

DECOMMISSIONING—Impacts to geology and soils from decommissioning would be similar to impacts from construction. Activities to clean up, recontour, and reclaim disturbed lands during decommissioning would mitigate long-term impacts to soils—SMALL.

Surface Water Impacts

CONSTRUCTION—Impacts to surface waters and related habitats from construction (road crossings, filling, erosion, runoff, spills or leaks of fuels and lubricants for construction equipment) would be mitigated through proper planning, design, construction methods, and best management practices. Some impacts directly related to the construction activities would be temporary and limited to the duration of the construction period. U.S. Army Corps of Engineers permits may be required when filling and crossing of wetlands. Temporary changes to spring and stream flow from grading and changes in topography and natural drainage patterns could be mitigated or restored after the construction phase. Impacts from incidental spills of drilling fluids into local streams could occur, but would be temporary due to the use of mitigation measures. Impacts from roads, parking areas, and buildings on recharge to shallow aquifers would be SMALL, owing to the limited area of impervious surfaces proposed. Impacts from infiltration of drilling fluids into the local aquifer would be localized, small, and temporary—SMALL to MODERATE depending on site-specific characteristics.

OPERATION—Through permitting processes, federal and state agencies regulate the discharge of storm water runoff and the discharge of process water. Impacts from these discharges would be mitigated as licensees would operate within the conditions of their permits. Expansion of facilities or pipelines during operations would generate impacts similar to construction—SMALL to MODERATE depending on site-specific characteristics.

AQUIFER RESTORATION—Impacts from aquifer restoration would be similar to impacts from operations due to use of the same (in-place) infrastructure and similar activities conducted (e.g., well field operation, transfer of fluids, water treatment, storm water runoff)—SMALL to MODERATE depending on site-specific characteristics.

DECOMMISSIONING—Impacts from decommissioning would be similar to impacts from construction. Activities to clean up, recontour, and reclaim disturbed lands during decommissioning would mitigate long-term impacts to surface waters—SMALL to MODERATE depending on site-specific characteristics.

Groundwater Impacts

CONSTRUCTION—Water use impacts would be limited by the small volumes of groundwater used for routine activities such as dust suppression, mixing cements, and drilling support over short and intermittent periods. Contamination of groundwater from construction activities would be mitigated by best management practices—SMALL.

OPERATION—Potential impacts to shallow aquifers can occur from leaks or spills from surface facilities and equipment. Shallow aquifers are important sources of drinking water in some areas of the four uranium milling regions. Potential impacts to the ore-bearing and surrounding aquifers include consumptive water use and degradation of water quality (from normal production activities, off-normal excursion events, and deep well injection disposal practices). Consumptive use impacts from withdrawal of groundwater would occur because approximately 1 to 3 percent of pumped groundwater is not returned to the aquifer (e.g., process bleed). That amount of water lost could be reduced substantially by available treatment methods (e.g., reverse osmosis, brine concentration). Effects of water withdrawal on groundwater would be expected to be SMALL as the ore zone normally occurs in a confined aquifer. Estimated drawdown effects vary depending on site conditions and water treatment technology applied. Excursions of lixiviant and mobilized chemical constituents could occur from failure of well seals or other operational conditions that result in incomplete recovery of lixiviant. Well-seal-related

excursions would be detected by the groundwater monitoring system, and periodic well mechanical integrity testing, and impacts would be expected to be mitigated during operation or aquifer restoration. Other excursions could result in plumes of mobilized uranium and heavy metals extending beyond the mineralization zone. The magnitude of potential impacts from vertical excursions would vary depending on site-specific conditions. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations, including well tests, monitoring, and development of procedures that include excursion response measures and reporting requirements. Impacts from the alterations of ore body aquifer chemistry would be SMALL, because the aquifer would (1) be confined, (2) not be a potential drinking water source, and (3) be expected to be restored during the restoration period. Potential environmental impacts to confined deep aquifers below the production aquifers from deep well injection of processing wastes would be addressed by the underground injection permitting process regulated by the states and NRC's approval process—SMALL to LARGE, depending on site-specific conditions.

AQUIFER RESTORATION—Potential impacts would be from consumptive use and potential deep disposal of brine slurries after reverse osmosis, if applicable. The volume of water removed from the aquifer and related impacts would be dependent on site-specific conditions and the type of water treatment technology the facility uses. In some cases, groundwater consumptive use for the aquifer restoration has been reported to be less than groundwater use during the ISL operation, and drawdowns due to aquifer restorations have been smaller than drawdown caused by ISL operations. Potential environmental impacts associated with water consumption during aquifer restorations are determined by (1) the restoration techniques chosen, (2) the volume of water to be used, (3) the severity and extent of the contamination, and (4) the current and future use of the production and surrounding aquifers near the ISL facility or at the regional scale—SMALL to MODERATE, depending on site-specific conditions.

DECOMMISSIONING—Potential impacts from decommissioning would be similar to construction (water use, spills) with an additional potential to mobilize contaminants during demolition and cleanup activities. Contamination of groundwater from decommissioning activities would be mitigated by implementation of an NRC-approved decommissioning plan and use of best management practices—SMALL.

Terrestrial Ecology Impacts

CONSTRUCTION—Potential terrestrial ecology impacts would include the removal of vegetation from the well fields and the milling site, the modification of existing vegetative communities, the loss of sensitive plants and habitats from clearing and grading, and the potential spread of invasive species and noxious weed populations. These impacts would be expected to be temporary because restoration and reseeding occur rapidly after the end of construction. Introduction of invasive species and noxious weeds would be mitigated by restoration and reseeding after construction. Shrub and tree removal and loss would take longer to restore. Construction noise could affect reproductive success of sage-grouse leks by interfering with mating calls. Temporary displacement of some animal species would also occur. Critical wintering and year-long ranges are important to survival of both big game and sage-grouse. Raptors breeding onsite may be impacted by construction activities or milling operations, depending on the time of year construction occurs. Wildlife habitat fragmentation, temporary displacement of animal species, and direct or indirect mortalities would be possible. Implementation of wildlife surveys and mitigation measures following established guidelines would limit impacts. The magnitude of impacts depends on whether a new facility is being licensed or an existing facility is being extended—SMALL to MODERATE, depending on site-specific habitat conditions.

OPERATION—Habitats could be altered by operations (fencing, traffic, noise), and individual takes could occur due to conflicts between species habitat and operations. Access to crucial wintering habitat and water could be limited by fencing. However, the State of Wyoming Game and Fish Department specifies fencing construction techniques to minimize impediments to big game movement. Migratory birds could be affected by exposure to constituents in evaporation ponds, but perimeter fencing and netting would limit impacts. Temporary contamination or alteration of soils would be likely from operational leaks and spills and possible from transportation or land application of treated waste water. However, detection and response to leaks and spills (e.g., soil cleanup) and eventual survey and decommissioning of all potentially impacted soil limit the magnitude of overall impacts to terrestrial ecology. Mitigation measures such as perimeter fencing, netting, alternative sites, and periodic wildlife surveys would reduce overall impacts—SMALL.

AQUIFER RESTORATION—Impacts include habitat disruption, but existing (in-place) infrastructure would be used during aquifer restoration, with little additional ground disturbance. Migratory birds could be affected by exposure to constituents in evaporation ponds, but perimeter fencing and netting would limit impacts. Contamination of soils could result from leaks and spills and land application of treated waste water. However, detection and response techniques, and eventual survey and decommissioning of all potentially impacted soils, would limit the magnitude of overall impacts to terrestrial ecology. Mitigation measures such as perimeter fencing, netting, and alternative sites would reduce overall impacts—SMALL.

DECOMMISSIONING—During decommissioning and reclamation, there would be a temporary disturbance to land (e.g., excavated soils, buried piping, removal of structures). However, revegetation and recontouring would restore habitat altered during construction and operations. Wildlife would be temporarily displaced, but are expected to return after decommissioning and reclamation are completed and vegetation and habitat are reestablished—SMALL to MODERATE, depending on site-specific conditions.

Aquatic Ecology Impacts

CONSTRUCTION—Clearing and grading activities associated with construction could result in a temporary increase in sediment load in local streams, but aquatic species would recover quickly as sediment load decreases. Clearing of riparian vegetation could affect light and thus the temperature of water. Construction impacts to wetlands would be identified and managed through U.S. Army Corps of Engineers permits, as appropriate. Construction impacts to surface waters and aquatic species would be temporary and mitigated by best management practices—SMALL.

OPERATION—Impacts could result from spills or releases into surface water. Impacts would be minimized by spill prevention, identification, and response programs, and National Pollutant Discharge Elimination System (NPDES) permit requirements—SMALL.

AQUIFER RESTORATION—Activities would use existing (in-place) infrastructure, and impacts could result from spills or releases of untreated groundwater. Impacts would be minimized by spill prevention, identification, and response programs, and NPDES permit requirements—SMALL.

DECOMMISSIONING—Decommissioning and reclamation activities could result in temporary increases in sediment load in local streams, but aquatic species would recover quickly as

sediment load decreases. With completion of decommissioning, revegetation, and recontouring, habitat would be reestablished and impacts would, therefore, be limited—SMALL.

Threatened and Endangered Species Impacts

CONSTRUCTION—Numerous threatened and endangered species and state species of concern are located in the four uranium milling regions. Small fragmentation of habitats would occur, but most species readapt quickly. The magnitude of impact would depend on the size of a new facility or extension to an existing facility and the amount of land disturbance. Inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing impacts—SMALL to LARGE—depending on site-specific habitat and presence of threatened or endangered species.

OPERATION—Impacts could result from individual takes due to conflicts with operations. Small fragmentation of habitats would occur, but most species readapt quickly. The magnitude of impact would depend on the size of a new facility or extension to an existing facility and the amount of land disturbance. Impacts could potentially result from spills or permitted effluents, but would be minimized through the use of spill prevention measures, identification and response programs, and NPDES permit requirements. Inventory of threatened or endangered species developed during site-specific reviews would identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing impacts—SMALL to LARGE—depending on site-specific habitat and presence of threatened or endangered species.

AQUIFER RESTORATION—Impacts could result from individual takes due to conflicts with aquifer restoration activities (equipment, traffic). Existing (in-place) infrastructure would be used during aquifer restoration, so additional land-disturbing activities and habitat fragmentation would not be anticipated. Impacts may result from spills or releases of treated or untreated groundwater, but impacts would be minimized through the use of spill prevention measures, identification and response programs, and NPDES permit requirements. Inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations with the U.S. Fish and Wildlife Service would assist in reducing impacts—SMALL.

DECOMMISSIONING—Impacts resulting from individual takes would occur due to conflicts with decommissioning activities (equipment, traffic). Temporary land disturbance would occur as structures are demolished and removed and the ground surface is recontoured. Inventory of threatened or endangered species developed during site-specific environmental review of the decommissioning plan would identify unique or special habitats, and Endangered Species Act consultations with the U.S. Fish and Wildlife Service would assist in reducing impacts. With completion of decommissioning, re-vegetation, and re-contouring, habitat would be reestablished and impacts would, therefore, be limited—SMALL to LARGE.

Air Quality Impacts

CONSTRUCTION—Fugitive dust and combustion (vehicle and diesel equipment) emissions during land-disturbing activities associated with construction would be small, short-term, and reduced through best management practices (e.g., dust suppression). For example, estimated fugitive dust emissions during ISL construction are less than 2 percent of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and less than 1 percent for PM_{10}. For NAAQS attainment areas, nonradiological air quality impacts would be SMALL. A Prevention of

Significant Deterioration Class I area exists in only one of the four regions (Wind Cave National Park in the Nebraska-South Dakota-Wyoming Region). More stringent air quality standards would apply to a facility that impacts the air quality of that area. If impacts were initially assessed at a higher significance level, permit requirements would impose conditions or mitigation measures to reduce impacts—SMALL.

OPERATION—Radiological impacts can result from dust releases from drying of lixiviant pipeline spills, radon releases from well system relief valves, resin transfer or elution, and gaseous/particulate emissions from yellowcake dryers. Only small amounts of low dose materials would be expected to be released based on operational controls and rapid response to spills. Required spill prevention, control, and response procedures would be used to minimize impacts from spills. HEPA filters and vacuum dryer designs reduce particulate emissions from operations, and ventilation reduces radon buildup during operations. Compliance with the NRC-required radiation monitoring program would ensure releases are within regulatory limits. Other potential nonradiological emissions during operations include fugitive dust and fuel from equipment, maintenance, transport trucks, and other vehicles. For NAAQS attainment areas, nonradiological air quality impacts would be SMALL. A Prevention of Significant Deterioration Class I area is located in the Nebraska-South Dakota-Wyoming Region (Wind Cave National Park). More stringent air quality standards would apply to a facility that impacts the air quality of that area. If impacts were initially assessed at a higher significance level, permit requirements would impose conditions or mitigation measures to reduce impacts—SMALL.

AQUIFER RESTORATION—Because the same infrastructure is used, air quality impacts are expected to be similar to, or less than, those during operations. For NAAQS attainment areas, nonradiological air quality impacts would be SMALL. Where a Prevention of Significant Deterioration Class I area exists, such as the Wind Cave National Park in the Nebraska-South Dakota-Wyoming Region, more stringent air quality standards would apply to a facility that impacts the air quality. If impacts were initially assessed at a higher significance level, permit requirements would impose conditions or mitigation measures to reduce impacts—SMALL.

DECOMMISSIONING—Fugitive dust, vehicle, and diesel emissions during land-disturbing activities associated with decommissioning would be similar to, or less than, those associated with construction, would be short-term, and would be reduced through best management practices (e.g., dust suppression). Potential impacts would decrease as decommissioning and reclamation of disturbed areas are completed. For NAAQS attainment areas, nonradiological air quality impacts would be SMALL. However, where a Prevention of Significant Deterioration Class I area exists (Wind Cave National Park in the Nebraska-South Dakota-Wyoming Region), more stringent air quality standards would apply to a facility that impacts the air quality of that area. If impacts were initially assessed at a higher significance level, permit requirements would impose conditions or mitigation measures to reduce impacts—SMALL.

Noise Impacts

CONSTRUCTION—Noise generated during construction would be noticeable in proximity to operating equipment, but would be temporary (typically daytime only). Administrative and engineering controls would be used to maintain noise levels in work areas below Occupational Health and Safety Administration (OSHA) regulatory limits and mitigated by use of personal hearing protection. Traffic noise during construction (commuting workers, truck shipments to and from the facility, and construction equipment such as trucks, bulldozers, and compressors) would be localized, and limited to highways in the vicinity of the site, access roads within the site, and roads in the well fields. Relative increases in traffic levels would be SMALL for the

larger roads, but may be MODERATE for lightly traveled rural roads through smaller communities. Noise may also adversely affect wildlife habitat and reproductive success in the immediate vicinity of construction activities. Noise levels decrease with distance, and at distances more than about 300 m [1,000 ft], ambient noise levels would return to background. Wildlife avoid construction areas because of noise and human activity. Generally, the uranium districts are located more than 300 m [1,000 ft] from the closest community. As a result, noise impacts would be SMALL to MODERATE.

OPERATION—Noise-generating activities in the central uranium processing facility would be indoors, reducing offsite sound levels. Well field equipment (e.g., pumps, compressors) would be contained within structures (e.g., header houses, satellite facilities), also reducing sound levels to offsite receptors. Administrative and engineering controls would be used to maintain noise levels in work areas below OSHA regulatory limits and mitigated by use of personal hearing protection. Traffic noise from commuting workers, truck shipments to and from the facility, and facility equipment would be expected to be localized, limited to highways in the vicinity of the site, access roads within the site, and roads in well fields. Relative increases in traffic levels would be SMALL for the larger roads, but may be MODERATE for lightly traveled rural roads through smaller communities. Most noise would be generated indoors and mitigated by regulatory compliance and best management practices. Noise from trucks and other vehicles is typically of short duration. Also, noise usually is not discernable to offsite receptors at distances of more than 300 m [1,000 ft.] Generally, the uranium districts are located more than 300 m [1,000 ft] from the closest community—SMALL to MODERATE.

AQUIFER RESTORATION—Noise generation is expected to be less than during construction and operations. Pumps and other well field equipment contained in buildings reduce sound levels to offsite receptors. Existing operational infrastructure would be used, and traffic levels would be expected to be less than those during construction and operations. There are additional sensitive areas that should be considered within some of the regions, but because of decreasing noise levels with distance, aquifer restoration activities would have only SMALL and temporary noise impacts for residences, communities, or sensitive areas, especially those located more than about 300 m [1,000 ft] from specific noise-generating activities. Noise usually is not discernable to offsite receptors at distances more than 300 m [1,000 ft]. Generally, the uranium districts are located more than 300 m [1,000 ft] from the closest community—SMALL to MODERATE.

DECOMMISSIONING—Noise generated during decommissioning would be noticeable only in proximity to equipment and temporary (typically daytime only). Administrative and engineering controls would be used to maintain noise levels in work areas below OSHA regulatory limits and mitigated by use of personal hearing protection. Noise levels during decommissioning would be less than during construction and would diminish as less and less equipment is used and truck traffic is reduced. Noise usually is not discernable to offsite receptors at distances more than 300 m [1,000 ft]. Generally, the uranium districts are located more than 300 m [1,000 ft] from the closest community—SMALL to MODERATE.

Historical and Cultural Resources Impacts

CONSTRUCTION—Potential impacts during ISL facility construction could include loss of, or damage and temporary restrictions on access to, historical, cultural, and archaeological resources. The eligibility evaluation of cultural resources for listing in the National Register of Historic Places (NRHP) under criteria in 36 CFR 60.4(a)–(d) and/or as Traditional Cultural Properties (TCP) would be conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. The evaluation of impacts to any

historic properties designated as TCPs and tribal consultations regarding cultural resources and TCPs also occurs during the site-specific licensing application and review process. To determine whether significant cultural resources would be avoided or mitigated, consultations with State Historic Preservation Offices (SHPO), other government agencies (e.g., U.S. Fish and Wildlife Service and State Environmental Departments), and Native American Tribes (the THPO) occur as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction. These procedures typically require the licensee to stop work and to notify the appropriate federal, tribal, and state agencies with regard to mitigation measures—SMALL or MODERATE to LARGE depending on site-specific conditions.

OPERATION—Because less land disturbance occurs during the operations phase, potential impacts to historical, cultural, and archaeological resources would be less than during construction. Conditions in the NRC license requiring adherence to procedures regarding the discovery of previously undocumented cultural resources would apply during operation. These procedures typically require the licensee to stop work and to notify the appropriate federal, tribal, and state agencies with regard to mitigation measures—SMALL, depending on site-specific conditions.

AQUIFER RESTORATION—Because less land disturbance occurs during the aquifer restoration phase, potential impacts to historical, cultural, and archaeological resources would be less than those during construction. Conditions in the NRC license requiring adherence to procedures regarding the discovery of previously undocumented cultural resources would apply during aquifer restoration. These procedures typically require the licensee to stop work and to notify the appropriate federal, tribal, and state agencies with regard to mitigation measures—SMALL, depending on site-specific conditions.

DECOMMISSIONING—Because less land disturbance occurs during the decommissioning phase and because decommissioning and reclamation activities would be focused on previously disturbed areas, potential impacts to historical, cultural, and archaeological resources would be less than during construction. Conditions in the NRC license requiring adherence to procedures regarding the discovery of previously undocumented cultural resources would apply during decommissioning and reclamation. These procedures typically require the licensee to stop work and to notify the appropriate federal, tribal, and state agencies with regard to mitigation measures—SMALL, depending on site-specific conditions.

Visual and Scenic Impacts

CONSTRUCTION—Visual impacts result from equipment (drill rig masts, cranes), dust/diesel emissions from construction equipment, and hillside and roadside cuts. Most of the four uranium milling regions are classified as Visual Resource Management (VRM) Class II through IV by the U.S. Bureau of Land Management. A number of VRM Class II areas surround national monuments (El Morro and El Malpais), the Chaco Culture National Historic Park, and sensitive areas managed within the Mount Taylor district in the Northwestern New Mexico Uranium Milling District and would have the greatest potential for impacts to visual resources. Most of these areas, however, are located away from potential ISL facilities at distances greater than 16 km [10 mi]. Most potential facilities are located in VRM Class III and IV areas. The general visual and scenic impacts associated with ISL facility construction would be temporary and SMALL, but from a Native American perspective, any construction activities would likely result in adverse impacts to the landscape, particularly for facilities located in areas within view of tribal lands and areas of special significance such as Mount Taylor. As previously discussed,

a Prevention of Significant Deterioration Class I area (Wind Cave National Park) is located in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Prevention of Significant Deterioration Class I areas require more stringent air quality standards that can affect visual impacts. Nevertheless, most potential visual impacts during construction would be temporary as equipment is moved and would be mitigated by best management practices (e.g., dust suppression). Because these sites are in sparsely populated areas and there is generally rolling topography of the region, most visual impacts during construction would not be visible from more than about 1 km [0.6 mi]. The visual impacts associated with ISL construction would be consistent with the predominant VRM Class III and IV—SMALL.

OPERATION—Visual impacts during operations would be less than those associated with construction. Most of the well field surface infrastructure has a low profile, and most piping and cables would be buried. The tallest structures include the central uranium processing facility {10 m [30 ft]} and power lines {6 m [20 ft]}. Because these sites are in sparsely populated areas and there is generally rolling topography of the regions, most visual impacts during operations would not be visible from more than about 1 km [0.6 mi]. Irregular layout of well field surface structures such as wellhead protection and header houses would further reduce visual contrast. Best management practices, and design (e.g., painting buildings) and landscaping techniques would be used to mitigate potential visual impact. The uranium districts in the four regions are all located more than 16 km [10 mi] from the closest VRM Class II region, and the visual impacts associated with ISL construction would be consistent with the predominant VRM Class III and IV—SMALL.

AQUIFER RESTORATION—Aquifer restoration activities would use in-place infrastructure. As a result, potential visual impacts would be the same as, or less than, those during operations—SMALL.

DECOMMISSIONING—Because similar equipment would be used and activities conducted, potential visual impacts during decommissioning would be the same as, or less than, those during construction. Most potential visual impacts during decommissioning would be temporary as equipment is moved and would be mitigated by best management practices (e.g., dust suppression). Visual impacts would be low, because these sites are in sparsely populated areas, and impacts would diminish as decommissioning activities decrease. An approved site reclamation plan is required prior to license termination, with the goal of returning the landscape to preconstruction conditions (predominantly VRM Class III and IV). Some roadside cuts and hill slope modifications, however, may persist beyond decommissioning and reclamation—SMALL.

Socioeconomic Impacts

CONSTRUCTION—Potential impacts to socioeconomics would result predominantly from employment at an ISL facility and demands on the existing public and social services, tourism/recreation, housing, infrastructure (schools, utilities), and the local work force. Total peak employment would be about 200 people, including company employees and local contractors, depending on timing of construction with other stages of the ISL lifecycle. During construction of surface facilities and well fields, the general practice would be to use local contractors (drillers, construction), as available. A local multiplier of 0.7 (U.S. Bureau of the Census) is used to indicate how many ancillary jobs could be created (in this case about 140). For example, local building materials and building supplies would be used to the extent practical. Most employees would live in larger communities with access to more services. Some construction employees, however, would commute from outside the county to the ISL facility, and skilled employees (e.g., engineers, accountants, managers) would come from outside the

local work force. Some of these employees would temporarily relocate to the project area and contribute to the local economy through purchasing goods and services and taxes. Because of the small relative size of the ISL workforce, net impacts would be SMALL to MODERATE.

OPERATION—Employment levels for ISL facility operations would be less than those for construction, with total peak employment depending on timing and overlap with other stages of the ISL lifecycle. Use of local contract workers and local building materials would diminish, because drilling and facility construction would diminish. Revenues would be generated from federal, state, and local taxes on the facility and the uranium produced. Employment types would be similar to construction, but the socioeconomic impacts would be less due to fewer employees—SMALL to MODERATE.

AQUIFER RESTORATION—In-place infrastructure would be used for aquifer restoration, and employment levels would be similar to those for operations—SMALL to MODERATE.

DECOMMISSIONING—A skill set similar to the construction workforce would be involved in dismantling surface structures, removing pumps, plugging and abandoning wells, and reclaiming/recontouring the ground surface. Employment levels and use of local contractor support during decommissioning would be similar to those required for construction. Employment would be temporary, however, as decommissioning activities are short in duration. Because of similar employment levels, other socioeconomic impacts would be similar to construction—SMALL to MODERATE.

Public and Occupational Health and Safety Impacts

CONSTRUCTION—*Worker safety would be addressed by standard construction safety* practices. Fugitive dust would result from construction activities and vehicle traffic, but would likely be of short duration and would not result in a radiological dose. Diesel emissions would also be of short duration and readily dispersed into the atmosphere—SMALL to MODERATE.

OPERATION—Potential occupational radiological impacts from normal operations would result from (1) exposure to radon gas from the well field, (2) ion-exchange resin transfer operations, and (3) venting during processing activities. Workers would also be exposed to airborne uranium particulates from dryer operations and maintenance activities. Potential public exposures to radiation could occur from the same radon releases and uranium particulate releases (i.e., from facilities without vacuum dryer technology). Both worker and public radiological exposures are addressed in NRC regulations at 10 CFR Part 20, which require licensees to implement an NRC-approved radiation protection program. (Measured and calculated doses for workers and the public are commonly only a fraction of regulated limits.) Nonradiological worker safety matters are addressed through commonly applied occupational health and safety regulations and practices. Radiological accident risks could involve processing equipment failures leading to yellowcake slurry spills, or radon gas or uranium particulate releases. Consequences of accidents to workers and the public are generally low, with the exception of a dryer explosion which could result in worker dose above NRC limits. The likelihood of such an accident would be low, and therefore the risk would also be low. Potential nonradiological accidents impacts include high consequence chemical release events (e.g., ammonia) for both workers and nearby populations. The likelihood, however, of such release events would be low based on historical operating experience at NRC-licensed facilities, primarily due to operators following commonly applied chemical safety and handling protocols—SMALL to MODERATE.

AQUIFER RESTORATION—Activities during aquifer restoration overlap with similar activities during operations (e.g., operation of well fields, waste water treatment and disposal). The resultant impacts on public and occupational health and safety would be bound by operational impacts. The reduction of some operational activities (e.g., yellowcake production and drying, remote ion exchange) will limit the relative magnitude of potential worker and public health and safety hazards—SMALL.

DECOMMISSIONING—Worker and public health and safety would be addressed in a NRC-required decommissioning plan. This plan details how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning, how ensuring the safety of workers and the public would be maintained, and how applicable safety regulations would be complied with—SMALL.

Waste Management Impacts

CONSTRUCTION—Relatively small-scale construction activities (Section 2.3) and incremental well field development at ISL facilities would generate low volumes of construction waste—SMALL.

OPERATION—Operational wastes primarily result from liquid waste streams including process bleed, flushing of depleted eluant to limit impurities, resin transfer wash, filter washing, uranium precipitation process wastes (brine), and plant wash down water. State permit actions, NRC license conditions, and NRC inspections ensure the proper practices would be used to comply with safety requirements to protect workers and the public. Waste treatments such as reverse osmosis and radium settling would be used to segregate wastes and minimize disposal volumes. Potential impacts from surface discharge and deep well injection would be limited by the conditions specified in the applicable state permit. NRC regulations address constructing, operating, and monitoring for leakage of evaporation ponds used to store and reduce volumes of liquid wastes. Potential impacts from land application of treated wastewater would be addressed by NRC review of site-specific conditions prior to approval and routine monitoring in decommissioning surveys. Offsite waste disposal impacts would be SMALL for radioactive wastes as a result of required preoperational disposal agreements. Impacts for hazardous and municipal waste would also be SMALL due to the volume of wastes generated. For remote areas with limited available disposal capacity, such wastes may need to be shipped greater distances to facilities that have capacity; however, the volume of wastes generated and magnitude of such shipments are estimated to be low—SMALL.

AQUIFER RESTORATION—Waste management activities during aquifer restoration would use the same treatment and disposal options implemented for operations. Therefore, impacts associated with aquifer restoration would be similar to operational impacts. While the amount of wastewater generated during aquifer restoration would be dependent on site-specific conditions, the potential exists for additional wastewater volume and associated treatment wastes during the restoration period. However, this would be offset to some degree by the reduction in production capacity from the removal of a well field. NRC review of future ISL facility applications would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

DECOMMISSIONING—Radioactive wastes from decommissioning ISL facilities (including contaminated excavated soil, evaporation pond bottoms, process equipment) would be disposed of as byproduct material at an NRC-licensed facility. A preoperational agreement with a licensed disposal facility to accept radioactive wastes ensures sufficient disposal capacity

would be available for byproduct wastes generated by decommissioning activities. Safe handling, storage, and disposal of decommissioning wastes would be addressed in a required decommissioning plan for NRC review prior to starting decommissioning activities. Such a plan would detail how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure the safety of workers and the public and compliance with applicable safety regulations. Overall, volumes of decommissioning radioactive, chemical, and solid wastes would be SMALL.

ABBREVIATIONS/ACRONYMS

BLM	U.S. Bureau of Land Management
CBSA	Core-Based Statistical Area
CEA	Cumulative Effects Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CEQ	Council on Environmental Quality
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FONSI	Finding of No Significant Impact
GEIS	Generic Environmental Impact Statement
ISL	*In-situ* Leach
MIT	Mechanical Integrity Testing
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act
NDEQ	Nebraska Department of Environmental Quality
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
PVC	Polyvinyl Chloride
RFFA	Reasonably Foreseeable Future Action
SHPO	State Historic Preservation Officer
TDS	Total Dissolved Solids
THPO	Tribal Historic Preservation Officer
UCL	Upper Control Limit
UIC	Underground Injection Control
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
VRM	Visual Resource Management
WDEQ	Wyoming Department of Environmental Quality

SI* (MODERN METRIC) CONVERSION FACTORS

Approximate Conversions From SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
Length				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
Area				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
Volume				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
m^3	cubic meters	0.0008107	acre-feet	acre-feet
Mass				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
Temperature (Exact Degrees)				
°C	Celsius	1.8 °C + 32	Fahrenheit	°F

*SI is the symbol for the International System of Units. Appropriate rounding should be performed to comply with Section 4 of ASTM E380 (ASTM International. "Standard for Metric Practice Guide." West Conshohocken, Pennsylvania: ASTM International. Revised 2003.).

1 INTRODUCTION

The Atomic Energy Act and the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) authorize the U.S. Nuclear Regulatory Commission (NRC) to issue licenses for the possession and use of source material and byproduct material. The statutes require NRC to license facilities that meet NRC regulatory requirements that were developed to protect public health and safety from radiological hazards. *In-situ* leach (ISL) uranium milling facilities must meet NRC regulatory requirements in order to obtain this license to operate.

> **Generic Environmental Impact Statement (GEIS)**
>
> A GEIS is an environmental impact statement that assesses the scope of the environmental effects that would be associated with an action (such as issuing a license for an ISL facility) at numerous sites. The Commission directed the NRC staff to prepare the GEIS to cover as many of the potential uranium recovery sites as possible.
>
> **Supplemental EIS (SEIS)**
>
> A supplemental EIS updates or supplements an existing EIS (such as the GEIS). The Commission directed the NRC staff to issue site-specific supplements to the GEIS for each new license application.

NRC licensing process is designed to assure the safe operation of ISL facilities. In addition to information for a safety evaluation review, license applicants must submit an environmental report as part of their license application. Under the NRC's environmental protection regulations in Title 10, Part 51 of the Code of Federal Regulations (10 CFR Part 51), which implement the National Environmental Policy Act (NEPA), issuance of a new license to possess and use source material for uranium milling requires an environmental impact statement (EIS) or a supplement to an EIS (SEIS). NRC will prepare an EA, SEIS or EIS for applications to amend or renew an existing ISL facility license in accordance to regulatory requirements in 10 CFR Part 51.

NRC prepared this Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities to help fulfill this requirement. The GEIS was prepared to assess the potential environmental impacts associated with the construction, operation, aquifer restoration, and decommissioning of an ISL facility in four specified geographic areas. The intent of the GEIS is to determine which impacts would be essentially the same for all ISL facilities and which ones would result in varying levels of impacts for different facilities, thus requiring further site-specific information to determine the potential impacts. As such, the GEIS provides a starting point for NRC's NEPA analyses for site-specific license applications for new ISL facilities, as well as for applications to amend or renew existing ISL licenses.

1.1 Rationale of the GEIS

In the GEIS, NRC assesses the environmental impacts that could be associated with an ISL facility in four geographic areas of the western United States. The rationale for developing the GEIS is that ISL facilities use the same or very similar technology such that the potential environmental impacts associated with technology could be assessed on a generic (programmatic) basis. In this way, repetitive reviews of certain of these impacts could be avoided, thus focusing NRC's evaluation on unique issues of concern for each site.

NRC developed this GEIS using (1) knowledge gained during the past 30 years of licensing and regulating these facilities, (2) the active participation of the State of Wyoming as a cooperating agency, and (3) public comments received during the preparation of the GEIS.

NRC structured the GEIS by identifying four geographic regions (Figure 1.1-1) to use for the environmental impact analysis. These regions were identified based on several considerations, including

- Past and existing uranium milling sites are located within states where NRC has regulatory authority over uranium milling.
- Potential new sites are identified based on NRC understanding of where the uranium recovery industry has plans to develop uranium deposits using ISL technology (NRC, 2009).
- Locations of previously identified uranium deposits within portions of Wyoming, Nebraska, South Dakota, and New Mexico (EPA, 2006, 2007) (Figure 1.1-2).

In this GEIS, NRC documents the potential environmental impacts that would be associated with the construction, operation, aquifer restoration, and decommissioning of an ISL facility in

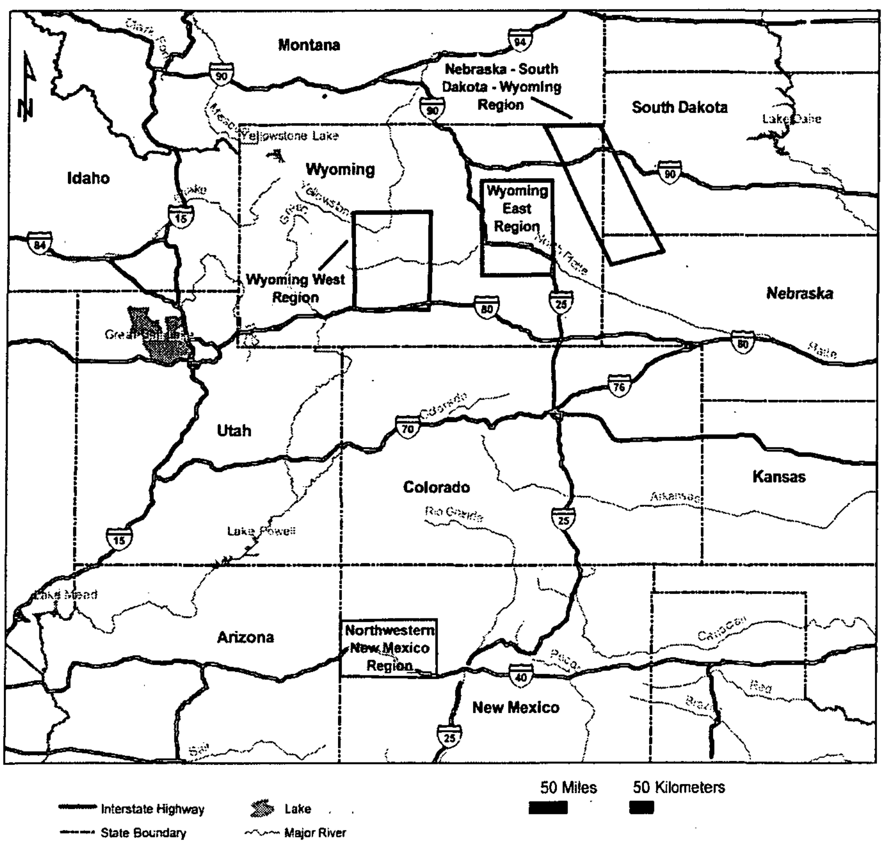

Figure 1.1-1. Four Geographic Regions Used as a Framework for the Analyses Presented in This GEIS

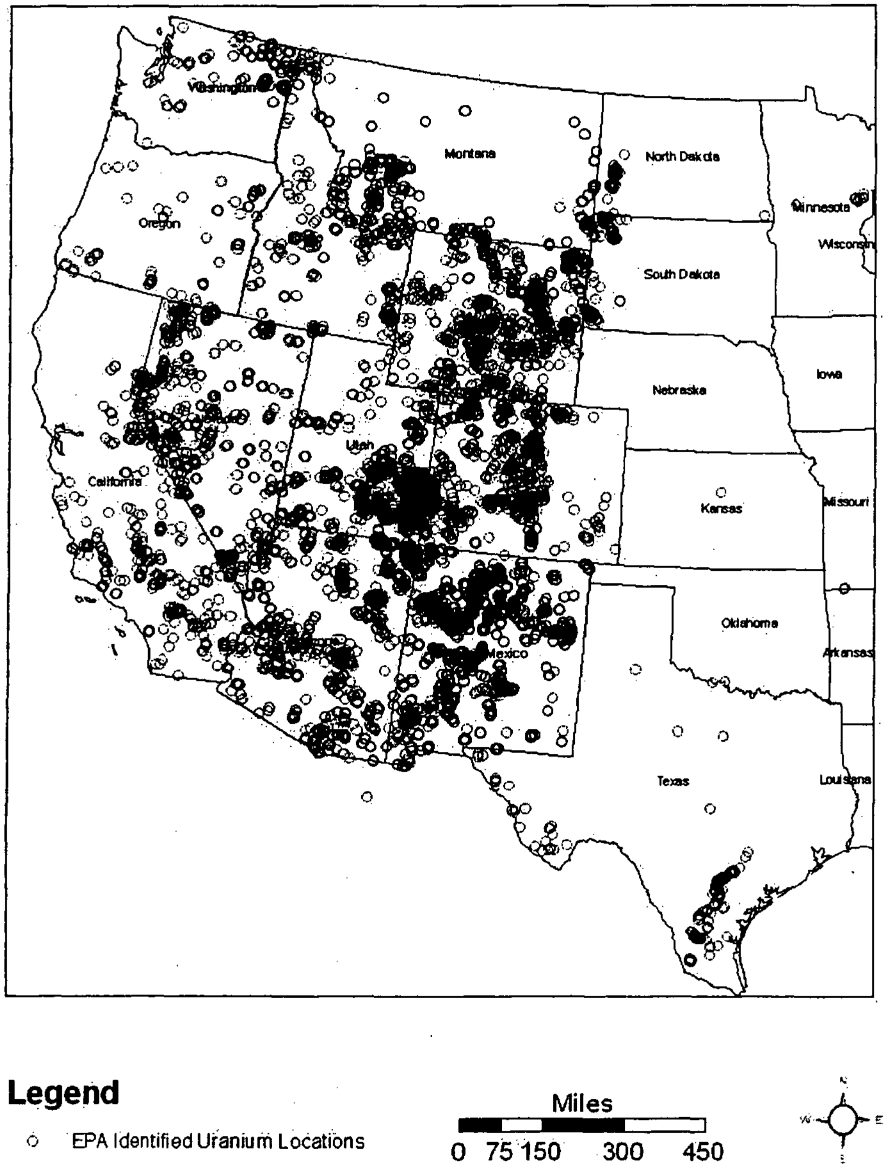

Figure 1.1-2. Major Uranium Reserves Within the United States (From Energy Information Administration, 2004)

the four specified regions of the Western United States. NRC intends that the GEIS will improve the efficiency of the licensing process by (1) providing an evaluation of the types of environmental impacts that may occur from licensing an ISL facility; (2) identifying and assessing impacts that are expected to be generic (the same or very similar) at ISL facilities with specified plant or site characteristics; and (3) identifying the scope of environmental impacts that need to be addressed in site-specific environmental reviews. The GEIS also provides information that will aid in the preparation of the site-specific environmental reviews for

ISL facilities and to help NRC maintain consistency when evaluating license applications involving the ISL process.

The availability of the GEIS does not change the basic practices and guidance that the NRC staff uses to conduct environmental reviews. In particular, the GEIS does not change the need for a detailed review of the information submitted by the applicant, nor does it change the need for conclusions in site-specific environmental assessments (EAs), SEISs, or EISs to be supported by sufficient technical bases that are transparent and traceable to supporting information. The NRC staff conducting environmental reviews is responsible for ensuring the conclusions of its environmental reviews are adequately supported by sufficient technical bases, whether that information is tiered off the GEIS or based on unique site-specific analyses.

The GEIS in no way relieves license applicants from the responsibility to adequately characterize and describe the proposed facility and site conditions in license application submittals. Information, methods, or analyses included in the GEIS that are applicable to a particular proposal could be used or referenced by license applicants provided the applicability and suitability of such referenced information is clear and its use does not significantly affect the completeness of any application.

1.2 The Proposed Federal Action

In states where NRC is the regulatory authority over the licensing of uranium milling (including the ISL process), NRC has a statutory obligation to assess each site-specific license application to ensure it complies with NRC regulations before issuing a license. The proposed federal action is to grant an application to obtain, renew, or amend a source material license for an ISL facility.

<u>The Proposed Federal Action</u>

To grant applications to obtain, renew, or amend source material licenses for an ISL facility.

<u>Purpose for the Proposed Federal Action</u>

To provide an option for applicants to use or licensees to continue to use ISL technology for uranium recovery.

Under NRC's environmental protection regulations at 10 CFR 51.20(b)(8), issuing a license to possess and use source material to a uranium milling facility is identified as a major federal action that requires the preparation of an EIS or a supplement to a EIS (SEIS). NRC will prepare a SEIS for new ISL facility license applications. NRC will prepare an EA, SEIS or EIS for applications to amend or renew an existing ISL facility license. The environmental review requirements for a material license are in 10 CFR Part 51. NRC's public health and safety requirements for ISL facilities are found in 10 CFR Parts 20 and 40. Parts 20, 40, and 51 require applicants to provide NRC with sufficient information to evaluate the impacts to public health and safety and the environment during the life cycle of the ISL facility. NRC then prepares safety and environmental reviews that are used by NRC officials to decide whether to grant the source material license.

In reviewing an ISL license application, NRC will use the GEIS as starting point for its site-specific environmental reviews. NRC will evaluate site-specific data and information to determine whether the applicant's proposed activities and the site characteristics are consistent with those evaluated in the GEIS. NRC will then determine which sections of the GEIS can be incorporated by reference and which impacts conclusions can be adopted in the site-specific environmental review, and whether additional data or analysis is needed to determine the environmental impacts for a specific resource area. Additionally, the GEIS provides guidance in the evaluation for certain impact analyses (e.g., cumulative impacts, environmental justice) for

which the GEIS did not make impact conclusions. No decision on whether to license an ISL facility will be made based on the GEIS alone. The licensing decision will be based, in part, on a site-specific environmental analysis that makes use of the GEIS.

1.3 Purpose and Need for the Proposed Federal Action

Commercial uranium recovery companies have approached NRC with plans to submit as many as 15 license applications for new uranium recovery facilities, as well as up to 9 applications for the restart or expansion of existing facilities in the next several years (NRC, 2009). The majority of these potential applications (perhaps 18 of the 24) would involve use of the ISL process. The companies have indicated that these new, restarted, and expanded ISL facilities would be located in Wyoming, South Dakota, Nebraska, and New Mexico.

NRC is the regulatory authority responsible for issuing a source material license for ISL facilities in those four states. 10 CFR Part 51 regulations require evaluating the environmental impacts of the ISL facility as part of the licensing process. Recognizing that the technology for ISL uranium milling is relatively standardized, that the applications may be submitted over a relatively short period of time, and that the potential ISL facilities would be located in relatively discrete regions in the western United States, NRC decided to prepare a GEIS to avoid unnecessary duplicative efforts and to identify environmental issues of concern to focus on in site-specific environmental reviews. In this way, NRC could increase the efficiency and consistency in its site-specific environmental review of license applications for ISL facilities (NRC, 2007b) and so provide an option for applicants to use and licensees to continue to use the ISL process for uranium recovery.

The purpose and need of the proposed federal action has no role in a company's decision to submit a license application to NRC for ISL uranium recovery at a particular location. From the company's perspective, the purpose of submitting an ISL license application for a new license, or renewal or amendment of an existing license, is to use or continue to use ISL technology to recover uranium at a specific site. The company could propose the use of different uranium recovery methods, including conventional milling. NRC has concluded that it is not appropriate to determine the purpose and need for a site-specific license application in the GEIS. The purpose and need for each ISL license application will be addressed in the site-specific environmental review in order to evaluate whether reasonable alternative uranium recovery methods are appropriate for the evaluation of potential environmental impacts.

1.4 Analytical Approach Used in the GEIS

1.4.1 Objectives

The GEIS serves to increase efficiency and eliminate repetitive discussions in NRC's environmental review process by identifying and evaluating environmental impacts that are generic and common to ISL uranium recovery facilities. Information from the GEIS can be summarized and incorporated by reference into the subsequent site-specific environmental review documents.

The GEIS also identifies resource areas that need site-specific information to more fully assess the environmental impacts to particular resource areas. The site-specific environmental impact analysis also will include any new or significant information necessary to evaluate the ISL facility license application.

1.4.2 Methodology

For the GEIS, NRC identified the potential environmental impacts associated with the ISL process and the resource areas that could be affected. The general methodology for doing so was to (1) describe the ISL process activities that could affect the resource, (2) identify the resource(s) that can be affected, (3) evaluate past licensing actions and associated environmental review documents and other available information, (4) assess the nature and magnitude of the potential environmental impacts to the resource(s), (5) characterize the significance of the potential impacts, and (6) identify site conditions and mitigation measures that may affect the significance.

For some types of impacts analyses (e.g., cumulative impacts, environmental justice evaluations), NRC recognized the difficulty in making determinations in the GEIS, given the location-specific nature of these analyses. For these categories, NRC collected information and conducted initial evaluations, which are documented in the GEIS. The purpose of this information gathering and initial evaluation is intended to provide background data and guidance for the site-specific analyses for these types of impact evaluations.

1.4.3 Structure of the GEIS

In this GEIS, NRC systematically evaluated the potential environmental impacts of construction, operation, aquifer restoration, and decommissioning of an ISL uranium recovery facility in four separate geographic regions of the western United States:

- **The Wyoming West Uranium Milling Region** includes portions of four Wyoming counties (Carbon, Fremont, Natrona, and Sweetwater).

- **The Wyoming East Uranium Milling Region** includes portions of eight Wyoming counties (Albany, Campbell, Carbon, Converse, Johnson, Natrona, Platte, and Weston) east of the Bighorn Mountains.

- **The Nebraska-South Dakota-Wyoming Uranium Milling Region** includes the portions of northwestern Nebraska (Dawes and Sioux Counties), western South Dakota (Custer, Fall River, Lawrence, and Pennington Counties), and the extreme eastern portion of Wyoming (Crook, Niobrara, and Weston Counties).

- **The Northwestern New Mexico Uranium Milling Region** includes McKinley County and portions of Cibola and Sandoval Counties.

1.4.3.1 Describing the ISL Process

Chapter 2 of this GEIS describes the ISL process, addressing construction, operation, aquifer restoration, and decommissioning of an ISL facility. This description is based on historical operations information from ISL facilities NRC licenses and regulates. The construction stage includes well field development and the construction of surface facilities and supporting infrastructure. Operations includes injection and production of solutions from uranium mineralization in the subsurface, as well as the process to recover the uranium from these solutions. Aquifer restoration includes activities to restore the groundwater quality in the production zone after uranium recovery is completed within a well field. Decommissioning includes the final stages of removing surface and subsurface infrastructure and reclaiming the

surface after uranium production activities at a site have been completed. Chapter 2 of the GEIS also includes a section on financial surety arrangements, where the licensee or applicant establishes a bond or other financial mechanism prior to operations to ensure that sufficient funds are available to complete aquifer restoration, decommissioning, and reclamation activities.

Site-specific license applications may not include all stages of the ISL process. For example, an applicant may propose to limit activities to well field construction, uranium mobilization, and ion exchange, and then ship the uranium-bearing resin to an existing processing plant for final processing. In this case, the applicant's license application would likely exclude the construction, operation, and decommissioning of a processing plant. NRC categorizes the ISL operations by various stages so relevant portions of the GEIS can be incorporated by reference into subsequent site-specific environmental reviews. For practical reasons, the GEIS emphasizes commonly used technologies (including some variants), but all possible variants of ISL technology are not addressed. Proposals to use technologies not addressed in the GEIS will be evaluated by NRC in a site-specific licensing review.

1.4.3.2 Describing the Affected Environment

GEIS Chapter 3 describes the affected environment for each of the four geographic regions using the environmental resource areas identified in NRC (2003b), which provides guidance to the NRC staff in conducting environmental reviews. These resource areas are

- Land use
- Transportation
- Geology and soils
- Water resources
- Ecology
- Air quality
- Noise
- Historical and cultural resource
- Visual and scenic resources
- Socioeconomic
- Public and occupational health
- Waste management

NRC staff will conduct independent, site-specific environmental reviews for each license application (see Section 1.8.3). GEIS Chapter 3 is divided into regional area discussions to facilitate using the GEIS in these site-specific reviews. Relevant sections of the regional discussions can be incorporated by reference in the site-specific environmental reviews.

1.4.3.3 Identifying Environmental Issues and Characterizing Significance

In Chapter 4, NRC evaluates the potential environmental impacts of construction, operation, aquifer restoration, and decommissioning of an ISL facility in each of the four regions. In essence, this involves conceptual placement of an ISL facility with the characteristics described in GEIS Chapter 2 within each of the four regional areas described in Chapter 3 and then describing and evaluating the significance of potential impacts in each region separately. The description for each identified potential environmental impact includes the type and magnitude of the ISL activity that would affect the environment and the attributes of the resource area that would be potentially affected.

Classifying Impact Significance (after NRC, 2003b)

- *Small Impact*: The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource considered.
- *Moderate Impact*: The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource considered.
- *Large Impact*: The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource considered.

The assessment of impacts considers potential environmental consequences at each stage in an ISL facility lifecycle—construction, operation, aquifer restoration, and decommissioning/ reclamation—and presents them for each of the resource areas identified in Chapter 3.

According to the Council on Environmental Quality (CEQ), the significance of impacts is determined by examining both context and intensity (40 CFR 1508.27). Context is related to the affected region, the affected interests, and the locality, while intensity refers to the severity of the impact, which is based on a number of considerations. In describing the significance of potential impacts in this GEIS, the NRC used the significance levels identified in NUREG–1748 (NRC, 2003b) (see text box).

Considerations related to potential cumulative impacts are described in Chapter 5, and environmental justice is discussed in Chapter 6. Mitigation measures and best management practices that may reduce potential environmental impacts are identified and discussed in Chapter 7. Required monitoring programs are described in Chapter 8 and are included in the determination of significance. Chapter 9 discusses the process for NRC consultation with federal, tribal, state, and local agencies. In Chapter 10, impacts are summarized in a table for each of the four geographic regions. The structure of this GEIS is shown graphically in Figure 1.4-1.

1.5 Scope of the GEIS

The scoping process occurs early in the development of an EIS in accordance with NEPA. Scoping provides an opportunity for the public and other stakeholders to identify key issues and concerns that they believe should be addressed in the document. The NRC requirements for scoping are found at 10 CFR 51.26–29, while the general NRC approach to scoping is described in NUREG–1748 (NRC, 2003b, Section 4.2.3).

1.5.1 The GEIS Scoping Process

On July 24, 2007, NRC published in the *Federal Register* a notice of intent to prepare a GEIS to examine the potential impacts associated with ISL uranium recovery facilities (NRC, 2007b). In that notice, NRC described the scoping process for the GEIS and established a public comment period from July 24, 2007, to September 4, 2007. NRC also announced dates and times for two public scoping meetings to be held—one in Albuquerque, New Mexico, and the other in Casper, Wyoming. NRC published a revised notice of intent in the *Federal Register* on August 31, 2007, announcing a third public scoping meeting in Gallup, New Mexico, and extended the public comment period to October 8, 2007 (NRC, 2007c). Following the Gallup public meeting, NRC subsequently extended the comment period further to October 31, 2007, and finally to November 30, 2007 (NRC, 2007c). At each of the three public scoping meetings, NRC described its role and mission and reviewed NRC procedures and responsibilities. Tribal, state, and local government agencies; concerned local citizens; and other stakeholders were then invited to identify scoping issues and concerns and ask questions. Transcripts (NRC, 2008b, 2007d,e) were prepared for all three meetings and are available online at the NRC Agencywide Documents Access and Management System (ADAMS), which is accessible at www.nrc.gov or through the NRC website for the GEIS at http://www.nrc.gov/materials/uranium-recovery/geis.html.

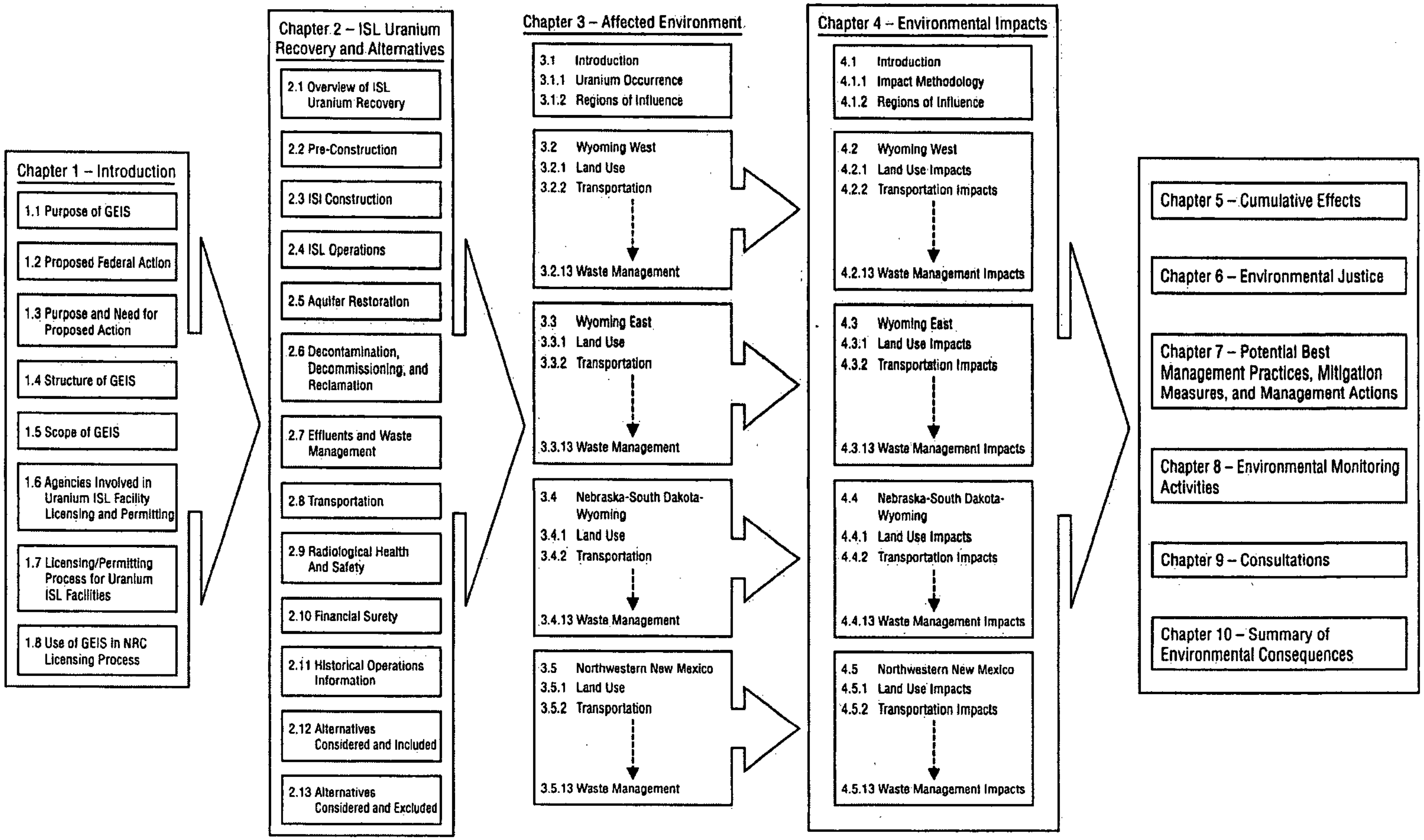

Figure 1.4-1. Structure of This GEIS

In addition to the comments received at the public meetings, NRC accepted written comments submitted either by regular mail or electronically. Using these varied methods, comments were received from approximately 1,600 entities (i.e., federal, state, and local agencies; industry organizations; public advocacy groups; and individual members of the public). A summary of comments NRC received during scoping is provided in a scoping summary report included as Appendix A to this GEIS.

1.5.2 Issues Studied in Detail

From the scoping process, NRC determined that the following issues identified by the public and other stakeholders would be addressed in the GEIS.

- **Proposed Action and Alternatives.** Scoping comments recommended clarifying the scope of the proposed action. Commenters also suggested a variety of alternatives for consideration. The proposed action is described in Section 1.2, and alternatives are described in Sections 2.12 and 2.13.

- **Applicable Statutes, Regulations, and Agencies.** Scoping comments expressed a need to clarify applicable regulations and the roles of government agencies in regulating ISL facilities. Various statutes, regulations, and implementing agencies at the federal, state, and local levels that have a role in regulating ISL facilities are identified and discussed in Section 1.6. The roles of these agencies are also described, as appropriate.

- **Purpose of the GEIS and Use in Site-Specific Licensing Reviews.** A number of scoping comments conveyed various interpretations of the purpose and intended use of the GEIS, suggesting the purpose and intended use needed to be clarified. For example, some thought the GEIS was going to be the only NEPA analysis conducted for all ISL facilities, while others thought the GEIS would eliminate or substantially degrade the rigor of NRC site-specific environmental reviews. A statement of purpose is included in Section 1.3, the NRC licensing process is described in Section 1.7.1, and the ways NRC intends to use the GEIS to evaluate environmental impacts in site-specific licensing reviews are provided in Section 1.8.

- **Opportunities for Public Involvement.** Many scoping comments reflected a perception that the GEIS would limit public involvement in ISL licensing. Some requested the opportunities for public involvement be described. Section 1.8.4 describes opportunities for public participation in the ISL licensing process.

- **Applicable Rulemaking Activities.** Some scoping comments recommended a discussion of ongoing rulemaking activities that are applicable to ISL licensing or the GEIS. The GEIS is based on the regulations in effect at the time of writing.

- **Land Use.** Concerns regarding potential land use impacts on ranching operations and livestock were raised during the scoping process. Potential impacts to existing land uses in the ISL milling regions including potential impacts to ranching, grazing, recreation, industrial, and cultural activities are discussed in Sections 4.2.1, 4.3.1, 4.4.1, and 4.5.1.

- **Transportation.** Scoping comments addressed general concerns with the safety of shipping yellowcake, road construction, fugitive dust generation, infrastructure damage, and incidental livestock kills. Potential radiological and nonradiological impacts from ISL transportation activities are discussed in Sections 4.2.2, 4.3.2, 4.4.2, and 4.5.2. Impacts from shipment of supplies, yellowcake product, and wastes associated with each phase of the ISL facility lifecycle are discussed. Normal transportation and accident conditions are considered. Potential nonradiological impacts evaluated include dust and noise generation, impacts on infrastructure such as roads, incidental livestock and wildlife kills, and changes to local traffic conditions. Potential radiological impacts considered include direct radiation and potential release of radioactive material from accidents during shipment.

- **Geology.** Scoping comments were received regarding the extent of soil disturbance and the utility of a generic analysis of geology. The GEIS describes the geology of the ISL milling regions in sufficient detail to support the evaluation of impacts to geology and soils (Sections 4.2.3, 4.3.3, 4.4.3, and 4.5.3) and groundwater (Sections 4.2.4.2, 4.3.4.2, 4.4.4.2, and 4.5.4.2) from ISL activities. GEIS Chapter 2 describes soil-disturbing activities (e.g., clearing, excavation, drilling, trenching, road construction, leaks, spills) and the magnitude of surface area disturbed at existing ISL facilities.

- **Water Resources.** A variety of water resource issues was raised in scoping comments including concerns about potential groundwater and surface water contamination, water availability and consumptive use, groundwater protection requirements, and aquifer restoration goals and techniques. The GEIS addresses potential impacts to surface waters, groundwater, and wetlands from each phase of the ISL facility lifecycle in Sections 4.2.4, 4.3.4, 4.4.4, and 4.5.4. Specific topics addressed include permitted surface water discharges, leaks and spills, groundwater excursions, consumptive water use, aquifer restoration, deep well injection, and applicable regulations. Hydrologic conditions in uranium milling regions are considered, as well as available restoration technologies and methods. The restoration of the aquifer water quality in the production zone following operations is addressed. Data from aquifer restoration efforts at ISL sites inform the analysis. Regulatory requirements and the roles of various federal, state, and local agencies regarding aquifer restoration are also discussed. Potential for groundwater impacts, in particular, is a key concern that has been historically an area of focus in NRC ISL licensing reviews.

- **Ecology.** Scoping comments on ecology raised topics regarding surface disturbance impacts on wildlife and vegetation, practices for isolating wildlife from exposure to uranium and other metals, recommended construction guidelines, habitat loss and fragmentation, and avoiding establishment of invasive species. The GEIS assesses the potential impacts to ecology in the uranium milling regions from all phases of the ISL facility lifecycle in Sections 4.2.5, 4.3.5, 4.4.5, and 4.5.5. This assessment includes consideration of potential impacts to terrestrial, aquatic, and threatened and endangered species. Specific topics addressed include evaluating ecoregions and habitat for a variety of listed species and assessing potential impacts from surface disturbances, habitat loss and fragmentation, and incidental kills. Applicable regulations and various management practices designed to protect species or mitigate potential impacts are discussed.

- **Meteorology, Climatology, and Air Quality.** Scoping comments included general environmental and safety concerns about the potential for airborne contamination, the magnitude of facility airborne releases, and applicable regulations. GEIS Sections 4.2.6, 4.3.6, 4.4.6, and 4.5.6 consider the potential impacts of all phases of the ISL facility lifecycle on local and regional air quality from both radiological and nonradiological emissions. The radiological air emissions addressed in the GEIS include radon from well fields, processing, and waste treatment operations and the potential for uranium particulate emissions from yellowcake drying operations. Nonradiological emissions addressed in the GEIS include combustion engine exhausts from trucking and well drilling operations and fugitive dusts from a variety of activities.

- **Noise.** Scoping comments on noise were limited to a statement regarding the low levels of noise ISL facilities generate. NRC recognizes that some activities in the ISL facility lifecycle can potentially generate additional noise, and impacts are evaluated in the GEIS Sections 4.2.7, 4.3.7, 4.4.7, and 4.5.7. This evaluation includes noise from well field development, uranium processing activities, and trucking activities associated with all phases of the ISL facility lifecycle.

- **Historic and Cultural.** Scoping comments were provided on historic and cultural resources including recommendations for documenting compliance with the National Historic Preservation Act requirements protecting historic properties on tribal lands, concerns about the notification process when cultural artifacts are found at an ISL facility, and opportunities for public participation regarding historic and cultural concerns. A number of individuals and organizations, primarily in New Mexico, expressed concerns on topics regarding proximity of uranium facilities to Native American communities and requested government-to-government consultations and documentation of consultations in the GEIS. The GEIS assesses potential impacts from all phases of the ISL facility lifecycle on historical and cultural resources in Sections 4.2.8, 4.3.8, 4.4.8, and 4.5.8. Local and regional historic and cultural properties and practices in ISL milling regions such as those involving Native American communities and governments are included. A description of NRC's process for consultation with Native American governments is provided in GEIS Chapter 9.

- **Visual Resources.** Scoping comments on visual resource impacts were varied. Potential impacts to visual resources in uranium milling regions from all phases of the ISL facility lifecycle are assessed in GEIS Sections 4.2.9, 4.3.9, 4.4.9, and 4.5.9. Assessments consider scenic vistas and sensitive viewsheds within uranium milling regions and ISL facility lifecycle impacts on these resources based on proximity.

- **Socioeconomics.** Scoping comments recommended evaluating social and economic impacts to local communities including job creation impacts; changes to tax base; and cumulative impacts on housing, roads, services, and labor to towns already overburdened by oil, gas, and coal development. The GEIS assesses potential impacts to socioeconomic conditions in uranium milling regions from all phases of the ISL facility lifecycle in Sections 4.2.10, 4.3.10, 4.4.10, and 4.5.10. Local and regional characteristics pertaining to demographics, income, tax structure and distribution, housing, employment, finances, education, and services are considered.

- **Public and Occupational Health.** A number of scoping comments expressed general public and worker safety concerns and more specific concerns about potential

contamination of soils, surface water, air, and groundwater; risks from radon gas and spills and from processing chemicals and resins; and emergency response and reporting. Potential impacts to public and occupational health from all phases of the ISL facility lifecycle are assessed in GEIS Sections 4.2.11, 4.3.11, 4.4.11, and 4.5.11. Both nonradiological (including chemical) and radiological effluents and releases under normal (routine) and accident conditions are assessed. Dose calculation results from previously licensed ISL facilities that include airborne uranium particulate and radon gas are provided. Hazards and risks for ISL processing chemicals are also considered. Potential soil contamination impacts from leaks and spills are discussed in Sections 4.2.3, 4.3.3, 4.4.3, and 4.5.3, and potential groundwater contamination is addressed in 4.2.4, 4.3.4, 4.4.4, and 4.5.4.

- **Waste Management.** Scoping comments expressed concerns about waste management in general and also about handling and disposal practices, deep well injection and permitted discharges, land application, disposal capacity, annual waste volumes, transportation, and applicable regulations. The GEIS considers impacts from waste management activities in all phases of the ISL facility lifecycle in Sections 4.2.12, 4.3.12, 4.4.12, and 4.5.12. Generation, handling, treatment, transportation, and final disposal of chemical, radiological, and municipal wastes are addressed. Constituents in various waste streams are identified, and volume estimates are provided.

- **Decontamination, Decommissioning, Reclamation.** A number of scoping comments expressed concerns about the site cleanup after operations end. The GEIS assesses impacts to the environment from terminating ISL operations, which include removal of facilities and equipment, disposal of waste materials, cleanup of contaminated areas, and reclamation of lands to pre-milling conditions. Decommissioning impacts are assessed for each resource area discussed in Chapter 4. Waste volume estimates by type of waste are provided, and applicable requirements are discussed.

- **Accidents.** Scoping comments requested consideration of credible accident scenarios. Potential accident conditions are assessed in various sections in the GEIS. This includes considering a range of possible accidents and off-normal operating conditions and estimating and evaluating consequences including well field leaks and spills, excursions, processing chemical spills, and ion-exchange resin and yellowcake transportation accidents.

- **Environmental Justice.** A range of opinions was provided in scoping comments on environmental justice in the GEIS. Some commenters thought it should be included in the GEIS, and others thought it should not be included. Still others provided various suggestions on how to do the analysis. GEIS Chapter 6 discusses the potential for disproportionately high and adverse environmental and health impacts on minority and low income populations from future ISL licensing in the specified uranium milling regions.

- **Cumulative Impacts.** Scoping comments on cumulative impacts offered a number of suggestions for reasonably foreseeable future actions to be included in the GEIS, including coal bed methane operations and oil and gas development. GEIS Chapter 5 describes past, present, and reasonably foreseeable future actions in the uranium milling regions and evaluates which resource areas would be potentially impacted by both ISL facilities and the types of reasonably foreseeable future actions identified in the regions. Due to the complex and site-specific nature of a cumulative impact assessment, the

GEIS provides useful information for understanding the potential for cumulative impacts when licensing future ISL facilities in the milling regions, but does not make conclusions regarding cumulative impacts for specific sites.

- **Monitoring.** Scoping comments on monitoring recommended the GEIS discuss monitoring programs designed to assess impacts from operations and waste management practices. The GEIS discusses various monitoring techniques and programs (Chapter 2, Chapter 8) used to detect radiological and nonradiological contaminants within and beyond ISL facility boundaries. This discussion includes effluent monitoring, workplace radiological monitoring, groundwater monitoring to detect potential excursions, and environmental monitoring at the facility boundary.

- **Financial Assurance.** Scoping comments recommended the GEIS discuss bonding for complete restoration of groundwater and land. Requirements and practices designed to ensure companies engaged in ISL recovery have sufficient funds to close down operations, restore aquifers, decontaminate and decommission facilities, and reclaim lands are described in GEIS Section 2.10.

1.5.3 Issues Eliminated From Detailed Study

The analyses presented in this GEIS focus on potential impacts within the four geographic regions described in Section 1.1 and illustrated in Figure 1.1-1; they are not intended to provide a detailed assessment of any specific site. Yellowcake transportation from uranium mills to the uranium hexafluoride (UF_6) conversion facility in Metropolis, Illinois, is anticipated to be by truck over existing highways. Access roads may need to be constructed to bring the yellowcake from the mill to the state and national (interstate) highway system. The existing national transportation routes are not expected to be altered. Because the environmental impacts of national transportation of yellowcake uranium have been previously analyzed, they are not studied in detail within this GEIS (NRC, 1977, 1980). These previous studies evaluated potential impacts by applying conservative risk assessment methods and assumptions to yellowcake transportation under conditions that remain applicable to present-day transportation conditions (see Section 3.2.2).

1.5.4 Issues Outside of the Scope of the GEIS

NRC has determined that comments received on topics in the following areas are outside the scope of this GEIS:

- NRC licensing process and the decision to prepare the GEIS
- General support or opposition for GEIS or uranium milling
- Requests for cooperation or agreements
- Matters that are regulated by Agreement States
- Impacts associated with conventional uranium milling past or present
- Requests for compensation for past mining impacts

- Resolution of dual regulation issues
- Consideration of human-induced climate change
- Analysis of all variations of ISL technology
- Alternative sources of uranium feed material
- Expanded cumulative impact analysis
- Energy debate
- NRC credibility

A discussion of why NRC determined that comments in these topic areas were outside the scope of the GEIS is provided in the Scoping Summary Report (Appendix A of the GEIS).

1.6 Agencies Involved in Uranium ISL Facility Licensing

A variety of federal, tribal, state, and local agencies potentially have a role in licensing and permitting an ISL uranium facility. Specific statues and regulations that may be applicable for uranium ISL facilities are detailed in Appendix B.

1.6.1 Federal Agencies

1.6.1.1 NRC

NRC responsibilities include regulating the nuclear industry in a manner that

- Protects public health and safety;
- Protects the environment; and
- Protects and safeguards materials and nuclear facilities in the interest of national security.

NRC is the federal agency with lead responsibility in licensing and regulating uranium ISL facilities through the statutory requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 and the Atomic Energy Act of 1954, as amended. In part, these statutes require that NRC ensure source material, as defined in Section 11z of the Atomic Energy Act and byproduct material, as defined in Section 11e.(2) of the Atomic Energy Act, is managed to conform with applicable regulatory requirements. Congress authorized the U.S. Environmental Protection Agency (EPA) to promulgate standards of general application for 11e.(2) material in Section 275 of the Atomic Energy Act. EPA standards of general application for 11e.(2) byproduct material were established in 40 CFR Part 192. The UMTRCA and the Atomic Energy Act also require that the generally applicable standards EPA promulgates for nonradiological hazards under UMTRCA be consistent with the standards EPA promulgates under the Solid Waste Disposal Act/Resource Conservation and Recovery Act for such hazards. NRC conforming regulations are in 10 CFR Part 40, Appendix A.

NRC is the regulatory authority for ISL facilities unless NRC relinquishes its authority to a state in a written agreement. Additional information on the Agreement State Program can be found at http://www.nrc.gov/about-nrc/state-tribal/agreement-states.html.

1.6.1.2 EPA

EPA also has a role in permitting nonradiological emissions and effluents. Water quality issues are administered predominantly through underground injection control (UIC) programs and National Pollutant Discharge Elimination System (NPDES) permits. Air quality issues are addressed through National Ambient Air Quality Standards (NAAQS) and National Emission Standards for Hazardous Air Pollutants programs. These programs may be administered directly by EPA, by states and tribes granted primacy, or by joint programs between EPA and a state (EPA, 2008a–f). EPA issues permits in unauthorized states or tribal areas that are subject to exclusive federal jurisdiction.

1.6.1.3 Occupational Safety and Health Administration

The mission of the Occupational Health and Safety Administration (OSHA) is to assure the safety and health of workers in the United States, and it is the lead federal agency with responsibility for regulating the industrial safety of the work force at uranium ISL facilities. Recognizing the different agency responsibilities, NRC and OSHA have entered into a memorandum of understanding to coordinate their inspection programs and avoid duplication of effort (Occupational Safety and Health Administration, 1988). As part of this program, NRC inspectors do not perform the role of OSHA, but they may identify safety concerns or receive complaints from employees about working conditions within the areas of responsibility for OSHA, notifying the OSHA Regional Office as appropriate (Occupational Safety and Health Administration, 1988).

1.6.1.4 U.S. Department of Transportation

The U.S. Department of Transportation regulates the shipments of radiological and nonradiological hazardous materials and sets regulatory requirements for type and condition of hazardous material containers, the mechanical condition of the transportation vehicles, the training of personnel, and the routing requirements, package labels, vehicle placards, and shipping papers associated with shipments of radioactive materials. The U.S. Department of Transportation also inspects containers, storage facilities, and carrier equipment (Office of Technology Assessment, 1986).

1.6.1.5 U.S. Department of Interior, U.S. Bureau of Land Management

The U.S. Department of Interior, U.S. Bureau of Land Management (BLM) is responsible for managing the National System of Public Lands and the federal minerals underlying these lands. The BLM is also responsible for managing split estate situations where federal minerals underlie a surface that is privately held or owned by state or local government (see Section 3.1.2.2). In certain cases, the BLM also manages federal surface estates overlying privately or state-owned minerals. Operators on mining claims, including ISL uranium recovery operations, must submit a plan of operations and obtain BLM approval before beginning operations beyond those for casual use. For exploration operations disturbing less than 2 ha [5 acres], operators must submit a notice at least 15 days prior to commencing these operations. The BLM will periodically field inspect operations on plans of operation and notices. The BLM surface management program is more fully explained at 43 CFR Part 3809.

1.6.1.6 Other Federal Agencies

For individual new uranium ISL facilities proposed near or on federally managed lands, agencies such as the U.S. Forest Service or National Park Service may have jurisdiction or special expertise that leads to a role in reviewing applications for these facilities. The Bureau of Indian Affairs has responsibilities under 25 CFR Part 216 to evaluate mineral leases involving lands held in trust for Native American tribes. Other federal agencies that may be consulted on specific resource areas include the U.S. Army Corps of Engineers (wetlands), the U.S. Department of Energy Office of Legacy Management (e.g., administration of adjacent legacy sites), and the U.S. Fish and Wildlife Service (endangered and threatened species).

1.6.2 Tribal Agencies

Native American tribes do not formally have licensing authority over uranium ISL facilities. Consultations with Native American tribes would be conducted in a government-to-government relationship that exists based on applicable federal law and treaties (NRC, 2003a) during the ISL licensing process. EPA can authorize tribes to implement specific environmental permitting programs. Tribes may also have their own local laws that impact ISL facilities. Additionally, tribes may have a tribal historic preservation officer that would coordinate with NRC to support cultural resource inventories for ISL facility applications.

1.6.3 State Agencies

Individual states have regulatory authority over construction, operation, aquifer restoration, and decommissioning and reclamation at uranium ISL facilities through state-administered permitting processes. For the purposes of the GEIS, specific agencies within each state that have regulatory authority over uranium ISL facilities are identified in the following sections.

1.6.3.1 Wyoming Department of Environmental Quality

The lead agency for permitting uranium ISL facilities in Wyoming is the Wyoming Department of Environmental Quality (WDEQ). With statutory authority from the Federal Surface Mining Reclamation and Control Act and the Wyoming Environmental Quality Act, the Land Quality Division within WDEQ administers and enforces permits and licensing requirements for all operators engaged in land-disturbing activities related to mining and reclamation within Wyoming. In the context of Wyoming regulations, uranium ISL facilities are considered to be noncoal mining activities that are subject to Land Quality Division permits. Each operation must be covered by a reclamation bond to provide financial surety that reclamation requirements can be met. Through its review and consultation program, the Wyoming State Historic Preservation Office (SHPO) coordinates with NRC and WDEQ to support cultural resource inventories for uranium ISL facilities.

1.6.3.2 Nebraska Department of Environmental Quality

The Nebraska Department of Environmental Quality (NDEQ) regulates air and water quality, with statutory authority from the Nebraska Environmental Protection Act. General water quality standards and use classifications are established in Title 117 (surface water) and Title 118 (groundwater) of the Nebraska Administrative Code (NDEQ, 2006a,b). The Nebraska NPDES program is described in Title 119 (NDEQ, 2005), and the regulatory requirements for underground injection, mineral production wells, and waste disposal wells related to ISL uranium recovery are governed by UIC requirements in Title 122 of the Nebraska Administrative

Code (NDEQ, 2002a). The Nebraska SHPO is a division of the Nebraska State Historical Society. The Nebraska SHPO manages historic preservation programs within the state, which includes developing and maintaining a statewide historic preservation plan and providing supporting planning programs for other state agencies.

1.6.3.3 South Dakota Department of Environment and Natural Resources

With renewed interest in uranium resources in South Dakota, the 2006 State Legislature passed legislation to fill gaps in the existing state laws that govern uranium exploration and recovery. This legislation authorized the South Dakota Board of Minerals and Environment to develop rules to issue state permits and licensing requirements to ISL facilities under the South Dakota Mined Land Reclamation Act (South Dakota Codified Law 45–6B). The final rules were adopted in April 2007 (South Dakota Department of Environment and Natural Resources, 2007a). The South Dakota SHPO is a program of the South Dakota State Historical Society within the Department of Tourism and State Development. The South Dakota SHPO manages historic preservation programs within the state and coordinates and plans historic preservation efforts across the state.

1.6.3.4 New Mexico Environment Department

The New Mexico Environment Department was established under the provisions set forth in the Department of the Environment Act by the 40th State Legislature, enacted July 1, 1991 (Laws of 1991, Chapter 25). The New Mexico Environment Department, with statutory authority from the New Mexico Oil and Gas Act and the New Mexico Water Quality Act, has UIC permitting authority over uranium ISL facilities. The New Mexico SHPO is part of the Historic Preservation Division within the New Mexico Department of Cultural Affairs. The New Mexico SHPO administers historic preservation programs within the state and provides information and technical assistance to state agencies, local governments, and private owners.

1.7 Licensing and Permitting Process for a Uranium ISL Facility

As noted in Section 1.6, NRC has statutory authority through the Atomic Energy Act and UMTRCA to regulate uranium ISL facilities. In addition to obtaining an NRC license, uranium ISL facilities must obtain the necessary permits from the appropriate federal, tribal, and state agencies. The NRC licensing process and other potential federal, tribal, and state permitting processes are briefly discussed in this section to provide a basic understanding of potential permitting requirements for uranium ISL facilities in the four geographic regions in Figure 1.1-1. This is not intended to be an exhaustive description of all permits that may be necessary for a specific facility.

1.7.1 The NRC Licensing Process

The general NRC process for licensing facilities is described in NRC (2003b) and illustrated in Figure 1.7-1. This process has been modified for ISL facilities. After receiving a license application for either a new facility or the renewal or amendment of an existing facility license, NRC conducts an acceptance review to determine whether the application is complete enough

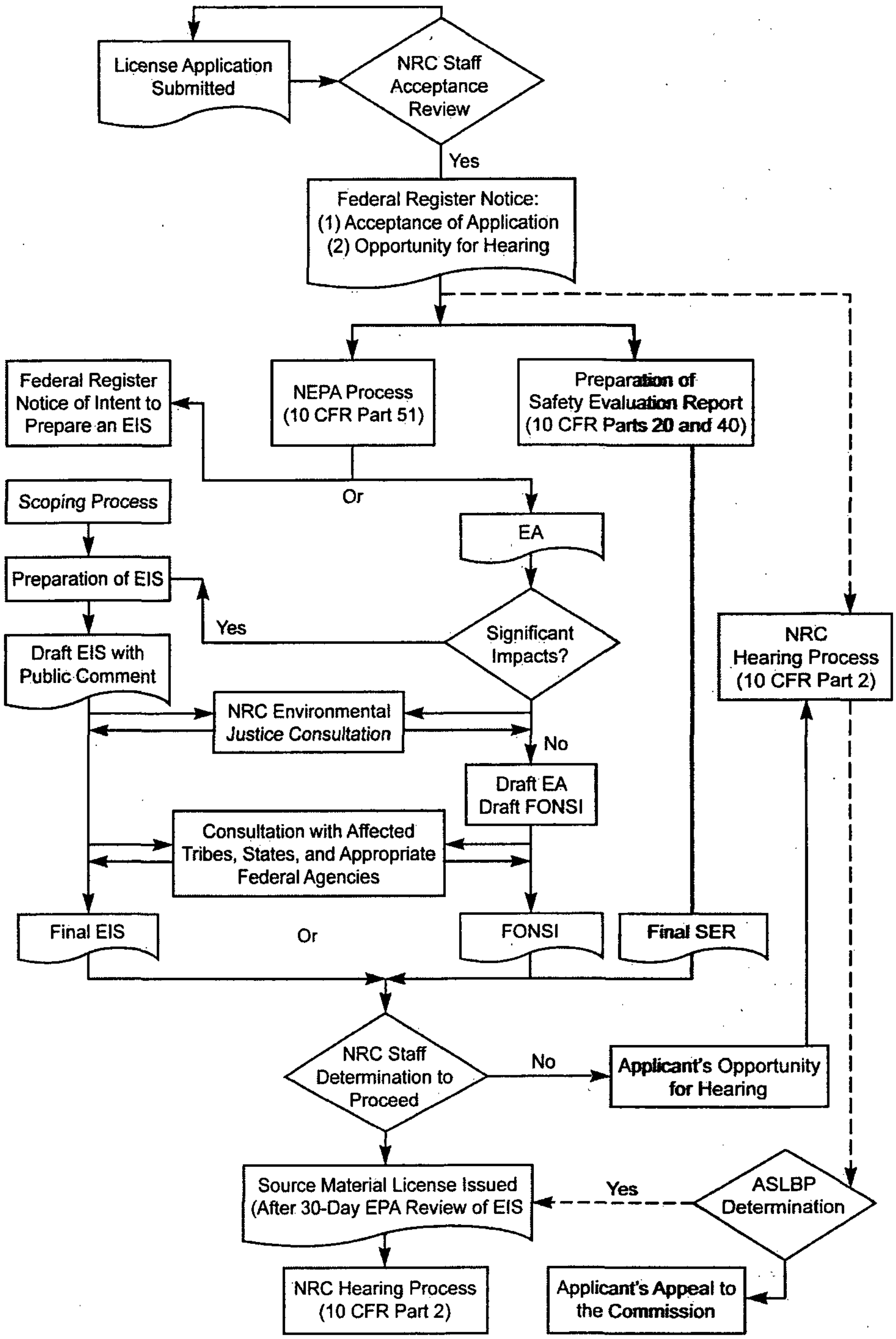

Figure 1.7-1. General Flow Diagram of the NRC Licensing Process for 10 CFR Part 40 Licenses (From NRC, 2003a). ASLBP–Atomic Safety Licensing Board Panel; EA–Environmental Assessment; EIS–Environmental Impact Statement; FONSI–Finding of No Significant Impact; NEPA–National Environmental Policy Act; SER–Safety Evaluation Report.

to support more detailed technical review. If NRC determines that a new license or license renewal application is acceptable for detailed review, it will formally docket the application and publish a Notice of Availability of the application in the *Federal Register*. For license amendment applications, the results of NRC's acceptance review can be documented in a letter to the licensee. NRC's detailed technical review of an application (either for a new license or for the renewal or amendment of an existing license) is composed of a safety review and an environmental review. NRC conducts the safety review to assess compliance with the regulatory requirements of 10 CFR Part 20 and 10 CFR Part 40, Appendix A. In parallel with the safety review, the NRC staff is required under NEPA to conduct an environmental review for each license application. The NRC environmental protection regulations applicable to licensing actions are found in 10 CFR Part 51. As appropriate, the NRC staff may propose license conditions to ensure that specific features of a given site are taken into account in protecting worker and public health and safety and the environment. The NRC hearing process (10 CFR Part 2) applies to NRC licensing actions and offers stakeholders a separate opportunity to raise concerns with the proposed action during the licensing process.

If a new license is issued or a license amendment granted, NRC ensures that the licensee complies with the conditions of its NRC license and the applicable regulations through an inspection program managed out of one of its four regional offices. The NRC Region IV office in Arlington, Texas, would manage inspection programs for ISL uranium recovery facilities located in each of the four regions analyzed in this GEIS.

NRC inspections are guided by the NRC inspection manual, which includes detailed procedures for various types of inspections. Examples of topics addressed by ISL facility inspections include construction, management organization and controls, training of personnel, radiation protection programs, facilities and equipment, environmental protection, financial assurance, transportation of radioactive materials, radioactive waste management, efforts to maintain effluents as low as is reasonably achievable (ALARA), emergency preparedness, decommissioning, and security of nuclear materials. Inspections occur at least annually, but NRC inspection staff can adjust the inspection frequency based on a number of variables, including licensee performance. Inspections can be announced or unannounced. In addition to inspections, the NRC staff reviews the licensee-submitted semiannual effluent and environmental monitoring reports and takes the necessary actions to respond to reported incidents at ISL facilities (e.g., spills, excursions, and other reportable events).

The inspection process may identify violations that are subject to enforcement actions by the agency. The NRC enforcement policy endeavors to deter non-compliances by emphasizing the importance of compliance with NRC requirements. The enforcement policy also encourages prompt identification and comprehensive correction of violations. Accordingly, licensees, contractors, and their employees who do not achieve the high standard of compliance expected by NRC, are subject to enforcement sanctions. As part of the enforcement process, NRC considers the recent performance history and the number and severity of violations for a given licensee. Further, licensees, employees, and contractors who engage in deliberate misconduct or who deliberately submit incomplete or inaccurate information to NRC are subject to significant enforcement sanctions, including civil penalties and legally binding orders.

1.7.2 EPA Permitting

Under environmental laws such as the Clean Water Act, the Safe Drinking Water Act, and the Clean Air Act, EPA has statutory authority to regulate activities that may affect the environment. EPA permitting that is most relevant for uranium ISL facilities is related to underground injection of the leaching solution (i.e., the lixiviant) and liquid effluents, surface discharge of treated waters and industrial and construction stormwaters, and air quality.

1.7.2.1 Water Resources

Under the Safe Drinking Water Act, EPA was granted primary authority to regulate underground injection and protect current and future sources of drinking water. Underground injection is broadly defined as the process of placing fluids underground through wells or other similar conveyance systems. EPA implements this responsibility through its UIC program (EPA, 2008a). EPA may administer the programs directly for states or tribal lands or jointly with the state or tribal government. Alternatively, EPA may also authorize individual states or tribes to administer the UIC programs in accordance with EPA regulations. Currently, Wyoming, Nebraska, and New Mexico are authorized states. South Dakota administers the UIC program jointly with EPA, with the state administering the program for UIC Class II permits (EPA, 2008b).

Native American tribes can follow the same rules as states for obtaining authorization (40 CFR Part 145) if they are considered a "Federally Recognized Tribe" and have been designated for "Treatment Similar to a State." Tribes that want to enforce the federal UIC requirements must submit an application for approval of their program to EPA. As of this writing (April 2009), EPA has approved applications from two tribes (the Fort Peck Assiniboine and Sioux Tribes in Montana and the Navajo Nation) to implement UIC programs for Class II (oil and gas-related) injection wells. In the absence of tribal authorization, EPA can directly administer the UIC program in tribal areas even if they are located in a State with an approved UIC program.

UIC Permitting (from EPA, 2008a)

In the four regions covered in this GEIS, the state implements UIC permitting for all five UIC permit classes for Wyoming, Nebraska, and New Mexico and for UIC Class II for South Dakota. Classes I and III are most applicable to uranium ISL facility operations.

- *Aquifer Exemption.* UIC criteria for exemption of an aquifer that might otherwise be defined as an underground source of drinking water are found at 40 CFR 146.4. These criteria include whether the aquifer is currently a source of drinking water and whether the water quality is such that it would be economically or technologically impractical to use the water to supply a public water system.
- *Industrial and Municipal Waste Disposal Wells (UIC Class I).* This permit class governs deep disposal of industrial, commercial, or municipal waste below the deepest usable aquifer. This type of injection uses wells and requires applied pressure. It includes all wells that dispose of waste on a commercial basis, even if the waste would be otherwise eligible for disposal into a Class II well (e.g., WDEQ, 2005, 1993). For uranium ISL facilities, this type of UIC permit is necessary to use deep well injection for waste disposal.
- *Mining Wells (UIC Class III).* These permits govern injection wells drilled to recover minerals. They includes experimental technology wells; underground coal gasification wells; and wells for the *in-situ* recovery of materials such as copper, uranium, and trona. For uranium ISL facilities, this type of UIC permit covers wells that inject the lixiviant into the uranium mineralization.
- *Shallow Nonhazardous Injection Wells (UIC Class V).* This permit class covers all injection wells not included in Classes I-IV. In general, Class V wells inject nonhazardous fluids into or above underground sources of drinking water and are typically shallow, onsite disposal systems. However, some deep Class V wells inject below underground sources of drinking water.

Unless authorized by rule or by permit, any underground injection is unlawful and violates the Safe Drinking Water Act and UIC regulations. Before an NRC-licensed uranium ISL facility can

begin operations at any project site, the licensee must obtain the necessary UIC authorizations. These will include (1) an aquifer exemption (also called exempting the aquifer as an underground source of drinking water) for the aquifer or portion of the aquifer where the uranium mobilization and recovery will occur and (2) a Class III UIC permit to operate injection wells. In addition, if deep well injection will be used to dispose of certain liquid wastes, the licensee will need to obtain a Class I UIC permit.

Under the provisions of the Clean Water Act, the NPDES program regulates discharges of pollutants from a point source into surface water of the United States. Operators of a point source discharge must obtain an NPDES discharge permit (EPA, 2008d). The permits contain limitations and conditions that are intended to protect surface water quality. Permits can cover either operational (industrial stormwater and process water including dewatering, produced water, and treated wastewater) or construction phases. Construction stormwater NPDES authorizations are applied for and issued annually under a general permit based on projected construction activities. For a construction stormwater authorization, a notice of intent is filed before construction activities begin.

As with the UIC program, EPA either directly administers the NPDES permitting program or may authorize the permitting authority to a state or tribe (EPA, 2008e). State-implemented NPDES programs (covering commercial industrial facilities such as ISL uranium mills) are authorized in Wyoming, Nebraska, and South Dakota. EPA directly administers the NPDES program in New Mexico and in Indian Country (EPA, 2008f).

1.7.2.2 Air Quality

EPA was given the primary responsibility to set standards and oversee the Clean Air Act. Similar to water protection programs, EPA may authorize the states, tribes, and local agencies to prevent and control air pollution. Under the Clean Air Act, EPA developed the following standards:

- National Primary and Secondary Ambient Air Quality Standards in 40 CFR Part 50
- National Emission Standards for Hazardous Air Pollutants in 40 CFR Part 40
- Prevention of Significant Deterioration in 40 CFR Part 52

As described in 40 CFR Part 51, Requirements for Preparation, Adoption, and Submittal of Implementation Plans, states must develop state implementation plans consisting of regulations, programs, and policies that describe how each state will control air pollution under the Clean Air Act. Agencies must obtain EPA approval for these implementation plans. The permitting process is a mechanism agencies use to put the implementation plans into effect. EPA's Tribal Authority Rule gives tribes the ability to (1) develop air quality management programs, (2) write air pollution reduction rules, and (3) implement and enforce these rules. Similar to the states, tribes must obtain EPA approval for these implementation plans.

The Clean Air Act permitting process is divided into two programs: the New Source Review program (preconstruction) and the Title V program (operation). NRC is not the regulatory authority for Clean Air Act permitting. Permitting authorities are identified in Table 1.7-1. The New Source Review requires stationary air pollution sources to obtain permits prior to construction. This is commonly referred to as construction or preconstruction permitting.

Three types of New Source Review permits exist: (1) Prevention of Significant Deterioration, (2) nonattainment New Source Review, and (3) minor New Source Review. In attainment areas (i.e., those areas where air quality meets the NAAQS), Prevention of Significant Deterioration permits are required for major stationary pollutant sources that are new or making major modifications. The threshold for classification as a major source in an attainment area is either 90.7 or 227 metric tons [100 to 250 short tons] of a regulated pollutant, depending on the source. In nonattainment areas, the nonattainment New Source Review permits are required for major stationary pollutant sources that are new or making major modifications. The threshold for classification as a major source in a nonattainment area is generally 90.7 metric tons [100 short tons] of a regulated pollutant. This threshold can be lower for areas with more serious nonattainment problems. The minor New Source Review permits are for sources that do not require Prevention of Significant Deterioration or nonattainment New Source Review permits. A minor New Source Review permit is intended to support the Prevention of Significant Deterioration and nonattainment New Source Review programs by implementing permit conditions as needed that limit emissions from sources not covered by those two programs. The factors that determine which permit applies to a particular proposed ISL facility are the NAAQS compliance status and whether the facility was classified as a major or minor source. Specific requirements would be determined by the appropriate regulatory authority on a site-specific basis.

Operating permits, called Title V permits, are required for most large sources and some smaller sources of air pollution. State or local agencies issue most Title V permits. In general, ISL facilities do not meet the emissions thresholds that invoke Title V requirements or require operating permits. However, to the extent that an ISL facility would meet the general requirements identified for EPA regulations at 40 CFR Part 70 and 71 {e.g., by exceeding either a general emissions threshold of 90.7 metric tons [100 short tons] for any air pollutant, lower thresholds for areas that are in nonattainment with air quality standards, or major source thresholds for hazardous air pollutants}, the licensee or applicant would need to obtain the necessary Title V permit before beginning operations.

Table 1.7-1. New Source Review Permit Summary Information for Nebraska, New Mexico, South Dakota, and Wyoming*

Area	Permitting Authority	Regulations
Nebraska†	State and local agencies	State Implementation Plan
New Mexico†	State and local agencies	State Implementation Plan
South Dakota†	State agency	State Implementation Plan‡
Wyoming†	State agency	State Implementation Plan
Indian country (all four states)	Appropriate U.S. Environmental Protection Agency regional office	40 CFR 52.21

*Modified from U.S. Environmental Protection Agency. "Prevention of Significant Deterioration (PSD) Permit Program Status: February 2009." 2009. <http://www.epa.gov/nsr/where.html> (29 April 2009).
†Except for Indian country.
‡Except for Prevention of Significant Deterioration permitting that is regulated by 40 CFR 52.21.

1.7.3 Other Federal Agencies

NRC and the U.S. Department of Transportation jointly regulate the safety of radioactive material shipments. The NRC regulations to transport radiological materials such as yellowcake and uranium-loaded resins are established in 10 CFR Part 71. For example, refined yellowcake is packaged and shipped in 208-L [55-gal], 18-gauge steel drums holding an average of 430 kg [950 lb]. The U.S. Department of Transportation classifies this as Type A packaging (49 CFR Parts 171–189 and 10 CFR Part 71).

Because the federal government manages a portion of the land in the four geographic regions discussed in this GEIS, BLM may control surface access at uranium ISL sites proposed for federal lands. BLM administers grazing on public ranchlands through field offices located in each state. The licensee must obtain the necessary mineral rights and environmental clearances from BLM for surface disturbances and approval for temporary occupancy. BLM requires (per 43 CFR 3809) the ISL licensee or applicant to submit a plan of operations. The BLM-required information can be (and usually is) included as part of the applicant's state-required forms/applications. Unlike NRC, BLM considers all mineral recovery to be mining. BLM regulates land use for operations proposed on BLM land and where the surface rights are privately owned and the mineral rights are under federal jurisdiction.

1.7.4 Tribal Agencies

Like states, Native American tribes can be authorized to implement the EPA Clean Water Act and Clean Air Act programs and can have their own permitting authority (e.g., Navajo Nation Environmental Protection Agency). This is discussed further in Sections 1.7.2.1 and 1.7.2.2. Additionally, NRC has a responsibility to consult with tribes; the process for doing so is discussed in GEIS Chapter 9.

At least one tribe, the Navajo Nation, has enacted tribal legislation that prohibits all uranium processing activities. On April 29, 2005, Navajo Nation President Joe Shirley, Jr. signed the Diné Natural Resources Protection Act of 2005. The Navajo ban on uranium milling and processing presents a number of complex legal and policy issues, including whether a particular site falls under the definition of "Navajo land" in the Diné Natural Resources Protection Act of 2005.

The NRC approach to these types of jurisdictional issues has been to fulfill NRC statutory mandates to evaluate license applications and determine whether a particular application complies with the Atomic Energy Act and NRC regulations. At the same time, NRC recognizes that other governmental entities, in this case the Navajo Nation, may also have jurisdiction over some issues. The Commission acknowledges and recognizes that the Navajo Nation has certain sovereign powers under federal law. In general, although a license applicant may demonstrate that it meets the Atomic Energy Act and NRC regulations and thereby receives an NRC license, the applicant may nonetheless need to address other applicable requirements and obtain other necessary permits from appropriate regulatory authorities to go forward with its project.

1.7.5 State Agencies

The following sections briefly describe relevant state permitting requirements for Wyoming, Nebraska, South Dakota, and New Mexico.

1.7.5.1 Wyoming

WDEQ provides general guidance on Wyoming regulatory requirements for ISL operations in several reports (WDEQ, 2000a, 2005). WDEQ issues state permits relevant to ISL uranium recovery operations under Title 35, Chapter 11, of the Wyoming Environmental Quality Act. Most of these permits are related to water supply and air and water quality issues and include aquifer exemption; UIC Class I, III, and V permits; and NPDES permits (WDEQ, 2007, 2005, 2001, 2000b, 1993, 1984). In Wyoming, injection of fluids at an ISL mine unit for uranium production operations requires UIC Class III wells. Injection of ISL waste for disposal underground requires either a Class I or Class V UIC permit. In addition, the WDEQ Land Quality Division issues permits to mine for noncoal resources and for *in-situ* recovery operations (WDEQ, 2003, 2000a). These permits identify site-specific requirements related to establishing baseline conditions (e.g., water, soils, vegetation, cultural values) and establishing reclamation bonds based on estimated site-specific costs. The WDEQ Land Quality Division holds joint bonds with BLM for exploration and mining on BLM lands. A memorandum of understanding exists between WDEQ Land Quality Division and BLM for surface management of locatable mineral operations. Wyoming also implements the NPDES program regarding discharges to surface waters. With regard to air quality permitting, WDEQ establishes the NAAQS requirements (WDEQ, 2006) (see Table 1.7-1). In addition, the Wyoming State Land Use Planning Act established a State Land Use Commission to govern leases, easements, and temporary uses of state lands. The state also regulates drilling and well spacing and requires drilling permits for wells, regardless of land ownership.

1.7.5.2 Nebraska

The regulations established in Title 122 of the Nebraska Administrative Code ensure proper well construction and regulate the injection of fluids containing potential contaminants into, above, or below underground sources of drinking water. NDEQ must approve injection wells, which must be operated and managed in accordance with the applicable NDEQ regulations. NDEQ issues and reviews UIC permits, conducts inspections, and performs compliance reviews for wells that inject fluids into the subsurface to ensure that injection activities comply with state and federal regulations and that groundwater is protected from potential contamination sources. Similar to WDEQ in Wyoming, NDEQ has authority over and manages Class I, III, and V wells in Nebraska. Injection wells not included in the other specific classes are considered Class V wells. In Nebraska, regulations adopted in 2002 prohibit a number of Class V well types, including radioactive waste disposal wells. The NDEQ UIC program is currently closing existing waste disposal systems that fall into these prohibited types. EPA reviews and approves the aquifer exemption portion of the NDEQ UIC program (40 CFR 146.4). Nebraska also implements the NPDES program regarding discharges to surface waters. With regard to air quality permitting, NDEQ establishes the ambient air quality standards through a state-administered NAAQS program described in Title 129 of the Nebraska administrative code (NDEQ, 2002b).

1.7.5.3 South Dakota

As described in Section 1.6.3.3, recent legislation passed in South Dakota establishes permitting requirements for uranium recovery activities. Activities covered under these permits include sinking shafts, tunneling, and drilling test holes, cuts, or other works to extract samples (including bulk samples) to confirm the commercial grade of a uranium deposit before mining operations or test facility development begins. Uranium milling, including ISL uranium recovery, requires a state mine permit issued under South Dakota Codified Law 45-6B and South Dakota

Administrative Rule Chapter 74:29. The Board of Minerals and Environment evaluates permit applications for uranium exploration in South Dakota (South Dakota Department of Environment and Natural Resources, 2007a, 2006). South Dakota implements the NPDES program regarding discharges to surface waters. The South Dakota Department of Environmental and Natural Resources is the air quality permitting authority through its NAAQS program (South Dakota Department of Environment and Natural Resources, 2007b).

1.7.5.4 New Mexico

Water quality standards in New Mexico are established in accordance with Water Quality Control Commission regulations in Title 20, Chapter 6, Part 2 of the New Mexico Administrative Code. The New Mexico Environment Department administers the state's UIC programs. For ISL uranium milling operations on state-regulated lands in New Mexico, an operator must obtain a Class III injection well permit and an aquifer exemption from EPA requiring aquifer cleanup and monitoring to protect surrounding underground sources of drinking water. For operations outside Indian lands in New Mexico, operators need to obtain the Class III injection well permit and a temporary aquifer designation from the New Mexico Environment Department, subject to EPA review and approval. EPA directly administers the NPDES program for surface water discharges in New Mexico. With regard to air quality permitting, the New Mexico Environment Department is the permitting authority through its NAAQS program (New Mexico Environmental Department, 2002).

1.8 Use of the GEIS in the NRC Licensing Process

NRC plans to use the GEIS to fulfill the requirement at 10 CFR 51.20(b)(8) for the preparation of an EIS or supplement to an EIS for the issuance of a source material license for an ISL uranium milling facility. NRC will use the GEIS to prepare a supplemental EIS (SEIS), incorporating by reference the relevant sections of the GEIS, and supplementing the GEIS evaluations with site-specific analysis as necessary for the issuance of a new ISL license. Additionally, NRC will use the GEIS in its review of applications to renew or amend existing ISL licenses.

As an independent federal agency, NRC uses other CEQ regulations as guidance for its NEPA reviews. In this case, CEQ's regulation at 40 CFR 1502.4 allows, and in some cases requires, preparation of EISs for "broad federal actions." In preparing EISs on broad actions, the CEQ offers different approaches for agencies to take in their evaluations. These include evaluating proposals (1) geographically (i.e., those actions occurring in the same general location) and (2) generically (i.e., those actions which have relevant similarities, such as common timing, impacts, alternatives, methods or implementation, media, or subject matter).

Another concept associated with the preparation of "broad action" EISs is tiering. Tiering (defined in 40 CFR 1508.28) is a procedure by which more specific or more narrowly focused environmental documents can be prepared without duplicating relevant parts of previously prepared, more general, or broader documents. The more specific environmental document incorporates by reference the general discussions and analyses from the existing broader document and concentrates on the issues and impacts of the project that are not specifically covered in the broader document. NRC environmental regulations, in discussing the format for presentation of material in EISs, note that the techniques of tiering and incorporation by reference described respectively in CEQ's NEPA regulations may be used as appropriate to help present issues, eliminate repetition, or reduce the size of the EIS (see 10 CFR Part 51, Subpart A, Appendix A). NRC plans to use tiering and incorporation by reference in making use of the GEIS for environmental reviews of site-specific ISL license applications.

The following discussion provides a more detailed description of how the NRC staff will use the GEIS as part of the staff's environmental reviews for new ISL license applications and for applications to renew or amend existing licenses. The discussion is also applicable to NRC's review of applications to renew or amend existing NRC ISL licenses.

1.8.1 Applicant or Licensee Environmental Report

License applicants must submit an environmental report to support their application for an NRC license to possess and use source material for ISL uranium milling. NRC regulations at 10 CFR 51.45 list the general content of the environmental report to include, among other things

- A description of the proposed action
- A statement of its purposes
- A description of the environment affected
- Consideration of the impact of the proposed action on the environment
- Identification of any adverse environmental effects that cannot be avoided
- Discussion of alternatives to the proposed action

To help potential uranium milling license applicants develop their environmental reports, NRC provides additional guidance in

- Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for *In-Situ* Uranium Solution Mining" (NRC, 1982)

- NUREG–1569, "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications" (NRC, 2003a)

- NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs" (NRC, 2003b)

1.8.2 Acceptance Review of the License Application and Environmental Report

After receiving a new license or license renewal application and accompanying environmental report, the NRC staff first reviews the application and environmental report for completeness. This initial "acceptance review" ensures that the application and environmental report are sufficiently comprehensive and address all relevant aspects of the applicant's proposed actions. When the NRC staff determines that the application is acceptable to warrant detailed technical review, the application is officially docketed in accordance with NRC's regulations at 10 CFR Part 2. Then NRC publishes in the *Federal Register* notice of the public availability of the application and accompanying notice of opportunity for hearing on the application.

In its subsequent detailed technical review of an ISL license application, the NRC staff analyzes the health and safety impacts (documented in a Safety Evaluation Report) and the potential environmental impacts of the proposed action (discussed in a separate environmental review document—a SEIS for issuance of a new ISL license, or EA, SEIS or EIS for license renewals or amendments).

1.8.3 NRC's Site-Specific Environmental Review

To meet its NEPA obligations related to a site-specific license application, the NRC staff will conduct an independent, detailed, comprehensive evaluation of the potential environmental impacts of the applicant's proposed action for construction, operation, aquifer restoration, and decommissioning of an ISL facility. This site-specific evaluation will make use of the discussion and conclusions reached in the GEIS to the extent applicable to the specific site.

As the basis for its independent evaluation, the NRC staff will rely initially on the applicant's detailed environmental report for information on the proposed action. The applicant's environmental report would include detailed information about the potential ISL facility location, the extent of proposed operations and schedule, and the surrounding local and regional affected environment. The NRC staff will confirm important attributes of these descriptions through visits to the proposed site location and vicinity, independent research activities, and consultations with appropriate federal, tribal, state, and/or local agencies. Additionally, the NRC staff typically requests additional information from the applicant. These requests require the applicant to provide the information and data the NRC staff considers necessary to determine the potential environmental impacts.

The NRC staff will focus on the applicant's assessment of potential environmental impacts from the proposed action and the identified alternatives. In its site-specific environmental review document, NRC will evaluate a reasonable range of alternatives to the applicant's proposal, including the "no-action" alternative. This range of alternatives may include alternatives not identified by the applicant, as well as those outside NRC's jurisdiction. The NRC staff will independently evaluate the applicant's analysis of the potential impacts to each resource area identified in NRC (2003b) (e.g., air quality, transportation, groundwater). As needed, the NRC staff will independently confirm and verify essential aspects of the analysis. Confirmatory analyses could involve the use of computer codes and other verification techniques.

The NRC Safety Review

In addition to meeting its responsibilities under the Atomic Energy Act of 1954, as amended, NRC prepares a Safety Evaluation Report to analyze the safety of the proposed action and assess its compliance with applicable NRC regulations.

The safety and environmental reviews are conducted in parallel (Figure 1.7-1). Although there is some overlap between the content of a Safety Evaluation Report and the environmental review document, the intent of the documents is different.

To aid in the decision process, the environmental review document summarizes the more detailed analyses included in the Safety Evaluation Report. For example, the environmental review document would not address how accidents are prevented but the environmental impacts that would result if an accident occurred.

Much of the information describing the affected environment in the environmental review document also is applicable to the Safety Evaluation Report (e.g., demographics, geology, and meteorology) (NRC, 2003b).

The GEIS is intended to improve the efficiency of the licensing process by (1) providing an evaluation of the types of environmental impacts that may occur from ISL uranium milling facilities, (2) identifying and assessing impacts that are expected to be generic (the same or similar) at all ISL facilities (or those with specified facility or site characteristics), and (3) identifying the scope of environmental impacts that need to be addressed in site-specific environmental reviews. The GEIS also provides information that will aid in the preparation of site-specific environmental documents.

First, the NRC staff will compare the applicant's description of the proposed facility, ISL process, and affected environment to those in the GEIS. The NRC staff will then summarize and

incorporate by reference the relevant sections of the GEIS into the site-specific environmental review document. Secondly, the NRC staff will use the GEIS to help determine the significance of site-specific environmental impacts. The GEIS provides criteria for each environmental resource area to help determine the significance level of potential impacts (e.g., SMALL, MODERATE, or LARGE). The NRC staff will apply these criteria to site-specific conditions to determine the significance of potential impacts. Finally, the NRC staff will compare the conditions of the proposed site and activities under review to the conditions and aspects identified and discussed in the GEIS to see whether the conclusions for the environmental impact to a particular resource area can be adopted in the site-specific environmental review document. The NRC staff may determine that the GEIS conclusions for a specific resource area can be adopted in full, only in part, or not at all. The determination of the extent to which the GEIS conclusions can be adopted will be discussed in detail in the site-specific review, including the supporting information and data that form the basis for that determination. Additionally, the NRC staff will also determine the significance of environmental impacts for resource areas where the GEIS conclusions can be adopted only in part or not at all. The NRC staff will document the basis for that determination in the site-specific evaluation. The site-specific review will incorporate by reference and adopt significance conclusions from the GEIS, as appropriate. This process of using the GEIS in site-specific environmental reviews is consistent with the concept of tiering, discussed previously (see Section 1.8).

1.8.4 Public Participation Activities

As stated in Section 1.8.2, upon acceptance of a license application for detailed technical review, NRC publishes in the *Federal Register* a notice of opportunity for hearing on the application. Individuals or entities that may be affected by the potential issuance of the site-specific ISL license may request a hearing under the NRC formal hearing process. 10 CFR Part 2 provides the requirements that must be met to be granted a hearing.

As discussed previously, the NRC staff will prepare an environmental review document in support of its review of ISL-related licensing actions (i.e., new license, renewal or amendment). For new ISL license applications, the NRC staff will prepare a SEIS. The NRC staff will follow the public participation procedures outlined in 10 CFR Part 51, which can include requests for public input on the scope of the SEIS and for public comment on the draft SEIS.

Before taking a licensing action on a licensee's proposal to amend or renew its existing NRC license, the NRC may prepare an environmental assessment and if so, also may make the draft EA and the accompanying draft Finding of No Significant Impact (FONSI) available for public comment. The decision to do so would take into account the provisions in 10 CFR 51.33 concerning the similarity of the proposed action to actions normally requiring preparation of an EIS and the precedent-setting nature of the proposed action. Additionally, NRC may consider the level of public interest and the contentious nature of the proposed action in determining whether to publish a draft EA/FONSI for public comment. The NRC staff would address public comments received on the draft environmental assessment/FONSI in the staff's final environmental review document. This approach is consistent with NRC regulations.

1.8.5 The NRC Final Environmental Review Document and Findings

The NRC staff will issue the final environmental review document as part of the licensing review documentation for each site-specific licensing action (i.e., new license, renewal, amendment). The final document will provide the NRC staff's site-specific environmental review determinations that consider public input and the evaluations in the GEIS, to the extent

applicable. The final environmental document and the site-specific Safety Evaluation Report together form the basis for the NRC's decision on whether to issue a 10 CFR Part 40 source material license to the applicant for ISL uranium milling or to grant a licensee's application to renew or amend its existing NRC license.

The NRC final action to issue a license may also be subject to a formal NRC hearing. As discussed in Section 1.8.4, 10 CFR Part 2 provides NRC's requirements concerning hearings.

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2 *IN-SITU* LEACH URANIUM RECOVERY AND ALTERNATIVES

Chapter 2 provides information on uranium recovery using the *in-situ* leach (ISL) process. The first part of the chapter gives basic information on the type of uranium deposits that are amenable to ISL technology and an overview description of the parts of an ISL facility. Sections 2.2 through 2.6 describe stages of an ISL facility's lifecycle, including preconstruction, construction, operation, aquifer restoration, and decommissioning. Development and the initial licensing decision at an ISL facility are not based on comprehensive information on all aspects of the site and planned operations (NRC, 2003a). During the preconstruction (or prelicensing) period, to support its license application, the applicant provides enough information to generally locate the ore body and understand the natural systems involved. During construction and operations, more detailed geologic and hydrologic information is collected as each area of the site is developed and brought into production. Sections 2.7 through 2.10 include discussions of aspects such as occupational radiation health monitoring, waste management, transportation, and financial assurance that are common to all ISL uranium facilities and not confined to a single stage. Section 2.11 summarizes operational experience of ISL facilities regulated by the U.S. Nuclear Regulatory Commission (NRC). Sections 2.12 and 2.13 discuss the alternatives considered in this Generic Environmental Impact Statement (GEIS).

This chapter is organized by stages in the life of an ISL facility. NRC recognizes that other than the preconstruction phase, the other four phases could be performed concurrently. However, describing the ISL process in terms of these stages aids in the discussion of the ISL process and in the evaluation of potential environmental impacts from an ISL facility.

Characteristics of Uranium Deposits That Are Amenable to ISL Extraction

Certain geologic and hydrological features make a uranium deposit suitable for ISL technologies (based on Holen and Hatchell, 1986):

- **Deposit geometry.** The operator defines well field boundaries based on the geometry of the specific uranium mineralization. The deposit should generally be horizontal and have sufficient size and lateral continuity to enable economic uranium extraction.
- **Permeable host rock.** The host rock must be permeable enough to allow the mining solutions to access and interact with the uranium mineralization. Preferred flow pathways such as fractures may short circuit portions of the mineralization and reduce the recovery efficiency. The most common host units are sandstones.
- **Confining layers.** Hydrogeologic (formation) geometry must prevent uranium-bearing fluids (i.e., lixiviant) from vertically migrating. Typically, low permeability layers such as shales or clays confine the uranium-bearing sandstone both above and below. This isolates the uranium-producing horizon from overlying and underlying aquifers.
- **Saturated conditions.** For ISL extraction techniques to work, the mineralization should be located in a hydrologically saturated zone.

2.1 Overview of ISL Uranium Recovery

Only certain uranium deposits are amenable to the ISL recovery process. To understand why the ISL recovery process is an effective recovery method for certain uranium deposits, it is necessary to understand the chemical and physical characteristics of uranium ore. This section describes the geochemistry of uranium, provides a brief geologic overview of uranium ore bodies in the four GEIS regions, and generally describes ISL facilities.

2.1.1 Geochemistry of Uranium

Natural uranium occurs in minerals as each of these isotopes: U-238 (99.274 percent), U-235 (0.720 percent), and U-234 (0.0055 percent) (EPA, 2007a) and predominantly exists in one of two ionic states: U^{6+} (the uranyl oxidized ion) and U^{4+}

(the uranous reduced ion) (EPA, 1995). In the oxidized (uranyl) state, uranium is more readily dissolved and is highly mobile in the environment (e.g., in soil, surface water, and groundwater). In the uranous (U^{4+}) state, uranium solubility is very low (i.e., it does not readily dissolve in water). Common uranous minerals include uraninite (UO_2), pitchblende (a crystalline variant of uraninite), and coffinite [$U(SiO_4)(OH)_4$] (EPA, 1995; Nash, et al., 1981).

2.1.2 Physical Characteristics of Uranium Deposits

Uranium subject to recovery in the United States is primarily found in four types of deposits: stratabound, breccia pipes, vein, and phosphatic (EPA, 1995). Deposits that are generally amenable to ISL recovery in the four GEIS regions are stratabound deposits. These deposits are contained within a single layer (stratum) of sedimentary rock. It is theorized that these deposits were formed through the transport of uranium (and associated elements) by oxidizing groundwater (i.e., groundwater with chemical properties that cause the uranium ion to lose electrons) (EPA, 1995; Nash, et al., 1981). The groundwater likely flowed through uranium-containing rocks, causing the uranium to dissolve and leach from the rock. The uranium remained soluble in the groundwater until it encountered a reducing environment, (i.e., an environment with chemical properties that caused the uranium ion to gain electrons), became less soluble in water, and precipitated.

Depending upon the environmental conditions, stratabound deposits can take a variety of physical forms and are typically described as either roll-front deposits or tabular deposits. Roll-front deposits (Figure 2.1-1) are found in basins in Wyoming, southwestern South Dakota, and northwestern Nebraska. Tabular deposits (see Figure 2.1-2) are found in the Colorado Plateau, including northwestern New Mexico.

A roll-front deposit is a uranium ore-body deposited at the interface of oxidizing and reducing groundwater (EPA, 1995; Nash, et al., 1981). In basins in Wyoming, oxidized groundwater containing uranium flowed through permeable sandstone beds until reducing groundwater was reached, and the uranium precipitated out at this interface. The sandstone beds are generally confined by low- or semi-permeable units such as claystones, siltstones, mudstones, or shales. As the oxidizing and reducing environments migrated within the sandstone beds, the uranium ore deposited over a laterally extended area (EPA, 1995). These roll-front deposits have a crescent shape and may extend hundreds of meters [feet], but may be only a few meters [feet] thick. Depending on the continuity and displacement along faults of sandstone beds and confining units, roll-front deposits can be discordant, asymmetrical, and irregularly shaped and can cut across sedimentary structures.

The tabular deposits of the Colorado Plateau were formed when oxidized groundwater with higher concentrations of uranium and vanadium flowed through zones of highly permeable organic matter (humates), gases (hydrogen sulfide), or liquids capable of reducing the uranyl ion (EPA, 1995). The uranium deposited in the areas where the reducing conditions were created. The deposits are typically tabular and can be found in sandstones, limestones, siltstones, and conglomerates scattered throughout the Colorado Plateau, including northwestern New Mexico. The tabular deposits found in northwestern New Mexico result from organic matter and occur in sandstones and siltstones. Like roll-front deposits, tabular uranium deposits in Northwestern New Mexico are amenable to uranium extraction by ISL techniques. The tabular deposits are confined within low permeability layers and have sufficient size and lateral continuity to allow

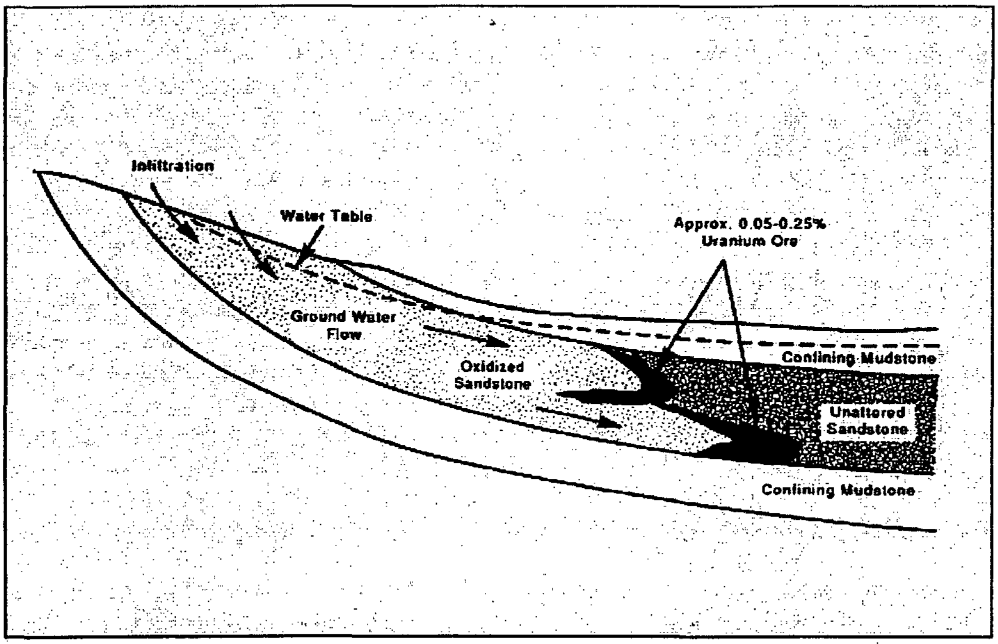

Figure 2.1-1. Simplified Cross Section of Sandstone Uranium Roll-Front Deposits Formed by Regional Groundwater Migration (NRC, 1997a)

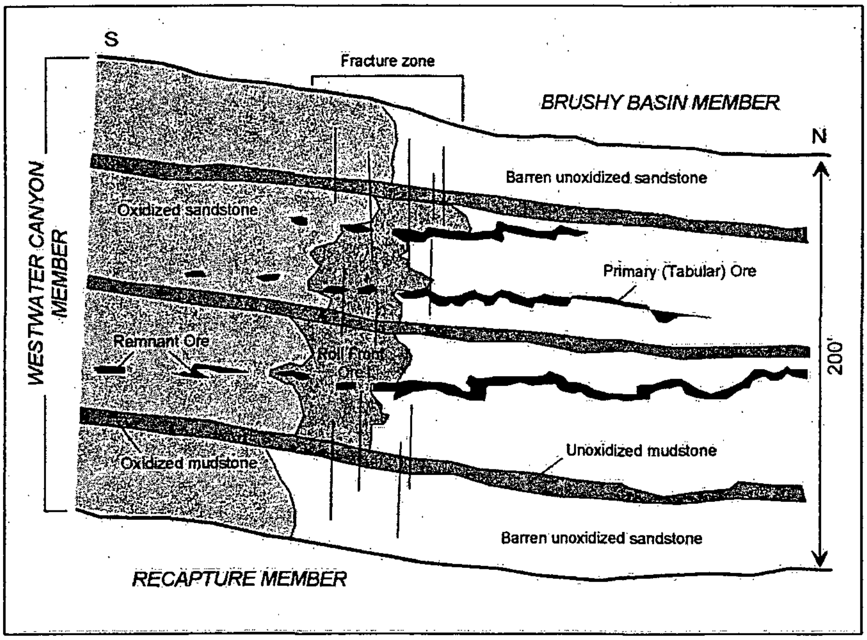

Figure 2.1-2. Schematic Diagram of the Types of Tabular Stratabound Uranium Deposits in the Grants Uranium District, New Mexico (Modified from Holen and Hatchell, 1986)

economic extraction of uranium. These deposits can range from about 0.5 to 2 m [2 to 6 ft] thick and be hundreds of meters [feet] wide. These deposits have provided over 50 percent of the uranium production in the United States (EPA, 1995).

Uranium concentrations in the ore deposit vary depending on system geochemistry and hydrology. For example, in New Mexico, uranium deposits typically contain about 0.2 to 0.3 percent U_3O_8 by weight, while deposits in Wyoming contain lower concentrations (about 0.1 to 0.25 percent) (Energy Information Administration, 2004; McLemore, 2007). The depth to the uranium mineralization ranges from about 100–300 m [328 to 984 ft] (e.g., Church Rock, New Mexico; Gas Hills, Wyoming; Smith Ranch, Wyoming; and Crow Butte, Nebraska) to greater than 560 m [1,840 ft] at Crownpoint, New Mexico. The most common uranium minerals in roll-front deposits are uraninite (UO_2), pitchblende, and coffinite [$U(SiO_4)(OH)_4$]. Minor quantities of the uranium-vanadium mineral tyuyamunite [$Ca(UO_2)_2(VO_4)_2 \cdot H_2O$] are also typically present (Nash, et al., 1981).

2.1.3 General Description of ISL Facilities

This section briefly describes the layout of an ISL facility. More detailed descriptions of the individual stages of ISL uranium recovery (construction, operations, aquifer restoration, decommissioning/reclamation) are included in Sections 2.3 through 2.6. A commercial ISL facility consists of both an underground and a surface infrastructure. The underground infrastructure includes injection and production wells drilled to the uranium mineralization zone, monitoring wells drilled to the surrounding ore body aquifer and to the adjacent overlying and underlying aquifers, and perhaps deep injection wells to dispose of liquid wastes. ISL facilities in the uranium milling regions considered in this GEIS (i.e., Wyoming West, Wyoming East, Nebraska-South Dakota-Wyoming, and Northwestern New Mexico) are commonly exposed to freezing conditions during winter months. Therefore, pipelines to transfer groundwater extracted from the well fields to the uranium processing circuit are buried to avoid freezing and thus are considered to be part of the underground infrastructure.

ISL facilities also include a surface infrastructure that supports uranium processing. The surface facilities can include a central uranium processing facility, header houses to control flow to and from the well fields, satellite facilities that house ion-exchange columns and reverse osmosis equipment for groundwater restoration, and ancillary buildings that house administrative and support personnel. Surface impoundments such as solar evaporation ponds may be constructed to manage liquid effluents from the central processing plant and the groundwater restoration circuit (Figure 2.1-3).

The surface extent of a full-scale (i.e., commercial) ISL facility includes a central processing facility and supporting surface infrastructure for one or more well fields (sometimes called mine units) and encompasses about 1,000 to 6,000 ha [2,500 to 16,000 acres] (NRC, 1992, 1997a) (see Section 2.11). However, the total amount of land

What is Yellowcake?

Yellowcake is the product of the uranium extraction (milling) process; early production methods resulted in a bright yellow compound, hence the name *yellowcake*. The material is a mixture of uranium oxides that can vary in proportion and in color from yellow to orange to dark green (blackish) depending on the temperature at which the material was dried (level of hydration and impurities). Higher drying temperatures produce a darker, less soluble material. Yellowcake is commonly referred to as U_3O_8 and is assayed as pounds U_3O_8 equivalent. This fine powder is packaged in drums and sent to a conversion plant that produces uranium hexafluoride (UF_6) as the next step in the manufacture of nuclear fuel.

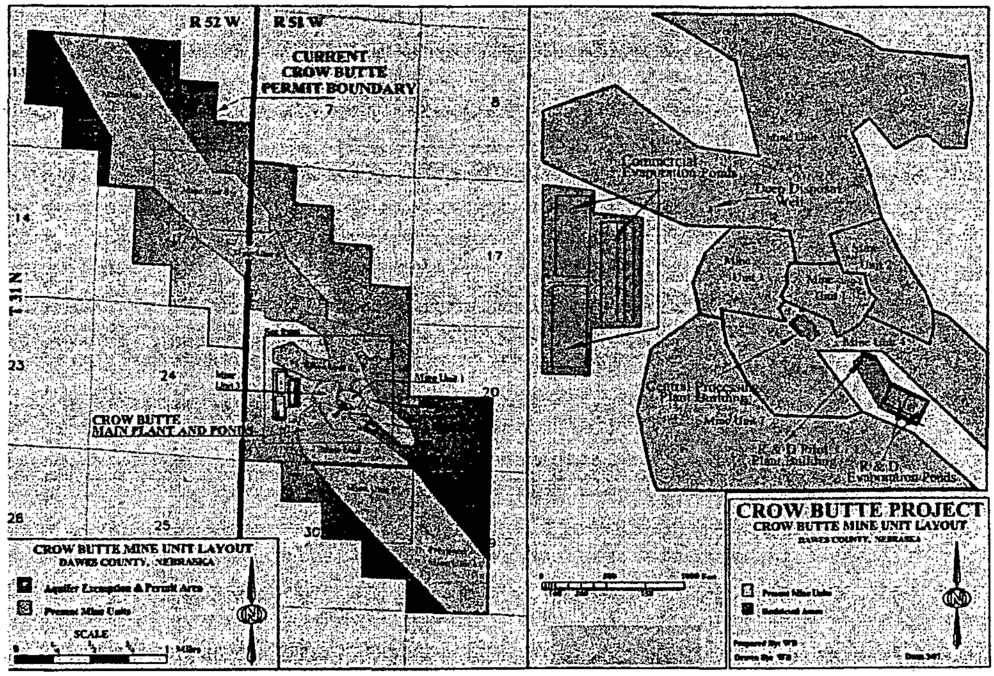

Figure 2.1-3. Layout of the Crow Butte Uranium Project in Dawes County, Nebraska (From Crow Butte Resources, Inc., 2007)

disturbed by such infrastructure and ongoing activities at any one time is much smaller, and only a small portion around surface facilities is fenced to limit access (Figures 2.1-3 and 2.1-4). Well fields typically are not enclosed by fencing.

NRC establishes the total flow rates and the maximum amount of uranium that can be produced annually at a commercial ISL facility using license conditions. NRC-licensed flow rates typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min], and licensed maximum limits on annual uranium production range from about 860,000 to 2.5 million kg/yr [1.9 million to 5.5 million lb/yr] of yellowcake (NRC, 1995, 1998a,b, 2006, 2007). Actual production rates are generally somewhat lower than these limits (Energy Information Administration, 2008).

2.2 Preconstruction

The applicant must characterize the potential site to support an application for a license to construct and operate an ISL facility (NRC, 2003a, Chapters 2 and 7). During the initial licensing review for a new ISL facility, NRC does not require a comprehensive discussion of all aspects of the site and of planned operations (NRC, 2003a). Instead, at this stage, the applicant needs to provide enough information to generally locate the uranium mineralization, understand the natural systems involved, and establish baseline conditions prior to operation. If a license is granted, more site-specific data are collected during the construction and operations phases of the ISL facility. For example, the licensee would collect more detailed geologic information and perform pump tests as each well field is developed (NRC, 2003a). This site-specific data confirms that the well field possesses the characteristics that will make it suitable for ISL extraction before being brought into production.

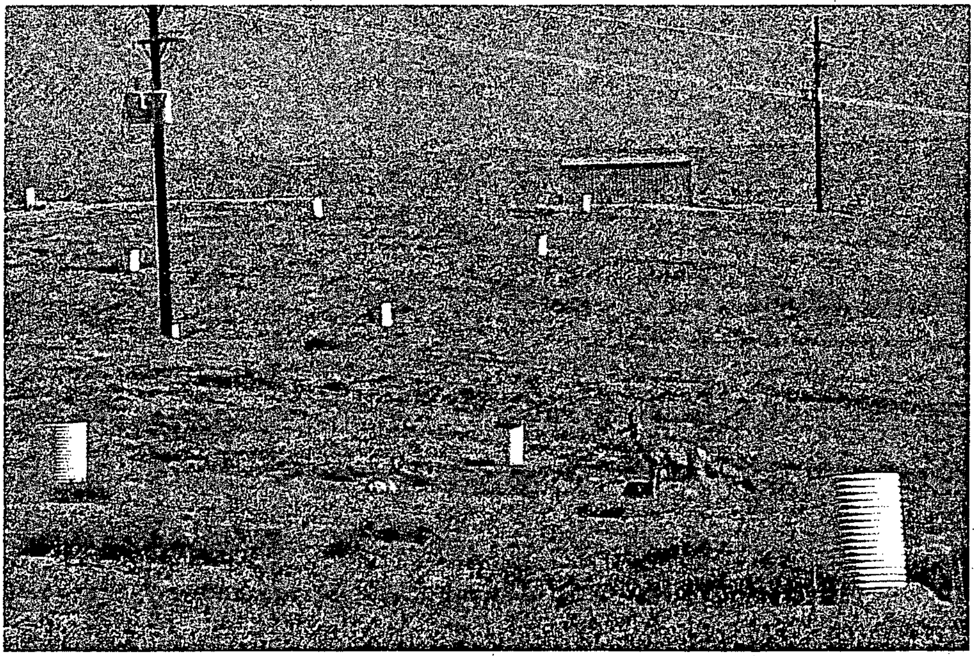

Figure 2.1-4. Well Heads and a Header House at Smith Ranch, Converse County, Wyoming

The general types of site baseline information to be provided by the license applicant are described in NRC guidance (NRC, 2003a, Chapter 2; 1982). Specific features of the site or its environs may also be identified and used by the applicant to support the proposed facility description. The applicant provides maps to locate the proposed site and identify proposed surface facilities, well fields, and other features of the ISL facility. In addition to providing information about the proposed site location and the environment in the vicinity of that location (e.g., water use, subsurface geology, hydrology, ecology, historical and cultural resources), the applicant also provides population data and assessments of trends in population and industry (NRC, 2003b, Appendix C).

Given the nature of the ISL uranium recovery process, hydrologic characterization of the site is a critical component of the preconstruction activities. This characterization describes surface-water features in the site area and the specific groundwater hydrogeologic setting, including detailed hydrogeologic and hydraulic descriptions of the proposed uranium production zone, adjacent aquifers, and low-permeability units that isolate the production zone.

In support of its license application, the applicant determines the background groundwater quality at and in the vicinity of the site (NRC, 2003a). An NRC-accepted list of constituents to be sampled for determining baseline water quality is shown in Table 2.2-1. This list includes the constituents and water quality parameters that are expected to increase in concentration as a result of ISL activities and that are of concern to the water use of the aquifer. Alternatively, applicants can propose a list of constituents that is tailored to a particular location. In such cases, sufficient technical bases must be provided for the selected constituent list (NRC, 2003a). State and other federal agencies with jurisdiction over groundwater could also specify

Table 2.2-1. Typical Baseline Water Quality Parameters and Indicators*		
Physical Indicators		
Specific Conductivity	Total Dissolved Solids†	pH‡
Major Elements and Ions		
Alkalinity	Chloride	Sodium
Bicarbonate	Magnesium	Sulfate
Calcium	Nitrate	
Carbonate	Potassium	
Trace and Minor Elements		
Arsenic	Iron	Selenium
Barium	Lead	Silver
Boron	Manganese	Uranium
Cadmium	Mercury	Vanadium
Chromium	Molybdenum	Zinc
Copper	Nickel	
Fluoride	Radium-226§	
Radiological Parameters		
Gross Alpha‖	Gross Beta	
Boron	Manganese	Uranium
Cadmium	Mercury	Vanadium
Chromium	Molybdenum	Zinc
Copper	Nickel	
Fluoride	Radium-226§	
Radiological Parameters		
Gross Alpha‖	Gross Beta	

*Based on U.S. Nuclear Regulatory Commission (NRC). NUREG–1569, "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications—Final Report." Table 2.7.3-1. Washington, DC: NRC. June 2003.
† Laboratory only.
‡ Field and laboratory determination.
§ If site initial sampling indicates the presence of thorium-232, then radium-228 should be considered in the baseline sampling, or an alternative may be proposed.
‖ Excluding radon, radium, and uranium.

constituents, which may or may not be included in the NRC-accepted list. In this case, the applicant would be accountable to the subject state or federal agency for characterizing and restoring these constituents.

To determine background groundwater quality conditions, at least four sets of samples, spaced sufficiently in time to establish seasonal variability, should be collected and analyzed for each constituent (NRC, 2003a). NRC verifies the accuracy of the water quality data by ensuring that the applicant's or licensee's procedures include (1) acceptable sample collection methods, (2) a set of sampled parameters that is appropriate for the site and ISL extraction method, and (3) collection of sample sets that are sufficient to represent natural spatial and temporal variations in water quality.

Applicants or licensees also collect site-specific data to establish background radiological characteristics. These data should include measurements of radionuclides occurring in important flora and fauna, soil, air, and surface and groundwaters that ISL operations could affect.

2.3 Construction

General construction activities associated with ISL facilities include drilling wells, clearing and grading associated with road construction and building foundations, building construction, trenching and laying pipelines, and building evaporation pond impoundments. Construction-related activities continue throughout much of the life of the project as well fields are developed and additional wells and surface structures are added. For a satellite facility, the initial construction of the surface facilities would take about 2–3 months (NRC, 2004). Construction and testing of a well field may require about a year and a half (NRC, 2006), with four to eight drill rigs and support vehicles operating in the field (NRC, 2004, 1997a). Well field construction requires about 50 to 75 personnel (NRC, 2004).

2.3.1 Underground Infrastructure

The underground infrastructure at an ISL facility is established to inject and extract lixiviant, monitor groundwater quality, and transfer fluids between the wells and production facilities.

Lixiviant

A leachate solution composed of native groundwater and chemicals added by the ISL facility operator and pumped underground to mobilize (dissolving) uranium from a uranium ore body.

2.3.1.1 Well Fields

Well Field Design. The licensee establishes the injection and production well patterns to recover uranium using an approach and site characterization information that are reviewed and approved by NRC. The well patterns are developed for a specific site, and installation for a given well field is based on the subsurface geometry of the ore deposit. Various pattern shapes are used, although five-spot and seven-spot patterns are common (NRC, 2003a). A typical well arrangement using five- and seven-spot patterns is shown in Figure 2.3-1. Because roll-front uranium deposits normally have irregular shapes, some of the well patterns in a given well field are also irregular, and the licensee may alter well patterns to fit the size, shape, and boundaries of individual ore bodies. Depending on ore body geometry and surface topography, well spacing for common well patterns (e.g., the five-spot or seven-spot patterns) is typically between 12 and 50 m [40 and 150 ft] apart (NRC, 1998; Energy Metals Corporation, 2007a; Lost Creek ISR, LLC, 2007).

Ore body size and geometry will also influence the number of wells in a well field. For example, at the Crow Butte ISL facilities in Dawes County, Nebraska, the number of injection and production wells varied from about 190 in the first well field (MU-1) to about 900 in later well fields (MU-5 and MU-6) (NRC, 1998b).

Three types of wells are predominant at uranium ISL facilities:

- Injection wells for introducing solutions into the uranium mineralization
- Production wells for uranium production
- Monitoring wells for assessing ongoing operations

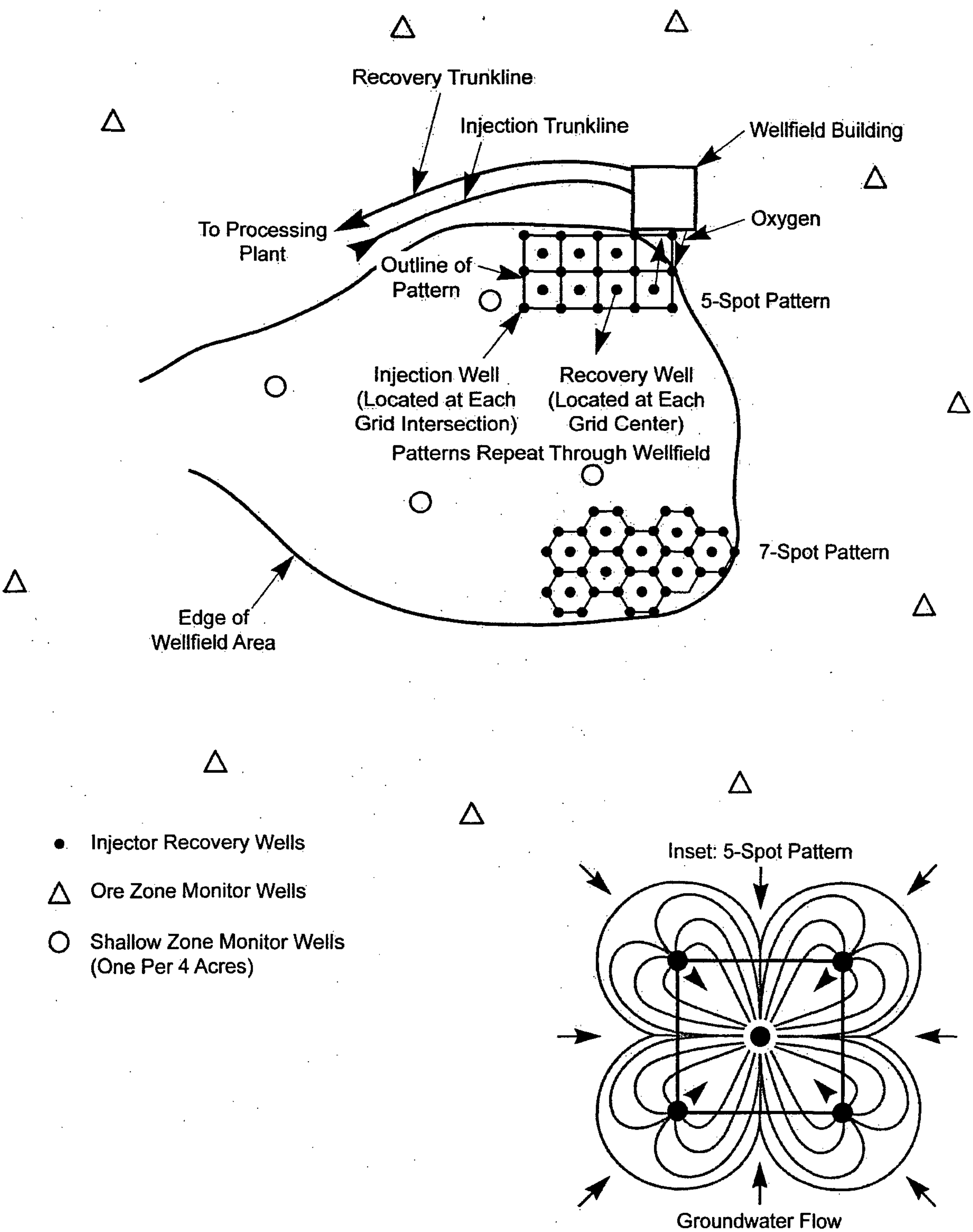

Figure 2.3-1. Schematic Diagram of a Well Field Showing Typical Injection/Production Well Patterns, Monitoring Wells, Manifold Buildings, and Pipelines (From NRC, 1997a)

The licensee or applicant may also drill deep injection wells permitted by the EPA or state and approved by NRC for liquid waste disposal. Injection and production wells are connected to manifolds in a nearby header house (Figure 2.3-2). The manifolds connect to pipelines that carry solutions to and from the recovery plant or satellite facility. Meters and control valves (usually computerized) in individual well lines monitor and control flow rates and pressures for each well to maintain water balance and to aid in identifying leaks (Figure 2.3-3). The well field piping is typically high-density polyethylene pipe, polyvinyl chloride (PVC), and/or steel. Individual well lines and larger trunk lines to the recovery plant are buried below the frost line {e.g., 2 m [6 ft] in Wyoming} to prevent solutions from freezing (NRC, 2006).

Commercial-scale uranium ISL facilities usually have more than one well field. For example, the Crow Butte facility in Dawes County, Nebraska, has constructed 10 well fields since 1991 and has plans for an eleventh (Crow Butte Resources, Inc., 2007). The Reynolds Ranch satellite facility in Converse County, Wyoming, plans to establish eight well fields (NRC, 2006). As described in Section 2.1.1, the well fields are developed in sequence, and at any one time, different well fields are likely to be in different stages of construction, operation, aquifer restoration, and decommissioning/reclamation (Crow Butte Resources, Inc., 2007). Construction and testing for each well field may require up to a year and a half before production begins (NRC, 2006). The locations and boundaries for each well field are adjusted as more detailed data on the subsurface stratigraphy and uranium mineralization distribution are collected during well field construction.

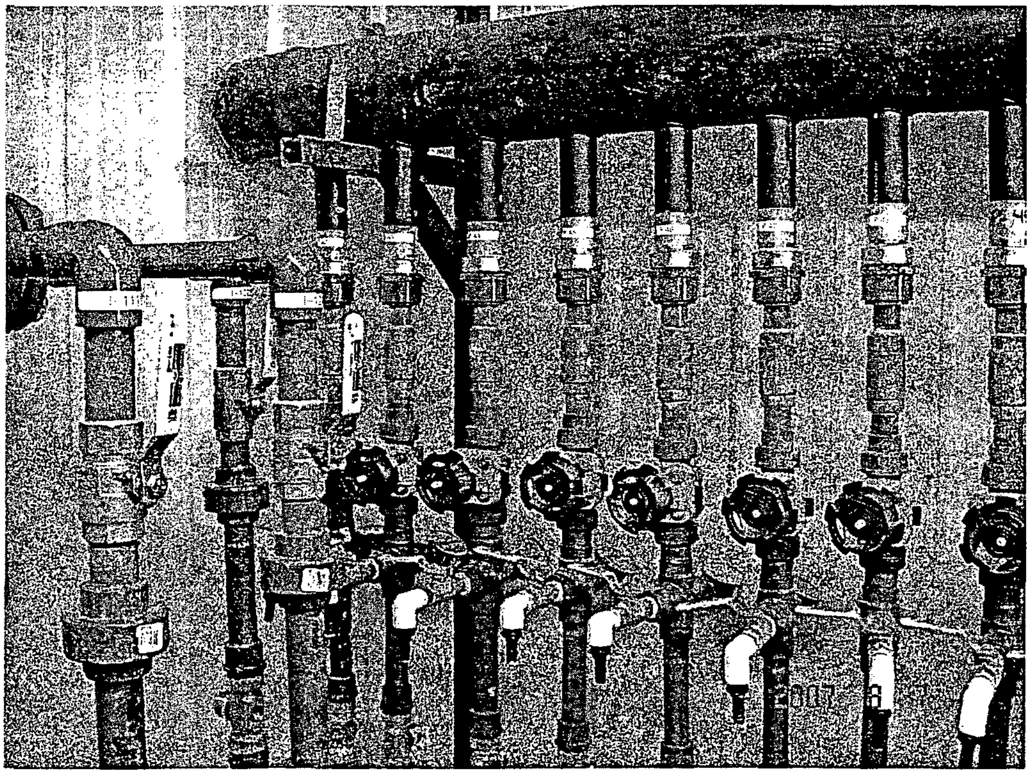

Figure 2.3-2. Manifold Inside Well Field Header House at an ISL Facility

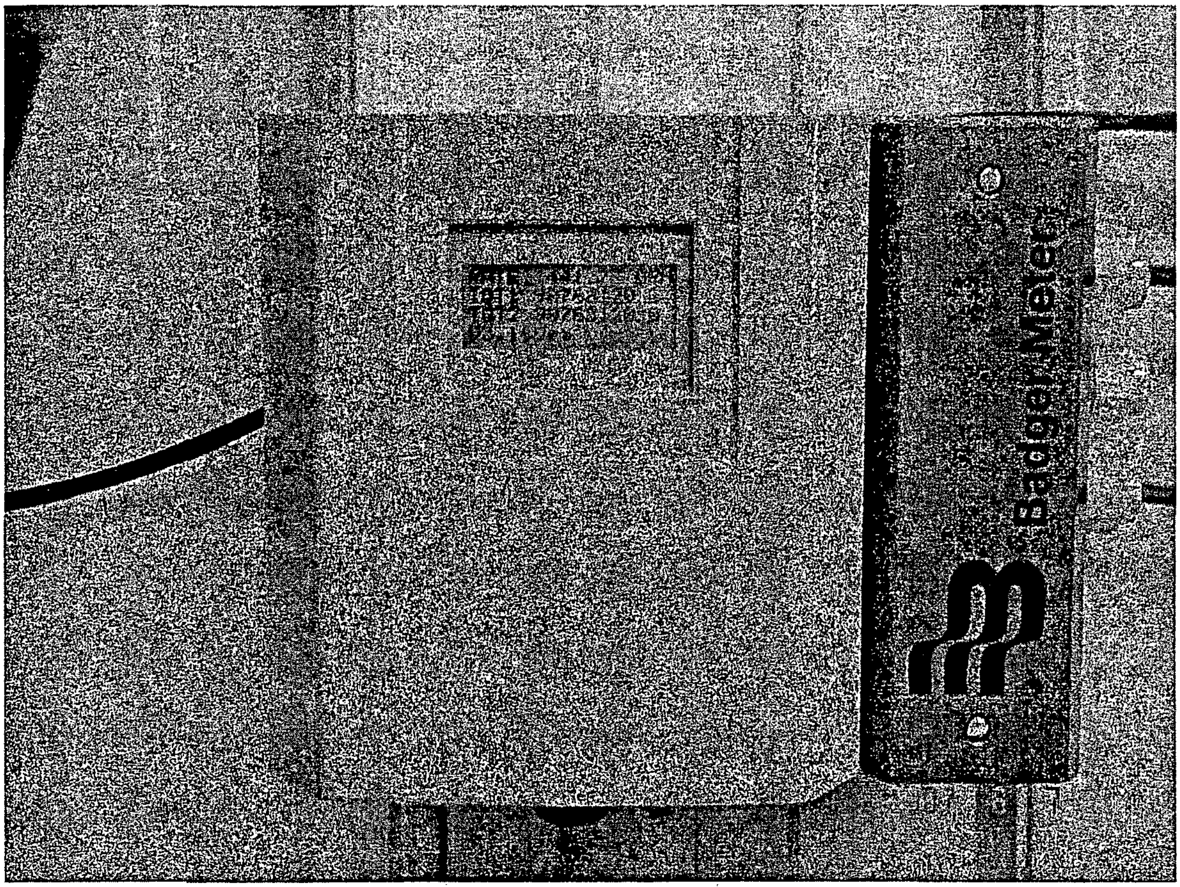

Figure 2.3-3. Computerized Meter for Monitoring Well Field Flow Rates

Well Drilling. Standard drilling techniques are used to develop ISL well fields. Temporary access roads for drilling rig trucks, support vehicles, and excavators lead to each well location. At the drilling location, a flat drill pad may be graded. At most ISL well fields, injection, production, and monitoring wells are drilled to the desired depth {e.g., 100–300 m [328–984 ft] for a target uranium production zone} by a standard method such as mud rotary drilling. In this method, a string of drill pipe and a drill bit are rotated against the formation. A water-based drilling fluid (mud) is circulated through the hole to lubricate the bit and to carry the drilled material to the surface. A temporary mud pit is excavated in the ground next to the drill site to contain the drilling mud. Depending on the depth to the uranium mineralization and site-specific hydrogeological characteristics, other drilling methods may be used.

While a well field is being drilled, detailed stratigraphic information and uranium ore occurrence data are collected. The locations and boundaries of a well field are then adapted to the subsurface geometry of a specific ore body. As the driller reaches the final depth of a well, it is usually logged with a variety of downhole geophysical tools (e.g., natural gamma ray logging, electrical resistivity) to characterize the well stratigraphy and is then reamed out to adjust the borehole diameter to construct a well. Residual cuttings and drilling fluids are typically held in the mud pit after drilling and construction activities are completed. Depending on state and local

regulations, such pits are backfilled and graded or are alternatively emptied and cleaned, and residual solids and liquids are transported and disposed of offsite (NRC, 2006).

Well Construction. The geologic units above the aquifer of interest typically are sealed with steel, fiberglass, or PVC casing grouted in place (Figure 2.3-4). This firmly sets the casing and prevents groundwater leakage from or to overlying aquifer(s). Grouts and casing materials are selected by the licensee or applicant to be inert with respect to the lixiviant and based on the depth of the well and anticipated well pressures. PVC or fiberglass casings are generally used in wells less than 300 m [1,000 ft] deep (NRC, 2003a). Wells deeper than 300 m [1,000 ft], or those subjected to high-pressure grouting techniques, are subject to collapse. In these instances, steel or fiberglass casing is generally necessary. The possibility that chemical reactions may take place between the casing and the mineral constituents in the water affects the choice of casing material used for monitoring wells. Iron oxide in steel-cased wells will adsorb trace and heavy metals dissolved in the groundwater. The applicant would use casing that is inert to these metals, such as PVC or fiberglass.

Depending on local hydrogeologic conditions, the following well construction steps generally are followed:

- Open holes to sections of the uranium mineralized aquifers screened with either steel, fiberglass, or PVC
- Screens are then connected to the ground surface with steel, fiberglass, or PVC riser pipes.
- The space between the casing and the borehole (i.e., the annulus) is filled with properly graded sand or gravel pack material, or the formation is simply left to collapse around the screen.
- A bentonite clay seal is installed above the top of the screen.
- The annulus above the bentonite seal between the screen/riser pipe assembly and the borehole is typically grouted to the ground surface with a mixture of cement, bentonite, and water.

Well heads are completed above ground to make access and maintenance easier. Depending on local weather and land conditions, a variety of protective enclosures is used around the well head to protect it from the elements. Before the well head construction of an injection or production well is completed, the well is connected by underground piping to an injection or production manifold in a nearby header house.

Mechanical Integrity Testing

After completion and before bringing into service, injection and recovery wells are tested for mechanical integrity. As described in NRC (2003a, Section 3.1.3), a packer is set above the well screen, and the well casing is filled with water. At the surface, the well is pressurized with either air or water to 125 percent of the maximum operating pressure, which is calculated based on the strength of the casing material and depth. The well pressure is monitored to ensure significant pressure drops do not occur through borehole leaks. A pressure drop of no more than 10 percent in a period of 10 to 20 minutes indicates the casing and grout are sound (i.e., do not leak) and the well is fit for service. Well integrity tests are also performed if a well has been damaged by surface or subsurface activities or has been serviced with equipment or procedures that could damage the well casing, such as insertion of a drill bit or cutting tool. Additionally, each well is retested periodically (once each 5 years or less) to ensure its continued integrity. If a well casing fails a mechanical integrity test, the well is taken out of service, repaired, and retested. If an acceptable test cannot be obtained after repairs, the well is plugged and abandoned.

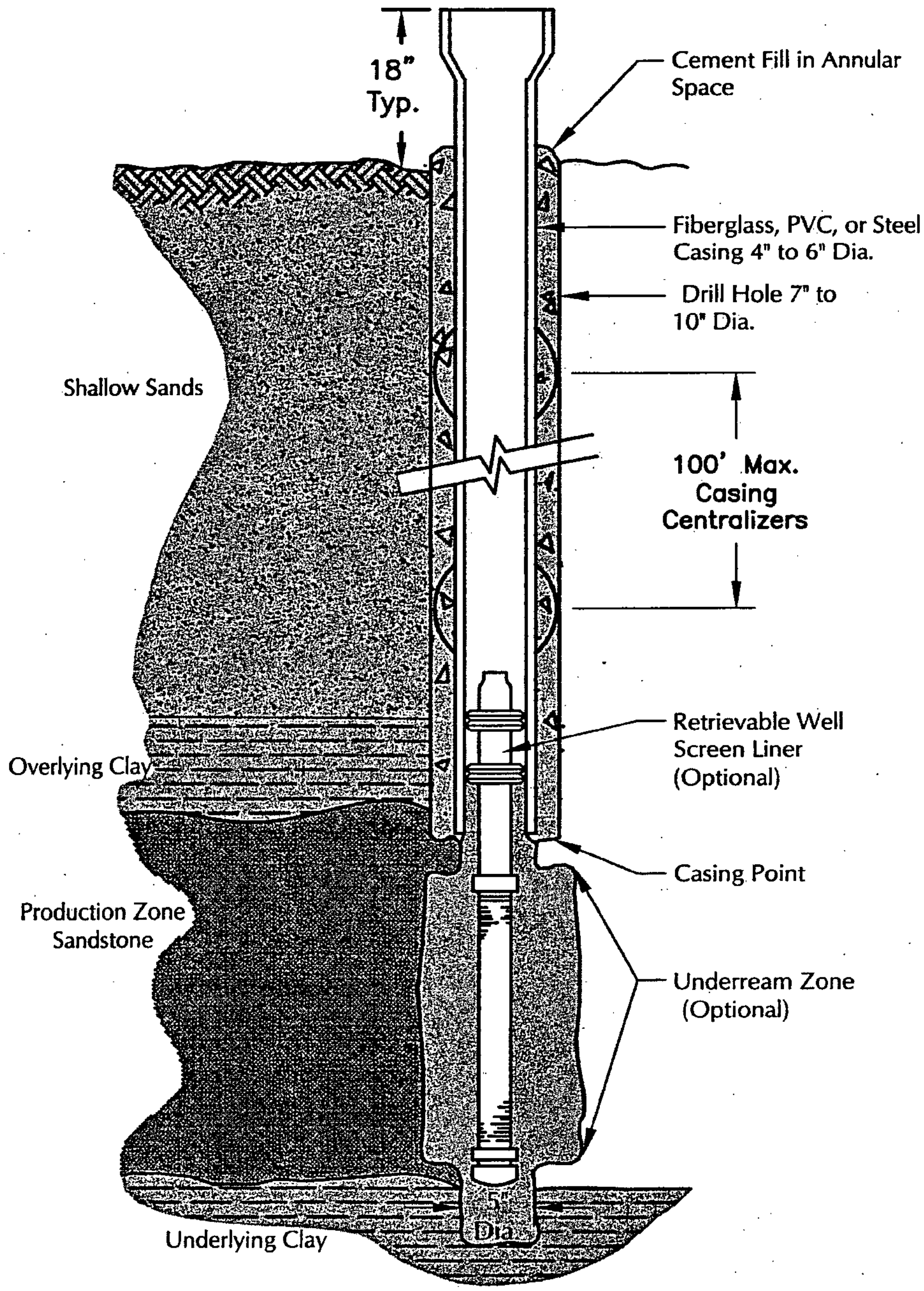

Figure 2.3-4. Cross Section of a Typical Injection, Production, or Monitoring Well Completed Using the Underreamed Method (Modified From NRC, 1997) [1 in = 2.54 cm; 1 ft = 0.305 m]

Monitoring wells are not usually connected to any other structure but can have cables connected to sensors in the well (NRC, 2006).

Well Development and Integrity Testing. Wells are usually developed using an air lift method or other pumping method appropriate for local conditions. Well development removes remaining drilling mud, cuttings, and fine particles (i.e., silt and clay) from inside the well, the screen, and the surrounding gravel/sand pack. Development improves well yield by enhancing hydraulic communication between the undisturbed aquifer and the well. The licensee also performs a mechanical integrity test (MIT) to verify that the well casing does not fail, causing water loss during injection or recovery operations. In an MIT, the bottom and top of the casing are plugged (sealed) with an inflated downhole packer or similar sealing device. The well is pressurized, and pressure gauges monitor pressure changes inside the casing. Based on site-specific conditions, after maintaining a specified pressure for a specified period without a measurable decrease, the well casing is considered to have passed an MIT and the well is fit for injection or production operations (NRC, 2006).

2.3.1.2 Pipelines

A network of process pipelines and cables are typically installed as part of the underground infrastructure:

- Between the central uranium processing facility or the satellite facility and the header houses for transporting lixiviant
- Between the header houses and well fields for injecting and recovering lixiviant
- Between the central processing facility and wastewater disposal sites (e.g., deep injection wells, evaporation ponds)

The network of process pipelines and cables required in ISL operations may be buried because of freezing temperatures that are common in the regions considered in this GEIS and because of safety and land imprint issues. Depending on local winter conditions, burial trenches can be excavated as deep as 2 m [6 ft] to avoid freezing (e.g., NRC, 2006). Pipes used to convey water, lixiviant, and wastewater are placed in these unlined trenches along with numerous electrical, communication, and sensor cables. Trenches are typically backfilled with native soil and graded to surrounding topography. Pipeline pressures are measured and recorded to monitor for potential leaks and spills that might result from the failure of fittings and valves.

2.3.2 Surface Facilities

ISL facilities require construction of surface facilities, ranging from standard industrial buildings with associated power, water, heating, ventilation, and air conditioning equipment to specialized structures such as evaporation ponds (NRC, 2003a). Examples of surface facilities include

- Central uranium processing facilities, with a typical footprint of about 3,060 m^2 [33,000 ft^2] (NRC, 1998b)
- Satellite facilities {about 1,200 m^2 [13,000 ft^2] (NRC, 2006)} that contain remote ion-exchange facilities

- Administration, operation, and field offices or other support facilities
- Pump and header houses for equipment to transfer lixiviant between the wells and pipelines
- Liquid effluent handling facilities, such as solar evaporation ponds. Typical evaporation ponds have surface areas ranging from 0.04 to 2.5 ha [0.1 to 6.2 acres] (NRC, 1998a; Crow Butte Resources, Inc., 2007)

Between the well fields and surface facilities, roads may be constructed (dirt and/or paved) for access:

- To well fields and pump houses
- Between the well fields/pump houses and the satellite facilities
- Between the satellite facilities and the central processing facility
- Between the processing plant and transportation routes

The surface facilities and access roads are designed and built using standard construction techniques. Specific building codes are used as appropriate. Construction vehicles may include bulldozers, drilling rigs, water trucks, forklifts, pump hoist trucks, coil tubing trucks, pickup trucks, portable air compressors, and other support vehicles.

Evaporation ponds may be constructed to dispose of effluent from the processing circuit or from aquifer restoration activities. These impoundments are designed and constructed with liners and leak detection systems installed in accordance with applicable NRC guidance (NRC, 2008a). Embankments for these evaporation ponds are constructed to resist erosion from wave action. The size and shape of the ponds are designed based on the amount of water that must be managed and the evaporation rates for the region. Sufficient space is provided so that the contents of one pond may be transferred to another to allow any identified pond system leaks to be repaired while meeting freeboard requirements from possible wave action.

2.4 Operations

Although specific operations will vary depending on the individual operator and site-specific characteristics, the ISL uranium recovery process generally involves two primary operations: (1) injection of barren lixiviant to mobilize uranium in underground aquifers and (2) extracting and processing the pregnant lixiviant in surface facilities to recover the uranium and prepare it for shipment (see text box).

Basic Steps in Uranium Mobilization

- **Groundwater Injection.** The operator injects a nonuranium-bearing (barren) extraction solution or lixiviant through wells into the mineralized zone. The lixiviant moves through pores in the production zone, dissolving uranium and other metals.
- **Groundwater Extraction.** Production wells withdraw the resulting "pregnant" lixiviant, which now contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

2.4.1 Uranium Mobilization

During ISL operations, chemicals, such as sodium carbonate/bicarbonate, ammonia, sulfuric acid, gaseous oxygen, and hydrogen peroxide, are added to the groundwater to produce a leaching solution or lixiviant. The lixiviant is injected into the production zone to mobilize (dissolve) uranium from the underground formation and subsequently remove uranium from the deposit.

2.4.1.1 Lixiviant Chemistry

The lixiviant that is selected must leach uranium from the host rock and keep it in solution during groundwater pumping from the host aquifer. Based on experience with conventional uranium milling, early ISL facilities tended to use aggressive acid-based lixiviants, such as sulfuric acid (International Atomic Energy Agency, 2001). These acid-based systems generally achieved high yield and efficient, rapid uranium recovery, but they also dissolved other heavy metals associated with uranium in the host rock and other chemical constituents that required additional remediation. In the United States, acid-based lixiviants have been used only for small-scale research and development operations [e.g., Nine Mile Lake and Reno Ranch in Wyoming (Mudd, 2001)], but have not been used in commercial operations (Davis and Curtis, 2007; International Atomic Energy Agency, 2005). Licensees or applicants may propose the use of acid-based lixiviants in the future. Other technologies that used ammonia-based lixiviants experienced difficulties: the ammonia tended to adsorb onto clay minerals in the subsurface. The ammonia desorbs slowly from the clay during restoration, and therefore the system requires that much larger amounts of groundwater be removed and processed during aquifer restoration (Energy Information Administration, 1995; Davis and Curtis, 2007). Although applicants or licensees may decide to use different lixiviants for a given deposit (see text box "Lixiviant Selection" in Section 2.4.1.2), ISL operations in the United States are expected to use alkaline lixiviants that are based on sodium carbonate-bicarbonate as the complexing agent and gaseous oxygen or hydrogen peroxide as the oxidizing agents (Table 2.4-1). All currently active and proposed ISL facilities in Wyoming, Nebraska, and New Mexico use alkaline-based lixiviants (NRC, 2006, 2004, 1998a, 1997a; Energy Metals Corporation, U.S., 2007a). Therefore, for the purposes of the analyses presented in this GEIS, it is assumed that alkaline lixiviants will be used in ISL uranium recovery operations.

Table 2.4-1. Typical Lixiviant Chemistry (From NRC*, 1998b)

Species	Range (in mg/L)†	
	Low	High
Sodium (Na)	≤400	6,000
Calcium (Ca)	≤20	500
Magnesium (Mg)	≤3	100
Potassium (K)	≤15	300
Carbonate (CO_3)	≤0.5	2,500
Bicarbonate (HCO_3)	≤400	5,000
Chloride (Cl)	≤200	5,000
Sulfate (SO_4)	≤400	5,000
Uranium (as U_3O_8)	≤0.01	500
Vanadium (as V_2O_5)	≤0.01	100
Total Dissolved Solids	≤1,650	12,000
pH (in std unit)	≤6.5	10.5

*NRC = U.S. Nuclear Regulatory Commission
†1 mg/L is approximately equal to 1 part per million (ppm)

The principal geochemical reactions caused by the lixiviant are the oxidation and subsequent dissolution of uranium and other metals from the ore body (Davis and Curtis, 2007). These reactions are effectively the reverse of those that initially caused the uranium deposition. The oxidant (oxygen or hydrogen peroxide) in the lixiviant oxidizes uranium from the relatively insoluble tetravalent state (U^{4+}) to the more soluble hexavalent state (U^{6+}). Once the uranium is in the 6+ oxidation state, the dissolved carbonate/bicarbonate causes the formation of aqueous uranyl-carbonate complexes that maintain oxidized uranium in solution as uranyl ion (UO_2^{2+}).

2.4.1.2 Lixiviant Injection and Production

Dissolved carbonate/bicarbonate lixiviants are created by introducing reagents such as sodium carbonate/bicarbonate or by injecting carbon dioxide gas (CO_2) into the groundwater. Carbon dioxide can also be added for pH control (Table 2.4-1). Lixiviant is pumped down injection wells to the mineralized zones, where it oxidizes and dissolves uranium from the sandstone formation (Figure 2.4-1). The uranium-bearing solution migrates through the pore spaces in the sandstone and is recovered by production wells. This uranium-rich (pregnant) lixiviant is pumped to the processing plant or satellite ion-exchange facility, where the uranium is extracted through a series of chemical processes. Stripped of its uranium, the now-barren lixiviant is recharged with carbonate/bicarbonate and oxidant, and the solution is returned through the injection wells to dissolve additional uranium. This process continues until the operator determines that further uranium recovery is uneconomical.

Lixiviant Selection

The geology and groundwater chemistry determine the proper leaching techniques and chemical reagents ISL milling uses for uranium recovery. For example, if the ore-bearing aquifer is rich in calcium (e.g., limestone or gypsum), alkaline (carbonate) leaching might be used [e.g., as discussed by Hunkin (1977)], acid systems were generally considered unsuitable for Texas deposits because of higher carbonate]. Otherwise, acid (sulfate) leaching might be preferable. The leaching agent chosen for the ISL operation may affect the type of potential contamination and vulnerability of aquifers during and after ISL operations.

For example, acid leaching ISL uranium recovery at Nine Mile Lake and Reno Ranch, Wyoming, presented two major problems: (1) gypsum precipitated on well screens and within the aquifer during uranium recovery, plugging wells and reducing the formation permeability (critical for economic operation) and (2) the precipitated gypsum gradually dissolved after restoration, increasing salinity and sulfate levels in groundwater (Mudd, 2001).

Typical ISL uranium recovery operations in the United States use an alkaline sodium bicarbonate system to remove the uranium from ore-bearing aquifers. Alkaline lixiviants are used in all currently active and proposed ISL facilities in Wyoming, Nebraska, and New Mexico (NRC, 2006, 2004, 1998a, 1997a; Energy Metals Corporation, U.S., 2007) (see Table 2.4-1). Alkaline-based ISL operations are considered to be easier to restore than acid mine sites (Tweeton and Peterson, 1981; Mudd, 1998).

During the uranium recovery process, the groundwater in the production zone becomes progressively enriched in uranium and other metals that are typically associated with uranium in nature. The most common metals are arsenic, selenium, vanadium, iron, manganese, and radium. These and other constituents such as chloride, which is introduced by the ion-exchange resin system, are removed or precipitated from the groundwater during aquifer restoration after uranium recovery is completed. Aquifer restoration is detailed in Section 2.5.

The production wells are normally positioned to pump pregnant lixiviant from a number of injection wells. After processing for the uranium but before reinjection below ground, about 1–3 percent of the lixiviant, called the production bleed, is removed from the circuit and disposed (see Section 2.7.2). The purpose of the production bleed is to ensure that more groundwater is extracted than re-injected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field.

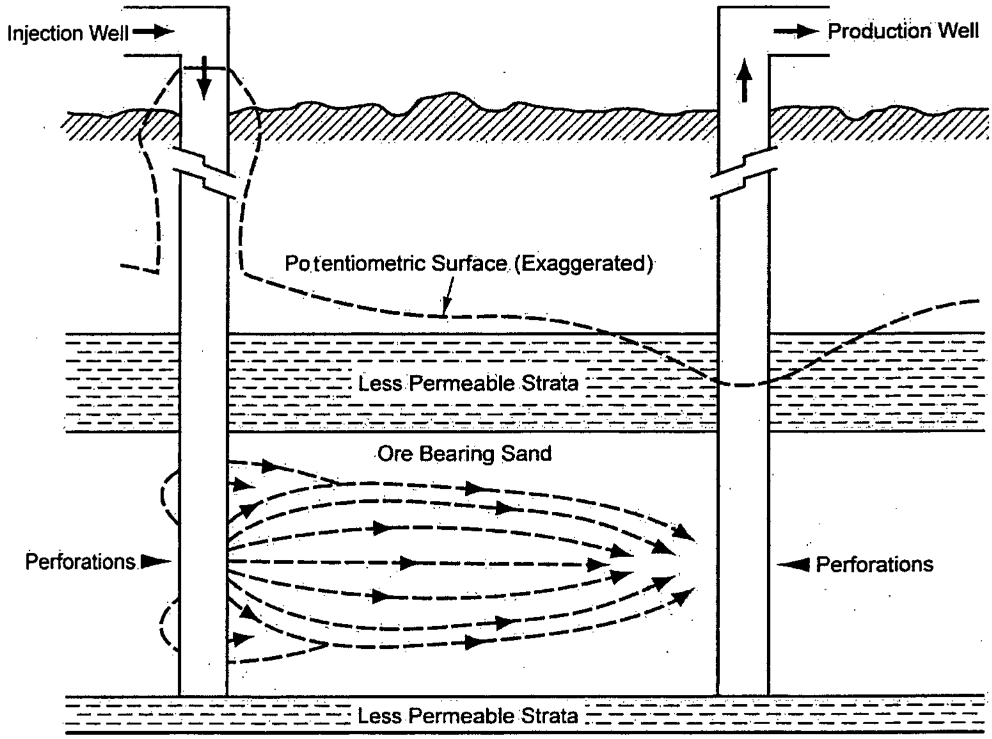

Figure 2.4-1. Idealized Schematic Cross Section To Illustrate Ore-Zone Geology and Lixiviant Migration From an Injection Well to a Production Well (From NRC, 1997a)

Pregnant lixiviant is pumped from the well fields by submersible pumps located in each production well. In some cases, booster pumps are installed in the lines to the processing plants or satellite facilities. Given the seasonal temperature variation in the four regions considered in this GEIS, the main injection and production lines to and from the processing plants may be buried up to several meters [feet] to prevent freezing. These lines are usually 10.2- to 35.6-cm [4- to 14-in]-diameter high-density polyethylene or PVC pipes. The pregnant lixiviant is enriched in uranium relative to groundwater {typically about 60 mg/L [0.0005 lb/gal]} and is also likely to contain the trace elements and contaminants as discussed previously. The pipeline pressures are monitored continuously for spills and leaks.

2.4.1.3 Excursions

ISL operations may affect the groundwater quality near the well fields when lixiviant moves from the production zone and beyond the boundaries of the well field. This unintended spread, either horizontally or vertically, of recovery solutions beyond the production zone is known as an excursion. An excursion can be caused by

- Improper water balance between injection and recovery rates
- Undetected high permeability strata or geologic faults
- Improperly abandoned exploration drill holes

- Discontinuity within the confining layers
- Poor well integrity, such as a cracked well casing or leaking joints between casing sections
- Hydrofracturing of the ore zone or surrounding units

NRC license and underground injection control (UIC) permit conditions require that licensees conduct periodic tests to protect against excursions. These include but are not limited to

- Conducting pump tests for each well field prior to operations within the well field to evaluate the confinement of the production horizon
- Continued well field characterization to identify geologic features (e.g., thinning confining layers, fractures, high flow zones) that might result in excursions
- Mechanical integrity testing of each well to check for leaks or cracks in the casing

An excursion that moves laterally from the production zone is a horizontal excursion. Vertical excursions occur where barren or pregnant lixiviant migrates into other aquifers above or below the production zone.

Identifying Excursion Indicators and UCLs

The applicant or licensee proposes excursion indicators and upper control limits (UCLs) based on lixiviant content and baseline groundwater quality (see Section 2.2.7). The licensee's safety evaluation and review panel (SERP) approve the excursion indicators and proposed UCLs. The SERP-approved UCLs are subject to the NRC staff review and oversight. UCLs are set on a well field basis and are concentrations for excursion indicators that provide early warning if leaching solutions are moving away from the well fields. As described in NRC (2003a, Section 5.7.8.3), the best excursion indicators are easily measurable parameters that are found in higher concentrations during ISL operations than in the natural waters. For example, at most ISL uranium recovery operations, chloride is selected because it does not interact strongly with minerals in the subsurface, it is easily measured, and chloride concentrations are significantly increased during ISL operations. Conductivity, which is correlated to total dissolved solids, is also considered a good excursion indicator because of the high concentrations of dissolved constituents in the lixiviant as compared to the surrounding aquifers (Staub, et al., 1986; Deutsch, et al., 1985). Total alkalinity (carbonate plus bicarbonate plus hydroxide) is used as an indicator in well fields where sodium bicarbonate or carbon dioxide is used in the lixiviant.

A minimum of three excursion indicators is selected, and the UCLs are determined using statistical analyses of the preoperational baseline water quality in the well field. The NRC staff has identified several statistical methods that can be used to establish UCLs. For example, in areas with good water quality (total dissolved solids less than 500 mg/L), the UCL may be set at a value of 5 standard deviations above the mean of the measured concentrations. Conversely, if the chemistry or a particular excursion indicator is very consistent, a concentration may be specified as the UCL. If baseline data indicate that the groundwater is homogeneous across the well field, the same UCLs may be used for all monitoring wells. Alternatively, if the water chemistry in the well field is highly variable, UCLs may be set for individual wells. An excursion is defined to occur when two or more excursion indicators in a monitoring well exceed their UCLs (NRC, 2003a). Alternate excursion detection procedures (e.g., one excursion indicator exceeded in a monitor well by a specified percentage) may also be used if approved by NRC.

2.4.1.4 Excursion Monitoring

Licensees must maintain groundwater monitoring programs (see Chapter 8) to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. Monitoring wells are sampled at least every 2 weeks during well field operations to verify that ISL solutions are contained within the operating well field (NRC, 2003a). Geochemical excursion indicators are identified based on well field preoperational baseline water quality (see text box "Identifying Excursion Indicators and UCLs").

The spacing of horizontal excursion monitoring wells is based on site-specific conditions, but typically they are spaced about 90–150 m [300–500 ft] apart and screened in the production zone (NRC, 2003a, 1997a; Mackin, et al., 2001a; Energy Information Administration, 1995). The distance between monitoring wells and the distance of monitoring wells from the well field are typically similar (NRC, 2006, 1997a). The specific location and spacing of the monitoring wells is established on a site-by-site basis by license condition. It is often modified according to site-specific hydrogeologic characteristics, such as the extent of the confining layer, hydraulic gradient, and aquifer transmissivity. Well placement may also be modified as the licensee gains experience detecting, recovering, and remediating these excursions.

NRC licenses also include requirements to establish monitoring wells in overlying and, as appropriate, in underlying aquifers to detect vertical excursions. Although uranium deposits are typically located in hydrogeologic units bounded above and below by adequately confining units, the possibility of vertical contaminant transport must be considered. Historically, these monitoring wells are more widely spaced than those within the host aquifer, although underlying aquifer monitoring wells may not be required under some circumstances (Mackin, et al., 2001a).

Historically, frequency of vertical monitoring wells at licensed ISL facilities has been (1) one monitoring well per 1.6 ha [4 acres] of well field in the first overlying aquifer, (2) one monitoring well per 3.2 ha [8 acres] in each higher aquifer, and (3) one monitoring well per 1.6 to 3.2 ha [4 to 8 acres] in the underlying aquifer (Mackin, et al., 2001a). These monitoring wells are typically sampled every 2 weeks during operations.

An excursion is defined to occur when two or more excursion indicators in a monitoring well exceed their UCLs (NRC, 2003a). Alternatively, since the advent of performance-based licensing, procedures to identify excursions can be imposed through site-specific license conditions. For example, an excursion may be defined to occur when one excursion indicator is exceeded in a monitoring well by a certain percentage. If an excursion is detected, the licensee takes several steps to notify NRC and confirm the excursion through additional and more frequent sampling (NRC, 2003a) (see Chapter 8). As described in NRC guidance (NRC, 2003a, Section 5.7.8.3), licensees typically retrieve horizontal excursions by adjusting the flow rates of the nearby injection and production wells to increase process bleed in the area of the excursion. To address vertical excursions, licensees may adjust injection and production flow rates in the area of the excursion and pump directly from the affected monitoring wells or from other wells drilled for that purpose. Vertical excursions are more difficult to retrieve, persisting for years in some cases (see Section 2.11.4). If an excursion cannot be recovered, the licensee may be required to stop injection of lixiviant into a well field (NRC, 2003a, Section 5.7.8.3).

2.4.2 Uranium Processing

Uranium is recovered from the pregnant lixiviant and processed into yellowcake in a multistep process (Figure 2.4-2). The following sections briefly describe key aspects of the uranium process circuit.

2.4.2.1 Ion Exchange

As pregnant lixiviant from the production wells enters the ion-exchange circuit, it may either be stored in a surge tank or sent directly to the ion-exchange columns (Figure 2.4-3). The ion-exchange columns contain ion-exchange resin composed of small, negatively charged

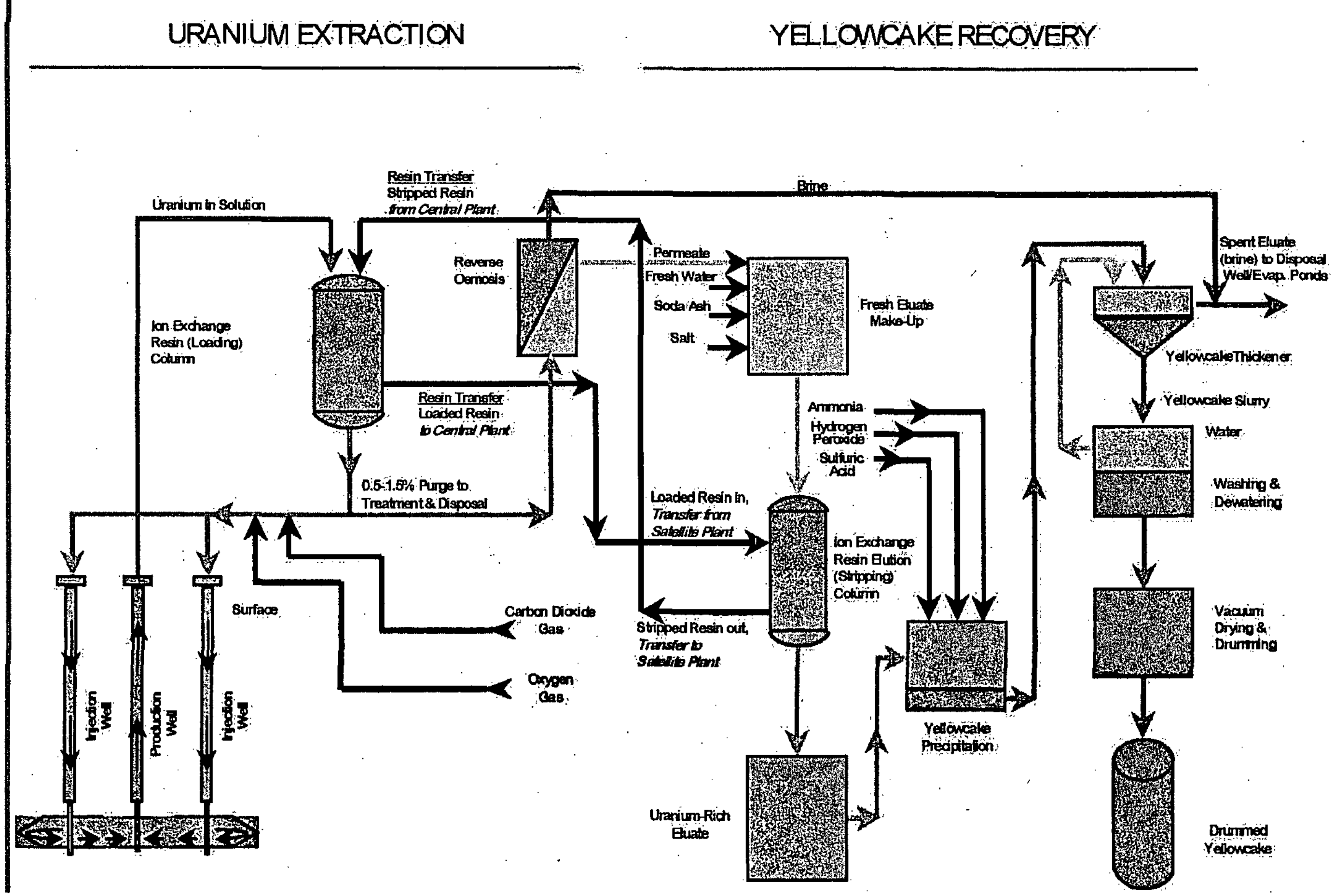

Figure 2.4-2. Flow Diagram of an ISL Uranium Recovery Process (Mackin, et al., 2001a)

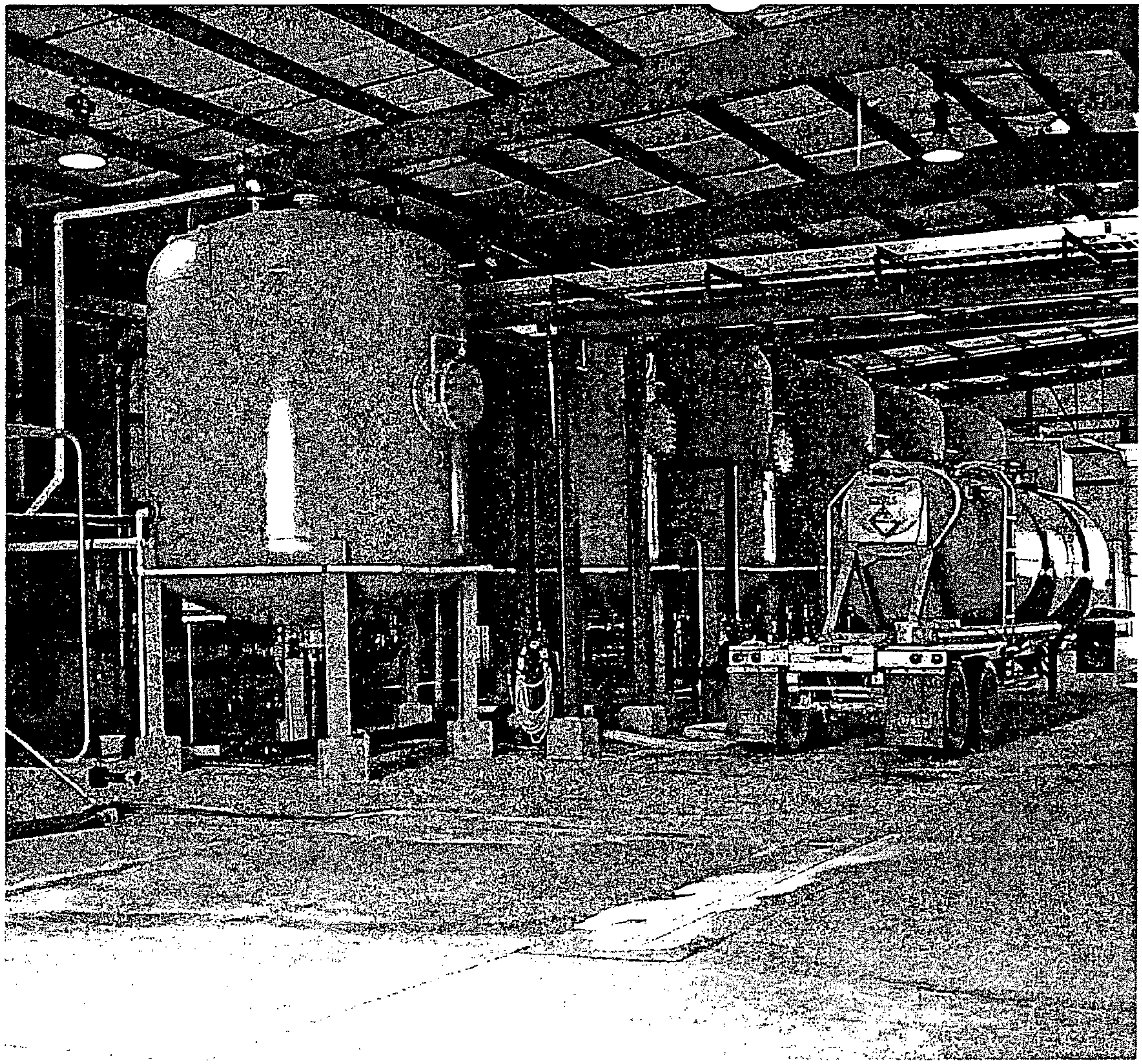

Figure 2.4-3. Typical Ion-Exchange Vessels in an ISL Facility

polymer or plastic particles. The number and size of ion-exchange columns in the circuit may vary, depending on facility design. For example, at the Smith Ranch Uranium Project in Converse County, Wyoming, the ion-exchange circuit consists of six pressurized downflow vessels, each with a volume of 14.2 m^3 [501.5 ft^3] (Stout and Stover, 1997). At the Crow Butte facility in Dawes County, Nebraska, the ion-exchange circuit consists of eight upflow columns, with a recent addition of six downflow columns, each about 3.5 m [11.5 ft] in diameter and 4.6 m [15 ft] tall and a volume of about 44 m^3 [1,554 ft^3] (NRC, 2007; Crow Butte Resources, Inc., 2007). In the ion-exchange columns, the uranium is adsorbed onto resin beads that selectively remove uranium from solution. The primary reaction is the exchange of the uranium carbonate complexes for chloride. The lixiviant exiting the ion-exchange columns normally contains less than 5 mgL of uranium (Energy Metals Corporation, U.S., 2007a; Lost Creek ISR, LLC, 2007).

Based on average uranium concentrations in production fluids at ISL sites (e.g., 120 to 150 mg/L [120 to 150 ppm]; Lost Creek ISR, LLC, 2007), greater than 95 percent of the uranium is extracted during the ion-exchange process. The (now barren) lixiviant is recharged with oxidant and bicarbonate, and is returned to the well field for reinjection and further uranium recovery. This barren lixiviant carries chloride that was exchanged for uranium on the resin. The chloride content of the water in the ore-bearing aquifer builds up with time as the lixiviant is circulated and the resin is recharged. The production bleed discussed in Section 2.4.1 is removed downstream of the ion-exchange columns, before re-injecting the barren lixiviant into the well field (see Figure 2.4-2).

When the resin beads in the ion-exchange columns become saturated with uranium, the columns are taken offline, and other columns are brought online. Some facilities may not process the ion-exchange resins further (NRC, 2004, 2006). In these facilities (called satellite facilities), the resin is discharged to a truck and then transported to a facility that has the capacity for further processing of the uranium-loaded resin. Later sections of this GEIS assess the hazards associated with transferring and transporting loaded ion-exchange resin.

2.4.2.2 Elution

At ISL facilities that can process resin, after the resin is loaded with uranium, it enters the elution circuit. In addition, uranium-loaded resins transported from satellite plants in a remote ion-exchange operation enter the processing circuit at this point. In the elution circuit, the uranium is washed (eluted) from the resin, and the resin is made available for further cycles of uranium absorption. The resin may be eluted directly in the ion-exchange column, or it may be transferred to a separate elution tank. In the elution process, the uranium is removed from the resin by flushing with a concentrated brine solution (eluant). After the uranium has been stripped from the resin, the resin may be rinsed with a sodium carbonate or bicarbonate solution. This rinse removes the high chloride eluant physically entrained in the resin and partially converts the resin to bicarbonate form. The resulting uranium-rich solution is termed pregnant or rich eluant and typically contains 8 to 20 g/L [0.067 to 0.17 lb/gal] of uranium (Mackin, et al., 2001a). It is normally discharged to a holding tank. After enough pregnant eluant is obtained, it is moved to the precipitation, drying, and packaging circuit (Mackin, et al., 2001a).

2.4.2.3 Precipitation, Drying, and Packaging

In the precipitation and drying circuit, the pregnant eluant is typically acidified using hydrochloric or sulfuric acid to destroy the uranyl carbonate complex. Hydrogen peroxide (H_2O_2) is then added to precipitate the uranium as uranyl peroxide. Caustic soda (NaOH) or ammonia (NH_3) is also normally added at this stage to neutralize the acid remaining in the eluate. The (now barren) eluant is typically recycled. Water left over from these processes may be reused in the eluant circuit or may be disposed as 11e.(2) byproduct material. Effluent management is discussed in Section 2.7.2.

After the precipitation process, the resulting slurry is sent to a thickener where it is settled, washed, filtered, and dewatered (Figure 2.4-4). At this point, the slurry is 30 to 50 percent solids. This thickened slurry may be transported offsite to a uranium processing plant to produce yellowcake, or it may be filter pressed to remove additional water, dried, and packaged onsite.

> **Byproduct Material**
>
> 11e.(2) byproduct materials are tailings or waste generated by extraction or concentration of uranium or thorium processed ores, as defined under Section 11e.(2) of the Atomic Energy Act.

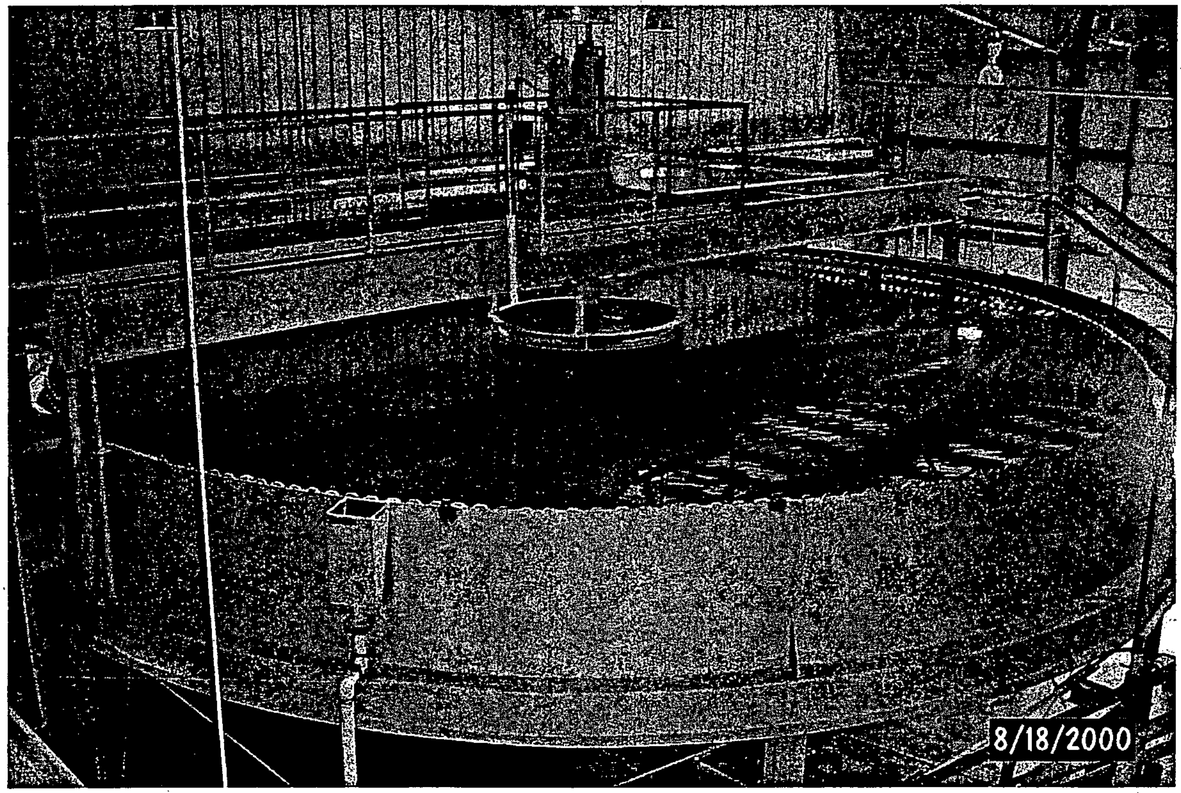

Figure 2.4-4. A Typical Thickener for an ISL Uranium Processing Facility

For onsite processing, the slurry is next dried in the yellowcake dryer. Historically, two kinds of yellowcake dryers have been used: multihearth dryers and vacuum dryers. Older uranium ISL facilities used gas-fired multi-hearth dryers. These dryers typically dry the yellowcake at about 400 to 620 °C [750 to 1,150 °F]. Because of the high temperatures involved, any organic contaminants in the yellowcake (e.g., grease from bearings) will be completely burned and will exit the system with the dryer offgas. This is advantageous because leftover organic residues in the packaged yellowcake product may oxidize while in the drum, causing the drum to pressurize and burst due to the evolution of gases (primarily CO_2) (NRC, 1999). The offgas discharge from the dryer is scrubbed with a high intensity venturi scrubber that is 95 to 99 percent efficient at removing uranium particulates before they are released to the atmosphere. Solutions from the scrubber are normally returned to the precipitation circuit and are processed to recover any uranium particulates. As a result, the stack discharge normally contains only water vapor and quantities of uranium fines that are managed to be below regulatory limits (see Section 2.7.1 and Chapter 8).

Newer ISL facilities usually use vacuum yellowcake dryers. In a vacuum dryer (Figure 2.4-5), the heating system is isolated from the yellowcake so no radioactive materials are entrained in the heating system or its exhaust. The drying chamber that contains the yellowcake slurry is under vacuum. Therefore, any potential leak would cause air to flow into the chamber, and the

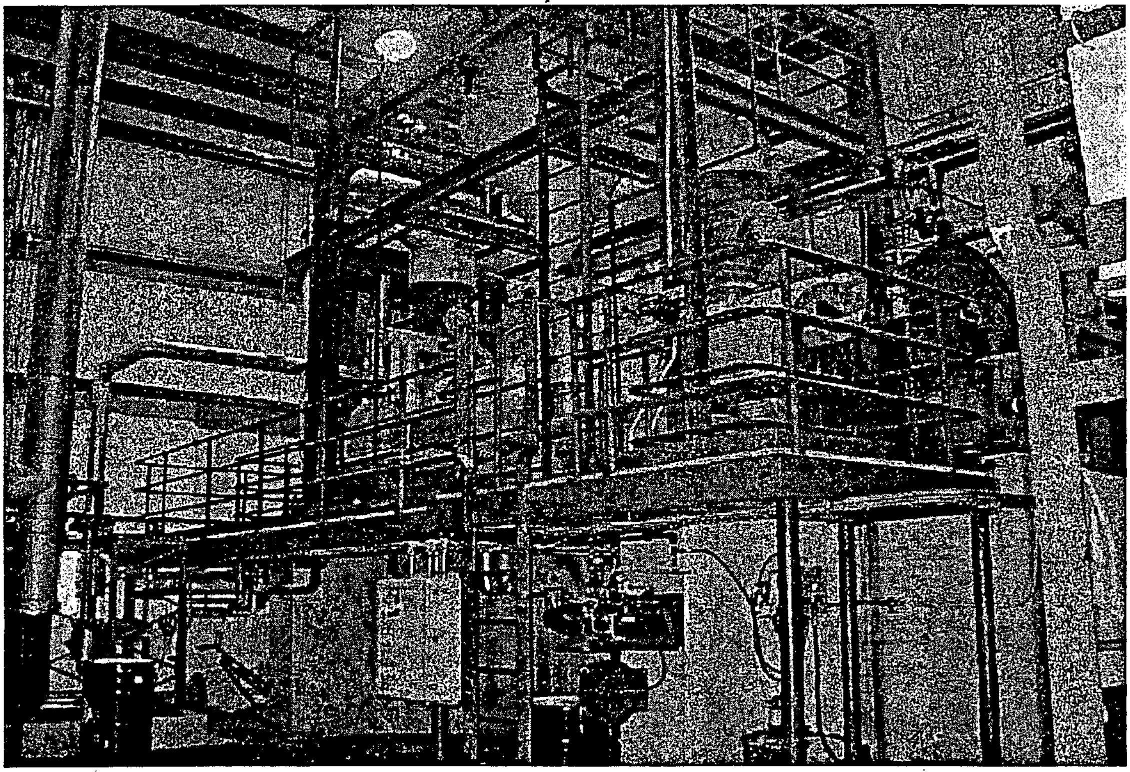

Figure 2.4-5. Typical Vacuum Dryer for Uranium Yellowcake Processing at an ISL Uranium Processing Facility

drying can take place at relatively low temperature {e.g., 149 °C [250 °F]}. Moisture in the yellowcake is the only source of vapor. Emissions from the drying chamber are normally treated in two ways. First, vapor passes through a bag filter to remove yellowcake particulates with an efficiency exceeding 99 percent. Any captured particulates are returned to the drying chamber. Second, any water vapor exiting the drying chamber is cooled and condensed. This process is designed to capture virtually all escaping particles (Mackin, et al., 2001a).

The dried product (yellowcake) is removed from the bottom of the dryer and packaged in drums for eventual shipping offsite. The packaging area normally has a baghouse dust collection system to protect personnel and to minimize yellowcake release. Air from the baghouse dust collection system is typically routed to the dryer offgas line and scrubber. During drum loading, the drum is normally kept under negative pressure via a drum hood with a suction line. The drum hood transports any released particulates to a baghouse dust collector. The filtered air from this baghouse joins the dryer offgas and is passed through the scrubber. Parameters important to the effective operation of the dryer must be monitored, and existing NRC regulations at 10 CFR Part 40, Appendix A, Criterion (8), prohibit dryer operations when these parameters are outside prescribed ranges. After the dried product is cooled, it is packaged and shipped in 208-L [55-gal] drums (Figure 2.4-6).

Figure 2.4-6. Labeled and Placarded 208-L [55-gal] Drum Used for Packaging and Shipping Yellowcake

2.4.3 Management of Production Bleed and Other Liquid Effluents

Uranium mobilization and processing produce excess water that must be properly managed. The production wells extract slightly more water than is re-injected into the host aquifer, which creates a net inward flow of groundwater in the well field. This production bleed is about 1 to 3 percent of the circulation rate, which can amount to an excess production of several tens to a hundred liters per minute (several tens of gallons per minute). As described in Section 2.4.1, the production bleed is diverted from the ISL circuit after the uranium is removed in the ion-exchange resin system, but before the lixiviant is recharged. This water still contains lixiviant and minerals leached from the aquifer. The excess water can be discharged to an evaporation pond or a deep well injection for disposal, or treated further for discharge to the environment (Section 2.7.2). Other liquid waste streams produced during ISL operation can include spent eluant from the ion-exchange system and liquids from process drains. These are handled in the same manner as the production bleed.

2.5 Aquifer Restoration

The purpose of aquifer restoration is to return well field water quality parameters to the standards in 10 CFR 40, Appendix A, Criterion 5(B)(5) or another standard approved by NRC

(NRC, 2009). Before ISL operations can begin, the portion of the aquifer designated for uranium recovery must be exempted as an underground source of drinking water, in accordance with the Safe Drinking Water Act (see Section 1.7.2.1). Groundwater adjacent to the exempted portion of the aquifer, however, must still be protected.

Prior to well field operations, applicants and licensees must determine baseline groundwater quality for the production zone (NRC, 2003a). In their applications, applicants or licensees identify the list of constituents to be sampled, which are typically similar to the NRC-accepted list of constituents shown in Table 2.2-1. Applicants or licensees may identify other constituents, or remove constituents, as long as a basis for the constituent(s) is provided and approved by NRC. State and other federal agencies with jurisdiction over groundwater could also specify constituents, which may or may not be included in the NRC-accepted list. In this case, the applicant would be accountable to the subject state or federal agency for characterizing and restoring these constituents.

To determine baseline water quality conditions prior to well field operations, applicants or licenses collect at least four sets of samples, spaced sufficiently in time to establish seasonal variability, and analyze the samples for the identified constituent (NRC, 2003a). An NRC-acceptable set of samples should include all well field perimeter monitoring wells and all upper and lower monitoring wells. Additionally, the applicant or licensee should sample at least one production/injection well per acre in the well field or enough production/injection wells to provide an adequate statistical population if fewer than one well per acre is used. NRC verifies the accuracy of baseline water quality data by ensuring that the applicant's or licensee's procedures include (1) acceptable sample collection methods, (2) a set of sampled parameters that is appropriate for the site and ISL extraction method, and (3) collection of sample sets that are sufficient to represent natural spatial and temporal variations in water quality.

After uranium recovery has ended, the groundwater in the well field contains constituents that were mobilized by the lixiviant. Licensees usually begin aquifer restoration in each well field soon after the uranium recovery operations end (NRC, 2008b). Aquifer restoration criteria for the site-specific baseline constituents are determined either on a well-by-well or well-field-by-well-field basis. NRC licensees are required to return water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license (NRC, 2009).

Aquifer restoration programs typically use a combination of methods including (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, (4) groundwater recirculation, and (5) stabilization monitoring (Energy Information Administration, 1995; Mackin, et al., 2001a; Davis and Curtis, 2007). NRC allows licensees the flexibility to select the restoration methods to be used for each well field (NRC, 2003a).

The EPA or state authorized to implement the EPA underground injection control program reviews any aquifer restoration plans for compliance with the applicable terms and conditions of the UIC permit requirements. NRC staff reviews any aquifer restoration plans for compliance with the NRC license to protect human health, safety, and the environment.

2.5.1 Groundwater Transfer

Groundwater transfer involves moving groundwater between the well field entering restoration and another well field where uranium leach operations are beginning, or alternately, within the

same well field, if one area is in a more advanced state of restoration than another (NRC, 2006). This technique displaces mining-affected waters in the restoration well field with baseline quality waters from the well field beginning leach operations. As a result, the groundwater in the two well fields becomes blended until the waters are similar in conductivity and therefore similar in the amount of dissolved constituents. Because water is transferred from one well field to another, groundwater transfer typically does not generate liquid effluents.

2.5.2 Groundwater Sweep

During groundwater sweep, the licensee pumps water from the well field to the processing plant through all production and injection wells without reinjection (Figure 2.5-1). This pumping causes uncontaminated, native groundwater to flow into the ore body, thereby flushing the contaminants from areas that have been affected by the horizontal spreading of the lixiviant in the affected zone during uranium recovery. Groundwater produced during the sweep phase will contain uranium and other contaminants mobilized during uranium recovery and residual lixiviant. The initial concentrations of these constituents would be similar to those during the uranium recovery operation phase, but would decline gradually with time (Davis and Curtis, 2007). The water removed from the aquifer during the sweep first is passed through an ion-exchange system to recover the uranium and then disposed either in evaporation ponds or via deep well injection in accordance with the limits in a UIC permit. The pumping rates used will depend on the hydrologic conditions at a given site, and the duration of the aquifer sweep

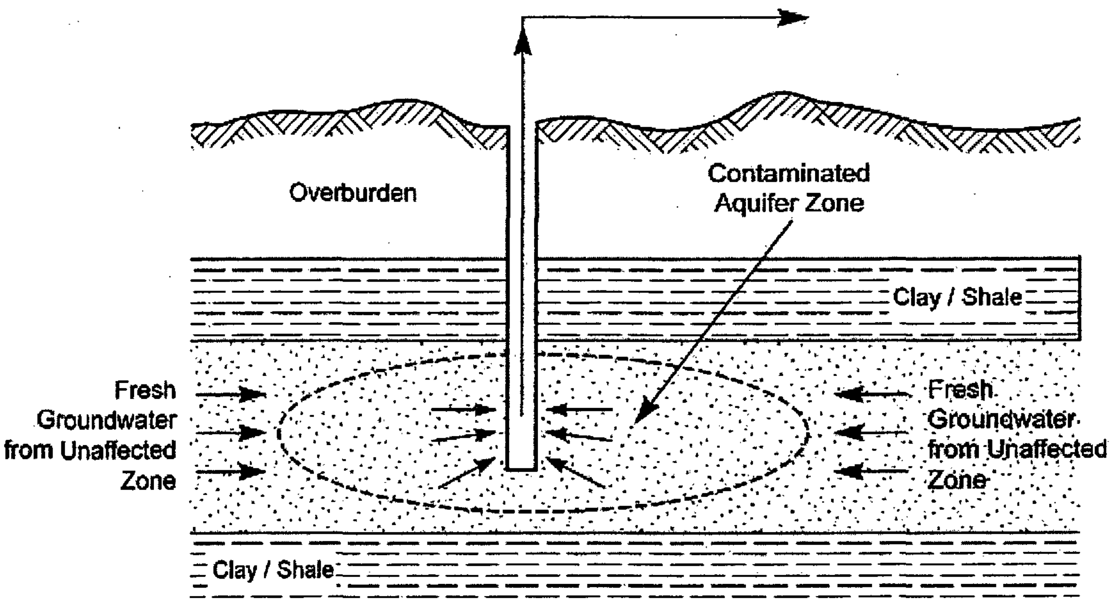

Figure 2.5-1. Schematic Diagram of Groundwater Sweep During Aquifer Restoration (After Energy Information Administration, 1995)

and volume of water removed depend on the volume of the aquifer affected by the ISL process. The aquifer volume typically is described in terms of "pore volumes" (see text box). Based on operational data (see Section 2.11.5), it is likely that more than one pore volume would be removed during the sweep. At the Crow Butte ISL facility in Dawes County, Nebraska, the pore volumes for the first six well fields {3.8 to 16.3 ha [9.3 to 40.2 acres]} were estimated to range from 58.3 to 298.7 million L [15.4 to 78.9 million gal] (NRC, 1998b). In comparison, the total pore volume for the nine well fields at the Irigaray Project was estimated to be 232.8 million L [61.5 million gal] (Cogema Mining, 2005).

2.5.3 Reverse Osmosis, Permeate Injection, and Recirculation

Reverse osmosis and permeate injection are used after groundwater sweep operations. This phase returns total dissolved solids, trace metal concentrations, and aquifer pH to baseline values (Davis and Curtis, 2007; NRC, 2003a). During permeate injection and recirculation, uranium in the groundwater is removed by passing the water through the ion-exchange circuit, as during operations. After that, other chemical constituents in the groundwater are removed by passing the groundwater through a reverse osmosis system consisting of pressurized, semipermeable membranes.

The reverse osmosis process yields two fluids: clean water (permeate: about 70 percent) that can be reinjected into the aquifer and water with concentrated ions (brine: about 30 percent) that cannot be reinjected directly. Water sent to the reverse osmosis system must be pretreated so the semipermeable membranes used in the system are not fouled. The pH is lowered, and additives called antiscalants are added to the groundwater upstream of the reverse osmosis unit to prevent precipitation of minerals (particularly calcium carbonate). Typically, sodium hexametaphosphate or polycarboxylic acid are used as antiscalants, and sulfuric acid is used for pH adjustment. After reverse osmosis, sodium hydroxide may be added to readjust the pH of the groundwater to baseline levels.

Pore Volume and Flare

Pore volume is a term used by the ISL industry to define an indirect measurement of a unit volume of aquifer water affected by ISL recovery. It represents the volume of water that fills the void space in a certain volume of rock or sediment. Pore volume provides a unit reference that an operator can use to describe the amount of lixiviant circulation needed to leach an ore body or describe the unit number of treated water circulations needed to flow through a depleted ore body to achieve restoration. A pore volume allows an operator to use relatively small-scale studies and scale the results to field-level pilot tests or to commercial well field scales. Typically, a "pore volume" is calculated by multiplying the surficial area of a well field (the area covered by injection and recovery wells) by the thickness of the production zone being exploited and the estimated or measured porosity of the aquifer material (NRC, 2003a).

A proportionality factor, known as "flare," is designed to estimate the amount of aquifer water outside of the pore volume that has been impacted by lixiviant flow during the recovery phase. The flare is usually expressed as a horizontal and vertical component to account for differences between the horizontal and vertical hydraulic conductivities of an aquifer material (NRC, 2003a).

The pumping and injection rates during this phase are likely to be similar to those during the sweep phase {hundreds of liters [gallons] per minute}, but depending on site hydrology, many pore volumes (often more than 10) may need to be circulated to achieve aquifer restoration goals (Davis and Curtis, 2007; Mackin, et al., 2001b). The net withdrawal from the aquifer depends on how the rejected liquid (reject) from the reverse osmosis system, which is about 30 percent of the pumping rate, is handled. Because the reject is a brine solution, it cannot be directly injected into the aquifer or discharged to the environment. The reject can be disposed directly in an evaporation pond or via a deep well injection in accordance with the discharge limits in a UIC permit. If the reject is sent directly to an evaporation pond or a deep disposal

well, the net withdrawal from the aquifer could be about 30 percent of the pumping rate {tens of liters [gallons] per minute}.

Alternatively, a brine concentrator can be used to treat the reject. The brine concentrator heats and evaporates the water, concentrating the brine, which then contains precipitated solids in the form of common salts. The brine concentration process typically results in about one part briny slurry and salts to 300 parts purified water. The purified water can be reintroduced into the aquifer, and thus the net withdrawal from the aquifer would be only a small percentage of the recirculation rate. The briny slurry is disposed in an evaporation pond or via deep well injection (Section 2.7.2).

After completing the reverse osmosis/permeate injection phase, the well field water will have characteristics similar to the permeate, and the recirculation phase takes place. To homogenize the groundwater, well field water may be circulated using the original injection and production wells. The quantity of water that is recirculated depends on site-specific baseline parameters and contaminant levels.

2.5.4 Stabilization

The purpose of the stabilization phase of aquifer restoration is to establish a chemical environment that reduces the solubility of dissolved constituents such as uranium, arsenic, and selenium. An important part of stabilization during aquifer restoration is metals reduction (Davis and Curtis, 2007). During uranium recovery, if the oxidized (more soluble) state is allowed to persist after uranium recovery is complete, metals and other constituents such as arsenic, selenium, molybdenum, uranium, and vanadium may continue to leach and remain at elevated levels. To stabilize metals concentrations, the preoperational oxidation state in the ore production zone should be reestablished as much as is possible. This is achieved by adding an oxygen scavenger or reducing agent such as hydrogen sulfide (H_2S) or a biodegradable organic compound (such as ethanol) into the uranium production zone during the later stages of recirculation (Davis and Curtis, 2007). The need for an aquifer stabilization phase will vary on a case-by-case basis, depending on how effectively the sweep and recirculation phases restore the affected aquifer to the required standards at a given site.

Following stabilization, the licensee monitors the groundwater by quarterly sampling to demonstrate that the approved standards for each parameter have been met and that any adjacent nonexempt aquifers are unaffected. As described in the case studies summarized in Davis and Curtis (2007), sampling at some sites after H_2S injection indicated that although reducing conditions were apparently achieved, they were not maintained over the longer term (see Section 2.11.5). The licensee would reinitiate aquifer restoration if stabilization monitoring determines it is necessary. Both the state permitting agency and the NRC must review and approve the monitoring results before aquifer restoration is considered to be complete.

2.6 Decontamination, Decommissioning, and Reclamation

Decommissioning an ISL facility is based on an NRC-approved decommissioning plan. This section discusses activities based on previous summaries (Energy Information Administration, 1995; Mackin, et al., 2001a). Details of decommissioning methods and criteria are provided in NUREG–1569, "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications" (NRC, 2003a). Unless otherwise authorized by NRC, licensees are required under 10 CFR 40.42 to complete site decommissioning within 2 years from the time the

decommissioning plan has been approved. The primary steps involved in decommissioning an ISL facility include:

- Conducting radiological surveys of facilities, process equipment, and materials to evaluate the potential for exposure during decommissioning
- Removing contaminated equipment and materials for disposal at an approved facility or for reuse
- Decontaminating items to be released for unrestricted use
- Cleaning up areas used for contaminated equipment and materials
- Cleaning up evaporation ponds
- Plugging and abandoning wells
- Surveying excavated areas for contamination and removing contamination to meet cleanup limits
- Backfilling and recontouring disturbed areas
- Performing final site soil radiation background surveys
- Revegetating and reclaiming disturbed areas
- Monitoring the environment

Structures, waste materials, and equipment are surveyed to identify any radiation hazards. Materials that meet NRC unrestricted release criteria for surface contamination (NRC, 2003a, Sections 5.7.6.3 and 6.3) are segregated from those that do not meet the limits. Alternatives for handling process buildings and equipment include reuse, removal, or disposal. Contaminated items are decontaminated to meet release criteria (NRC, 2003a) if they are to be released for offsite unrestricted use; otherwise, they are disposed of as 11e.(2) byproduct material in a licensed disposal facility. Estimated volumes of building demolition and removed equipment wastes for an ISL facility are provided in Table 2.6-1. Waste volume estimates are provided for byproduct material wastes [requiring 11e.(2) licensed disposal] and municipal solid wastes (e.g., materials suitable for unrestricted release).

Pond liners and leak detection systems are surveyed. If radiological contamination is found, the liners and detection systems are typically removed and disposed in a licensed disposal facility. Estimated volumes of pond reclamation wastes for an ISL facility are provided in Table 2.6-1.

Well fields are decommissioned after groundwater restoration has been completed. Proper well field decommissioning protects the groundwater supply and eliminates physical hazards. First, surface equipment (such as injection and production lines), electrical components, and well head equipment (such as valves, meters, or fixtures) are salvaged. Then buried piping is removed, and the wells are plugged and abandoned using accepted practices identified as part of an EPA- or state-administered UIC program. NRC decommissioning inspection also visually verifies that well sealing and abandonment is done according to plans. Estimated volumes of well field decommissioning wastes for an ISL facility are provided in Table 2.6-1. The well field

Table 2.6-1. Estimated Decommissioning and Reclamation Waste Volumes (yd^3)* for Offsite Disposal, Smith Ranch *In-Situ* Leach Facility†		
ISL Decommissioning Activity	**Byproduct Waste**	**Municipal Solid Waste**
Processing Equipment Removal	342	0
Building Demolition	546	531
Well Field Equipment	1,361	404
Trunk Line Removal	2,263	0
Contaminated Soil Removed	1,428	0
Evaporation Pond Reclamation	68	0

*To convert yd^3 to m^3, multiply by 0.7646.

†*Volumes were compiled and summed from an annual surety report.* McCarthy, J. "Smith Ranch: 2007–2008 Surety Estimate Revision." Letter (June 29) to G. Janosko, NRC. Glenrock, Wyoming: Power Resources International. 2007.

area is decontaminated in accordance with NRC regulatory limits at 10 CFR Part 40, Appendix A, and surveys are performed to ensure compliance with standards. Surface reclamation is completed using an NRC-approved plan.

Contaminated soils are cleaned up as necessary for decommissioning. Radiation surveys are conducted to determine whether any contaminated areas exist. Criteria at 10 CFR Part 40, Appendix A, are used for identifying contaminated soils and for determining when cleanup is complete. The NRC reviews and approves survey and sampling results. In the well fields where gamma radiation surveys correlate strongly with actual radiation concentrations in soil, (e.g., where contamination from leaks or spills of pregnant lixiviant would include uranium and daughter products including radium), gamma surveys are conducted as each well field unit is decommissioned. Soil samples are obtained from any areas that have elevated gamma readings. Areas contaminated with Ra-226, Ra-228, or other radionuclides exceeding the limits specified at 10 CFR Part 40, Appendix A, Criterion 6-(6), are cleaned up. Contaminated soil is removed and disposed as 11e.(2) byproduct material at a licensed disposal facility. The estimated volume of contaminated soil removal for an ISL facility is provided in Table 2.6-1. The most likely areas for contaminated soils are well field surfaces, evaporation pond bottoms and berms, process building areas, storage yards, transportation routes for uranium recovery products or contaminated materials, and pipeline runs. Areas used for land application of treated water are also surveyed and decontaminated as necessary.

All radioactive wastes generated during ISL facility decommissioning (as well as radioactive wastes generated during operations and aquifer restoration) are considered 11e.(2) byproduct material that must be disposed at a licensed facility (Section 2.7).

An NRC-approved surface reclamation plan ensures disturbed lands are returned to near preconstruction or to planned postoperational land use. Baseline data on soils, vegetation, wildlife, and radiation are used as guidelines for the surface reclamation. Areas disturbed by the uranium recovery operations are restored as closely as possible to preoperational conditions. Reclamation activities include replacing excavated soils, recontouring affected areas, reestablishing original drainage, and revegetation. The magnitude of reclamation activities varies, in part, with the size of the ISL facility. A large ISL facility, Smith Ranch (see Table 2.11-1) has estimated the need to apply approximately 43,748 m^3 [57,221 yd^3] of topsoil to the ground surface during site reclamation (McCarthy, 2007). Because topsoil excavated during construction was stockpiled and reseeded to limit erosion (NRC, 1992), the net amount of topsoil needed to replace topsoil removed during decommissioning is approximated by the

estimated volume of excavated soil destined for offsite disposal shown in Table 2.6-1 {1,092 m^3 [1,428 yd^3]}. After reclamation is complete, lands are normally capable of supporting wildlife and uses such as livestock grazing.

Financial surety arrangements (Section 2.10), established when an NRC license is granted, provide assurance that the costs of aquifer restoration and site decommissioning are covered when facility operations end. The surety also covers costs to close the site at any point during operations.

2.7 Effluents and Waste Management

ISL facilities generate airborne effluents, liquid wastes, and solid wastes that must be handled and disposed of properly. Effluents, waste streams, and waste management practices applicable to ISL facilities are described in this section. Transportation of wastes is discussed in Section 2.8.

2.7.1 Gaseous or Airborne Particulate Emissions

During construction, operations, aquifer restoration, and decommissioning, ISL facilities can produce airborne emissions including

- Fugitive dusts
- Combustion engine exhausts
- Radon gas emissions from lixiviant circulation and evaporation ponds
- Uranium particulate emissions from yellowcake drying

Fugitive dusts and engine exhausts are generated primarily during construction, transportation, and decommissioning activities. The fugitive dust is generated by travel on unpaved roads and from disturbed land associated with the construction of well fields, roads, and support facilities. Vehicles workers use to commute to the facility, to support onsite activities, to transport supplies to the site, or to transport product and wastes away from the site emit fuel combustion products. Diesel emissions originate from drill rigs, diesel-powered water trucks, and other equipment used during the construction phase. Operations rely on trucks for supply shipments and to transport product and some waste materials away from the site. Decommissioning activities produce emissions from construction equipment and from trucks used to haul waste materials offsite. Table 2.7-1 provides information from a previously licensed ISL satellite facility on the nature and duration of nonradiological emission-generating activities during construction, operation, and decommissioning. Table 2.7-2 contains the annual total releases and average air concentrations of particulate (fugitive dust) and gaseous (diesel combustion products) emissions estimated for the construction phase of the ISL facility near Crownpoint, New Mexico.

Radon gas is released during operation and aquifer restoration. Pressurized processing systems may contain most of the radon in solution; however, radon may escape from the processing circuit in the central uranium processing facility through vents or leaks, during well field operations, or during resin transfer when remote ion-exchange is used. For open air activities, the gas quickly disperses into the air. In closed processing areas, the building ventilation systems are designed to limit indoor radon concentrations. Radon detectors are placed in appropriate locations to ensure compliance with worker protection regulations in 10 CFR Part 20. Airborne particulate emissions from yellowcake drying and packaging and the filling of sodium bicarbonate storage containers are controlled by using vacuum drying

Table 2.7-1. Combustion Engine Exhaust Sources for the Gas Hills *In-Situ* Leach Satellite Facility During Construction, Operations, Reclamation, and Decommissioning*

Period	Activity	Equipment Type	Number of Units	Frequency of Operation	Duration of Operation
Construction	Initial Construction/ Well Field Road Construction	Scraper	1	8 hr/day, 5 day/wk	2 months
		Bulldozer	1	"	"
		Motor Grader	1	"	"
	Well Preparation	Truck Mount Rotary Drill Rig, Diesel Truck	4-8	8 hr/day, 5 day/wk	12 mo/yr
		Pump Pulling Vehicle 1-ton gas or diesel	2	"	"
		Motor Grader	1	"	3 mo/yr
		Backhoe	3	"	12 mo/yr
		Forklift	2	"	"
		Cementer (gas)	4	"	"
		Light Duty Truck	8-10	8 hr/day, 7 day/wk	"
	Construction Material Transport	Heavy Duty Water Truck (1,500 gal)	4-8	"	"
		Heavy Duty Diesel Truck	1	1 trip/day	2 mo/yr
	Commuting	Light Duty Vehicles	30	"	6 mo/yr
Operation	Satellite Facility	Gas or Propane Heater	6	24 hr/day	6 mo/yr
	Product Transport	Truck to Highland Site Diesel Semi with Trailer	2	1 trip/day	12 mo/yr
	Commuting	Light Duty Vehicles	30	"	"
Decommissioning	Reclamation	Scraper	1	2 × 8 hr shift/day*	2-3 yr
		Motor Grader	1	"	"
		Backhoe	2	"	"
		Heavy Duty Truck (Diesel)	3	"	"
		Light Duty Truck	15	"	"
		Light Duty Vehicles	20	1 trip/day	"

*NRC. "Environmental Assessment for the Operation of the Gas Hills Project Satellite In-Situ Leach Uranium Recovery Facility." Docket No. 40-8857. Washington, DC: NRC. January 2004.

Table 2.7-2. Estimated Particulate (Fugitive Dust) and Gaseous (Diesel Combustion Products) Emissions for the Crownpoint, New Mexico, *In-Situ* Leach Facility Construction Phase*

Emission Type	Annual Total (metric tons)†	Annual Average Concentration ($\mu g/m^3$)‡
Particulates	10.0	0.28
Sulfur dioxides (SO_x)	6.4	0.18
Nitrous oxides (NO_x)	76.2	2.1
Hydrocarbons	9.8	0.27
Carbon monoxide	63.7	1.8
Aldehyde	1.4	0.04

*Modified from U.S. Nuclear Regulatory Commission. NUREG–1508, "Final Environmental Impact Statement To Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico." Washington, DC: U.S. Nuclear Regulatory Commission. February 1997.
†Multiply metric ton value by 1.1023 to convert units to short ton.
‡Multiply $\mu g/m^3$ value by 2.74×10^{-8} to convert units to oz/yd^3.

equipment, wet scrubbers, or baghouse dust collection systems. The use of vacuum drying equipment at ISL facilities significantly reduces uranium releases from drying operations (NRC, 2003a).

Both radon releases and uranium particulate emissions can migrate downwind from processing facilities and well fields. Downwind radiation dose from such ISL facility emissions varies due to the effects of dispersion as a function of distance. Particulate emissions are further reduced by the effect of dry deposition during airborne transport. Calculations of downwind dose are based on estimating the relative air concentration of released radionuclides (which is proportional to dose). Figure 2.7-1 shows relative air concentration for particulate matter as a function of distance estimated for the Bison Basin ISL facility (NRC, 1981, Table D.3). These results apply to the downwind area with the highest relative air concentrations. As shown, relative air concentration of uranium particulates, and therefore dose, drops by about a factor of 10 from the first data point {500 m [1,640 ft]} to the second {1,500 m [4,920 ft]}. The reduction in relative air concentration, and therefore dose, becomes less significant as downwind distance increases. The effect of distance on air concentration estimates is less pronounced for transport of gases (e.g., radon) due to the absence of dry deposition, which does not apply to gaseous transport. Airborne transport and dose modeling results for ISL facility releases to air (including both radon and uranium particulate releases, where applicable) are provided in Sections 4.2.11.2, 4.3.11.2, 4.4.11.2, and 4.5.11.2.

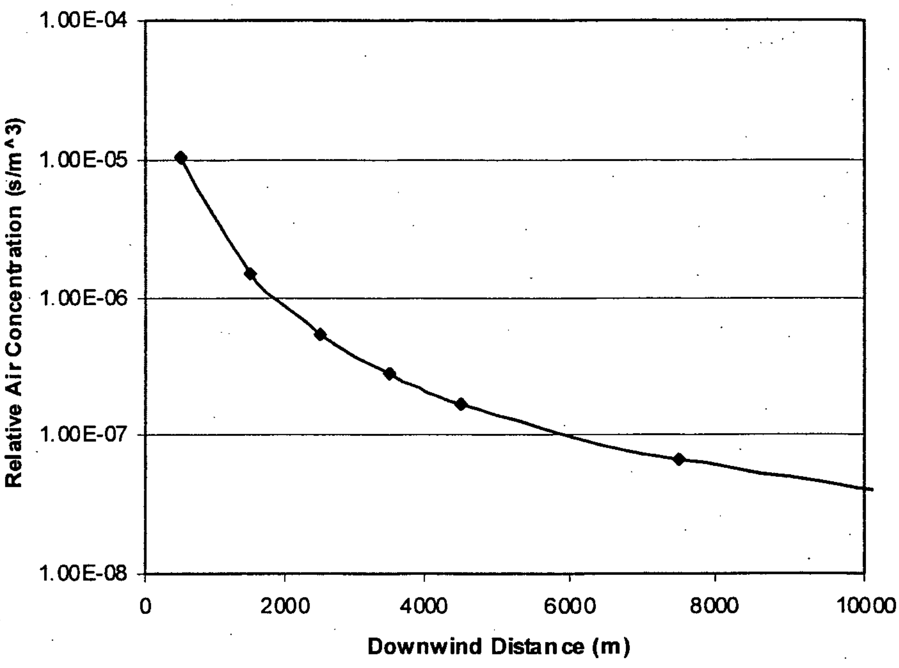

Figure 2.7-1. Downwind Distance Versus Relative Air Concentration (Which Is Proportional to Dose) [Bison Basin ISL Facility (NRC, 1981, Table D.3)]

2.7.2 Liquid Wastes

Liquid wastes from ISL facilities are generated during all phases of uranium recovery; construction, operations, aquifer restoration, and decommissioning. Liquid wastes may contain elevated concentrations of radioactive and chemical constituents. Table 2.7-3 shows estimated flow rates and constituents in liquid waste steams for the Highland ISL facility (NRC, 1978). Liquid waste streams are predominantly production bleed (1 to 3 percent of the process flow rate) and aquifer restoration water (NRC, 1997a). Additional liquid waste streams are generated from well development, flushing of depleted eluant to limit impurities, resin transfer wash, filter washing, uranium precipitation process wastes (brine), and plant wash down water.

ISL facilities have concrete curbed floors with drains and a sump to control and retain water from spills and wash downs. Sumps direct water to treatment facilities, to evaporation ponds, or back to the process circuit. Chemical tanks have berms that can hold tank contents if tanks rupture.

Some liquid wastes are treated at the processing facility to remove or reduce contaminants prior to disposal. Reverse osmosis is commonly used to segregate contaminants from liquid waste streams (e.g., Section 2.5.3). Radium concentrations are also selectively reduced when water is treated with barium chloride. The barium chloride chemically binds to radium in solution and deposits as a sludge that is sent to a licensed disposal facility. Results from Hydro

Table 2.7-3. Estimated Flow Rates and Constituents in Liquid Waste Streams for the Highland *In-Situ* Leach Facility*

	Water Softener Brine	Resin Rinse	Elution Bleed	Yellowcake Wash Water	Restoration Wastes
Flow Rate, gal/min	1	<3	3	7	450
As, ppm					0.1–0.3
Ca, ppm	3,000–5,000				
Cl, ppm	15,000–20,000	10,000–15,000	12,000–15,000	4,000–6,000	
CO_3, ppm		500–800			300–600
HCO_3, ppm		600–900			400–700
Mg, ppm	1,000–2,000				
Na, ppm	10,000–15,000	6,000–11,000	6,000–8,000	3,000–4,000	380–720
NH_4, ppm			640–180		
Se, ppm					0.05–0.15
Ra-226, pCi/L	<5	100–200	100–300	20–50	50–100
SO_4, ppm					100–200
Th-230, pCi/L	<5	50–100	10–30	10–20	50–150
U, ppm	<1	1–3	5–10	3–5	<1
Gross Alpha, pCi/L					2,000–3,000
Gross Beta, pCi/L					2,500–3,500

*NRC. NUREG–0489, "Final Environmental Statement Related to Operation of Highland Uranium Solution Mining Project, Exxon Minerals Company, USA." Washington, DC: NRC. November 1978.

Resources, Inc. reported in NRC (1997a) show radium concentrations of 74 pCi/l were reduced to less than 1 pCi/L following treatment with barium chloride.

Liquid effluent disposal practices that NRC previously has approved for use at specific sites include evaporation ponds, land application, deep well injection, and surface water discharge.

Evaporation ponds are used to retain the process-related liquid effluents that cannot be discharged directly to the environment. These effluents are 11e.(2) byproduct material. The residual solid waste materials normally remain in ponds until the ponds are decommissioned, when sludges are disposed of as 11e.(2) material at a licensed disposal facility (Section 2.6). Guidance for the construction, operation, and monitoring of evaporation ponds is found in NRC Regulatory Guide 3.11 (NRC, 2008a). Typical evaporation ponds have surface areas ranging from 0.04 to 2.5 ha [0.1 to 6.2 acres] (NRC, 1998a; Crow Butte Resources, 2007). Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee also must maintain sufficient reserve capacity in the retention pond system so the contents of a pond can be transferred to other ponds in the event of a leak and subsequent corrective action and liner repair. Licensees and applicants can minimize the likelihood of impoundment failure by designing the pond embankments in accordance with the criteria found in NRC Regulatory Guide 3.11 (NRC, 2008a). Sufficient freeboard height above the liquid level ensures containment during wind and rain events.

Land application uses agricultural irrigation equipment to apply treated water to land where the water can evaporate directly or be transpired by plants. Uranium and radium levels are reduced in the effluents disposed of by land application so as to limit contamination of surface soils and plants. Land application may also require approval and permitting by other state agencies. Areas of a site where land application of treated water takes place are included in environmental monitoring programs required by NRC and Sate regulators to ensure constituents of interest including uranium, radium, and selenium are maintained below levels of concern. Land application areas are also included in decommissioning surveys at the end of operations to ensure soil concentration limits are not exceeded.

Deep well injection involves pumping the waste fluids into a deep confined aquifer at depths typically greater than 1,524 m [5,000 ft] below the ground surface (NRC, 1997a). Aquifer water quality in the deep confined aquifer is often poor (e.g., high salinity or total dissolved solids) and below drinking water standards. NRC staff reviews and approves deep well injection as a method to dispose of particular process fluids such as reverse osmosis brine. As discussed in Section 1.7, a UIC permit from EPA or the appropriate state agency is required for a licensee to use this method of waste disposal at a specific site. These reviews by NRC and other agencies ensure that the disposal of wastes by this method complies with the dose limits in 10 CFR Part 20 and with appropriate National Pollutant Discharge Elimination System (NPDES) permit conditions. The approval process verifies that site-specific and regional characteristics limit the potential for contamination of local drinking water sources.

The discharge of pollutants to surface water requires an NPDES permit (Section 1.8). This permit specifies limits that are calculated to ensure the discharge does not cause a violation of water quality standards. A permit will not be issued to a new source or a new discharger if the discharge will cause or contribute to the violation of water quality standards. Specific requirements for uranium ISL facilities are provided in EPA regulations at 40 CFR Part 440, Part C.

2.7.3 Solid Wastes

All phases of the ISL facilities lifecycle generate solid wastes. These separate waste streams can produce materials that can be classified as 11e.(2) byproduct, ordinary municipal solid waste, and Resource Conservation and Recovery Act (RCRA) hazardous wastes. Radioactive wastes generated by ISL facilities are defined as 11e.(2) byproduct material by NRC. Unless suitable to remain onsite or to be released offsite for unrestricted use, 11e.(2) byproduct material wastes must be disposed at a facility that is licensed to accept byproduct waste. ISL facilities also generate normal trash (i.e., solid waste) that would be disposed at a local landfill. Some RCRA hazardous wastes (e.g., fluorescent lights, waste oil, and batteries) would be generated at an ISL facility, thereby requiring disposal at a facility approved for RCRA hazardous wastes. Soils in areas where ISL operations occur would be included in decommissioning surveys when operations end, and any contaminated soils that exceed NRC release limits at 10 CFR Part 40, Appendix A, Criterion 6 would be removed and disposed of as 11e.(2) byproduct waste. The largest volumes of solid wastes requiring disposal are generated during facility decommissioning (EPA, 2007a,b). Table 2.6-1 provides estimated volumes of byproduct and other solid ISL facility decommissioning wastes designated for offsite disposal.

2.8 Transportation

Trucks transport construction equipment and materials, operational processing supplies, ion-exchange resins, yellowcake product, and waste materials during all phases of an ISL facility lifecycle.

Construction equipment and materials are transported along local roads to the site to support facility and well field construction activities. Because ISL facilities are small magnitude construction projects, and well field construction is phased over a period of years, the magnitude of trucking activity to support construction is small relative to other industrial activities. The estimated frequency of truck shipments for construction of an ISL facility is provided in Table 2.8-1.

During the operational period, trucks supply an ISL facility with materials needed to support processing operations. Shipments involve hazardous chemicals such as ammonia, sulfuric acid, liquid and gaseous oxygen, hydrogen peroxide, sodium hydroxide, barium chloride, carbon dioxide, hydrochloric acid, sodium carbonate, sodium chloride, hydrogen sulfide, and sodium sulfide. These chemicals are commonly used in a variety of industrial applications, and the U.S. Department of Transportation regulates their transport. The estimated frequency of truck shipments to support ISL facility operation is provided in Table 2.8-1.

In areas where ore deposits are smaller and more spread out, a producer may construct a series of small satellite plants at the well field where ion-exchange processing is conducted remotely rather than at the central uranium processing facility (NRC, 2004a, 2006). The products of ion-exchange processing are then transported by truck to a central uranium processing facility (Section 2.4). Uranium production using these types of satellite facilities is sometimes known as satellite remote ion exchange (Finch, 2007). Facilities that incorporate remote ion-exchange operations will transport loaded ion-exchange resins or uranium slurry from well fields to centralized processing facilities by truck. These trucks are typically modified three-compartment cement trailers. The carbon steel compartments are pressurized and rubber lined. The first compartment carries the uranium-loaded resin, the second is empty, and the third compartment holds unloaded resins (Finch, 2007). Each shipment can contain about

Table 2.8-1. Estimated Annual Vehicle Trips for Phases of *In-Situ* Leach Facility Lifecycle

Cargo	Estimated Number of Truck Shipments	Remarks
Construction Equipment/Supplies	62*	1 per day for 2 months
Remote IX Shipments	365*	1 per day annually
Processing Chemicals	272†	Less than 1 per day annually
Processing Wastes	Range: 2.5–15*	Less than 1 per month annually
Yellowcake	Range: 21–145‡§‖¶#	Maximum is based on production assumed at the permitted limit at the largest facility
Decommissioning Municipal Solid Waste	44**	Based on waste volumes from Smith Ranch (Table 2.6-1) and truck volume of 20 yd^3/shipment
Decommissioning Byproduct Waste	100**	Based on waste volumes from Smith Ranch (Table 2.6-1) and truck volume of 20 yd^3/shipment
Employee Commuting	5,200–52,000 trips*	20 to 200 employees per day assumed for 12 months/yr. Maximum in range is expected to depend on timing of construction, drilling, and operational activities (Section 2.11.6)

*NRC. "Environmental Assessment for the Operation of the Gas Hills Project Satellite *In-Situ* Leach Uranium Recovery Facility." Docket No. 40-8857. Washington, DC: NRC. January 2004.
†NRC. "Environmental Assessment for Renewal of Source Material License No. SUA–1534—Crow Butte Resources Inc., Crow Butte Uranium Project Dawes County, Nebraska." Docket No. 40-8943. Washington, DC: NRC. 1998.
‡NRC. NUREG–0489, "Final Environmental Statement Related to Operation of Highland Uranium Solution Mining Project, Exxon Minerals Company, USA." Washington DC: NRC. November 1978.
§NRC. "Final Environmental Statement Related to the Operation of Bison Basin Project." Docket No. 40-8745. Washington, DC: NRC. 1981.
‖NRC. NUREG–1508, "Final Environmental Impact Statement To Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico." Washington, DC: NRC. February 1997.
¶NRC. "Environmental Assessment for Renewal of Source Material License No. SUA–1534—Crow Butte Resources Inc., Crow Butte Uranium Project Dawes County, Nebraska." Docket No. 40-8943. Washington, DC: NRC. 1998.
#NRC. "Environmental Assessment Construction and Operation of In Situ Leach Satellite SR-2 Amendment No. 12 to Source Material License No. SUA-1548—Power Resources, Inc., Smith Ranch-Highland Uranium Project (SR-HUP) Converse County, Wyoming." Docket No. 40-8964. Washington DC: NRC. December 2007.
**Waste volumes compiled and summed from estimates reported in McCarthy, J. "Smith Ranch: 2007–2008 Surety Estimate Revision." Letter (June 29) to G. Janosko, NRC. Glenrock, Wyoming: Power Resources International. 2007.

900–1,350 kg [2,000–3,000 lb] of uranium-loaded resin, although the actual amount depends on the size of the trailer. These trucks are generally sole-use vehicles that are labeled for this purpose in accordance with U.S. Department of Transportation requirements at 49 CFR 171–189 and NRC regulations at 10 CFR Part 71. In accordance with these regulations, no liquids are permitted in the truck during transport of uranium resins. The estimated frequency of remote ion-exchange truck shipments to support ISL facility operation is provided in Table 2.8-1. The distance of remote ion-exchange shipments varies depending on

site characteristics. For example, the Irigaray/Christensen Ranch ISL facility in Johnson County, Wyoming, has shipped ion-exchange resins 21 km [13 mi] (NRC, 1998a), whereas the Gas Hills ISL facility in Natrona and Freemont Counties in Wyoming has shipped ion-exchange resins about 224 km [140 mi] (NRC, 2004b).

The refined yellowcake product is packed in 208-L [55-gal], 18-gauge drums holding an average of 430 kg [950 lb] and classified by the U.S. Department of Transportation as Type A packaging (49 CFR Parts 171–189 and 10 CFR Part 71). The yellowcake is shipped by truck to a remote conversion plant that transforms the yellowcake to uranium hexafluoride (UF_6) for the enrichment step of the reactor fuel cycle. An average truck shipment contains approximately 40 drums or 17 metric tons [19 short tons] of yellowcake (NRC, 1980). The annual number of shipments from a given ISL facility depends on the yellowcake production rate of the facility. A range of estimated annual shipment totals based on prior ISL facility production limits is provided in Table 2.8-1.

Waste materials generated by construction, operation, aquifer restoration, and decommissioning activities, including byproduct and ordinary municipal waste streams, are segregated by waste type and transported by truck to approved disposal facilities. The estimated frequency of waste shipments for operation and decommissioning an ISL facility is provided in Table 2.8-1. Section 2.7 provides additional information on waste streams and waste management activities.

2.9 Radiological Health and Safety

NRC regulations at 10 CFR Part 20 address the health and safety of workers and the public in the event of exposure to radiation from all phases of an ISL facility's lifecycle. These regulations require ISL facility operators to develop and implement an NRC-approved radiation protection program. During NRC inspections and other oversight activities, including reviews of monitoring and incident reports, NRC checks compliance with this program. This section briefly summarizes basic elements of a 10 CFR Part 20 radiation protection program. More detailed descriptions of radiological safety requirements and programs are found in the regulations at 10 CFR Part 20 and applicable NRC guidance documents summarized in the NRC Standard Review Plan for ISL facilities (NRC, 2003a).

Uranium recovery facilities are also subject to the EPA's environmental standards for the uranium fuel cycle, in 40 CFR Part 190, which provide an annual dose limit of 0.25 mSv (25 mrem) whole body (plus limits for organ doses) from fuel cycle operations, but not including dose due to radon and its progeny.

A 10 CFR Part 20 radiological protection program includes plans and procedures addressing the following topics:

- **Effluent Control**. Effluents to air (e.g., radon, uranium particulates) and surface water (e.g., permitted wastewater discharges) must meet NRC limits in 10 CFR Part 20 for radioactive effluents and worker and public doses. To ensure proper performance to specifications, plans and procedures include minimum performance specifications for control technologies (e.g., yellowcake dryer emission controls) and frequencies of tests and inspections.

- **External Radiation Exposure Monitoring Program**. This program specifies survey methods (including monitoring locations), instrumentation, and equipment for measuring worker exposures to external radiation during routine and nonroutine operations, maintenance, and cleanup activities. The program is designed to ensure worker dose levels are as low as reasonably achievable and comply with NRC requirements in 10 CFR Part 20.

- **Airborne Radiation Monitoring Program**. This program determines concentrations of airborne radioactive materials (including radon) in the workplace during routine and nonroutine operations, maintenance, and cleanup. This program is designed to ensure airborne radiation releases and worker exposures are as low as reasonably achievable and meet requirements specified in 10 CFR Part 20.

- **Exposure Calculations**. Procedures document the methodologies used to calculate intake of airborne radioactive materials in the workplace during routine and nonroutine operations, maintenance, and cleanup activities.

- **Bioassay Program**. A bioassay program assesses biological intake of uranium by workers routinely involved in operations where radioactive material can be inhaled (e.g., yellowcake dust from dryer operations or baghouse maintenance). Programs include collection and analysis of urine samples that are assessed for the presence of uranium. Action levels are set to maintain exposures as low as reasonably achievable and within worker requirements in 10 CFR Part 20.

- **Contamination Control Program**. A contamination control program includes standard operating procedures to prevent employees from entering clean areas or leaving the site while contaminated with radioactive materials. Such programs involve radiation surveys of personnel and surfaces, housekeeping requirements, specifications to control contamination in processing areas, and controls for the release of contaminated equipment.

- **Environmental Monitoring Program**. This program measures concentrations and quantities of radioactive and nonradioactive materials released to the environment surrounding the facility. Such programs measure concentrations of constituents in the environment near and beyond the site boundary emphasizing surface water, groundwater, vegetation, food and fish, and soil and sediment. Direct radiation and radon are also measured. Offsite radiological and environmental monitoring is detailed in Chapter 8.

2.10 Financial Surety

NRC regulations [10 CFR Part 40, Appendix A, Criterion (9)] require that applicants or licensees cover the costs to conduct decommissioning, reclamation of disturbed areas, waste disposal, and groundwater restoration (Mackin, et al., 2001b). NRC annually reviews a licensee's financial surety to assess expansions in operations, changes in engineering design, completion of decommissioning activities, actual experience in aquifer restoration, and inflation. Specific considerations for estimating these costs are detailed in Appendix C of NRC, 2003a, and financial surety arrangements are discussed only briefly here.

Each licensee establishes financial surety arrangements before uranium recovery operations begin to assure there will be sufficient funds to carry out the activities described in Sections 2.5 and 2.6. The surety funds also must be sufficient for monitoring and control required as part of the license termination. Acceptable financial surety arrangements include surety bonds, cash deposits, certificates of deposit, deposits of government securities, parent company guarantees (subject to specific NRC criteria), trusts and standby trusts, irrevocable letters or lines of credit, and combinations of these instruments. Self-insurance is not an acceptable form of surety for NRC, although it may be accepted by individual states. The term of the surety mechanism must be open ended so that it will not expire before cleanup is complete.

As required under 10 CFR Part 40, Appendix A, Criterion 9, the licensee must supply enough information for NRC to verify that the amount of financial coverage will allow all decontamination and decommissioning and reclamation of sites, structures, and equipment used in conjunction with facility operation to be completed. Cost estimates for the following activities (where applicable) should be submitted to NRC with the initial license application or reclamation plan and should be updated annually as specified in the operator's NRC license. The financial surety estimate must include calculations of cost estimates based on completion of all activities by a third-party contractor (an independent contractor or operator who is not financially affiliated with the licensee), if necessary. Unit costs, calculations, references, assumptions, equipment and operator efficiencies, and other breakdown details must be provided.

In the required annual surety estimate, the licensee should add a contingency amount to the total cost estimate for the final site closure. NRC typically considers a 15 percent contingency to be an acceptable minimum amount (NRC, 2003a, Appendix C). The licensee is required by 10 CFR Part 40, Appendix A, Criterion 9, to adjust cost estimates annually to account for inflation and changes in reclamation plans. In addition, all costs are to be estimated based on third party, independent contractor costs (including overhead and profit in unit costs or as a percentage of the total). Licensee-owned equipment and the availability of licensee staff should not be considered in the financial surety estimate, because this can reduce cost calculations.

To avoid unnecessary duplication and expense, NRC also takes into account surety arrangements that other federal, state, or other local agencies may require. However, NRC is not required to accept such sureties if they are insufficient. NRC reviews the licensee's surety analysis annually to ensure that the funding reflects ongoing aquifer restoration and decommissioning/reclamation activities. The surety remains in place until the final NRC decommissioning surveys are complete and the license is terminated.

2.11 Information From Historical Operation of ISL Uranium Milling Facilities

2.11.1 Area of ISL Uranium Milling Facilities

The permitted areas for past and current ISL uranium recovery operations have varied in size. As shown in Table 2.11-1, facilities range from about 1,034 ha [2,552 acres] for the proposed Crownpoint facility in McKinley County, New Mexico, to more than 6,480 ha [16,000 acres] for the Smith Ranch property in Converse County, Wyoming. The central processing facility may occupy only 1 to 6 ha [2.5 to 15 acres], and satellite plants would be even smaller (NRC, 2006). Surface facilities are considered controlled areas where security fencing limits access. Select areas around header houses and well heads are fenced to prevent livestock grazing. Lands

near surface operations and in active uranium recovery are excluded from agricultural production for the duration of the project.

Table 2.11-1. Size of Permitted Areas for *In-Situ* Leach Facilities

Name	Permitted Area in Hectares [acres]	Status of Facility as of February 2008
Crownpoint, New Mexico	1,034 [2,552]*	Partially permitted and licensed
Crow Butte, Nebraska	1134 [2,800] †	Operating
Gas Hills, Wyoming (Satellite)	3,442 [8,500]‡	Under development as a satellite of Smith Ranch/Highland, intend to expand
Reynolds Ranch, Wyoming (Satellite	3,525 [8,704]§	Under development as satellite of Smith Ranch/Highland
Highland, Wyoming	6,075 [15,000] ‖	Operating, combined with Smith Ranch
Irigaray, Christensen Ranch	6,075 [15,000]¶	Licensed to restart operations
Smith Ranch, Wyoming	6,480 [16,000]#	Operating, combined with Highland, Gas Hills, North Butte, and Ruth, intend to expand

*NRC. NUREG–1508, "Final Environmental Impact Statement To Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico." Washington, DC: NRC. February 1997.
†NRC. "Environmental Assessment for Renewal of Source Material License No. SUA–1534—Crow Butte Resources Inc., Crow Butte Uranium Project Dawes County, Nebraska." Docket No. 40-8943. Washington, DC: NRC. 1998.
‡NRC. "Environmental Assessment for the Operation of the Gas Hills Project Satellite *In-Situ* Leach Uranium Recovery Facility." Docket No. 40-8857. Washington, DC: NRC. January 2004.
§NRC. "Environmental Assessment for the Addition of the Reynolds Ranch Mining Area to Power Resources Inc., Smith Ranch/Highlands Uranium Project Converse County Wyoming, Source Material License No SUA–1548." Docket No. 40-8964. Washington, DC: NRC. November 2006.
‖NRC. "Environmental Assessment for Renewal of Source Material License No. SUA-1511 Power Resources Inc., Highland Uranium Project Converse County, Wyoming." Docket No. 40-8857. Washington DC: NRC. August 18, 1995.
¶NRC. "Environmental Assessment for Renewal of Source Material License No. SUA–1341, Cogema Mining, Inc. Irigaray and Christensen Ranch Projects, Campbell and Johnson Counties, Wyoming." Docket No. 40-8502. Washington, DC: NRC. June 1998.
#NRC. "Environmental Assessment for Rio Algom Mining Corporation Smith Ranch *In-Situ* Leach Mining Project, Converse County, Wyoming in Consideration of a Source and Byproduct Material License Application." Docket No. 40-8964. Washington, DC: NRC. January 1992.

Much of the permitted area of a site is undisturbed, and surface operations (wells, processing facilities) affect only a small portion of it. The well fields, which include the injection and recovery (production) wells, are the areas where most activities that disturb the surface and subsurface take place. Less than half of the surface area allocated to well fields is expected to be disturbed by construction activities including access roads, drilling pits, header houses, and pipelines (NRC, 1995). Estimates of the amount of surface area disturbance reported for five NRC-licensed ISL facilities vary and range from 49 to 750 ha [120 to 1,860 acres] (NRC, 1998a,

1997a, 1992, 1987; Crow Butte Resources, Inc., 2007). These disturbed areas constitute approximately 1 to 70 percent of the permitted areas of the sites with an average of 15 percent of the permitted area disturbed among the five facilities. Considering the phased nature of ISL well development and utilization, and the practice of revegetating disturbed soils after construction, the amount of land that is disturbed by earth-moving activities at any time is relatively small. For example, while the total area disturbed by construction activities between 1987 and 2007 was about 530 ha [1,310 acres] for the Crow Butte ISL facility in Dawes County, Nebraska, only about 50 ha [120 acres] are estimated to be disturbed at any time (Crow Butte Resources, Inc., 2007). After the surface operations are complete and well fields are restored, the final steps of decommissioning and surface reclamation are intended to return the land to its preoperational conditions.

2.11.2 Spills and Leaks

During ISL operations and aquifer restoration, barren and pregnant uranium-bearing process solutions are moved through pipelines to and from the well field and among different surface facilities (e.g., processing circuit, evaporation ponds). If a pipeline ruptures or fails, process solutions can be released and (1) pond on the surface, (2) run off into surface water bodies, (3) infiltrate and adsorb in overlying soil or rock, or (4) infiltrate and percolate to groundwater. For example, from 2001 to 2005, the operators of the Smith Ranch-Highland uranium ISL facility in Converse County, Wyoming, reported 24 spills of uranium recovery solutions (NRC, 2006). The WDEQ identified more than 80 spills at the Smith-Ranch Highland site during commercial operations from 1988 to 2007 (WDEQ, 2008). This is the largest NRC-licensed ISL uranium recovery facility. The size of the spills at Smith Ranch-Highland has ranged from a 190- to 380-liter [50- to 100-gallon] spill in February 2004 to a 751,400-L [198,500-gal] spill of injection fluid in June 2007 (WDEQ, 2007; NRC, 2006). The spills most commonly involved injection fluids {0.5 to 3.0 mg/l [0.5 to 3.0 parts per million]} uranium, although spills of production fluids {10.0 to 152 mg/l [10.0 to 152 parts per million]} uranium also have occurred (NRC, 2007). These spills have been caused predominantly by the failure of joints, flanges, and unions of pipelines and at wellheads (NRC, 2006, 2007). The large June 2007 spill at Smith Ranch–Highland was the apparent result of a failed fitting. The spilled fluids flowed into a drainage and continued downstream for about 700 m [2,300 ft]. The WDEQ Land Quality Division estimated the affected area at 0.44 ha [1.08 acres] (WDEQ, 2007).

Reporting requirements for spills differ from state to state. NRC requirements for spill reporting are found in Subpart M of 10 CFR Part 20 and at 10 CFR 40.60. Additionally, NRC may incorporate reporting requirements as conditions in operating license. Generally, such NRC and state requirements include an immediate report (e.g., notification within 24 to 48 hours of the spill) followed by a later written report addressing items such as the conditions leading to the spill, the corrective actions taken, and the cleanup results achieved. A licensee documentation of spills helps in final site decommissioning activities.

For hazardous chemicals stored at the processing facility, spill responses would be similar to those described previously for yellowcake transportation, although nonradiological material spills are primarily reportable to the appropriate state agency and EPA. Concrete berms with at least the volume of the tank are used to contain spills from process chemical storage tanks and simplify cleanup (e.g., NRC, 1998a,b). The Occupational Safety and Health Administration sets worker exposure limits to process chemicals at ISL surface facilities. Typical onsite process chemicals and their quantities used at ISL facilities are presented in Tables 2.11-2 and 2.11-3.

Evaporation ponds are typically constructed in accordance with NRC staff guidance (NRC, 2008a), and license conditions require that these ponds be periodically monitored. Pond leaks have, however, occurred at active ISL facilities. For example, at the Crow Butte ISL facility in Dawes County, Nebraska, seven leaks were identified for three commercial evaporation ponds from 1991 through 1997 (NRC, 1998b). The volumes of the leaks ranged from about 257.4 to 1,135.6 L [68 to 300 gal], but in all cases, the leaks involved only the upper liner of the double-lined system. To repair the leaks, the licensee exposed the liner by transferring water to other ponds to lower the water level, patching the holes, and pumping the water from the underdrain system (NRC, 1998b). Since, 1997, the Crow Butte facility has reported and repaired an additional eight pond leaks, with the most recent leak identified and the pond linerrepaired in May 2006 (Teahon, 2006). From 1988 to 1997, one pond leak was reported in 1992 at the Irigary/Christensen Ranch ISL facility in Campbell and Johnson Counties, Wyoming (NRC, 1998a). The licensee corrective actions included temporarily transferring water to expose the liner and repair the leak.

Table 2.11-2. Common Bulk Chemicals Required at the Project Processing Sites*†

Shipped as Dry Bulk Solids	Shipped as Liquids and Gases
Salt (NaCl)	Hydrochloric acid (HCl)
Sodium bicarbonate ($NaHCO_3$)	Sulfuric acid (H_2SO_4)
Sodium carbonate (Na_2CO_3)	Hydrogen peroxide (H_2O_2)
Sodium hydroxide (NaOH)	Oxygen (O_2)
—	Carbon dioxide (CO_2)
—	Anhydrous ammonia (NH_3)
—	Diesel oil
—	Bottled gases
—	Liquefied petroleum gas (LPG)

*NRC. NUREG–1508, "Final Environmental Impact Statement to Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico." Washington, DC: NRC. February 1997.
†Energy Metals Corporation, U.S. "Application for USNRC Source Material License Moore Ranch Uranium Project, Campbell County, Wyoming: Environmental Report." ML072851249. Casper, Wyoming. Energy Metals Corporation, U.S. September 2007.

2.11.3 Groundwater Use

During construction, groundwater use is limited to routine activities such as dust suppression, mixing cements, and drilling support. Although large amounts of groundwater are moved and processed during ISL facility operations, most of the water is reinjected maintaining the overall water balance. A production bleed of about 1–3 percent, means that about 97–99 percent of the water produced from a well field is reinjected for additional uranium recovery. For example, for the proposed Reynolds Ranch addition to the Smith Ranch ISL facility in Converse County, Wyoming, the NRC staff estimated that the amount of water used in the ion-exchange columns at the satellite facilities or discharged to a deep disposal well could be as much as 1,480,000,000 L [391 million gal] over the course of an assumed operating period of 15 years (NRC, 2006). For the Crow Butte ISL facility in Dawes County, Nebraska, the average operating flow rate in 2007 was about 16,200 L/min [4,279 gal/min] (Cameco Resources, Inc., 2008). The total net volume of groundwater produced for 2007 (volume produced–volume injected) was 346,900,000 L [91,640,000 gal], and the production bleed ranged from about 1.1 to 1.6 percent. During the last six months of 2007, about 76,200,000 L [20,130,000 gal] was

disposed in the licensed Class I UIC deep disposal well and about 14,370,000 L [3,800,000 gal] was discharged to the evaporation pond system (Cameco Resources, 2008).

Table 2.11-3. Onsite Quantities of Process Chemicals at *In-Situ* Leach Facilities*

Chemical	Typical Onsite Quantity	Use in Uranium ISL Process
Ammonia (NH_3)	40,820 kg [90,000 lb]	pH adjustment
Sulfuric acid (H_2SO_4)	37,850 L [10,000 gal]	pH control during lixiviant processing, and splitting uranyl carbonate complex into CO_2 gas and uranyl ions in preparation for their precipitation
Liquid and gaseous oxygen	No specific typical quantities available	Oxidant in lixiviant, and precipitation of uranium as an insoluble uranyl peroxide compound
Hydrogen peroxide (H_2O_2)	26,500 L [7,000 gal]	Uranium precipitation and oxidant in lixiviant
Sodium hydroxide (NaOH)	Typically stored in 208-L [55-gal] drums	pH adjustment
Barium chloride ($BaCl_2$)	No specific typical quantities available	Precipitation of radium during groundwater restoration, and wastewater treatment
Carbon dioxide (CO_2)	No specific typical quantities available	Carbonate complexing
Hydrochloric acid (HCl)	37,850 L [10,000 gal]	pH adjustment
Sodium carbonate (Na_2CO_3)	64,350 L [17,000 gal]	Carbonate complexing and resin regeneration
Sodium chloride (NaCl)	127,000 kg [280,000 lb]	Resin regeneration
Hydrogen sulfide (H_2S)	No specific typical quantities available	Groundwater restoration
Sodium sulfide (Na_2S)	No specific typical quantities available	Groundwater restoration

*Mackin, P.C., D. Daruwalla, J. Winterle, M. Smith, and D.A. Pickett. NUREG/CR–6733, "A Baseline Risk-Informed Performance-Based Approach for *In-Situ* Leach Uranium Extraction Licensees." Washington, DC: NRC. September 2001.

2.11.4 Excursions

As discussed in Section 2.4, ISL operations may affect the groundwater quality near the well fields or in overlying or underlying aquifers if lixiviant travels from the production zone and beyond the well field boundaries. Monitoring wells are designed and placed to detect any lixiviant that moves out of the production zone. A monitoring well is placed on excursion status when two or more excursion indicators exceed their respective upper control limits (UCLs)

(NRC, 2003a). Alternate excursion detection procedures (e.g., one excursion indicator exceeded in a monitoring well by a specified percentage) may also be used if approved by NRC. NRC licensees are required by license conditions to identify reporting, monitoring, and response measures to be taken to determine the extent and cause of the excursion, as well as measures to recover the excursion and remove the well from excursion status.

Historical information for several facilities indicates that excursions occur at ISL operations (NRC, 2006, 1998a,b, 1995; Crow Butte Resources, Inc., 2007; Cameco Resources, 2008; Arbogast, 2008). For example, from 1987 to 1998, 49 wells were placed on excursion status at the Irigary and Christensen Ranch uranium recovery facility in Campbell and Johnson Counties in the Wyoming East Uranium Milling Region (NRC, 1998a). Most of these excursions were recovered within a period of weeks to months, but six vertical excursions proved more difficult to return to baseline, with two wells remaining on excursion status for at least 8 years. These excursions were believed to be due to improperly abandoned wells from earlier exploratory programs prior to regulation by a UIC program. In 2007, three wells were on excursion status at the Christensen Ranch project, with only one, originally identified in 2004, remaining on excursion status at the end of 2007 (Arbogast, 2008a). None of the earlier excursions that affected monitoring wells identified in NRC (1998a) were on excursion status in 2007 (Arbogast, 2008b). An additional well at the Christensen Ranch project was placed on excursion status in 2008 (Arbogast, 2008b).

From 1988 through 1995, 22 monitoring wells (11 vertical and 11 horizontal) were placed on excursion status for the Highland Uranium Project located in Converse County in the Wyoming East Uranium Milling Region (NRC, 1995). Most of the excursions were recovered within less than 1 year, but four horizontal excursions lasted up to at least five years. In two of these wells, the excursions were due to a thinning of the confining layer that separated two production zones. Groundwater pumping during restoration of the underlying production zone resulted in a hydraulic gradient that brought excursion fluids down from the overlying aquifer. One of the other excursions was believed to be the result of fluids migrating from an upgradient abandoned uranium mine (NRC, 1995). No cause was identified for the other long-term excursion at the Highland Uranium Project. Only one horizontal excursion was reported between 2001 and 2005 at the Smith Ranch-Highland uranium recovery facility, and corrective action brought the well back below the UCLs within less than one month (NRC, 2006).

At the Crow Butte ISL facility located in Dawes County, Nebraska (Nebraska-South Dakota-Wyoming Uranium Milling Region), the operator reported five vertical excursions into the overlying aquifer from the start of commercial operations in 1989 through the license renewal in 1998 (NRC, 1998b). In two cases, these excursions resulted from well integrity problems (borehole cement contamination and a failed casing coupling). One excursion resulted from a leak in a plugged and abandoned injection well, and the remaining two were believed to result from natural fluctuations in the groundwater quality (NRC, 1998b). Between 1999 and 2006, 17 wells at the Crow Butte facility were placed on excursion status (7 vertical and 10 horizontal) Most of these wells were restored below the UCLs within 1 to 6 months, although one vertical well took almost four years to restore (Crow Butte Resources, Inc., 2007). In the second half of 2007, three horizontal monitoring wells were on excursion status (Cameco Resources, 2008). These excursions were first identified in April 2000, December 2003, and September 2006 (Crow Butte Resources, Inc., 2007). The licensee believes that these longer term excursions resulted from well field geometry and well field flare as a result of ongoing groundwater transfer and well field restoration activities.

Operational experience at these facilities indicates that lixiviant excursions can result from

- Thinning or discontinuous confinement
- Improperly abandoned wells that may provide vertical flow pathways
- Casing failure or other well leaks
- Natural fluctuations in groundwater quality
- Improper balance of well field hydrologic gradients

Most horizontal excursions were recovered quickly (weeks to months) by repairing and reconditioning wells and adjusting pumping rates in the well field, consistent with the findings of Mackin, et al. (2001a). Vertical excursions tended to be more difficult to recover than horizontal excursions, and in a few cases, a well remained on excursion status for as long as 8 years.

2.11.5 Aquifer Restoration

Operational history at NRC-licensed ISL facilities is available to examine aquifer restoration at the well-field scale. Table 2.11-4 shows a summary of restoration data for a 12-ha [30-acre] area covered by Production Units 1–9 at the commercial-scale Cogema Irigaray ISL facility (Cogema, 2006a,b). A comparison of the baseline and postrestoration stability monitoring groundwater analytical data determined that for the water quality in the production zone, the individual restoration and stabilization data fell within the baseline ranges for all constituents except for calcium, magnesium, sodium, carbonate, chlorine, ammonium, total dissolved solids, conductivity, alkalinity, lead, barium, manganese, and radium-226. These data showed that, when comparing premining baseline ranges to postmining stabilization ranges, several constituents did not meet the premining baseline concentration levels. Additionally, postmining mean concentrations for nearly half of the constituents exceeded the premining baseline mean concentrations for the same constituents in Production Units 1–9 (Cogema, 2006a,b).

Catchpole, et al. (1992a,b) provide an early discussion of small-scale restoration efforts for research and development of ISL uranium recovery facilities in Wyoming. These include the Bison Basin facility in Fremont County (described in NRC, 1981), the Reno Creek project in Campbell County, and the Leuenberger Project in Converse County. Restoration activities required treatment of water from nine pore volumes at Bison Basin and five pore volumes at Reno Creek. In all cases, most water quality parameters were returned to within a statistical range of baseline values with the exception of uranium (Bison Basin and Reno Creek) and radium-226 (Leuenberger). For these parameters, Catchpole, et al. (1992a,b) report that water in the well field was returned to the same class of use.

Davis and Curtis (2007) detailed available information on aquifer restoration at ISL uranium recovery facilities. These include a pilot scale study by Rio Algom for the Smith Ranch facility in Converse County, Wyoming (Rio Algom Mining Corporation, 2001); the proposed Crownpoint ISL facility near Crownpoint, New Mexico (NRC, 1997); the commercial-scale A-Well Field at the Highland Uranium Project in Converse County, Wyoming (Power Resources, Inc., 2004a); and the commercial-scale Crow Butte Mine Unit No. 1 in Dawes County, Nebraska (NRC, 2002, 2003c). Rock core laboratory studies that Hydro Resources Inc. conducted for the Crownpoint facility (NRC, 1997a) also provide useful insights to water quality parameters that may present challenges for aquifer restorations.

Table 2.11-4. Irigaray Water Quality Summary for Designated Aquifer Restoration Wells*							
	Mine Units 1–9 Baseline			Mine Units 1–9 Round Four Restoration Results			Samples Exceeding Baseline Range
Constituents	Minimum	Maximum	Mean	Minimum	Maximum	Mean	
Major Ions (mg/L)							
Calcium	1.6	27.1	7.8	11.6	65	28.8	17
Magnesium	0.02	9	0.9	2.8	13	7.0	7
Sodium	95	248	125	107	275	185.6	2
Potassium	0.92	17.5	2.4	1.1	4.9	2.9	0
Carbonate	0	98	13.2	<1.0	<1.0	0.8	0
Bicarbonate	5	144	88.3	5.1	631	409	31
Sulfate	136	504	188.1	62.8	237	132.0	0
Chloride	5.3	15.1	11.3	0.1	117	39.4	32
Ammonia	0.05	1.88	0.3	0.05	36.1	8.5	13
Nitrogen Dioxide	<0.1	1	<0.4	<0.1	<0.1	<0.1	0
Nitrate	0.2	1	0.9	<0.1	0.12	0.1	0
Fluoride	0.11	0.68	0.29	0.1	0.22	0.12	0
Silica Dioxide	3.2	17.2	8.3	2.5	7.3	4.99	0
Total Dissolved Solids	308	784	404	343	968	626	5
Specific Conductivity	535	1,343	658	604	1,970	1094	5
Alkalinity	67.8	232	104	127	518	345	30
pH	6.6	11.0	9.00	7.07	8.40	7.76	0
Trace Metals (mg/L)							
Aluminum	0.05	4.25	0.160	<0.1	0.140	0.102	0
Arsenic	<0.001	0.105	0.007	<0.001	0.029	0.005	0
Barium	<0.01	0.12	0.060	0.03	0.200	0.095	1
Boron	<0.01	0.225	0.110	<0.05	0.100	0.088	0
Cadmium	<0.002	0.013	0.005	<0.002	0.005	0.004	0
Chromium	<0.002	0.063	0.020	<0.005	0.050	0.039	0
Copper	<0.002	0.04	0.011	<0.01	0.020	0.010	0
Iron	0.019	11.8	0.477	<0.03	0.500	0.113	0
Lead	<0.002	0.05	0.020	<0.001	0.090	0.039	1
Manganese	<0.005	0.19	0.014	0.060	0.950	0.215	13
Mercury	<0.0002	0.001	0.0004	<0.0002	<0.001	<0.001	0
Molybdenum	<0.02	0.1	0.060	<0.01	<0.1	0.069	0
Nickel	<0.01	0.2	0.100	<0.05	<0.05	<0.05	0
Selenium	<0.001	0.416	0.013	<0.001	0.086	0.019	0
Vanadium	<0.05	0.55	0.070	<0.05	<0.1	0.088	0
Zinc	0.009	0.07	0.016	<0.01	<0.01	<0.01	0
Radiometric (pCi/L)							
Uranium	0.0003	18.60	0.52	0.08	6.03	1.83	0
Radium-226	0	247.7	39.6	23.50	521.0	130.7	3

*Wichers, D.L. "Re: Request: Summary Table Irigaray Mine Unit Restoration RAI Response." E-mail to R. Linton (August 11), NRC. Mills, Wyoming: Cogema Mining, Inc. 2006.

Davis and Curtis (2007) generally concluded that for the sites and data they examined, aquifer restoration took longer and required more pore volumes than originally planned. For example, at the A-Well Field at the Highland Uranium Project, the licensee's original plan anticipated that restoration would last from four to seven years and require treating 5–7 pore volumes of groundwater. When uranium recovery in the well field ended in 1991, the baseline and class of use were not restored in the well field until 2004 (Table 2.11-5), and more than 15 pore volumes of water were involved (NRC, 2006, 2004). Similarly, WDEQ has noted that the C-Well field at the Smith Ranch-Highland Uranium Project has been undergoing restoration for 10 years (WDEQ, 2008). At the Crow Butte Mine Unit No. 1, more than 9.85 pore volumes of

Table 2.11-5. Baseline Groundwater Conditions, Aquifer Restoration Goals, and Actual Final Restoration Values the U.S. Nuclear Regulatory Commission Approved for the Q-Sand Pilot Well Field, Smith Ranch, Wyoming*†

Parameter (units)	Range	Mean	Restoration Goal	Actual Restoration
Arsenic (mg/L) ‡	0.001–.0013	0.004	0.05	0.008
Boron (mg/L)	0.002–0.70	0.15	0.54	0.14
Calcium (mg/L)	24–171	72	120	78
Iron (mg/L)	0.01–0.27	0.025	0.3	0.24
Magnesium (mg/L)	3–22	16	0.092	0.06
Manganese (mg/L)	0.01–0.077	0.023	Not applicable	0.1
Selenium (mg/L)	0.001–0.024	0.004	0.029	0.003
Uranium (mg/L)	0.001–3.1	0.28	3.7	1.45
Chloride (mg/L)	4–65	18	250	15
Bicarbonate (HCO_3) (mg/L)	129–245	199	294	254
Carbonate (CO_3) (mg/L)	Nondetectible–75	18	15	Nondetectible
Nitrate (mg/L)	0.1–1.0	0.4	Not applicable	0.13
Potassium (mg/L)	7–34	12	23	8
Sodium (mg/L)	19–87	28	41	38
Sulfate (mg/L)	100–200	124	250	128
Total dissolved solids (mg/L)	155–673	388	571	443
Specific conductivity (μmhos/cm)	518–689	582	827	642
pH (standard units)	7.5–9.4	8.0	6.5–8.6	7.0
Radium-226 (pCi/l)	6–1132	340	923	477
Thorium-230 (pCi/l)	0.027–4.65	1.03	5.62	3.4

*NRC. "Environmental Assessment for the Addition of the Reynolds Ranch Mining Area to Power Resources, Inc.'s Smith Ranch/Highlands Uranium Project Converse County, Wyoming." Source Material License No. SUA–1548. Docket No. 40-8964. Washington, DC: NRC. 2006.
†Sequoyah Fuels Corporation. "Re: License Application, Smith Ranch Project, Converse County, Wyoming." ML8805160068. Glenrock, Wyoming: Sequoyah Fuels Corporation. 1988.
‡1 mg/L = 1 ppm

groundwater were used in all the stages of aquifer restoration over approximately 5 years as compared to the 8 pore volumes estimated before restoration (NRC, 2002, 2003c). Crow Butte Resources extracted uranium from an additional 26 pore volumes using ion exchange, without lixiviant injection, prior to active restoration.

As a field test of groundwater stabilization during aquifer restoration, hydrogen sulfide gas was injected as a reductant into the Ruth ISL research and development facility in Campbell County, Wyoming. After 6 weeks of hydrogen sulfide injection, pH dropped relatively quickly from 8.6 to 6.3, and sulfate concentration increased from 28 ppm to 91 ppm indicating a more reducing environment (Schmidt, 1989; Davis and Curtis, 2007). Concentrations of dissolved uranium, selenium, arsenic, and vanadium decreased by at least one order of magnitude. After 1 year of monitoring, however, reducing conditions were not maintained, and uranium, arsenic, and radium concentrations began to increase.

Based on the available field data from aquifer restoration, Davis and Curtis (2007) concluded that aquifer restoration is complex and results could be influenced by a number of site-specific hydrological and geochemical characteristics, such as preoperational baseline water quality, lixiviant chemistry, aquitard thickness and continuity, aquifer mineralogy, porosity, and permeability. In some cases, such as at Bison Basin and Reno Creek, the aquifer was restored in a relatively short time. In other cases, restoration required much more time and treatment than was initially estimated (e.g., the A- and C- Well Fields at the Highland ISL facility.

2.11.6 Socioeconomic Information

Because they are generally located in remote areas, uranium ISL facilities tend to be important employers in the local economy. The total number of full-time, permanent employees and local contractors varies during an operational life that may span several decades. Based on employment levels at existing operations and projected employment for proposed projects, staff levels at ISL facilities range from about 20 to 200, with peak employment depending on the scheduling of construction, drilling, and operational activities (Crow Butte Resources, Inc., 2007; Power Resources, Inc., 2004a; NRC, 1997a).

Another economic effect from ISL facilities is contributions to the local economy through purchases and through tax revenues from the uranium produced at the facility. For example, at the Crow Butte ISL facility in Dawes County, Nebraska, local purchases of goods and services in 2006 were estimated at about $5,000,000 (Crow Butte Resources, Inc., 2007). Annual tax revenues depend on uranium prices and the amount of uranium produced at a given facility. For example, for a 272,155-kg [600,000-lb] increase in annual yellowcake production at the Crow Butte facility at a price of $80/lb, an incremental contribution to federal, state, and local taxes on the order of $1 million to $1.4 million would result (Crow Butte Resources, Inc., 2007).

2.12 Alternatives Considered and Included in the Impact Analysis

The NRC's environmental review regulations in 10 CFR Part 51 that implement the National Environmental Policy Act (NEPA) require the NRC to consider reasonable alternatives, including the no-action alternative, to a proposed action before acting on a proposal. The intent of this requirement is to enable the agency to consider the relative environmental consequences of an action given the environmental consequences of other activities that also meet the need for the action, as well as the environmental consequence of taking no action at all. The information in

this section does not constitute NRC's final consideration of reasonable alternatives for the site-specific environmental reviews of ISL license applications.

2.12.1 The No-Action Alternative

As defined in Chapter 1, the proposed federal action is NRC's determination to grant an application to obtain, renew, or amend a source material license for an ISL facility. Under the no-action alternative, NRC would deny the applicant's or licensee's request. As a result, the new license applicant may choose to resubmit the application to use an alternate uranium recovery method or decide to obtain the yellowcake from other sources. Licensees whose renewal application is denied would have to commence shutting down operations in a timely manner. Denials of license amendments would require the licensee to continue operating under its previously approved license conditions.

2.13 Alternatives Considered and Excluded From the Impact Analysis

Alternative methods for uranium recovery include conventional mining/milling methods and heap leaching. Heap leaching (i.e., use of chemical solutions to leach uranium from a pile of crushed ore) may be used for low grade or small ore bodies, but mining and some crushing and grading is necessary to build up the ore pile (EPA, 2007a; NRC, 1980). The heap leach process is a technology that is considered to be part of the conventional mining and milling industry; NRC regulates this technology using the criteria in 10 CFR 40, Appendix A, that are deemed applicable to such operations (NRC, 1980, Appendix B). These two alternative uranium recovery technologies are discussed further in Appendix C.

Because the GEIS focuses on the future licensing of ISL facilities and does not evaluate available technologies for uranium recovery, conventional mining/milling and heap leaching were not included in the impact analysis. However, such uranium recovery methods may be among the reasonable alternatives evaluated in a site-specific review of an ISL license application. As described in Section 2.1, there are particular types of uranium deposits that are amenable to ISL uranium recovery technology. In certain cases (e.g., the ore body is located near the surface, higher grade ores are present, the ore deposit is in an unsaturated formation), these deposits may also be accessible by conventional mining techniques, with the uranium in the mined ore recovered by conventional milling methods or by heap leaching. Therefore, a reasonable range of alternatives to be considered will be addressed in the site-specific environmental reviews.

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3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Introduction

This chapter of the Generic Environmental Impact Statement (GEIS) provides a description of the environmental conditions and resources in four regions of Wyoming, South Dakota, Nebraska, and New Mexico where previous and existing *in-situ* leach (ISL) uranium recovery operations have been licensed by NRC and where new ISL facilities may be proposed for U.S. Nuclear Regulatory Commission (NRC) review. These uranium milling regions are defined in Section 3.1.1 and provide the basis for the structure of Chapter 3, which describes the affected environments for each region. Section 3.1.2 includes general information that applies to each of the four regions.

3.1.1 Geographic Scope—Defining Uranium Milling Regions

For the purpose of analysis in this GEIS, NRC assumptions about potential future ISL facility locations were based on

- The locations of past and existing uranium milling operations in states where NRC has the regulatory authority over uranium recovery
- The locations where uranium milling companies have expressed interest in future uranium recovery using the ISL process
- The locations of historical uranium ore deposits in Wyoming, South Dakota, Nebraska, and New Mexico

In the United States, uranium ore deposits have been studied and developed in a number of western states: Arizona, Colorado, Montana, Nebraska, New Mexico, South Dakota, Utah, Washington, Wyoming, and Texas (see Figure 1.1-2). Regional ore deposits found in those states can encompass portions of several contiguous states.

The affected environment described in this chapter is further limited to states where NRC has authority to license ISL facilities. NRC does not have regulatory authority in all states, because at the state's request, NRC may relinquish its regulatory authority to the state. Therefore, in certain states, known as Agreement States, NRC has relinquished its regulatory authority to license uranium milling facilities. Colorado, Utah, and Texas are Agreement States with state, not NRC, regulation of uranium milling. NRC has retained its regulatory authority over uranium milling activities in non-Agreement States. Western non-Agreement States where NRC regulates uranium milling activities include Wyoming, South Dakota, Nebraska, and New Mexico. Montana, Arizona, and Nevada are also non-Agreement States with respect to uranium milling. No companies have indicated to NRC its plans at present to submit license applications to construct and operate ISL facilities in Montana, Arizona, or Nevada over the next several years (NRC, 2009).

Locations within Wyoming, South Dakota, Nebraska, and New Mexico that include ore deposits and where past, existing, or future uranium milling activities or interest has been identified are shown in Figures 3.1-1, 3.1-2, 3.1-3, and 3.1-4.

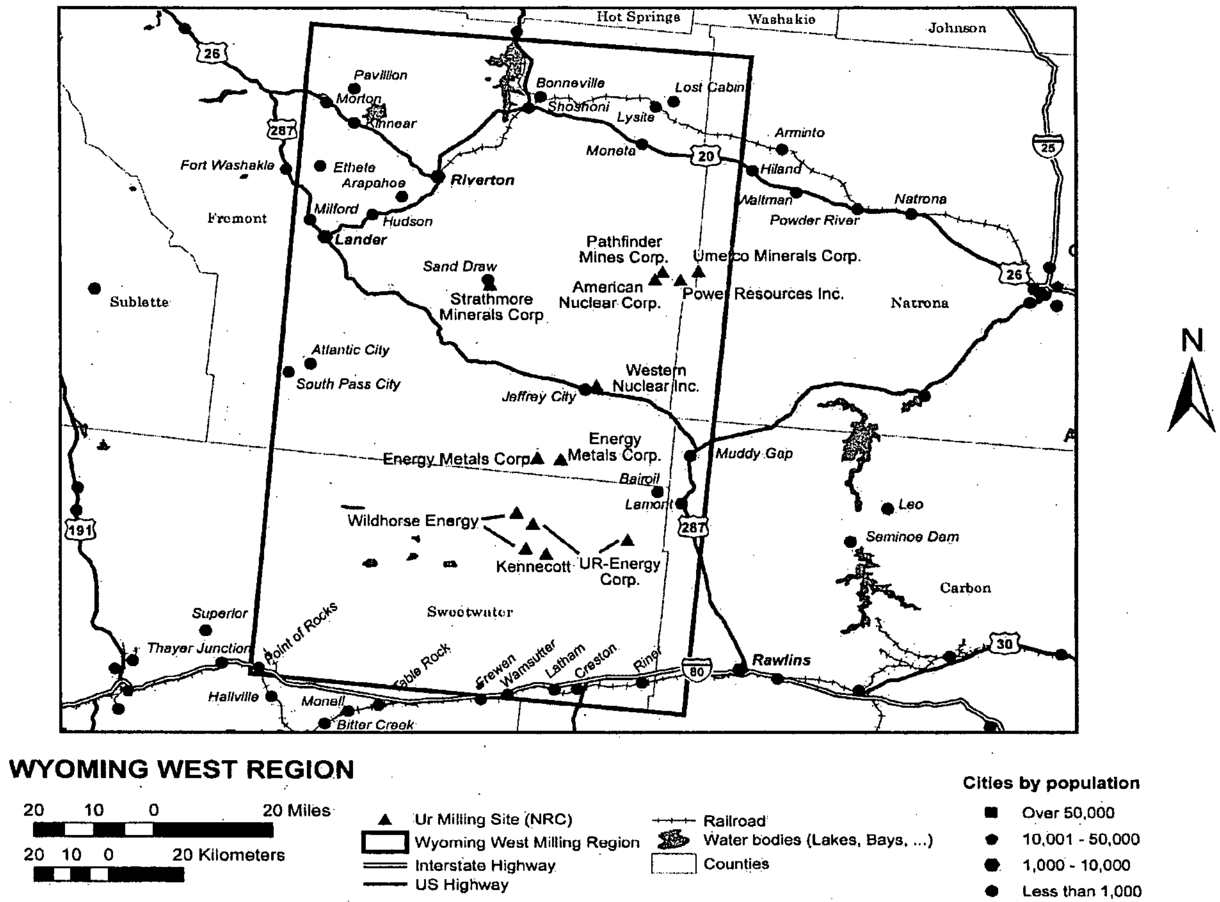

Figure 3.1-1. Wyoming West Uranium Milling Region With Current and Potential ISL Milling Sites

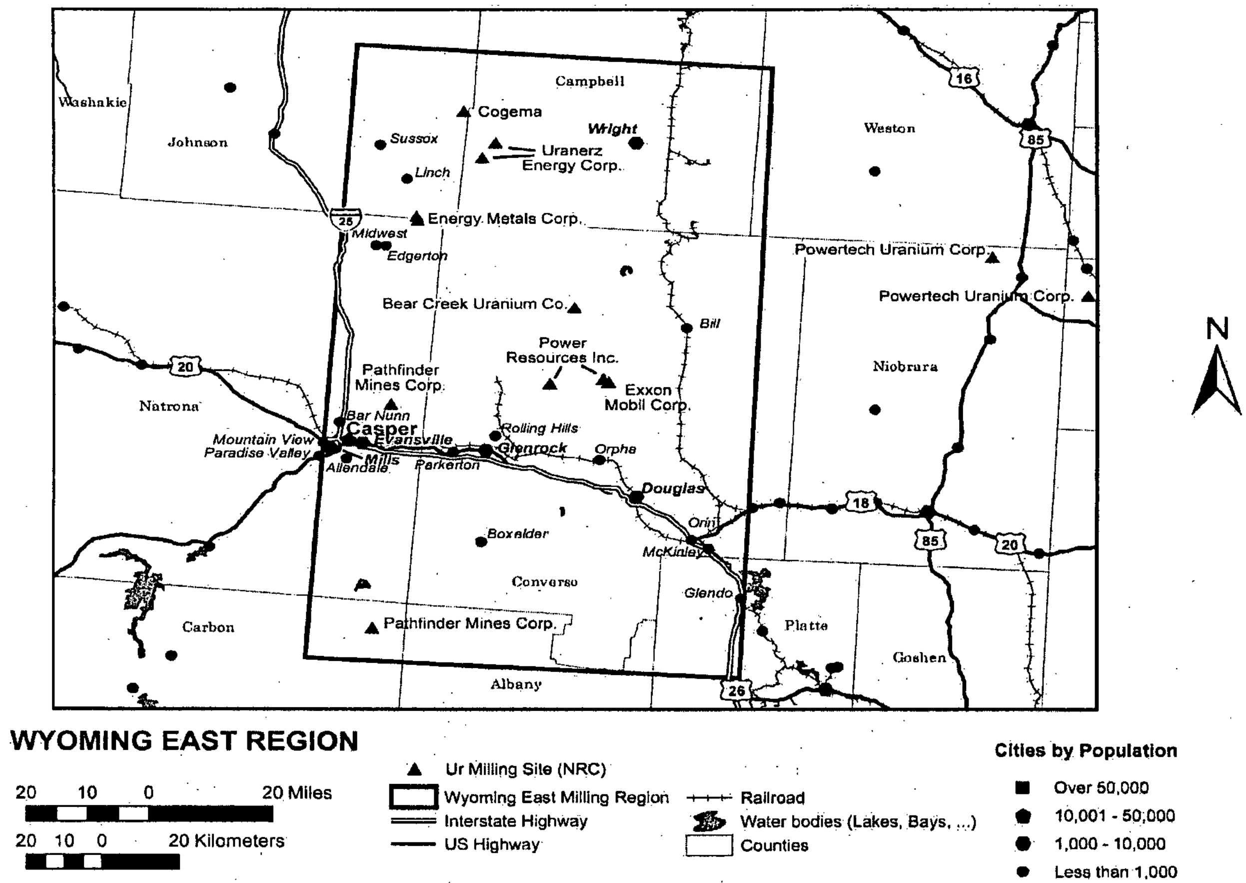

Figure 3.1-2. Wyoming East Uranium Milling Region With Current and Potential ISL Milling Sites

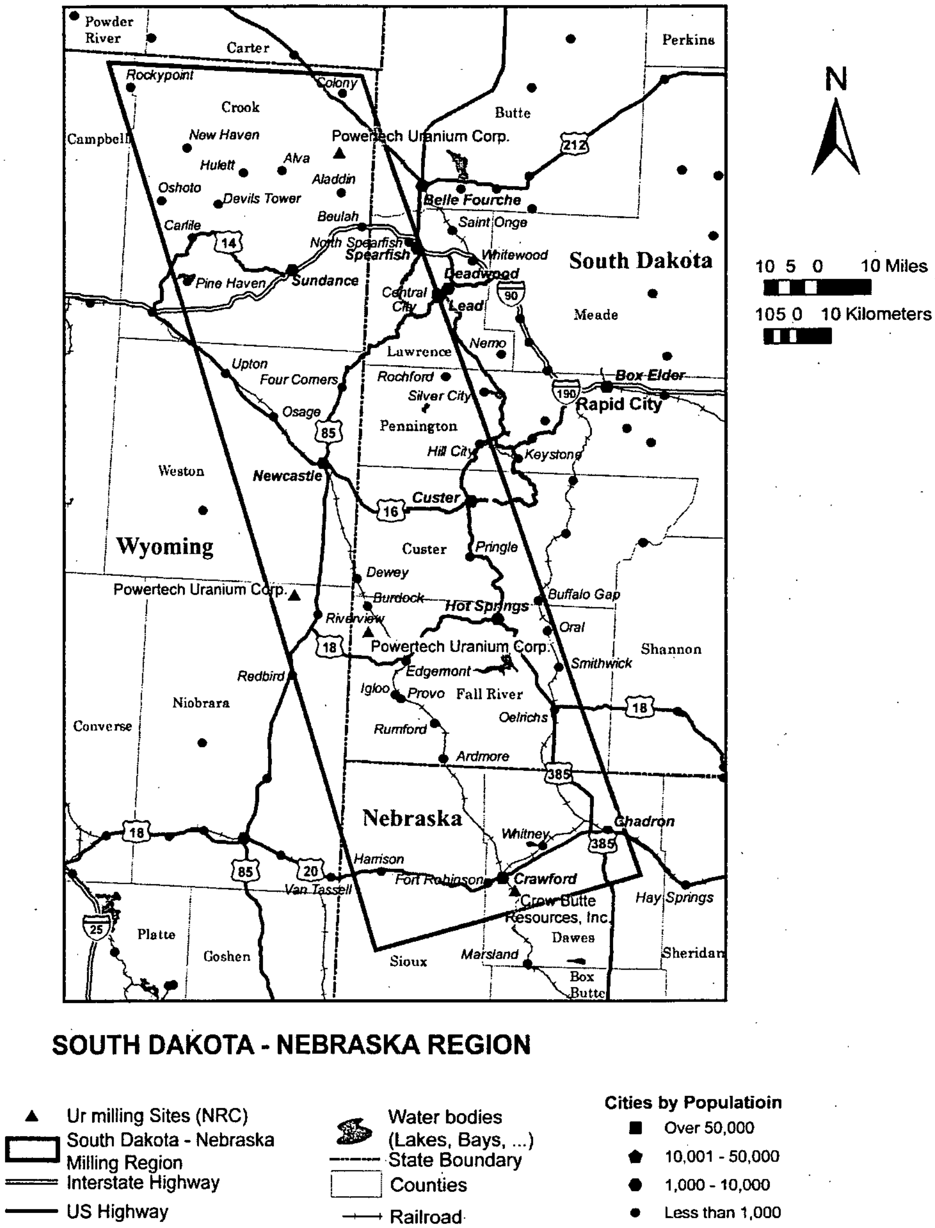

Figure 3.1-3. Nebraska-South Dakota-Wyoming Uranium Milling Region With Current and Potential ISL Milling Sites

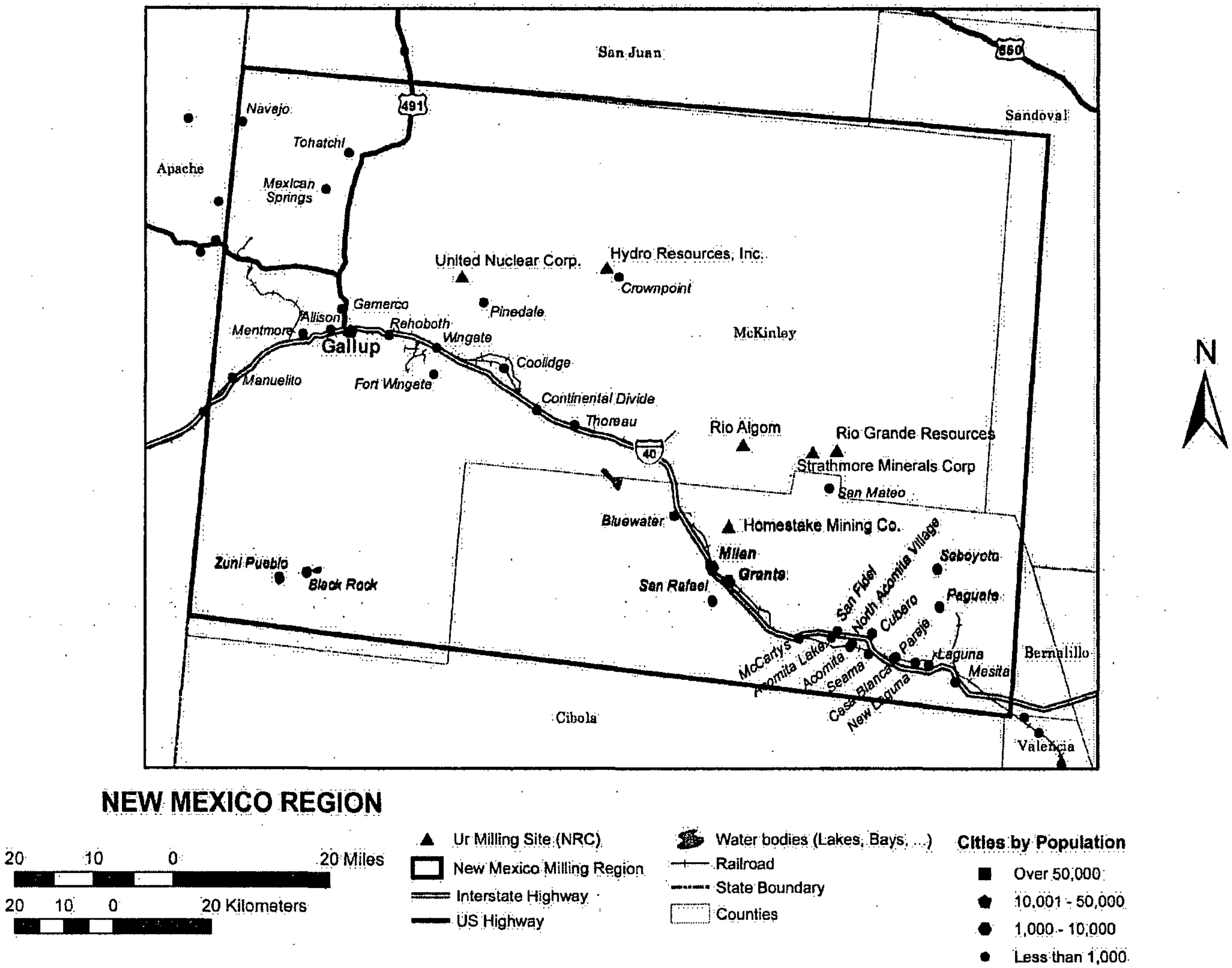

Figure 3.1-4. Northwestern New Mexico Uranium Milling Region With Current and Potential ISL Milling Sites

As shown in the figures, NRC has delineated separate uranium milling regions where the boundaries of each milling region encompass past, existing, and potential future ISL milling sites. In defining these regions, NRC also considered aspects of the affected environment (e.g., regional groundwater characteristics, regional demographics) such that potential future ISL milling sites within each region would more likely share those aspects for the purpose of evaluating potential environmental impacts. Therefore, NRC considers that these regions reasonably bound the geographic scope of the GEIS for describing the affected environment and for assessing potential environmental impacts within each region.

For the purposes of the GEIS, the regions have been named (see Section 1.4)

- Wyoming West Uranium Milling Region (Section 3.2)
- Wyoming East Uranium Milling Region (Section 3.3)
- Nebraska-South Dakota-Wyoming Uranium Milling Region (Section 3.4)
- Northwestern New Mexico Uranium Milling Region (Section 3.5)

Using this regional approach, the assessments of impacts in the GEIS may or may not be applicable or informative to reviews of ISL facilities proposed outside of the designated uranium milling regions. In such cases, the applicability of the GEIS would depend on the similarities of the proposed site and regional conditions with those described in the GEIS.

Identifying regions based on the locations of past, existing, and potential future uranium recovery operations as is done in the GEIS does not mean NRC prefers these locations or would prevent uranium recovery in other areas. It is the applicant or licensee that proposes the location of an ISL facility in the license application submitted to NRC, and NRC reviews such applications to fulfill its regulatory responsibilities.

3.1.2 General Information for All Uranium Milling Regions

To limit redundancies in discussing general information applicable to all four uranium milling regions addressed by the GEIS, that information is provided in this section.

3.1.2.1 Formation and Characteristics of Sandstone-Hosted Uranium Ore Deposits

Sandstone-hosted uranium deposits account for the vast majority of the uranium ore produced in Wyoming, South Dakota, Nebraska, and New Mexico (Chenoweth, 1988, 1991; Collings and Knode, 1984; McLemore and Chenoweth, 1989, 2003). Uranium mineralization in these sandstone deposits occurs primarily in what have been termed stratabound or roll-front deposits (Rackley, 1972; Renfro, 1969; Collings and Knode, 1984; McLemore, 2007). A conceptual model of a roll-front uranium deposit is illustrated in Figure 3.1-5. Roll fronts occur where water infiltrates from the surface and flows through an aquifer with slight amounts of uranium. Near the surface, oxidizing conditions cause the minerals and volcanic ash to weather (or dissolve) and release minute quantities of uranium into the groundwater. As groundwater continues to flow, it can encounter reducing conditions where the uranium is no longer stable in solution. In an aquifer, a reducing environment is characterized by the presence of hydrogen sulfide (H_2S), iron sulfides, or organic material. As a result, uranium precipitates from the groundwater and forms mineral coatings on the sediment grains in the formation. The principal ore minerals found in the roll-front deposits are uraninite (UO_2) and coffinite ($USiO_4$) with associated pyrite, marcasite (FeS_2), hematite (Fe_2O_3), ferroselite ($FeSe_2$), native selenium, jordisite (MoS_2), and calcite ($CaCO_3$). The zoning and alteration associated with the formation of a typical sandstone

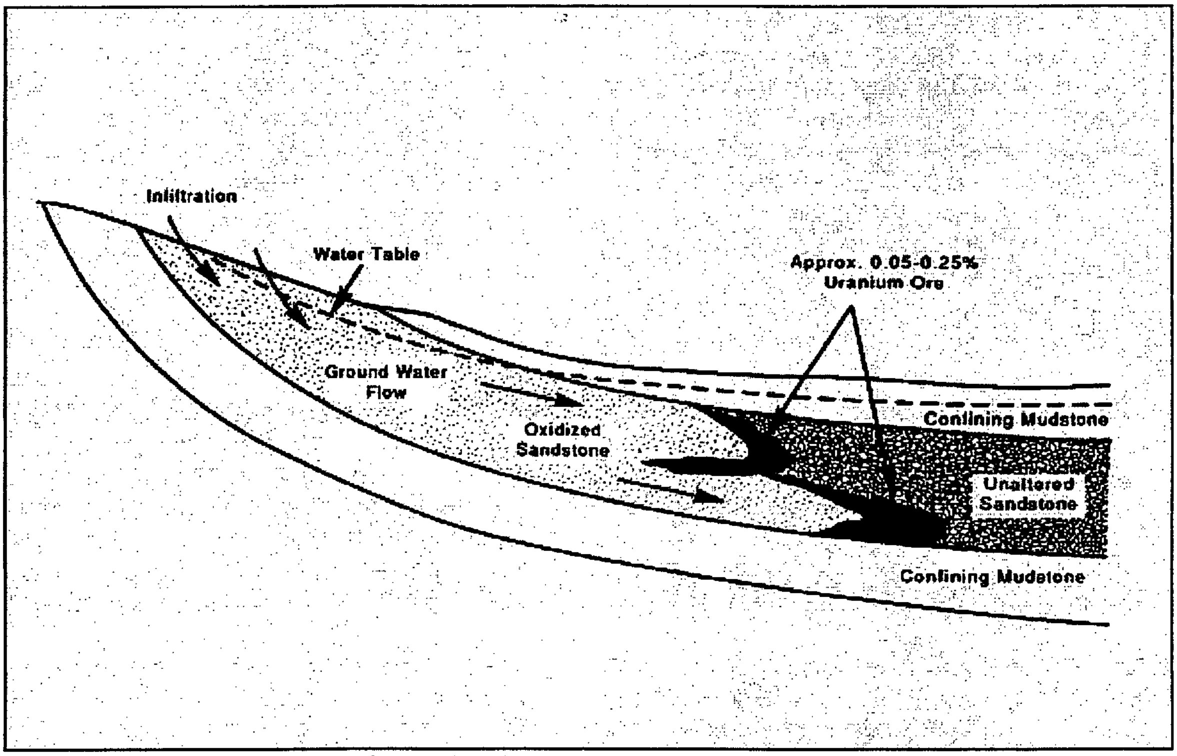

Figure 3.1-5. Simplified Cross Section of Sandstone Uranium Roll-Front Deposits Formed by Regional Groundwater Migration (NRC, 1997)

roll-front deposit are diagrammed in Figure 3.1-5. In addition to uranium, elements such as selenium, arsenic, molybdenum, and vanadium, which are generally mobile in oxidized conditions, are also precipitated in the vicinity of roll-front deposits because of the low solubility of their reduced forms. Harshman (1974) investigated the concentration and distribution of the ore and associated trace elements and minerals around the redox fronts of Wyoming ore deposits. Selenium, occurring as native selenium or ferroselite, was found at concentrations of several hundred ppm (parts per million) in zones at the edges of the altered sandstone or in reduced mineralized sandstone close to the redox interface. Molybdenum, occurring as jordisite, was found in highly variable concentrations, usually concentrated in the altered sandstone near the redox boundary. Vanadium, occurring as vanadium oxide (V_2O_4), was found at concentrations of several hundred ppm, deposited in the convex (reducing) side of the interface.

Roll-front deposits are ideally crescent- or C-shaped when viewed in cross section, with thin mineralization forming the tips of the crescents. Thick mineralization occurs in the center of the concave C-shaped ore body in the direction of groundwater flow. Individual mineralization fronts are typically from 0.6 m [2 ft] to more than 7.5 m [25 ft] thick and may be several hundred meters [feet] long. Fronts may coalesce to form ore bodies kilometers [miles] in length. Thin mineralized trails and more finely disseminated minerals branch off the main front and are located between fronts. High grade uranium roll-front deposits average about 0.2 percent U_3O_8. Lower grade ore (0.05–0.10 percent U_3O_8) is commonly present on the unaltered side of the higher grade roll front.

Several features are common to most major sandstone roll-front uranium deposits and their host rocks in Wyoming, South Dakota, Nebraska, and New Mexico (Rackley, 1972; McLemore, 2007). These features are: (1) sandstones of fluvial origin (i.e., produced by the action of a stream or river); (2) common association with arkosic (i.e., sediments with a considerable amount of the mineral feldspar) or micaceous sediment; (3) siltstones and mudstones interbedded with sandstones; (4) association with organic materials; (5) presence of pyrite in unweathered deposits; (6) gray color of the sandstones and light-gray or green color of the mudstones in unweathered deposits; (7) association with volcanic debris in the host formation or in overlying formations; (8) the discordant roll front features or solution fronts; and (9) the sharp contact between mineralized zones and adjacent carbonaceous-free or oxidized zones. The first seven features are related directly to the source rock, sedimentation, and the sedimentary environment; the last two features are related to the mineralizing process.

3.1.2.2 Complex Land Ownership Rights, Responsibilities, and Opportunities

The federal government, through the U.S. Bureau of Land Management (BLM) manages 2.8×10^8 ha [700 million acres] of subsurface mineral estate nationwide, including approximately 2.3×10^7 [58 million acres] where the surface is privately owned (BLM, 2007). In many cases, the surface rights and mineral rights were severed under the terms of the nation's homesteading laws. Applicable laws include the Coal Lands Act of 1909 and 1910; the Agricultural Entry Act of 1914; the Stock Raiding Homesteading Act of 1916; and the Mineral Leasing Act of 1920, as amended. These and other federal laws, regulations, and BLM policy directives provide the authority and direction for administering the development of federal mineral resources beneath privately owned surfaces.

The leasing and development of federal mineral resources occur in four phases including planning and leasing, permitting, drilling and production, and surface reclamation. In each phase, the BLM, the lessee/operator, and the private surface owner have rights, responsibilities, and opportunities.

Parcels of land or mineral estate that are open for leasing under the terms of a BLM land use plan may be nominated for leasing by companies or members of the public. BLM reviews every nomination to ensure that leasing the parcel would conform to the terms of the land use plan, which has been developed previously with broad public input.

The initial term for a federal mineral resource lease is 10 years, but lessees can apply to extend the lease at the end of the 10-year period. Successful bidding on and acquiring the lease gives the lessee or designated operator the right to enter and occupy as much of the surface as is reasonably required to explore, drill, and produce the mineral resources on the leasehold, subject to applicable federal laws, regulations, lease stipulations, and permit requirements. BLM works to encourage coordination and cooperation among all parties that have rights and responsibilities in these split estate situations.

Because federal mineral resources include uranium ore deposits, there is a potential for split estate situations to occur when there is interest in exploration or operations related to uranium milling in an ore deposit that is located on land where federal surface mineral resources are open for leasing under the terms of a BLM land use plan. BLM has programs and practices in place including planning, permitting and bonding that facilitate public involvement and encourage resolution of potential conflicts between surface owners and lessee/operators. Details of these programs including rights and responsibilities are discussed on the BLM

website (www.blm.gov). BLM also must fulfill the requirements of the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), the Endangered Species Act, the Clean Water Act, and other applicable laws regarding surface resources. NRC also has similar obligations with regard to licensing ISL facilities once an application for a license to operate has been submitted to NRC for review. NRC is currently working with BLM to develop working arrangements that will facilitate cooperation in efficiently meeting both agencies' obligations with respect to review of ISL facility proposals while limiting unnecessary duplication of effort. Results of these interactions (e.g., official agreements or memoranda of understanding) will be made available to the public once they have been developed.

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3.2 Wyoming West Uranium Milling Region

3.2.1 Land Use

Approximately 53.3 percent of the land in the state of Wyoming is public land (47 percent federal ownership and 6.3 percent state ownership). Most of these federal lands are located in the western and northwestern parts of Wyoming, and the vast majority of private lands is located in the eastern half of the state. BLM administers the largest amount of public land in the state (28 percent). BLM lands are mixed with private and state lands. Forty-eight percent of Wyoming privately owned surface land has a split-estate status (BLM, 2008a) (Section 3.1.2.2).

Private lands, including Native American lands, which are administered by the Bureau of Indian Affairs, represent 45.9 percent of Wyoming land. In terms of general landscape, Wyoming big sagebrush (30.8 percent) and mixed grass (20.2 percent) occupy about half of the land in Wyoming, while irrigated agriculture occupies only 4.2 percent of the land (Wyoming Geographic Information Science Center, 2008).

For the purpose of this GEIS, the Wyoming West Uranium Milling Region encompasses parts of Carbon, Fremont, Natrona, and Sweetwater Counties (Figure 3.2-1). This region, which is a part of the Rocky Mountain System, straddles the Wyoming Basin to the east and the Middle Rocky Mountains to the west (U.S. Geological Survey, 2004). Based on known past, current, and planned uranium milling operations, Figure 3.2-2 shows that these operations are concentrated in two major uranium districts known as the Crooks Gap area in the Great Divide Basin straddling northeastern Sweetwater County and southeastern Fremont County and the Gas Hills area in the Wind River Basin located in eastern Fremont County (see details in the Geology and Soils Section 3.2.3).

> **BLM Grazing Permit/ License/Lease**
> BLM grants official written permission to private permitees or lessees to allow a certain number, type, and class of their livestock to graze on public lands for a specified time period and on a defined rangeland.

The land ownership and use statistics for the Wyoming West Uranium Milling Region shown in Table 3.2-1 were calculated using the Geographic Information System used to prepare the map shown in Figure 3.2-1. The majority of the land of the four counties of this region is composed of federal land (66 percent) and Native American land (9 percent) (Table 3.2-1). Private lands, intermixed with BLM land, occupy approximately 25 percent of the region. The eastern tips of the Shoshone and Bridger National Forests form a very small part on the western edge of this region (1 percent). A portion of the Wind River Indian Reservation and land administered by the U.S. Bureau of Reclamation represent approximately 13 percent of the land at the northwestern corner of the Wyoming West Uranium Milling Region. Riverton, located in this corner, is the largest town of the region with almost 10,000 inhabitants (Figure 3.2-1). Riverton is located more than 80 km [50 mi] from the Crooks Gap area and the Gas Hills area. Towns in the vicinity of these two uranium districts include Jeffrey City, Sand Draw, and Bairoil, each of which has a population of a few hundred or less (Figure 3.2-2).

As shown on Figure 3.2-1, BLM manages the vast majority of the land in the Crooks Gap and the Gas Hills areas. The land is mostly used as rangeland for cattle and sheep grazing under the BLM permit system. Other land uses under BLM management include oil and gas development, wildlife habitat, and public recreation.

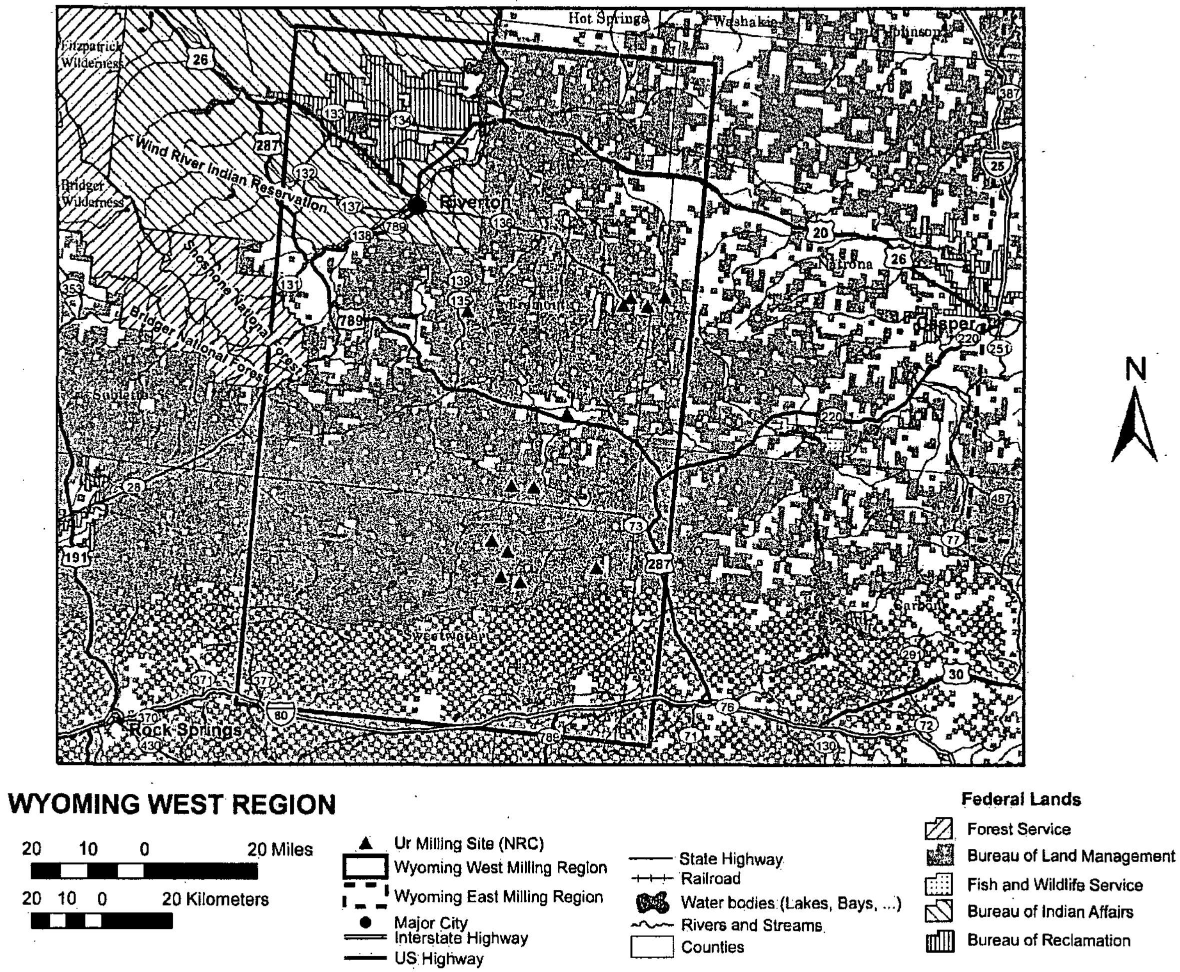


Figure 3.2-1. Wyoming West Uranium Milling Region General Map With Current and Future Uranium Milling Site Locations

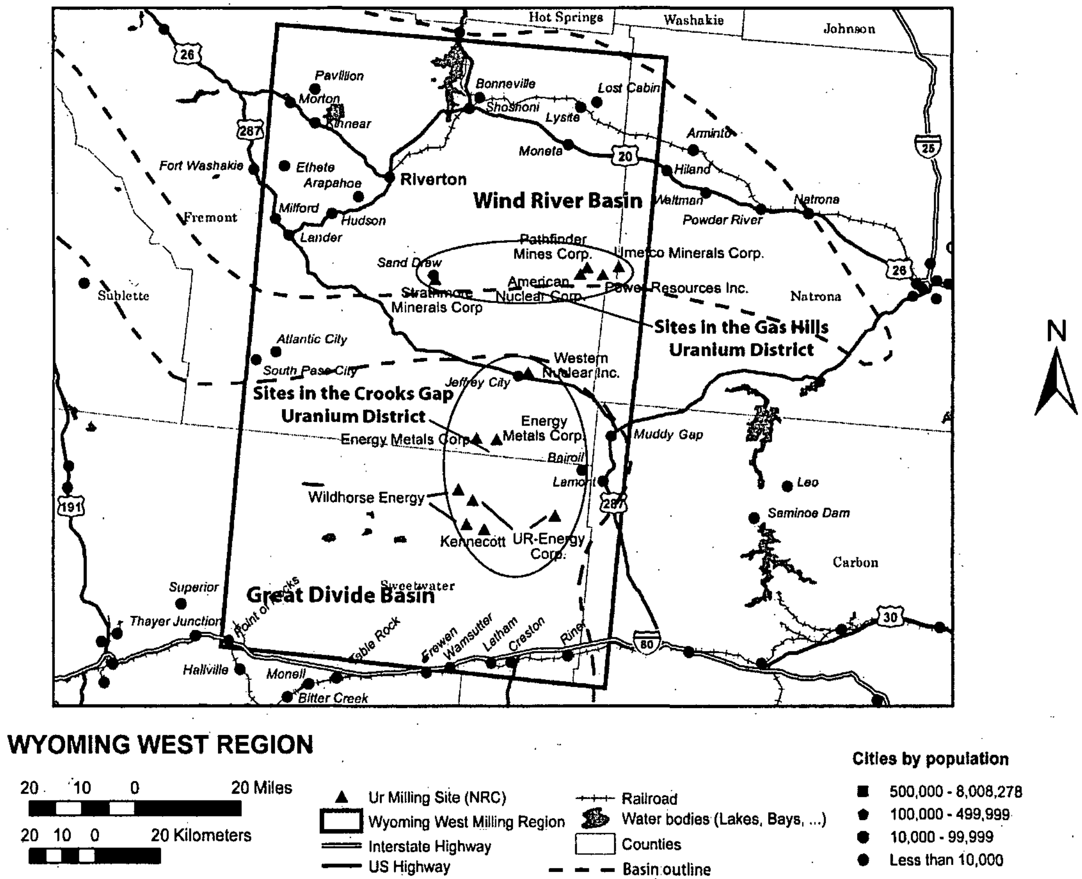


Figure 3.2-2. Map Showing Outline of the Wyoming West Uranium Milling Region and Locations of the Crooks Gap Uranium District in the Great Divide Basin and the Gas Hills Uranium District in the Wind River Basin

Table 3.2-1. Land Surface Ownership and General Use in the Wyoming West Uranium Milling Region			
Land Surface Ownership and General Use	**Area (mi^2)**	**Area (km^2)**	**Percent**
U.S. Bureau of Land Management, Public Domain Land	5,476	14,184	61.4
Private Lands	2,191	5,675	24.6
Bureau of Indian Affairs, Indian Reservations	809	2,095	9.1
Bureau of Reclamation	352	911	3.9
U.S. Forest Service, National Forest	87	226	1
Totals	8,915	23,090	100.0

Most of the private land in the eastern and southern part of the region is intermixed with BLM grazing land and is used to produce hay for feeding cattle in winter. Other scattered land uses in this region include wildlife habitat, wilderness areas, hunting, dispersed recreation and off-road vehicle use, oil and gas recovery, gas and carbon dioxide pipelines and transmission lines, and cultural and historical sites, such as the Oregon/Mormon Pioneer National Historic Trail (BLM, 1987, 2007e). The presence and extent of these land uses will have to be addressed on a site-specific basis at, and in the vicinity of, any new potential uranium milling facility.

3.2.2 Transportation

Past experience at NRC-licensed ISL facilities indicates these facilities rely on roads for transportation of goods and personnel (Section 2.8). As shown on Figure 3.2-3, the Wyoming West Uranium Milling Region is accessible by Interstate 80, which borders the south of the region between Rock Springs and Rawlins. The Wyoming West Uranium Milling Region is also accessed from the west by State Highway 28, from the northwest by U.S. Highway 26, from the north by U.S. Highway 20, and from the east by U.S. Highway 20 and State Route 220. Rail lines traverse the northern and southern portions of the region.

Areas of past, present, or future interest in uranium milling in the region are also shown in Figure 3.2-3. These areas are located in four main subregions when considering site access by local roads. Areas of milling interest that are located in the northeastern part of the region near the Natrona and Fremont County borders are accessible by State Route 136 from Riverton or by a local access road that travels south from Waltman until intersection with State Route 136. Another area of milling interest is in the central portion of the milling region adjacent to State Route 135, which is accessed from the north from Riverton or from the south from U.S. Highway 789. Traveling east from that point on U.S. Highway 789 to Jeffrey City is another area of milling interest. Other sites of interest in the southeastern portion of the Wyoming West Uranium Milling Region (Great Divide Basin Area in Sweetwater County) are accessible by unpaved local access roads that extend west from U.S. Highway 287 at Bairoil and a location farther south between Bairoil and Rawlins. These west-trending roads intersect a north and south-trending unpaved road that connects Wamsutter on the southern border of the region at Interstate 80 to Jeffrey City and Moneta to the north. U.S. Highway 287 continues south to Interstate 80.

Table 3.2-2 provides available traffic count data for roads that support areas of past or future milling interest in the Wyoming West Uranium Milling Region. Counts are variable with the

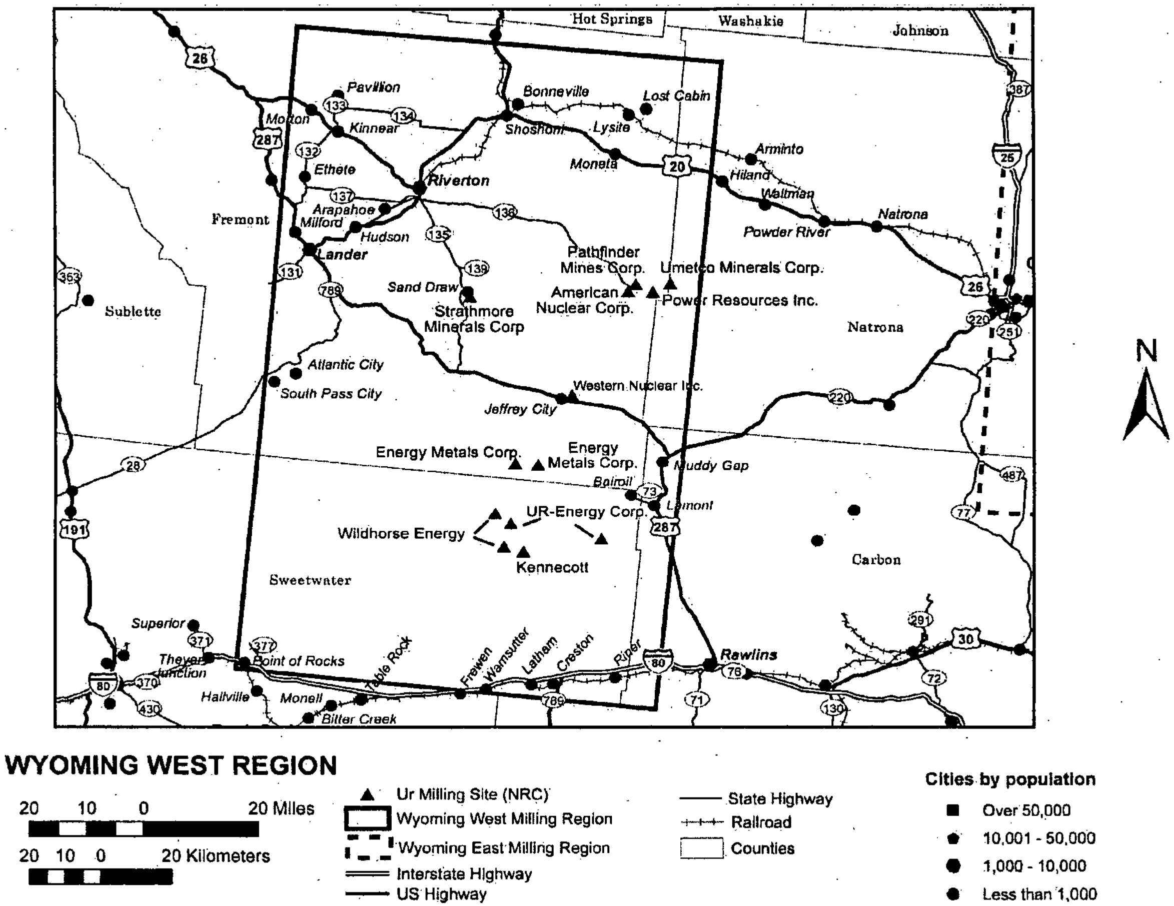


Figure 3.2-3. Wyoming West Uranium Milling Region Transportation Corridor

Table 3.2-2. Average Annual Daily Traffic Counts for Roads in the Wyoming West Uranium Milling Region*

Road Segment	Distance (mi)	Trucks		All Vehicles	
		2005	2006	2005	2006
State Route 136 to Riverton	44	10–20	20–30	130–260	200–270
State Route 135 from State Route 136 to State Route 789	1.04	170	210	840	1,090
State Route 789 from State Route 135 to U.S. Highway 26	1	570–650	570–650	11,500–17000	11,650–17,100
U.S. Highway 20/26 from Riverton to Shoshoni	22	520–650	520–650	3,340–19,580	5,100–19,620
U.S. Highway 20/26 from Shoshoni to Waltman	51	270–580	470–550	2,350–3,090	2,190–3,060
U.S. Highway 20/26 from Waltman to Casper	49	470–670	480–650	2,480–13,740	2,450–13,580
Interstate 25 from Casper to State Route 95	21	570–1,030	610–1,030	2,610–10,220	2,710–10,220
U.S. Highway 287 (State Route 789) at Lander South	-	390	400	5,080	4,550
U.S. Highway 287 (State Route 789) at Jeffrey City	-	140	140	850	890
U.S. Highway 287 at Muddy Gap	-	140	140	910	910
State Route 220 at Muddy Gap North	-	620	620	1910	1910
State Route 73 from Bairoil to Lamont	4.64	30	30	230	230
U.S. Highway 287 from Lamont to Muddy Gap	11	700	690	2,400	2,400

*Wyoming Department of Transportation. "Wyoming Department of Transportation Vehicle Miles." Data for Calendar Year 2005 and 2006 Provided on Request. Casper, Wyoming: Wyoming Department of Transportation, District 2 Office. April 18, 2008.

minimum all-vehicle count at 130 vehicles per day on State Route 136 to Riverton and the maximum on U.S. Highway 20 from Riverton to Shoshoni at 19,620 vehicles per day. Most all-vehicle counts in the Wyoming West Uranium Milling Region are above 800 vehicles per day. Yellowcake product shipments are expected to go from the milling facility to a uranium hexafluoride production (conversion) facility in Metropolis, Illinois (the only facility currently licensed by NRC in the United States for this purpose). Major interstate transportation routes are expected to be used for these shipments, which are required to follow NRC packaging and transportation regulations in 10 CFR Part 71 and U.S. Department of Transportation hazardous material transportation regulations at 49 CFR Parts 171–189.

Table 3.2-3 describes representative routes and distances for shipments of yellowcake from locations of uranium milling interest in the Wyoming West Uranium Milling Region. Representative routes are considered owing to the number of routing options available that could be used by a future ISL facility. Because transportation risks are dependent on shipment

Table 3.2-3. Representative Transportation Routes for Yellowcake Shipments From the Wyoming West Uranium Milling Region*

Origin	Destination	Major Links	Distance (mi)
South of Moneta, Wyoming	Metropolis, Illinois	Local access road to Waltman, Wyoming U.S. Highway 20 east to Casper, Wyoming Interstate 25 south to Denver, Colorado Interstate 70 east to St. Louis, Missouri Interstate 64 east to Interstate 57 Interstate 57 south to Interstate 24 Interstate 24 south to U.S. Highway 45 U.S. Highway 45 west to Metropolis, Illinois	1,390
Sand Draw, Wyoming	Metropolis, Illinois	Local access roads to State Route 135 State Route 135 south to U.S. Highway 287 U.S. Highway 287 south to Interstate 80 Interstate 80 east to Cheyenne, Wyoming Interstate 25 south to Metropolis, Illinois (as above)	1,400
Jeffrey City, Wyoming	Metropolis, Illinois	Local access roads to U.S. Highway 287 U.S. Highway 287 to Interstate 80 Interstate 80 east to Cheyenne, Wyoming Interstate 25 south to Metropolis, Illinois (as above)	1,360
Great Divide Basin Area, Wyoming	Metropolis, Illinois	Local access road south to Wamsutter Interstate 80 east to Cheyenne, Wyoming Interstate 25 south to Metropolis, Illinois (as above)	1,360

*American Map Corporation. "Road Atlas of the United States, Canada, and Mexico." Long Island City, New York: American Map Corporation. p. 144. 2006.

distance, identification of representative routes is used to generate estimates of shipment distances for evaluation of transportation impacts in Chapter 4 Section 4.2.2). An ISL facility could use a variety of routes for actual yellowcake shipments, but the shipment distances for alternate routes are not expected to differ significantly from those estimated for the representative routes.

3.2.3 Geology and Soils

Wyoming contains the largest known reserves of uranium in the United States and has been the nation's leading producer of uranium ore since 1995 (Wyoming State Geological Survey, 2005). Sandstone-hosted uranium deposits account for the vast majority of the ore produced in Wyoming (Chenoweth, 1991). In the Wyoming West Uranium Milling Region, uranium mineralization is found in fluvial sandstones in two major uranium districts: the Crooks Gap area of the Great Divide Basin and the Gas Hills area of the Wind River Basin (Figure 3.2-2). The uranium mineralization in the sandstone-hosted deposits in the Crooks Gap and Gas Hills areas is amenable to recovery by ISL milling. Since 1991, all uranium produced from sandstones in these two districts has been by the ISL method (Wyoming State Geological Survey, 2005).

The Crooks Gap area is located in Fremont and Sweetwater Counties and encompasses approximately 9,100 km^2 [3,500 mi^2] in south-central Wyoming (Bailey, 1969; Rackley, 1972; Boberg, 1981). In 1954, ore-grade mineralization was found at Crooks Gap, and by late 1957, 3,800 metric tons [4,200 tons] of ore had been mined, mostly from shallow workings (Bailey, 1969). Production plus minable reserves at Crooks Gap are estimated to be between 5,000 and 5,400 metric tons [5,500 and 6,000 tons] U_3O_8.

The Gas Hills Uranium District is located along the southeastern margin of the Wind River Basin in central Wyoming (Anderson, 1969; Rackley, 1972; Boberg, 1981). Uranium in the Gas Hills district was discovered in 1953, and ore production began in 1955 (Anderson, 1969). The mineralized ground encompasses an area of about 160 km^2 [100 mi^2]. Prior to 1968, the Gas Hills uranium district produced approximately 26 million metric tons [29 million tons] of U_3O_8, which accounted for about 12 percent of total uranium production in the United States (Chenoweth, 1991).

The dominant source of sediment in the Great Divide and the Wind River Basins was Precambrian (greater than 540-million-year-old) granitic rock of the Sweetwater Arch (Rackley, 1972) (Figure 3.2-4). The Sweetwater Arch is also referred to as the Granite Mountains (Bailey, 1969; Anderson, 1969; Lageson and Spearing,1988). The Sweetwater Arch is a large mass of granitic rock 140 km [87 mi] long, with a maximum width of 50 km [31 mi]. Uplift of the Sweetwater Arch began to affect sedimentation in the adjacent Great Divide Basin and Wind River Basin in Late Cretaceous time (65 to 99 million years ago). Rapidly subsiding portions of these basins received thick clastic wedges (i.e., wedges made up of fragments of other rock) of predominantly arkosic sediments (i.e., sediments containing a significant fraction of feldspar), while larger, more slowly subsiding portions of the basins received a greater proportion of paludal (marsh) and lacustrine (lake) sediments.

Sediment transported southward into the Great Divide Basin was deposited on an apron of alluvial fans (Rackley, 1972). One of the major fans is centered near the Crooks Gap Uranium District, and another is northwest of the Lost Soldier anticline. Sedimentation in the Gas Hills area of the Wind River Basin was on an alluvial (i.e., deposited by running water) fan in which ridges of older resistant rock protruded through the fan and controlled the movement of the streams and their pattern of deposition. Beginning in the middle Eocene (41 to 49 million years ago) and increasing in the Oligocene (23.8 to 33.7 million years ago), regional volcanic activity contributed a significant amount of tuffaceous materials (i.e., materials made from volcanic rock and mineral fragments in a volcanic ash matrix) to local sediments. Deposition within the basins probably continued through the Miocene (5.3 to 23.8 million years ago), but post-Miocene erosion has completely removed Oligocene and Miocene units.

A generalized stratigraphic section of Tertiary (1.8- to 65-million-year-old) formations in the Wyoming West Uranium Milling Region is shown in Figure 3.2-5. Stratigraphic descriptions presented here are limited to formations that may be involved in potential milling operations or formations that may have environmental significance, such as important aquifers and confining units above and below potential milling zones.

Formations hosting major sandstone-type uranium deposits in the Wyoming West Uranium Milling Region are the Wind River Formation in the Wind River Basin and the Bottle Springs Formation in the Great Divide Basin. Both the Wind River and Bottle Springs are lower Eocene (49 to 54.8 million years old) in age (Houston, 1969) and consist of interbedded, arkosic sandstone; conglomerate; siltstone; mudstone; and carbonaceous shale—all compacted but poorly cemented (Harshman, 1968). The source beds for uranium deposits are sandstones

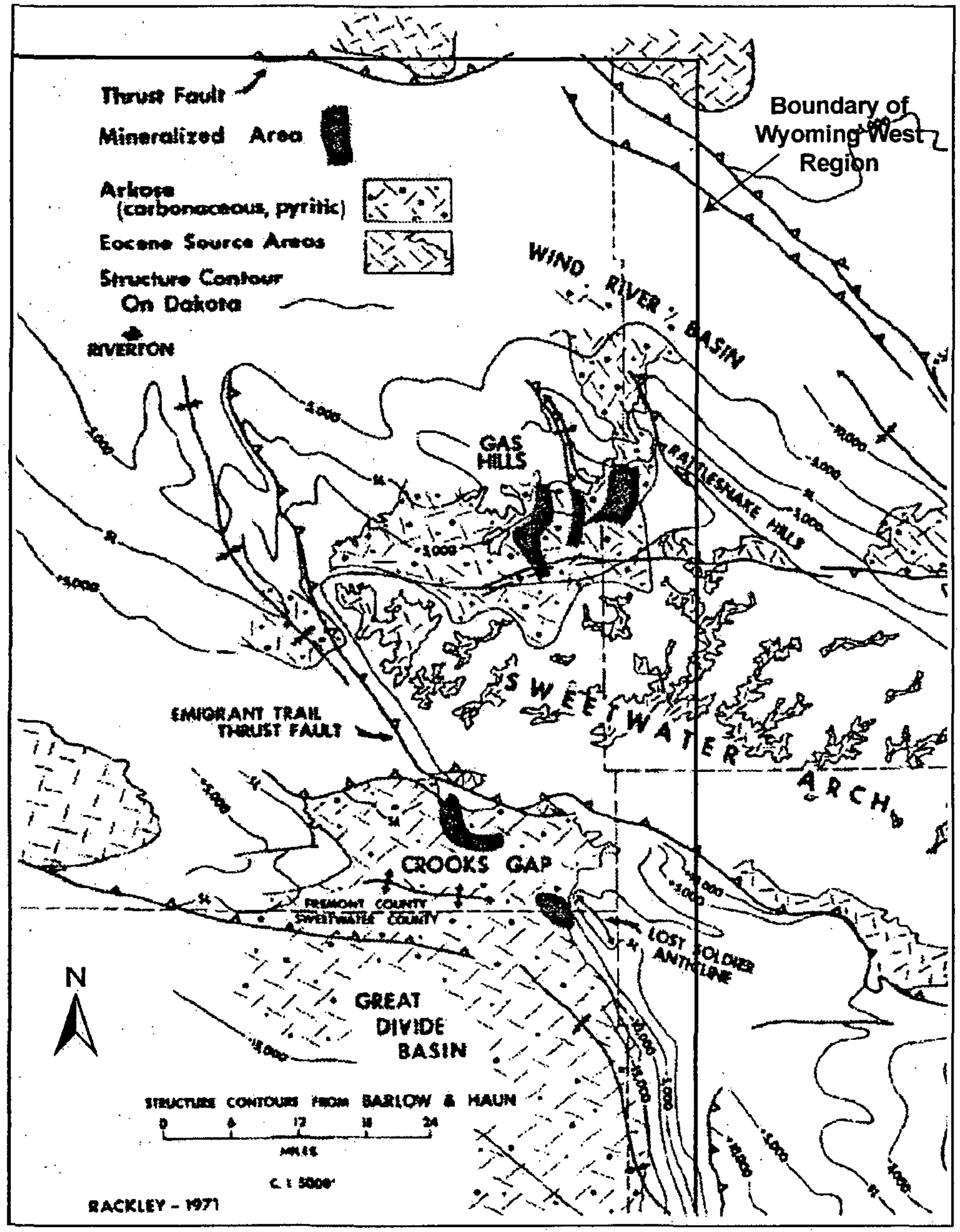


Figure 3.2-4. Index and Structure Map of Central Wyoming Showing Relation of Sweetwater Arch to the Great Divide Basin and the Wind River Basin. The Distribution of Arkosic, Carbonaceous Sediments, and Mineralized Areas in the Crooks Gap and Gas Hills Uranium Districts Are Also Shown (Modified From Rackley, 1972).

Central Wyoming				
System	Series		Formation	
Tertiary	Pliocene		Moonstone Formation	
	Miocene		Browns Park Formation	Split Rock Formation
	Oligocene		White River Formation	
	Eocene	Upper	Wagon Bed Formation	
		Middle		
		Lower	Battle Springs Formation	Wind River Formation
	Paleocene		Fort Union Formation	
Cretaceous	Upper		Lance Formation	

Figure 3.2-5. Stratigraphic Section of Tertiary Age Formations in the Great Divide Basin and Wind River Basin of Central Wyoming. Major Sandstone-Type Uranium Deposits Are Hosted in the Battle Springs Formation in the Great Divide Basin and the Wind River Formation in the Wind River Basin (Modified From Harshman, 1968).

interstratified with lensing mudstones and shales (Anderson, 1969). The mineralized zone in the Battle Springs Formation at Crooks Gap occurs in a stratigraphic range of as much as 460 m [1,500 ft] {i.e., occurs in a zone up to 460 m [1,500 ft] thick} (Stephens, 1964). In the Gas Hills Uranium District, mineralization in the Wind River Formation occurs in a stratigraphic range of perhaps 150 m [500 ft] (Bailey, 1969).

The Wagon Bed Formation conformably overlies the Wind River and Bottle Springs Formations. The Wagon Bed is composed of a series of interbedded arkosic sandstones and silicified claystones. Regionally, the Wagon Bed Formation may not be present in the central parts of the basins, having been removed by erosion. The White River Formation unconformably overlies the Wagon Bed Formation or the Wind River and Bottle Springs formations where the Wagon Bed has been removed by erosion. The White River consists of tuffaceous siltstone, claystone, and conglomerate with subordinate amounts of tuff. The White River overlaps older Tertiary formations and wedges out against pre-Tertiary rocks on the flanks of the basins. The White River Formation is overlain by the Browns Park Formation in the Great Divide Basin and the Split Rock Formation in the Wind River Basin. The Browns Park and Split Rock consist of tuffaceous siltstone and sandstone beds that sometimes cap prominent ridges (Harshman, 1968).

The Fort Union Formation underlies the Wind River and Bottle Springs Formations and, to a limited extent, is also a host of sandstone-type uranium deposits (Davis, 1969; Langden, 1973).

The Fort Union is a fluvial deposit consisting of alternating and discontinuous mudstones, siltstones, carbonaceous shales, and coarser arkosic sandstone. The Fort Union is unconformably underlain by sediments of the Lance Formation, which is in turn underlain by a thick sequence of older sandstones, mudstones, and shales.

The uranium deposits in the Wyoming West Uranium Milling Region are genetically related to geochemical interfaces or roll fronts (see Section 3.1.1). Principal ore minerals at Crooks Gap are meta-autunite, uraninite, and coffinite. The uranium minerals occur as earthy brown to black coatings on and interstitial fillings between quartz sand grains. In the Gas Hills district, roll fronts can be followed for long distances and individual ore bodies are found along them that may reach hundreds of meters [thousands of feet] in length.

The source of uranium in sandstone roll-front deposits in central Wyoming is a topic of conjecture. Four theories on the source of uranium in these occurrences have been suggested: (1) leached uranium from overlying ash-fall tuffs; (2) leached uranium from igneous and metamorphic rocks in the highlands surrounding the basins; (3) leached uranium from the host sandstones themselves; and (4) hydrothermal uranium from a magma source at depth (Harris and King, 1993). Combinations of these theories have been proposed as well (Boberg, 1981). The most popular theories are the (1) tuff leach and (2) highland leach. The tuff leach theory is supported by extensive geochemical studies on uranium removal from tuff (Zielinski, 1983, 1984; Trentham and Orajaka, 1986). Further, it was the tuff leach theory that led to the discovery of most of the large uranium deposits in Wyoming (Love, 1952). On the other hand, many sandstone-hosted uranium deposits in Wyoming are found adjacent to crystalline rocks, especially the uraniferous granites of the northern Laramie and Granite Mountains (Harris and King, 1993). Oxidized uranium leached from these crystalline terrains could have been transported to the sites of present mineralization.

Soils within the Wyoming West Uranium Milling Region are diverse and can vary substantially over relatively short distances. The distribution and occurrence of soils in central Wyoming can vary both on a regional basis (mountains, foothills, basins) and locally with changes in slope, geology, vegetation, climate, and time. The Great Divide Basin and the Wind River Basin present a mixture of old, tilted sedimentary rocks that often occur in bands along the basin margins and younger sediments showing varying degrees of incision by erosion in basin centers.

The topographic position and texture of typical soils in the Great Divide Basin and Wind River Basin areas of central Wyoming were obtained from Munn and Arneson (1998). This map was designed primarily for statewide study of groundwater vulnerability to contamination and would not be expected to be used for site-specific soil interpretations at proposed ISL milling facilities. For site-specific evaluations, detailed soils information would be expected to be obtained from published county soil surveys or the U.S. Department of Agriculture Natural Resource Conservation Service.

In the Great Divide and Wind River Basins areas, loamy-skeletal soils (rocky soils) with little or no subsoil development occur along bedrock outcrops that form ridges along the flanks of the basins. On gently sloping to moderately steep slopes associated with ridge flanks, alluvial fans, and alluvial terraces, fine to fine-loamy soils with well-developed horizons of clay accumulation are found. These soils are generally light colored and depleted in moisture. Moderately deep fine loamy over sandy and coarse loamy soils with well-developed soil horizons occur on terraces along major streams. Soils found on floodplains and drainageways include clay loams and fine-sand loams. Dark-colored, base-rich soils formed under grass are generally

associated with floodplains along streams with permanent high-water tables. These soils are generally very deep and have well-developed soil horizons.

3.2.4 Water Resources

Water resources of the Wyoming West Uranium Milling Region are described in terms of surface waters, wetlands and "Waters of the United States," and groundwater.

Areas regulated under Section 404 are collectively referred to as "Waters of the United States." Included are parts of the surface water tributary system down to the smallest streams; lakes, ponds, or other water bodies on those streams; and adjacent wetlands.

3.2.4.1 Surface Waters

The Wyoming West Uranium Milling Region (Figure 3.2.-1) includes major portions of Fremont and Sweetwater Counties and small portions of Carbon and Natrona Counties. Surface runoff to streams, in terms of average annual flow per unit area of a watershed, in the Wyoming West Uranium Milling Region varies from more than 13 cm/yr [5 in/yr] in the mountains to less than 1.3 cm/yr [0.5 in/yr] in the intermontane plains and valleys (Gebert, et al., 1987). The potential uranium milling sites are located in the intermontane areas. The watersheds within the Wyoming West Uranium Milling Region are listed in Table 3.2-4 along with the range of designated uses of surface water bodies assigned by the State of Wyoming (WDEQ, 2001). Because surface water uses are designated for specific water bodies, such as stream segments and lakes, within a watershed and the specific locations of future uranium milling activities are not known at this time, the range of designated uses is provided rather than a listing of designated uses for each water body within a watershed. Not all water bodies within a watershed may have all of the designated uses listed in Table 3.2-4. For example, a watershed may contain perennial streams, intermittent streams that flow only during portions of the year, and ephemeral streams that flow only because of surface runoff from local precipitation events. The perennial streams, and possibly portions of intermittent streams, may be designated as "fisheries," whereas ephemeral streams are unlikely to be designated as fisheries. The descriptions of the water bodies and their classifications in this section focus on perennial streams that generally have higher designated uses than the intermittent and ephemeral streams. For information regarding specific water bodies, refer to the Wyoming Department of Environmental Quality Surface Water Standards webpage (deq.state.wy.us/wqd/watershed/ surfacestandards).

Attainment Status

The attainment status of a water body refers to whether or not its water quality meets the standards for its designated use. The designated use of a water body is assigned by the state, such as swimming, drinking, and protection and propagation of aquatic life. If the chemical pollutants or other water quality parameters, such as temperature or turbidity, exceed the standards for its designed use, the attainment status of the water body is described as impaired.

The historical uranium milling districts included in the Wyoming West Uranium Milling Region are Gas Hills in the east-central portion of the Wyoming West Uranium Milling Region and Crooks Gap near the Fremont-Sweetwater County line (Figure 3.2-2). Watersheds in the Wyoming West Uranium Milling Region are Great Divide Closed Basin, Sweetwater River, Muskrat Creek, Little Wind River, Popo Agie River, Lower Wind River, Badwater Creek, and their associated tributaries. Historical or potential uranium milling sites are present in the Great

Table 3.2-4. Primary Watersheds in the Wyoming West Uranium Milling Region Range of Designated Uses of Water Bodies Within Each Watershed	
Watershed	**Range of State Classification of Designated Uses***
Great Divide Closed Basin	2AB to 4C
Main Stem Sweetwater River	1 (above Alkali Creek)
Sweetwater River and Tributaries	Generally 2AB (below Alkali Creek) with some tributaries 3B and 4B
Muskrat Creek	Generally 2AB with some tributaries 3B and 4B
Little Wind River	Generally 2AB with some tributaries 3B and 4B
Popo Agie River	Generally 2AB with some tributaries 3B and 4B
Lower Wind River	Generally 2AB with some tributaries 3B and 4B
Badwater Creek	Generally 2AB with some tributaries 3B and 4B

*Class 1 waters are described as "outstanding waters" and have designated uses including Drinking Water, Game Fish, Nongame Fish, Fish Consumption, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2AB waters have designated uses including Drinking Water, Game Fish, Non-Game Fish, Fish Consumption, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2A waters have designated uses including Drinking Water, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2B waters exclude Drinking Water from the Class 2AB uses. Class 2C waters exclude Drinking Water and Game Fish from the Class 2AB uses.
Classes 3A, 3B and 3C waters have designated uses including Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Classes 4A, 4B and 4C waters have designated uses including Recreation, Wildlife Agriculture, Industry, Scenic Value.
Official definitions of surface water classes and uses are in Wyoming Department of Environmental Quality Water Quality Rules and Regulations (http://soswy.state.wy.us/Rules/RULES/6547.pdf).

Divide, Sweetwater River, Muskrat Creek, Littlewind River, and Lower Wind River Watersheds (Figure 3.2-6).

The Great Divide Closed Basin is located in northeastern Sweetwater County and western Carbon County in an area with internal drainage and no outlet to either the Atlantic or Pacific Oceans (Figure 3.2-6). Surface water flows from the upland areas on the perimeter of the basin toward playa lakes near the center of the basin. The State of Wyoming has assigned surface classifications to streams in this watershed ranging from 2AB to 4C (WDEQ, 2001). Most of the streams are classified as 3A or 3B. The attainment status of these streams has not been assessed. The Crooks Gap Uranium District is partly located within the Great Divide Closed Basin.

The Sweetwater River Watershed is located north of the Great Divide Closed Basin Watershed in Sweetwater County. The Sweetwater River is a Class 1 water above Alkali Creek and Class 2AB water below Alkali Creek (Table 3.2-4). Crooks Creek is reported to be impaired due to oil and grease from oil and natural gas production (WDEQ, 2008). The average flow in the Sweetwater River near Alcova, Wyoming, for water years 1939 through 1973 (the period of continuous record) was 3.2 m^3/s [110 ft^3/s] (U.S. Geological Survey, 2008). The Crooks Gap Uranium District is partially within the Sweetwater River Watershed and is drained primarily by Crooks Creek and its tributaries. Topographic maps of the area show a number of unnamed springs and small impoundments on the ephemeral streams within the district.

The Muskrat Creek Watershed is located north of the Sweetwater River Watershed in Fremont County. Classifications of water bodies in the Muskrat Creek Watershed range from 2AB to 2C (Table 3.2-4). No data are available on average flow in Muskrat Creek. The Gas Hills uranium district is within the Muskrat Creek Watershed, which drains to the Wind River and ultimately to the Powder River (Figure 3.2-5). Muskrat Creek is ephemeral within the Gas Hills uranium

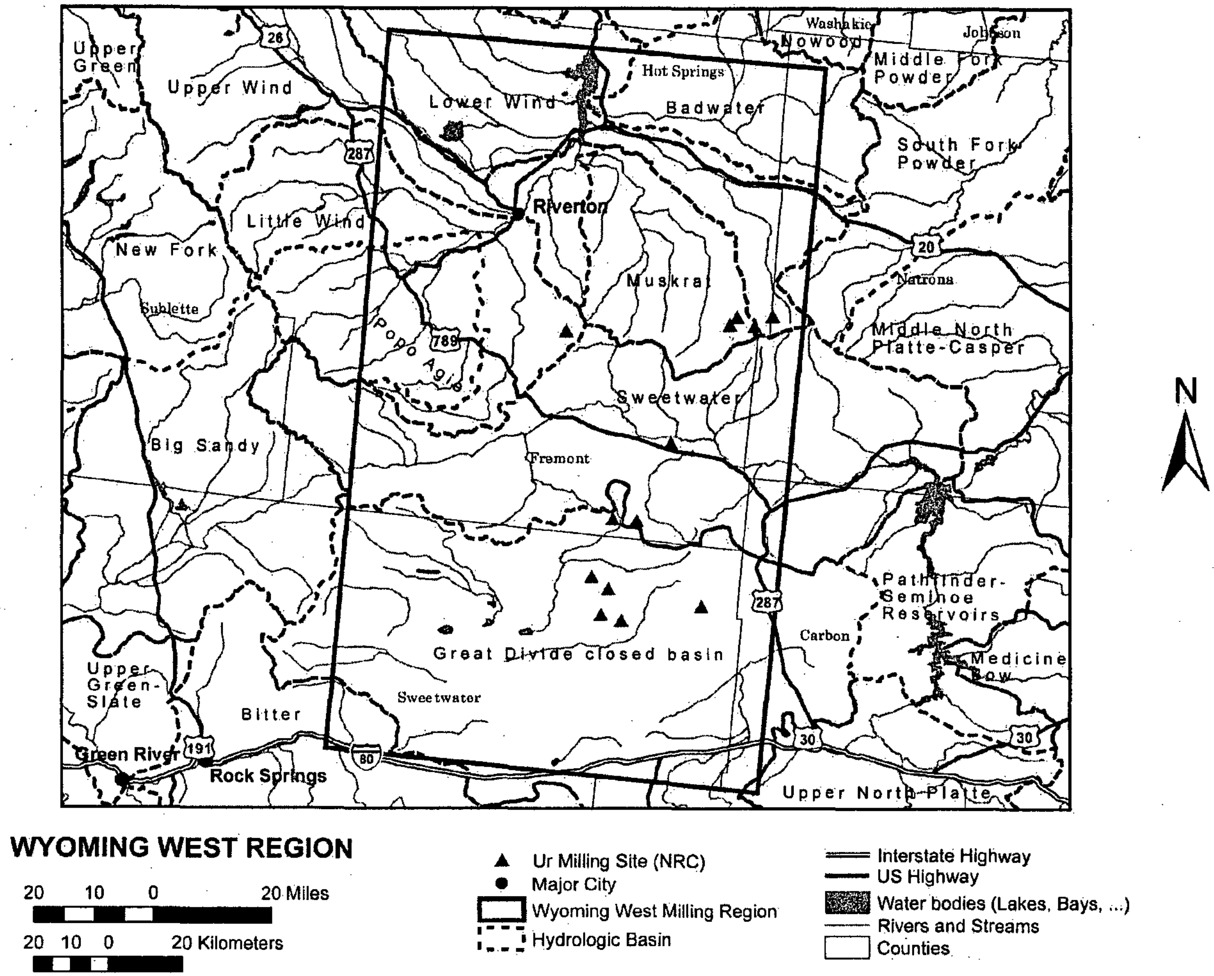


Figure 3.2-6. Watersheds in the Wyoming West Uranium Milling Region

district. The Gas Hills district is also drained by a number of other ephemeral stream channels with small surface water impoundments. Mapped springs in the district are Puddle Spring and Willow Spring.

The Little Wind River Watershed is located west of the Muskrat Creek Watershed and roughly centered on Riverton, Wyoming. The Little Wind River is classified as 2AB (Table 3.2-4). The average flow of the Little Wind River at Riverton for water years 1942 through 2008 was 16 m^3/s [556 ft^3/s] (U.S. Geological Survey, 2008).

The Popo Agie River Watershed is located west of the Little Wind River Watershed on the eastern flank of the Wind River Mountains in Fremont County. The Popo Agie River is classified as 2AB (Table 3.2-4). The average flow of the Popo Agie River between 1947 and 1971 was 2.3 m^3/s [80 ft^3/s] (U.S. Geological Survey, 2008). No historical uranium mining or milling has occurred within the Popo Agie Watershed.

The Lower Wind River Watershed is located north and downstream of the Little Wind River Watershed. Water bodies in the Lower Wind River Watershed are generally classified as 2AB with some tributaries classified as 3B; the difference is that 3B waters are not designated and protected for drinking water, fisheries, or fish consumption (Table 3.2-4). Lower Muddy Creek and Lower Poison Creek are described as impaired due to fecal coliform (WDEQ, 2008). The average flow of the Wind River below Boysen Reservoir is 29.5 m^3/s [1,040 ft^3/s] (U.S. Geological Survey, 2008).

The Badwater Creek Watershed is located on the northern edge of the Wyoming West Uranium Milling Region northeast of the Muskrat Creek Watershed. Water bodies in the Badwater Creek Watershed are generally classified as 2AB with some tributaries classified as 3B and 4B. The difference between 3B and 4B waters is that 4B waters do not have "other aquatic life" as a designated use (Table 3.2-4). No data are available on average flow in Badwater Creek.

3.2.4.2 Wetlands and Waters of the United States

The regulatory program of the U.S. Army Corps of Engineers (USACE) plays a critical role in the protection of the aquatic ecosystem and navigation. Under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899, the USACE performs the following services:

- Conducts jurisdictional determinations for wetlands and other Waters of the United States and navigable waters of the United States
- Authorizes activities in these jurisdictional areas through individual and general permits
- Ensures compliance of issued permits
- Enforces requirements of the law for unpermitted activities

Under Section 404 of the Clean Water Act, the Secretary of the Army is responsible for administering a regulatory program that requires permits to discharge dredged or fill material into waters of the United States, including wetlands.

Isolated waters such as playa lakes, prairie potholes, old river scars, cutoff sloughs, and abandoned construction and milling pits may also be waters of the United States if they meet certain criteria. Wetlands are found in many different forms including bottomland hardwood forests, wooded swamps, marshes, wet meadows, bogs, and playa lakes. Wetlands are of particular concern because they are valuable to restoring and maintaining the quality of the waters of the United States. Their functions include sediment trapping, nutrient removal, chemical detoxification, shoreline stabilization, aquatic food chain support, fish and wildlife habitat, floodwater storage, and groundwater recharge.

According to USACE (1987), wetlands are defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." A minimum of one positive indicator from each parameter (vegetation, hydrology, and soils) must be found to make a positive wetland determination.

- Vegetation—Under normal circumstances, an area is considered to have hydrophytic vegetation when more than 50 percent of dominant species, from all plant strata, are classified as Obligate (OBL), Facultative wet (FACW), or Facultative (FAC). Plants listed as Facultative Upland (FACUP), Not Listed (NL), or No Indicator (NI) are considered nonwetland plants for the purposes of wetland delineations.

- Hydrology—USACE (1987) requires that wetland soils must be continually saturated for a prolonged period (at least 5 percent) during the growing season.

- Soils—Hydric soils are those that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in their upper parts. Typical field indicators of hydric soils are the presence of thick organic layers, or in the case of predominantly mineral soils, a low chroma matrix (gray color) and/or bright mottling.

Man-made ponds and other surface features not immediately adjacent to traditional navigable waters do not fall under the jurisdiction of USACE. The landward regulatory limit for waters (in the absence of adjacent wetlands) is the ordinary high-water mark. The ordinary high-water mark is the line on the shores established by the fluctuations of water and indicated by physical characteristics such as

- A clear natural line impressed on the bank

- Shelving

According to the U.S. Fish and Wildlife Wetland Mapper (2007), numerous types of wetlands and waters are located within the region:

- **Perennial Streams**—A perennial stream has flowing water year round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow (USACE, 2000).

- **Intermittent Streams**—An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow (USACE, 2000).

- **Ephemeral Streams/Arroyos** (term used in arid regions)—An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral streambeds are located above the water table year round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow (USACE, 2000).

- Changes in the character of the soil
- Destruction of terrestrial vegetation
- The presence of litter and debris
- Other appropriate means that consider the characteristics of the surrounding areas

Waters of the United States and special aquatic sites that include wetlands would need to be identified and the impact delineated upon individual site selection for a potential ISL facility. Based on impacts and consultation with each area, an appropriate permit would need to be obtained from the local USACE district. Under Section 401 of the Clean Water Act, state water quality certification is required for work in waters of the United States. Within this region, the State of Wyoming regulates isolated wetlands and waters. Cumulative total project impacts greater than 0.04 ha [1 acre] require a general permit for wetlands mitigation by the Wyoming Department of Environmental Quality (WDEQ).

The majority of wetland areas located within the region consists of fresh water, ponds, emergent, or ponds with floating or submerged aquatic vegetation. These wetland areas are typically temporarily flooded on a seasonal basis. Numerous intermittent streams that are temporarily flooded are also found in the Wyoming West Uranium Milling Region.

3.2.4.3 Groundwater

Groundwater resources in the Wyoming West Uranium Milling Region are part of regional aquifer systems that extend well beyond the areas of uranium milling interest in this part of Wyoming. Uranium-bearing aquifers exist within these regional aquifer systems in the Wyoming West Uranium Milling Region. This section provides a general overview of the regional aquifer systems to provide context for a more focused discussion of the uranium-bearing aquifers in the Wyoming West Uranium Milling Region, including hydrologic characteristics, level of confinement, groundwater quality, water uses, and important surrounding aquifers.

3.2.4.3.1 Regional Aquifer Systems

The location of the Wyoming West Uranium Milling Region is shown in Figures 3.2-1 and 3.2-2. The Upper Colorado River Basin aquifer system is the major regional aquifer system (large-scale underground layer of water-bearing permeable rock or unconsolidated materials) in the southwest Wyoming West Uranium Milling Region. The Upper Colorado River Basin aquifer system extends over 51,800 km^2 [20,000 mi^2] in the Green River, the Great Divide, and the Washakie structural basins in the southwestern parts of Wyoming (Whitehead, 1996).

Groundwater in the Upper Colorado River Basin aquifer system flows from aquifer recharge areas toward the centers of the structural basins. Discharge from the aquifers is by upward leakage to shallower aquifers and to major streams. Groundwater is less than 61 m [200 ft] below the land surface in most parts of the aquifer system and is nearest the land surface near the major streams. In and near mountainous areas, depth to groundwater ranges from 152 to 305 m [500 to 1,000 ft].

The Upper Colorado River Basin aquifer system in southwestern Wyoming consists of layered sedimentary formations. Whitehead (1996) grouped the sedimentary formations

into five principal aquifers. From shallowest to deepest, they are the Laney aquifer, the Wasatch-Fort Union aquifer, the Mesaverde aquifer, a series of sandstone aquifers from the Dakota Sandstone through the Nugget Sandstone aquifers, and the Paleozoic aquifers.

The uppermost aquifer in the Wyoming part of the Upper Colorado River Basin aquifer system is the Laney aquifer. It is the highest permeability member of the Green River Formation. This aquifer consists of fractured sandstone beds and yields sufficient water for domestic and livestock watering supplies. Water in the Laney aquifer is fresh to slightly saline.

The Wasatch-Fort Union aquifer (that includes the Wasatch Formation and the Fort Union Formation) is composed of the major water-yielding sandstones interbedded with shale, mudstone, and some coal beds. The thickness of the Wasatch-Fort Union aquifer is notable and reported to be about 3,350 m [11,000 ft] thick in Sublette County and about 2,135 m [7,000 ft] thick near the center of the Great Divide Basin in south-central Wyoming. The regional groundwater flow direction in the eastern part of the aquifer is from recharge areas at basin margins toward the Great Divide Basin and southward into Colorado toward the center of the Washakie Basin. In the western part of the aquifer, water flows from recharge areas toward the Green River and its tributaries and toward the Flaming Gorge Reservoir in South Wyoming. Most of the fresh water in the Upper Colorado River Basin aquifer system is in the Wasatch-Fort Union aquifer, but the aquifer locally, where it is deeply buried, contains saline water. The Green River Formation overlies the Wasatch-Fort Union aquifer and forms an effective confining unit in most places.

The Mesaverde aquifer is composed of sandstone beds. In most places, the Mesaverde aquifer and the Wasatch-Fort Union aquifer are hydraulically connected. However, the Lewis Shale locally overlies the Mesavarde aquifer in the Great Divide and the Washakie Basins. The Mesaverde aquifer crops out at the land surface surrounding the Rock Springs Uplift. The groundwater flow direction in the Mesaverde aquifer is from recharge areas at the Rock Springs Uplift and near the eastern limit of the aquifer system toward the centers of structural basins. The aquifer contains fresh water locally at outcrop (recharge) areas, but it contains saline or brine water where the aquifer is deeply buried (e.g., in the Washakie Basin in southwestern Wyoming). The Mesaverde aquifer is hydraulically separated from deeper aquifers in Mesozoic rocks through thick confining layers that consist primarily of shale.

The Dakota and the Nugget aquifers consist of several sandstone formations separated by confining units. These aquifers crop out only locally in southwestern Wyoming and contain very saline water or brine in most places. A thick confining unit of Triassic- and Permian-aged rocks hydraulically separates them from the deeper Paleozoic aquifers.

The Tensleep Sandstone and the Madison Limestone are the principal aquifers in Paleozoic rocks. Groundwater in these aquifers flows toward the centers of the structural basins from adjacent topographically high areas. Groundwater discharges from the Tensleep Sandstone to the shallower aquifers occur by upward leakage. Much of the discharge from the Madison Limestone occurs by lateral movement of the groundwater into adjacent structural basins to the southeast and northeast. Because the Paleozoic aquifers are mostly deeply buried and contain saline water, they are not extensively used for water supply in southwestern Wyoming.

Recharge to the aquifers in most of the area is likely small, due to low annual precipitation and high evaporation rates (AATA International Inc., 2005). The mean annual precipitation in the Wyoming West Uranium Milling Region is typically in the range of 15–28 cm/yr [6–11 in/yr], but at high elevations, it locally exceeds 50 cm/yr [20 in/yr] based on precipitation data from

1971 to 2000 (AATA International Inc., 2005). The evaporation rate was estimated to be 105.9±7.1 cm/yr [41.7±2.8 in/yr] using the Kohler-Nordenson-Fox equation at the station in Lander, Wyoming (Curtis and Grimes, 2004).

In the central and northern portions of the Wyoming West Uranium Milling Region (near the Gas Hills region), the Wind River Formation contains the aquifers of primary importance. It consists of water-bearing sands and conglomerate units. The Wind River aquifer is underlain by a thick sequence of aquifers and aquitards. The primary aquifers in this sequence are the Cloverly Formation, the Nugget Formation, and the Pennsylvanian Tensleep Formation. Aquitards, which underlie the Wind River aquifer, are the Frontier, Mowry, Thermopolis, Morrison, Sundance, Chugwater, Dinwoody, and the Amsden Formations. The Chugwater and Sundance Formations comprise the primary aquitards underlying the Wind River Formation. The Wind River aquifer is overlain by the Wagon Bed, White River, and Split Rock Formation. Of these formations, the primary aquifer is the Split Rock Formation (NRC, 2004).

3.2.4.3.2 Aquifer Systems in the Vicinity of Uranium Milling Sites

An underlying hydrogeological system in past and current areas of uranium milling interest in the Wyoming West Uranium Milling Region consists of a thick sequence of primarily sandstone aquifers and shale aquitards. Uranium-bearing sandstone aquifers in the Wind River Formation (equivalent to the Battle Springs Formation at the proposed Lost Creek site and to the Green River Formation at the regional scale) are important sources for water supplies in the milling region.

Areas of uranium milling interest in the southern parts of the Wyoming West Uranium Milling Region near the Great Divide Basin (Crooks Gap) are underlain, from shallowest to deepest, by sedimentary deposits and sandstone layers (Quaternary aged), the Green River Formation, the Wasatch/Battle Springs Formation, the Fort Union Formation, and the Lance/Fox Hills Formation. This hydrogeological sequence is separated from the underlying Mesaverde Formation by the regionally continuous and impermeable Lewis Shale aquitard (AATA International Inc., 2005; Lost Creek ISR, LLC, 2007). All these formations host sandstone aquifers.

Areas of uranium milling interest in the northern parts of the Wyoming West Uranium Milling Region near the Gas Hills are underlain by the Late Tertiary-aged formation and deposits including the Split Rock, White River, and Wagon Bed Formations. Among these formations, the Split Rock Formation is the primary aquifer. This system is underlain by the Wind River Formation, the Fort Union Formation, and the Lance Formation. This sequence is underlain by a thick sequence of confined aquifers and aquitards. The most important underlying water supply aquifers involve the Cloverly aquifer, the Nugget Sandstone, and the Tensleep Sandstone (NRC, 2004).

3.2.4.3.3 Uranium-Bearing Aquifers

Uranium mineralization at locations of milling interest is typically hosted by the Early Tertiary-age confined sandstone aquifers in the Wyoming West Uranium Milling Region.

Confined sandstone beds in the Battle Springs Formation are the uranium-bearing aquifers in the Great Divide Basin (south-central Wyoming) within the southern portion of the Wyoming West Uranium Milling Region (AATA International Inc., 2005). Similarly, the Wind River Formation in the northern parts of the Wyoming West Uranium Milling Region near the Gas Hills

is the uranium-bearing aquifer. Uranium mineralization in the Gas Hills has been identified in six different sandstone layers in the Wind River Formation, which are named 30, 40, 60, 70, and 80 Sands. In some areas, these sand layers are hydraulically separated by confining units including siltstone, clay, and shale beds, while in other areas they are hydraulically and stratigraphically connected (NRC, 2004).

For ISL operations to begin, portions of the uranium-bearing sandstone aquifers in the Battle Springs Formation and in the Wind River Formation in the Wyoming West Uranium Milling Region would need to be exempted by the Underground Injection Control (UIC) Program administered by WDEQ (Section 1.7.2.1) for the purposes of uranium recovery (NRC, 2004).

Hydrogeological characteristics: In the Wyoming West Uranium Milling Region, the production aquifer system typically consists of confined sandstone aquifers. Aquifer properties (e.g., transmissivity, thickness, storage coefficient) vary spatially in the region. Based on field test data at the Gas Hills and in the Great Divide Basin, transmissivity of the ore-bearing aquifers ranges from 0.01–90 m^2/day [0.1–1,000 ft^2/day] in the region. For ISL operations to be practical, the hydraulic conductivity of the production aquifer must be large enough to allow reasonable water flow from injection to production wells. Hence, portions of the production aquifers with low hydraulic conductivities may not be amenable to uranium recovery using ISL techniques. The average storage coefficient of the ore-bearing aquifer is on the order of 10^{-4}, indicating the confined nature of the production aquifer (typical storage coefficients for confined aquifers range from 10^{-5}–10^{-3} (Driscoll, 1986, p. 68).

Hydrologic Terminology

Transmissivity: It is used to define the flow rate through the vertical section of an aquifer unit considering width and extending the full saturated height of an aquifer under unit hydraulic gradient. Transmissivity is a function of the aquifer's saturated thickness and hydraulic conductivity.

Storage Coefficient: It is used to characterize the capacity of an aquifer to release groundwater from storage in response to a decline in hydraulic head.

Hydraulic Conductitvity: It is a measure of the capacity of a porous medium to transmit water. It is used to define the flow rate per unit cross sectional area of an aquifer under unit hydraulic gradient.

Sandstone aquifers in the Battle Springs Formation are typically confined at the Lost Soldier and Lost Creek areas. However, the Battle Springs Formation locally crops out in the region, and hence the formation becomes locally unconfined. The transmissivity of the aquifer ranges from 8,690 to 24,800 L/day/m [700 to 2,000 gal/day/ft] {9–25 m^2/day [95 ft^2/day–270 ft^2/day]}, and the aquifer storage coefficient ranges from 3.0×10^{-4} to 8.0×10^{-4} (AATA International Inc., 2005; Lost Creek ISR, LLC, 2007). Lateral hydraulic gradients range from 0.05 at the Lost Soldier area to 0.0125 at the Lost Creek area, and range from 0.002 to 0.006 between these two sites (AATA International Inc., 2005). Hence, the lateral hydraulic gradients are an order of magnitude larger within the Lost Creek area and the Lost Soldier area than between these two sites. Collentine, et al. (1981, pp. 52–53) reported that wells in the Battle Spring aquifer typically yield 110–150 L/min [30–40 gal/min], but they are capable of yielding at least 570 L/min [150 gal/min].

Groundwater levels in the shallow, intermediate, and deep monitoring wells in the uranium-bearing aquifer were 55, 58, and 64 m [180, 190, and 210 ft] below the ground surface (AATA International Inc., 2005). These measurements indicate potential upward vertical flow within the Battle Springs Formation.

In the northern parts of the Wyoming West Uranium Milling Region, the uranium-bearing sandstone aquifers are typically confined as in the southern parts of the Wyoming West Uranium Milling Region. Transmissivity values in the uranium-bearing aquifers vary from 0.07 to 90 m^2/day [0.7 to 965 ft^2/day]. Aquifer storage coefficients vary in the range of 8.5×10^{-5} to 8.0×10^{-3}, with an average storage coefficient of 3.0×10^{-4} (NRC, 2004).

Level of confinement: The production aquifer is typically confined in the Wyoming West Uranium Milling Region; however, local unconfined conditions exist. The thickness of the confinement varies spatially.

At the regional scale, the thickness of the upper confinement of the Battle Springs Formation spatially varies. At the Lost Soldier and Lost Creek areas, the Battle Springs Formation is confined above by a 3- to 6-m [10- to 20-ft]-thick claystone unit (AATA International Inc., 2005). But, as noted previously, the Battle Springs Formation crops out over the northeastern portion of the Great Divide Basin, and hence locally unconfined conditions exist (Lost Creek ISR, LLC, 2007). The Battle Springs Formation is confined below by the continuous Lewis Shale at the local and regional scales. At the Lost Creek area, the Lewis Shale is up to 820 m [2,700 ft] thick (Lost Creek ISR, LLC, 2007). Thus, the sandstone aquifers in the Battle Springs Formation are confined at the Lost Soldier and Lost Creek areas. Aquitard vertical conductivity ranges from 1.2×10^{-3} to 2.2×10^{-3} m/day [4.0×10^{-3} to 7.3×10^{-3} ft/day] (AATA International Inc., 2005).

At the Gas Hills site, the production aquifers are typically confined. Five potential ISL sites are identified, and the thickness of the confinement spatially varies with the location of the potential ISL sites. For example, at Mine Unit 1, the uranium-bearing 70 Sand is confined above and below by relatively thick, continuous, low permeability units of the Wind River Formation. At Mine Unit 2, the 30, 50, 60, 70, and 80 Sands are typically separated by up to 6-m [20-ft]-thick confining layers. At Mine Unit 3, the 30, 40, and 50 Sands are separated by relatively thin {1.5- to 9-m [5- to 30-ft]-thick} confining layers. At Mine Unit 4, a 3- to 12-m [10- to 40-ft]-thick confining layer, overlies the 80 Sand locally in some parts of the region, while the 70 and 80 Sands are unconfined in other parts. The 60 Sand is locally confined above by a 3- to 6-m [10- to 20-ft]-thick confining layer and the 50 Sand is typically underlain by a 1.5- to 9-m [5- to 30-ft]-thick confining layer in the region. The 50 Sand at Mine 5 is confined above by a 4.5- to 12-m [15- to 40-ft]-thick confining unit and confined below by a 6- to 12-m [20-to 40-ft]-thick confining layer (NRC, 2004).

Groundwater quality: In some parts of the Wyoming West Uranium Milling Region, the total dissolved solids (TDS) levels in the uranium-bearing aquifers exceed the U.S. Environmental Protection Agency's (EPA's) drinking water standards. The uranium and radium-226 concentrations in the uranium-bearing aquifers typically exceed their respective EPA Maximum Contaminant Levels.

Groundwater of the Battle Springs Formation is of bicarbonate-sulfate-calcium type or bicarbonate-calcium type. The TDS level ranges from 200 to 400 mg/L [200 to 400 ppm], which is below the EPA's Secondary Drinking Water Standard of 500 mg/L [500 ppm]. In general, groundwater quality in the Battle Spring aquifer has the best overall quality in the county. The only notable exceptions were from high concentration of radionuclides (radium-226 and radium-228) in several samples (Mason and Miller, 2004). The quality of groundwater near the town of Bairoil meets drinking water quality standards for all chemical constituents except for the elevated uranium and radium-226 concentrations associated with the roll-front uranium deposits

(AATA International Inc., 2005). Uranium and radium-226 concentrations typically exceed their respective EPA Maximum Contaminant Levels of 0.03 mg/L [0.03 ppm] and 5 pCi/L.

Groundwater from the Wind River Formation in the Gas Hills area is of calcium-sulfate and calcium-sodium-bicarbonate-sulfate type. The TDS level in the Wind River Formation is commonly higher {623 to 1,887 mg/L [623 to 1,887 ppm]} than in the Battle Springs Formation and exceeds the EPA's Secondary Drinking Water Standard. Similar to the Battle Springs Formation, both the uranium {0.04 mg/L [0.04 ppm on the average]} and radium-226 (5–50 pCi/L away from the ore zone) exceed respective EPA Maximum Contaminant Levels (NRC, 2004).

Current groundwater uses: Groundwater withdrawn from the Battle Springs Formation is primarily used for public water supply and agricultural purposes of the town of Bairoil (AATA International Inc., 2005). Groundwater use in the Gas Hills area is typically limited to livestock, wildlife watering, and to a lesser extent, industrial uses. In vicinity of the Gas Hills area, groundwater is not used for domestic and irrigation supplies (NRC, 2004). At the regional scale, the Laney aquifer also yields sufficient water for domestic and livestock watering (Whitehead, 1996).

3.2.4.3.4 Other Important Surrounding Aquifers for Water Supply

At the regional scale, the Laney aquifer, the Wasatch-Fort Union aquifer, the Mesaverde aquifer, the Dakota and the Nugget aquifers, and the Paleozoic aquifers are the important aquifers for water supply in the region (Whitehead, 1996). Among these aquifers, the Paleozoic aquifers are used less extensively, because they are mostly deeply buried and contain saline water. The Laney and the Wasatch-Fort Union aquifers are locally hydraulically connected. The Mesaverde aquifer is also locally hydraulically connected to the overlying Wasatch-Fort Union aquifer. However, in most places, these two aquifers are separated by the Lewis Shale at the regional scale.

At the Great Divide, the Battle Springs Formation interfingers with sandstone aquifers in the Wasatch Formation and the Green River Formation, and it is underlain by sandstone aquifers in the Fort Union Formation and Lance/Fox Hills Formation. The Fox Hill Formation is considered to be a minor aquifer, but the others are usually considered to be relatively important aquifers in the region (AATA International Inc., 2005). The Fort Union aquifer is largely undeveloped in the Lost Creek area, and the reported transmissivity values are typically less than 30 m^2/day [325 ft^2/day] (Collentine, et al., 1981). The TDS levels in the Wasatch Formation in the west and south parts of the Great Divide Basin are typically higher than the EPA drinking water standards of 500 mg/L [500 ppm]. However, the TDS levels in the Battle Springs/Wasatch aquifers are generally less than 500 mg/L [500 ppm] along the northern side of the region (Lost Creek ISR, LLC, 2007).

In most parts of the Gas Hills area, the Wind River Formation is underlain by an aquitard that consists of the Chugwater (between the Nugget Sandstone and the Tensleep Sandstone) and Sundance Formations (between the Clovery Formation and the Tensleep Sandstone). The other important aquifers, including the Clovery Formation (equivalent to the Dakota Sandstone), Nugget Sandstone, and Pennsylvanian Tensleep Sandstone, are separated from the Wind River Formation by a series of thick aquitards.

3.2.5 Ecology

3.2.5.1 Terrestrial

A generalized overview and description of the habitat types and terrestrial species that may be found in areas used for milling operation are discussed in this section. These areas are broad and contain many subregions. For specific future locations of new milling sites, potential license applicants and the NRC review would be expected to address site-specific habitat types and terrestrial species.

Wyoming West Uranium Milling Region Flora

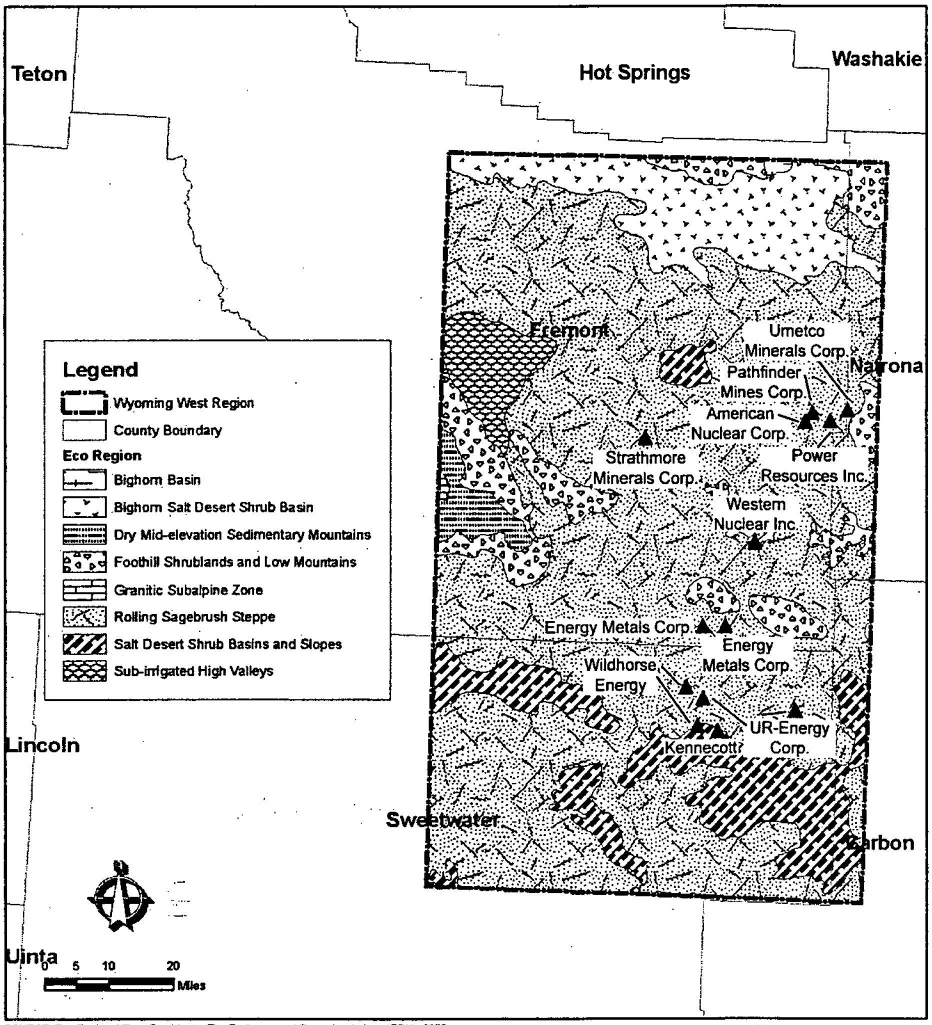
According to the EPA, the identified ecoregions in the Wyoming West Uranium Milling Region primarily consist of the Wyoming Basin and the Middle Rockies ecoregions (Chapman, et al., 2004). Figure 3.2-7 depicts the various ecoregions found within the Wyoming West Uranium Milling Region. Uranium milling districts within the uranium districts in the region are located within the Rolling Sagebrush Steppe and the Salt Desert Shrub Basin ecoregions of the Wyoming Basin.

The Wyoming Basin ecoregion is a broad, arid, intermontane basin interrupted by hills and low mountains and dominated by grasslands and shrublands. Nearly surrounded by forest-covered mountains, the region is drier than the Northwestern Great Plains to the northeast and does not have the extensive cover of pinyon-juniper woodland found in the Colorado Plateaus to the south. Much of the region is used for livestock grazing, although many areas lack sufficient forage to support this activity (Chapman, et al., 2004). Within the Wyoming Basin, the Wyoming West Uranium Milling Region contains several subecoregions that are described next, based on the descriptions of Chapman, et al. (2004).

The Rolling Sagebrush Steppe area of the Wyoming Basin is composed of rolling plains with hills, mesas, and terraces. Areas near the mountains may contain footslopes, ridges, alluvial fans, and outwash fans (Chapman, et al., 2004). The most abundant shrub vegetation in the region is Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), with silver sagebrush (*Artemisia cana*) and black sagebrush (*Artemisia nova*) occurring in the lowlands and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) in the higher elevations. Grass species include western wheatgrass (*Pascopyrum smithii*), needle-and-thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*), Sandberg bluegrass (*Poa secunda*), prairie junegrass (*Koeleria macrantha*), rabbitbrush (*Chrysothamnus nauseosus*), and fringed sage (*Artemisia frigida*) (Chapman, et al., 2004).

The Bighorn Basin is primarily an arid region influenced by the rainshadow effect of the Beartooth Mountains, Absaroka Range, and Pryor Mountains. This higher portion of the greater Bighorn Basin forms a transition from arid desert shrubland to semiarid shrubland. Sagebrush steppe vegetation dominates this region and is composed of species such as Wyoming big sagebrush, western wheat grass, blue wheatgrass (*Elymus magellanicus*), needle-and thread grass, blue grama, Sandberg bluegrass, junegrass (*Koeleria,* sp.), rabbitbrush, and fringed sage (Chapman, et al., 2004).

The Foothill Shrublands ecoregion serves as a transitional zone between the forested Dry Mid-Elevation Sedimentary Mountains ecoregion to the arid grassland and sagebrush regions in the Wyoming Basin and the High Plains (Chapman, et al., 2004). Vegetation found within this



SOURCE: Eco Regional Data Provided by The Environmental Protection Agency (EPA) - 2005

Figure 3.2-7. Ecoregions of the Wyoming West Uranium Milling Region (Based on Chapman, et al., 2004)

region include Sagebrush steppe communities, mountain mahogany woodlands that are often interspersed with mountain big sagebrush, blue grama, prairie junegrass, western wheatgrass, and ponderosa pine (*Pimas ponderosa*) savanna in the Laramie foothills (Chapman, et al., 2004).

The Subirrigated High Valleys are wet meadow systems located in areas of high drainage density beneath surrounding mountain ranges. Soil in this region remains moist due to the presence of a high water table. This region is abundant with floodplains, low terraces, riparian wetlands, and alluvial fans. As a result, the riparian areas and wet meadows are dominated by willows, alders, cottonwoods and wetland plants, such as horsetail (*Equisetum* sp.), spikerush (*Eleocharis* sp.), sedges (*Cyperaceae* sp.), and tufted hairgrass (*Deschampsia cespitosa*) found in low drainage areas. Shrubland areas may include Wyoming big sagebrush, western wheatgrass, needle-and-thread grass, blue grama, Sandberg blue grass, prairie junegrass, rabbitbrush, and fringed sage (Chapman, et al., 2004).

The Salt Desert Shrub Basins ecoregion is an arid environment that includes isolated playa lakes and sand dunes scattered throughout the Wyoming Basin. Vegetation in this area consists of arid land alkaline tolerant shrubs such as shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and Gardner saltbush (*Atriplex gardneri*) low in abundance. Plant life is more diverse on sand dunes, which provide greater moisture, higher permeability, and lower alkalinity than the basin floor. Vegetation found on stable sand dune areas includes alkali cordgrass (*Spartina gracilis*), Indian grass (*Sorghastrum nutans*), blowout grass (*Redfieldia flexuosa*), alkali wildrye (*Leymus simplex)*, and needle-and-thread grass (Chapman, et al., 2004).

The Bighorn Salt Desert Shrub Basins are composed of two large, arid, alkaline depressions surrounded by mountains. This region is geographically isolated from the other salt desert shrub basins in southern Wyoming. This region has a greater human influence due to the proximity to major rivers (Bighorn, Shoshone, and Greybull Rivers), which provide water for irrigation. This region receives approximately 15 cm [6 in] of precipitation per year and supports desert shrubs and grasses. Vegetation found in this region may consist of greasewood, Gardner saltbush, shadscale, alkali sacaton (*Sporobolus airoides*), and saltgrass (*Distichlis spicata*) (Chapman, et al., 2004). The vegetation around major rivers consists of open woodland of plains cottonwood (*Populus deltoides*), narrowleaf cottonwood (*Populus angustifolia*), peachleaf willow (*Salix amygdaloides*), and wild plum (*Prunus americana*).
The Middle Rockies ecoregion is composed of steep-crested, high mountains that are largely covered by coniferous forests.

The Bighorn and Beartooth Mountains and the Wind River and Teton Ranges comprise the Granitic Subalpine Zone. Snowmelt moisture, absorbed and released throughout the spring and summer, provides water for humans and wildlife living at lower elevations in the droughty, sedimentary fringes of these mountains. Subalpine forests are dominated by lodgepole pine (*Pinus contorta*) at the lower elevations, with subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) found in the higher elevations. The diversity of the understory is low and consists mostly of grouse whortleberry (*Vaccinium scoparium*), Oregon grape (*Mahonia aquifolium*), and birchleaf spirea (*Spiraea betulifolia*). The subalpine spruce-fir zone is not as heavily grazed by livestock as mid-elevation areas; it serves as summer range for mule deer (*Odocoileus hemious*) and elk (*Cervus Canadensis*) (Chapman, et al., 2004).

The Dry Mid-Elevation Sedimentary Mountains ecoregion includes the mid-elevation Bighorn Mountains and the drier northeastern portion of the Wind River Range that are underlain by sedimentary rocks. The lack of moisture in the soil is enhanced by the rainshadow effects of the two mountain ranges. Upland forest cover is open and patchy due to arid conditions. Forests of the Wind River Range are dominated by Douglas firs (*Pseudotsugai* ssp.) with an understory of grasses, forbs, and shrubs. Forest cover is more extensive on the east slopes of the Bighorns where there is more summer precipitation. A ponderosa pine/juniper/mountain mahogany association exists here similar to one in the Black Hills region to the east, but it is of limited extent. The forest of the eastern Bighorn Mountains lacks enough precipitation to support the eastern deciduous species and boreal vegetation present in the Black Hills. Some quaking aspen groves occur in this region, particularly in the Wind River Range (Chapman, et al., 2004).

A comprehensive listing of habitat types and species found in the aforementioned ecoregions has been compiled as part of the Wyoming Gap Analysis project (Wyoming Geographic Information Science Center, 2007a,b).

The Wyoming Gap Analysis project is part of the National Gap Analysis Program. It began in 1991 and was officially completed in November 1996. The program's main goal was to analyze the status of biodiversity within Wyoming, focusing on two biodiversity elements: land cover types and terrestrial vertebrate species. Land ownership and management for the state of Wyoming was combined with the data on land cover and species distributions in a geographic overlay. A Geographical Information System was used to determine which biodiversity elements were inadequately protected within the current system of areas managed for conservation (Wyoming Geographic Information Science Center, 2007a,b).

Wyoming West Uranium Milling Region Fauna

According to the official state list of birds, mammals, amphibians, and reptiles in Wyoming compiled by the Wyoming Game and Fish Department, approximately 246 bird, 127 mammal, 12 amphibian, and 27 reptile species are found in Wyoming. The official state list of the common and scientific names of the birds, mammals, amphibians, and reptiles in Wyoming can be obtained from the Wyoming Game and Fish Department (2007a).

According to the World Wildlife Fund's species database (World Wildlife Fund, 2007a,b), approximately 285 different species are found within the Wyoming Basin. Common animals found in this region include large game mammals such as moose (*Alces alce*), pronghorn (*Antilocapra americana*), elk, mule deer, white tailed deer (*Odocoileus virginianus*), bighorn sheep (*Ovis Canadensis*), and American black bear (*Ursus americanus*). Numerous rodents such as chipmunks (*Tamias* spp.), squirrels (*Speermophilus* spp.), shrews (*Sorex* spp.), and rabbits (*Sylvilagus* spp.) and numerous myotic bat species are found within this region. Reptiles and amphibians found in the region include species such as the western rattlesnake (*Crotalus viridis*), gopher snake (*Pituophis caterifer*), garter snake (*Thamnophis elegans*), tiger salamander (*Ambystoma tigrium*), Woodhouse's toad (*Bufo woodhouii*), and spadefoot toad (*Scaphiopus* spp.). A diverse number of birds also inhabit this region, including hawks like the Cooper's hawk (*Accipter cooperii*), goshawk (*Accipiter gentilis*), and red-tailed hawk (*Buteo jamaicensis*) and the golden eagle (Aquila chrysaetos). Common birds in the region include finches (*Leucosticte* spp.), sparrows, owls (*Otus* spp.), swallows (*Tachycinets* spp.), and vireos (*Vireo* spp.) in addition to other songbirds. A noted species within this region is the white-tailed prairie dog (*Cynomys leucurus*). The white-tailed prairie dog towns in this region provide food for predators such as the coyote (*Canis latrans*), the swift fox (*Vulpes velox*), and the

black-footed ferret (*Mustela nigripes*)—a federally recognized endangered species (World Wildlife Fund, 2007a,b).

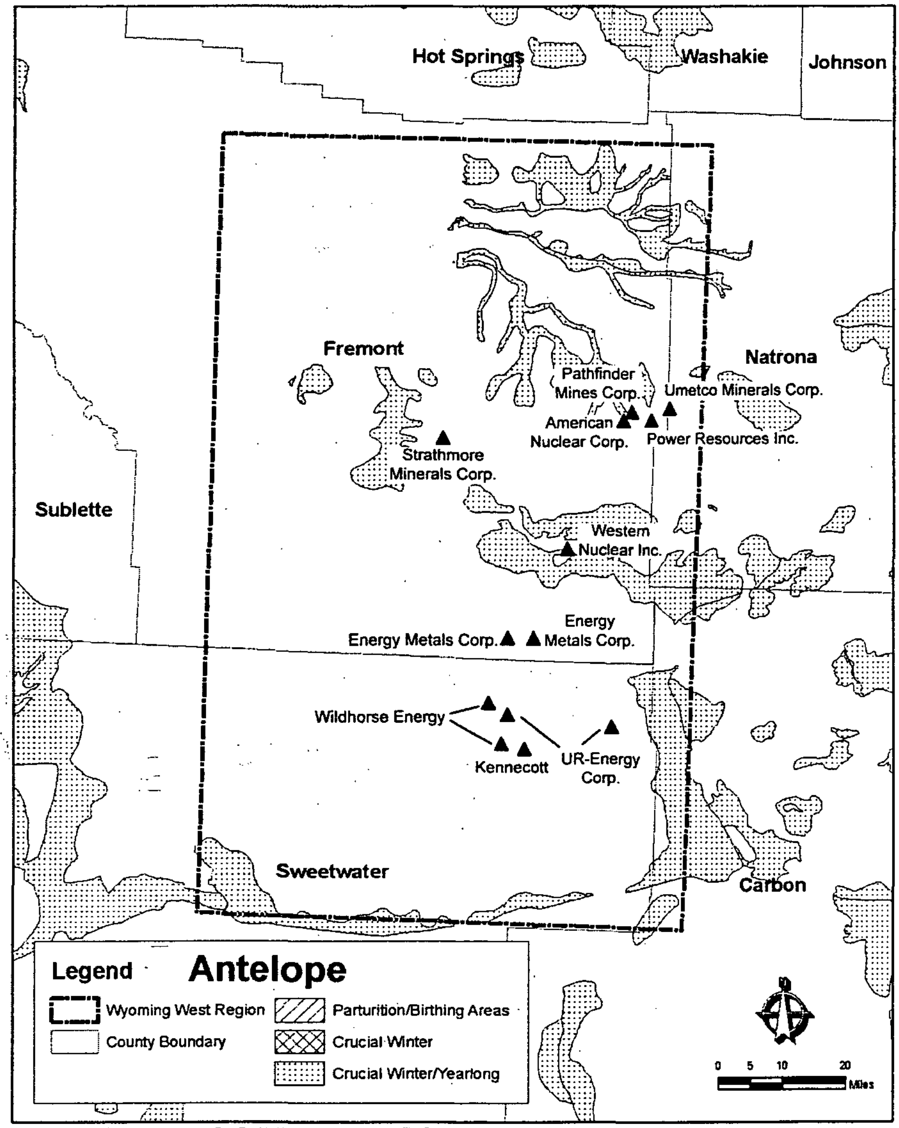
The Foothill Shrublands ecoregion is a transition region between the Dry Mid-Elevation Sedimentary Mountains ecoregion, Wyoming Basin Shrublands, the Northwest Great Plains, and the South Central Rockies Forest. Species found in this region will overlap all regions. Again, large mammal species such as bighorn sheep, cougar (*Puma concolor*), American bison (*Bison bison*), pronghorn, moose, elk, and coyotes can be found in this region. Shrews, voles (*Microtus* spp.), rabbits, squirrels, and prairie dogs common to the other ecoregions can also be found in this transition area. Raptors such as Cooper's hawk, goshawk, red-tailed hawk, golden eagles, and numerous owl species are bird predators in this area. Common bird species in the region include finches, sparrows, swallows, vireos, warblers, and kingbirds (*Tyrannus* spp.) in addition to other songbirds (World Wildlife Fund, 2007a–e).

The Middle Rockies ecoregion contains over 300 different species. This region features large, important herds of elk and mule deer, which are the main game species in this region. Large predators such as cougar and black bear are also abundant. Other mammals found in this region include the wolverine (*Gulo gulo*), lynx (*Lynx canadensis*), pronghorn, beaver (*Castor canadensis*), coyote (*Canis latrans*), Gunnison's prairie dog (*Cynomys gunnisoni*), black-tailed prairie dog (*Cynomys ludovicianus*), porcupine (*Eremophila dorsatum*), bat, and American marten (*Martes americana*). Numerous rodents such as squirrels, voles, rabbits, rats, and mice occur in this region. Common birds in the region include many of the species found throughout Wyoming like bluebirds (*Sialia* ssp.), sparrows, ducks, woodpeckers, owls, hawks, and eagles. Reptile and amphibian species include the soft-shelled turtle (*Apalone* spp.), plateau striped whiptail (*Cnemidophorus velox*), western rattlesnake, many-lined skink (*Eumeces multivirgatus*), fence lizard (*Sceloporus* spp.), tiger salamander, western toad (*Bufo boreas*), and the Baird's spotted toad (*Bufo punctatus*) (World Wildlife Fund, 2007a–e).

According to the Wyoming Game and Fish Department, crucial wintering habitats are found within this region for large game mammals and nesting leks for the greater sage grouse (*Centrocercus urophasianus*) (Wyoming Game and Fish Department, 2007b). Figures 3.2-8 through 3.2-14 depict the crucial winter and yearlong ranges for large mammals and game birds found in this region. Crucial wintering areas for some species were not identified in the region. However, maps of the region were included for completeness whether species were identified or not. Most of the crucial areas for big game animals in the Wyoming West Uranium Milling Region are located in the Rattlesnake Hills and Granite Mountains in the central and northwestern parts of the region, or along the Sweetwater River and its tributaries. Sites identified within Crook's Gap and Gas Hills Uranium Districts are located in or near crucial winter/yearlong habitat for antelope, moose, and mule deer. Numerous sage-grouse leks and nesting areas are located near sites in both uranium districts, particularly in the southeastern portion of the study region (i.e., Crook's Gap Uranium District).

3.2.5.2 Aquatic

Within the Wyoming West Uranium Milling Region, several watersheds have been listed as aquatic habitat areas. These areas include the Lower Wind River/Boysen Reservoir Watershed, Upper Sweetwater River Watershed, lower Sweetwater Watershed, Middle Fork Popo Agie, Middle North Platte River Corridor, and the South Fork Powder River Watersheds. These watersheds are part of the larger Lower Wind River, Sweetwater, South Fork Powder River, and Middle North Platte-Casper Watersheds previously discussed in Section 3.2.4.1 (Wyoming Game and Fish Department, 2007b). The two uranium districts within the Wyoming West



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.2-8. Antelope Wintering Areas for the Wyoming West Uranium Milling Region

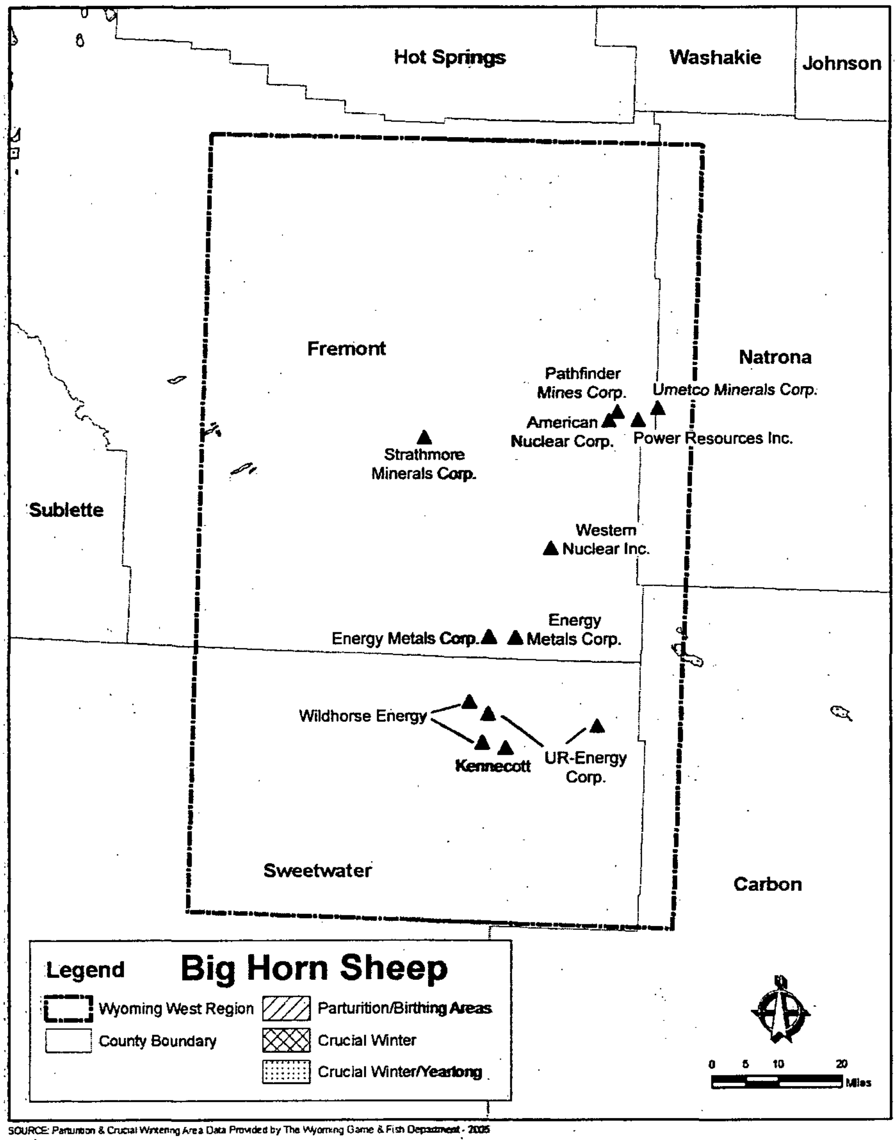
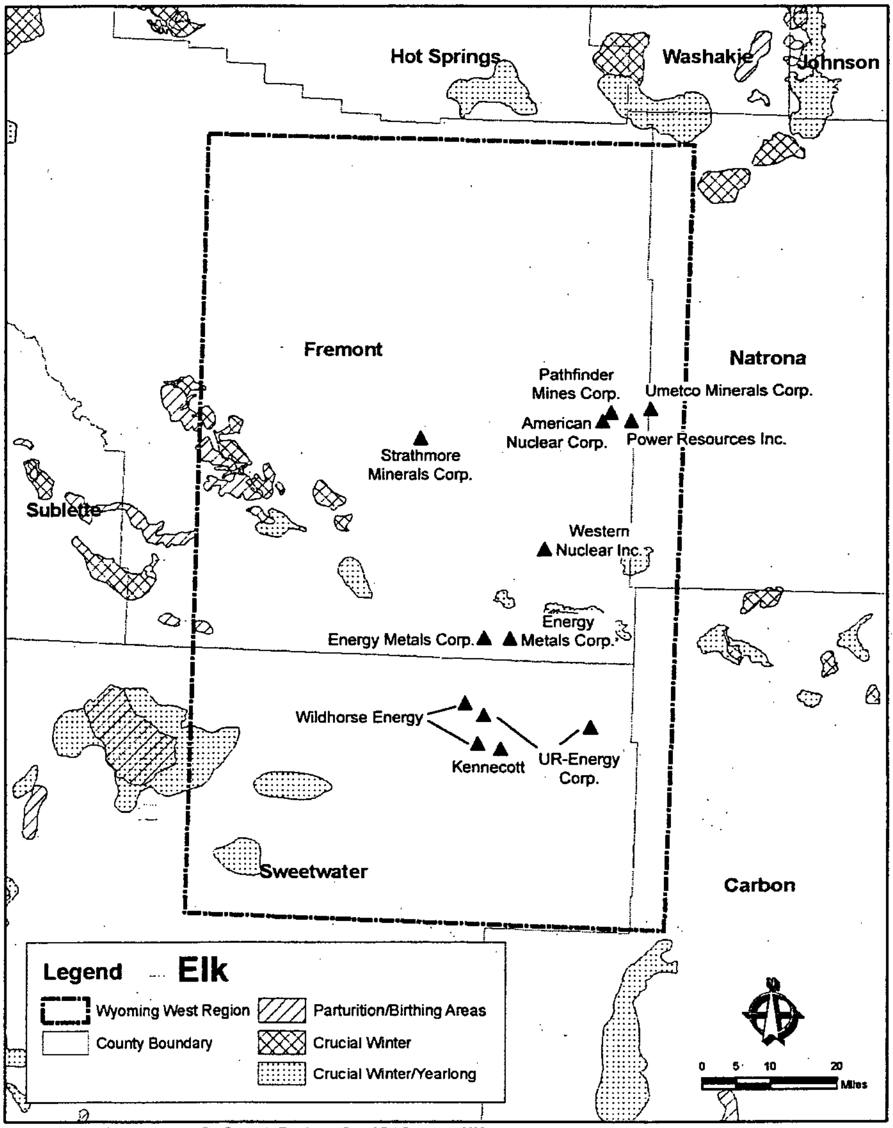
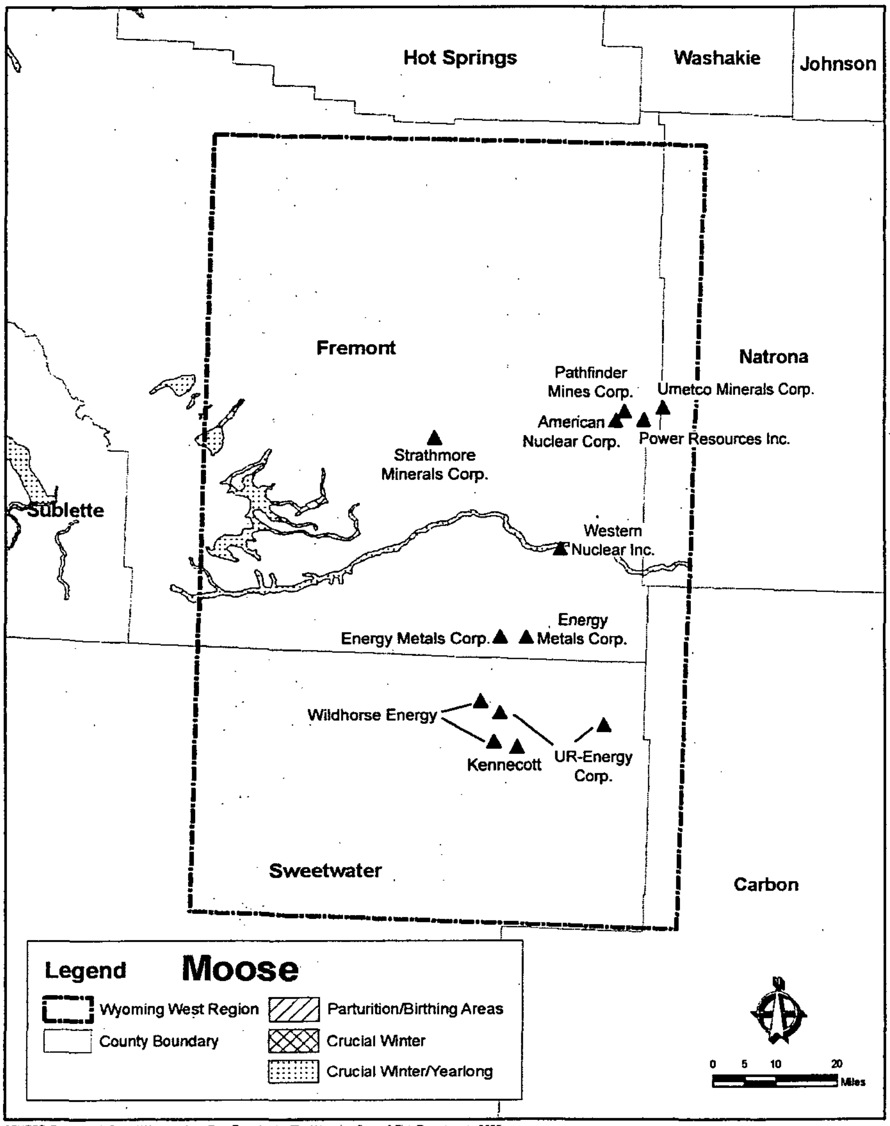


Figure 3.2-9. Big Horn Wintering Areas for the Wyoming West Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.2-10. Elk Wintering Areas for the Wyoming West Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.2-11. Moose Wintering Areas for the Wyoming West Uranium Milling Region

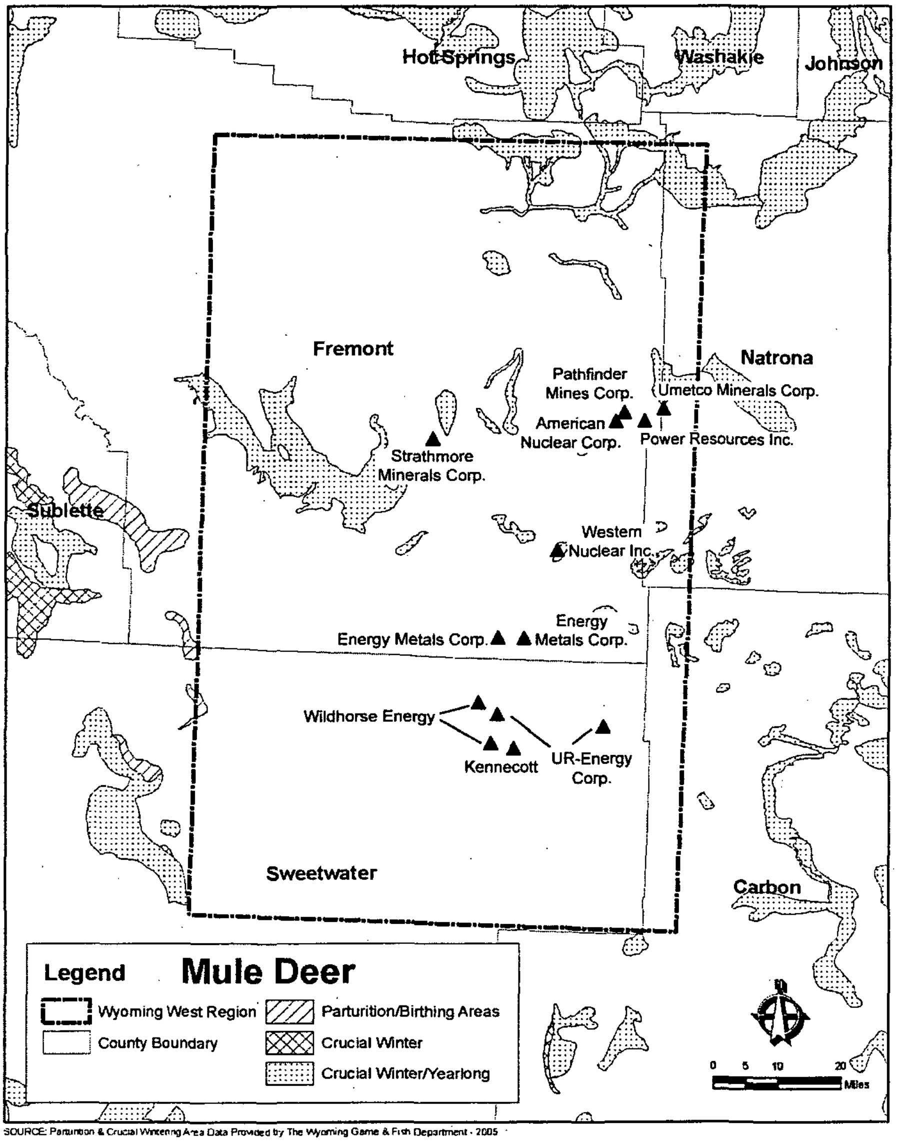
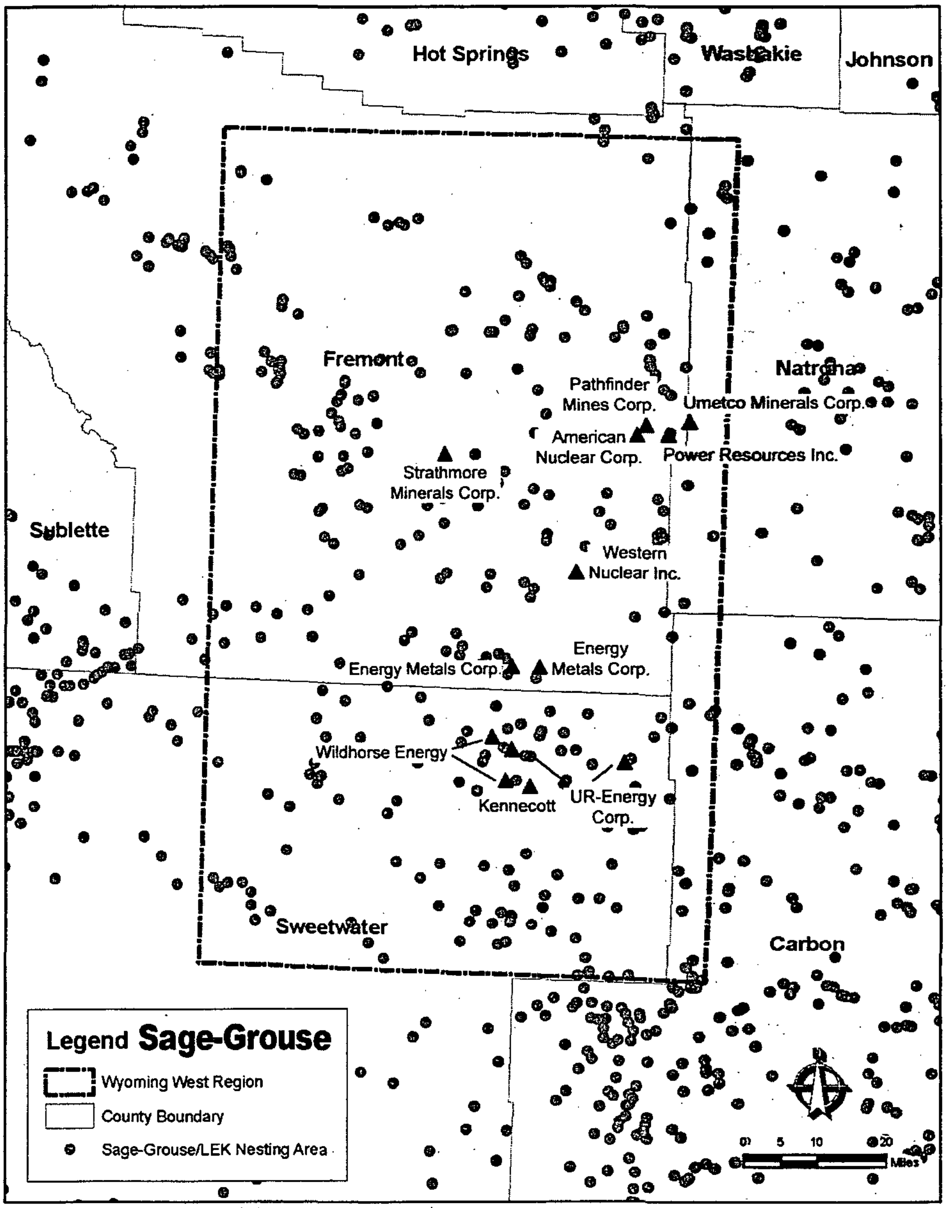
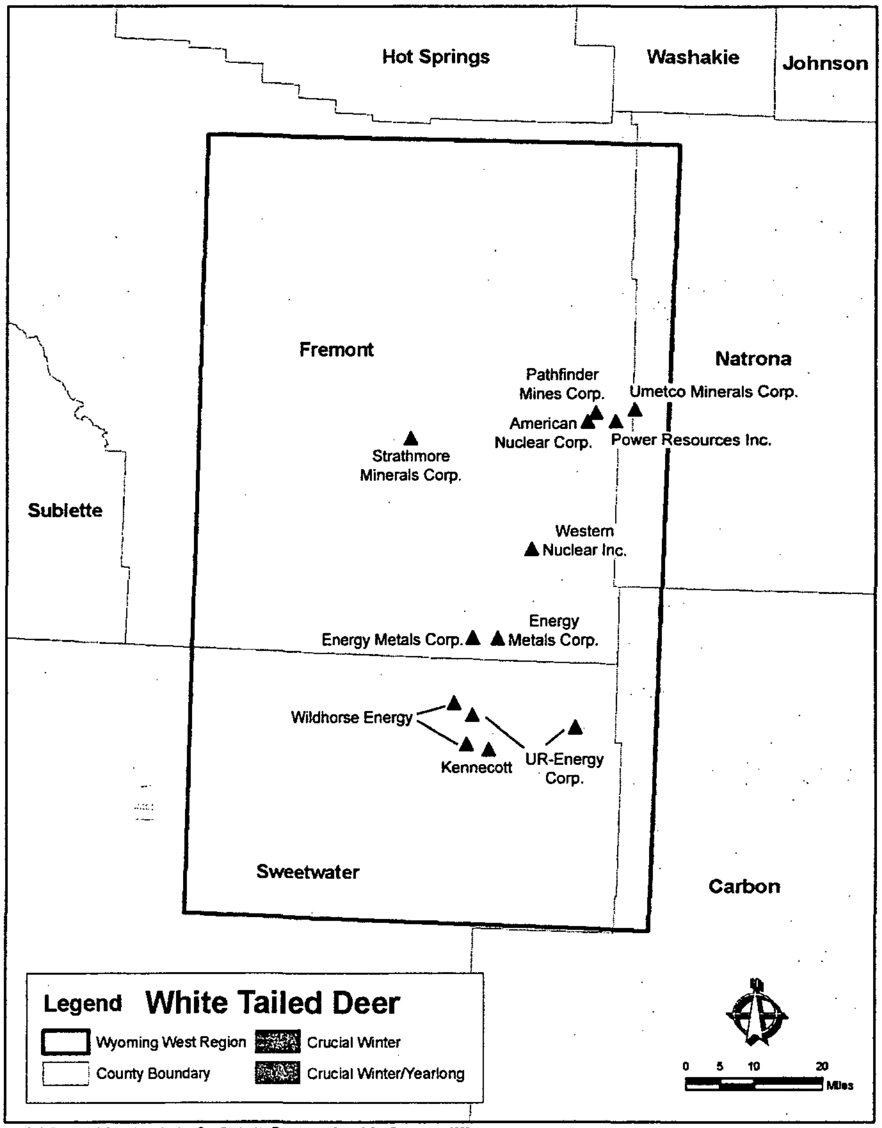


Figure 3.2-12. Mule Deer Wintering Areas for the Wyoming West Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.2-13. Sage-Grouse/Lek Nesting Areas for the Wyoming West Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.2-14. White Tailed Deer Wintering Areas for the Wyoming West Uranium Milling Region

Uranium Milling Region are located in the Sweetwater (Crooks Gap) and Wind River (Gas Hills) Watersheds.

According to the Wyoming Game and Fish Department (Wyoming Game and Fish Department, 2007b), there are approximately 49 native fish species found in the watersheds throughout the state. These species are identified in Table 3.2-5. Current conditions of these watersheds have been evaluated, and fish species that would benefit from conservation measures within the watersheds have been identified.

Table 3.2-5. Native Fish Species Found in Wyoming

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Bigmouth Shiner	*Notropis dorsalis*
Black Bullhead	*Ameiurus melas*
Bluehead Sucker	*Catostomus discobolus*
Brassy Minnow	*Hybognathus hankinsoni*
Burbot	*Lota lota*
Central Stoneroller	*Campostoma anomalum*
Channel Catfish	*Ictalurus punctatus*
Common Shiner	*Luxilus cornutus*
Creek Chub	*Semotilus atromaculatus*
Cutthroat Trout	*Oncorhynchus clarki*
Fathead Minnow	*Pimephales promelas*
Finescale Dace	*Phoxinus neogaeus*
Flannelmouth Sucker	*Catostomus latipinnis*
Flathead Chub	*Platygobio gracilis*
Goldeye	*Hiodon alosoides*
Hornyhead Chub	*Nocomis biguttatus*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
Lake Chub	*Couesius plumbeus*
Leatherside Chub	*Gila copei*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Mottled Sculpin	*Cottus bairdi*
Mountain Sucker	*Catostomus platyrhynchus*
Mountain Whitefish	*Prosopium williamsoni*
Orangethroat Darter	*Etheostoma spectabile*
Paiute Sculpin	*Cottus beldingi*
Pearl Dace	*Margariscus margarita*
Plains Killifish	*Fundulus zebrinus*
Plains Minnow	*Hybognathus placitus*
Plains Topminnow	*Fundulus sciadicus*
Quillback	*Carpiodes cyprinus*
Red Shiner	*Cyprinella lutrensis*
Redside Shiner	*Richardsonius balteatus*
River Carpsucker	*Carpiodes carpio*
Roundtail Chub	*Gila robusta*
Sand Shiner	*Notropis stramineus*

Table 3.2-5. Native Fish Species Found in Wyoming (continued)	
Common Name	**Scientific Name**
Sauger	*Stizostedion canadense*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*
Speckled Dace	*Rhinichthys osculus*
Stonecat	*Noturus flavus*
Sturgeon Chub	*Macrhybopsis gelida*
Suckermouth Minnow	*Phenacobius mirabilis*
Utah Chub	*Gila atraria*
Utah Sucker	*Catostomus ardens*
Western Silvery Minnow	*Hybognathus argyritis*
White Sucker	*Catostomus commersoni*

The Lower Wind River discharges into the Boysen Reservoir. Additional waterways that are included in the basin are the Stagner Creek, Gold Creek, Cottonwood Creek, Birdseye Creek, Reservoir Creek, Muddy Creek, Poison Creek, and Cottonwood Drain. Aquatic species found in this system include sauger (*Stizostedion canadense*), burbot (*Lota lota*), mountain whitefish (*Prosopium williamsoni*), stonecat (*Noturus flavus*), channel catfish (*Ictalurus punctatus*), longnose dace (*Rhinichthys cataractae*), northern redhorse (*Moxostoma aureouim*), and flathead chub (*Platygobio gracilis*). Sport fish that occur in the watershed include rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), walleye (*Sander vitreus*), brook trout (*Salvelinus fontinalis*), lake trout (*Salvelinus namaycush*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and black bullhead (*Ameiurus melas*) (Wyoming Game and Fish Department, 2007b).

The Middle Fork Popo Agie Watershed is found in the western and southern portion of the Wyoming West Uranium Milling Region. Contributing waterways include Saw and Sawmill Creeks. Species in this watershed have been impacted by erosion and sediment processes that have been accelerated by human activities such as prolonged annual herbivory, increased drainage from roads and trails, removal of water for irrigation, dewatering of wetlands, and rural subdivision development. Native species found within this watershed include the lakechub (*Couesius plumbeus*), longnose dace, longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersonii*), mountain sucker (*Catostomus platyrhynchus*), mountain whitefish, and fathead minnow (*Pimephales promelas*). Sport fish found in this watershed include rainbow trout, brown trout, brook trout, Yellowstone trout (*Oncorhynchus clarki bouvieri*), Snake River cutthroat trout (*Oncorhynchus clarki* ssp.), and grayling (*Thymallus thymallus*) (Wyoming Game and Fish Department, 2007b).

The Upper Sweetwater River headwaters in the Wind River Mountains flows across the South Pass uplift area. Native species found within this watershed include the lake chub, creek chub (*Semotilus atromaculatus*), longnose dace, longnose sucker, white sucker, mountain whitefish, fathead minnow, Iowa darter (*Etheostoma exile*), and mountain sucker. Sport fish found in this watershed include rainbow trout, brown trout, brook trout, Fall River rainbow (*Oncorhynchus mykiss gairdnerii*), Yellowstone cutthroat trout, Snake River cutthroat, and Bear River cutthroat (Wyoming Game and Fish Department, 2007b).

The Lower Sweetwater River Watershed is found in the south central portion of the Wyoming West Uranium Milling Region. Contributing waterways include Crook Creek and Willow Creek.

Species in this watershed have been impacted by erosion and sediment processes that have been accelerated by human activities such as prolonged annual herbivory and increase drainage from roads and trails as a result of previous uranium milling operations in the Green Mountain Area. Native species found within this watershed include the lake chub, creek chub, longnose dace, longnose sucker, white sucker, mountain sucker, fathead minnow, bigmouth sucker (*Ictiobus cyprinellus*) and Iowa darter. Sport fish found in this watershed include rainbow trout, brown trout, brook trout, Fall River rainbow, and Bear River cutthroat (Wyoming Game and Fish Department, 2007b).

The South Fork Powder River-Murphy Creek basin is relatively dry and sparsely vegetated. Most of the streams are ephemeral or intermittent with few perennial streams. Many of these stream channels are degraded or actively degrading. Native fish species that can be found in this watershed include the creek chub, fathead minnow, flathead chub, longnose dace, plains minnow, sand shiner (*Notropis stramineus*), mountain sucker, and the plains killifish (*Fundulus zebrinus*) (Wyoming Game and Fish Department, 2007b).

The Middle North Platte River Corridor portion of the watershed is located on the eastern side of the Wyoming West Uranium Milling Region. Species found within this watershed include the brassy minnow (*Hybognathus hankinsoni*), common shiner, creek chub, fathead minnow, longnose dace, sand shiner (*Notropis stramineus*), stoneroller (*Campostoma anomalum*), longnose sucker, and white sucker with the rainbow trout, brown trout, cutthroat trout and channel catfish being sport fish (Wyoming Game and Fish Department, 2007b).

The Sweetwater River Muddy Creek and Horse Creek Watersheds are located in the southern portion of the Wyoming West Uranium Milling Region. This watershed region has been impacted by intense herbivory; the successional advance of big sagebrush steppe and absence of beaver dams are the perceived bottlenecks limiting watershed function. Native species found within this watershed include the bigmouth shiner, creek chub, fathead minnow, longnose dace, sand shiner, longnose sucker, white sucker, and Iowa darter. Sport fish in the watershed include rainbow trout, brown trout, cutthroat trout, and brook trout.

3.2.5.3 Threatened and Endangered Species

Federally listed threatened and endangered species known to exist in habitats in the West Wyoming Uranium Milling Region include the following:

- Black-Footed Ferret (*Mustela nigripes*)—Ferrets were once found throughout the Great Plains, from Texas, New Mexico, and Arizona to southern Saskatchewan, Canada. Ferrets eat prairie dogs and live in prairie dog burrows. Typical wild ferret behavior revolves around prairie dog towns. Wild ferrets hunt prairie dogs at night, but occasionally they are active above ground during the day. This is especially true of female ferrets hunting to feed their young. In search of prey, they move from one prairie dog burrow to the next (U.S. Fish and Wildlife Service, 2008).

- Blowout Penstemon (*Penstemon haydenii*)—Limited to the sandhills region of west-central Nebraska, and sand dune habitat in the northeastern Great Divide Basin in Wyoming. In Nebraska this plant typically occurs in "blowouts"—sparsely vegetated depressions in active sand dunes created by wind erosion. In Wyoming it occurs on sandy aprons or the lower half of steep sandy slopes deposited at the base of granitic or sedimentary mountains or ridges. It occurs at elevations ranging from 850–1,150 m

[2,800–3,800 ft] in Nebraska to 2,030–2,270 m [6,680–7,440 ft] in Wyoming. This species can be found in west-central Nebraska in Box Butte, Cherry, Garden, Morrill and Thomas Counties, and in the Wyoming West Uranium Milling Region in northwestern Carbon County (Center for Plant Conservation, 2008).

- Bonytail Chub (Gila elegans)—Found in slower water habitats in the main stream such as eddies, pools, sidechannels, and coves. They are found in streams below 1,220 m [4,000 ft] elevation. The bonytail chub is endemic to the Colorado River basin and found throughout the mainstemrivers and backwaters of the Upper and Lower Basins. This species is one of the rarest of the Colorado River fishes and is close to extinction (*U.S. Fish and Wildlife Service*, 2008).

- Canada Lynx (*Lynx canadensis*)—The Canada lynx inhabits mountain regions, primarily at elevations between 2,356 and 2,869 m [7,730 and 9,410 ft] and on slopes of 8 to 12 percent. It usually occurs in extensive tracts of dense coniferous forest, primarily Engelmann spruce and subalpine fir. It feeds primarily on snowshoe hares, especially during winter (thereby making habitat for showshoe hares a key consideration for lynx habitat). Older forests with a substantial understory of conifers or small patches of shrubs and young trees provide good quality lynx foraging habitat. The most important component of denning habitat is large woody debris, especially dense tangles of fallen trees and root wads. Such preferred habitat is relatively limited in Wyoming and occurs primarily in multiple use areas of the Shoshone and Bridger-Teton National Forests along the western boundary of the Wyoming West Uranium Milling Region. The national parks and designated wilderness areas in Wyoming tend to be marginal lynx habitat as they are either dominated by dry even-aged lodgepole pine forests, or are too steep and at too high an elevation (Wyoming Game and Fish Department, 2008).

- Colorado Pikeminnow (*Ptychocheilus lucius*)—Colorado pikeminnow were once abundant in the main reach of the Colorado River and most of its major tributaries in Colorado, Wyoming, Utah, New Mexico, Arizona, Nevada, California and Mexico. Now, they exist primarily in the Green River below the confluence with the Yampa Rive;, the lower Duchesne River in Utah; the Yampa River below Craig, Colorado; the White River from Taylor Draw Dam near Rangely, Colorado downstream to the confluence with the Green River; the Gunnison River in Colorado; and the Colorado River from Palisade, Colorado, downstream to Lake Powell. It is believed that the Colorado pikeminnow populations in the upper Colorado River basin are now relatively stable and in some areas may even be growing (U.S. Fish and Wildlife Service, 2008).

- Humpback Chub (*Gila cypha*)—The humpback chub lives primarily in canyons with swift currents and white water. Historically, it inhabited canyons of the Colorado River and four of its tributaries: the Green, Yampa, White and Little Colorado rivers. Now, there are two populations near the Colorado/Utah border—one at Westwater Canyon in Utah and one in an area called Black Rocks, in Colorado. Though now smaller in number than they were historically, the two populations seem to be fairly stable in these two areas (U.S. Fish and Wildlife Service, 2008).

- Interior Least Tern (*Sterna antillarum athalassos*)—The nesting habitat of the interior least tern includes bare or sparsely vegetated sand, shell, and gravel beaches; sandbars; islands; and salt flats associated with rivers and reservoirs. The birds prefer open habitat and tend to avoid thick vegetation and narrow beaches. Sand and gravel

bars within a wide unobstructed river channel, or open flats along shorelines of lakes and reservoirs, provide favorable nesting habitat. Nesting locations are often at the higher elevations away from the water's edge because nesting usually starts when river levels are high and relatively small amounts of sand are exposed. The size of nesting areas depends on water levels and the extent of associated sandbars and beaches. Highly adapted to nesting in disturbed sites, terns may move colony sites annually, depending on landscape disturbance and vegetation growth at established colonies (Texas Parks and Wildlife Department, 2007).

- Pallid Sturgeon (*Scaphirhynchus albus*)—This species is a bottom dweller, found in areas of strong current and firm sand bottom in the main channel of large turbid rivers such as the Missouri and Plotte River. The pallid sturgeon is a member of a primitive family that, like other sturgeon, has lengthwise rows of bony plates covering its body, rather than scales. Pallids are slow growing, late-maturing fish that feed on small fishes and immature aquatic insects. Spawning occurs from June through August (Platte River Endangered Partnership, 2008).

- Piping Plover (*Charadrius melodus*)—Piping plovers breed only in North America in three geographic regions: the Atlantic Coast, the Northern Great Plains, and the Great Lakes. Plovers in the Great Plains make their nests on open, sparsely vegetated sand or gravel beaches adjacent to alkali wetlands, and on beaches, sand bars, and dredged material islands of major river systems (U.S. Fish and Wildlife Service, 2008).

- Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*)—This species lives primarily in heavily vegetated, shrub-dominated riparian (streamside) habitats and immediately adjacent upland habitats along the foothills of southeastern Wyoming south to Colorado Springs along the eastern edge of the Front Range of Colorado. Documented distribution includes Albany, Laramie, Platte Goshen, and Converse counties in Wyoming (U.S. Fish and Wildlife Service, 2008)

- Razorback Sucker (*Xyrauchen texanus*)—This is a large river species not found in smaller tributaries and headwater streams. Found in water from 1–3 m [4–10 ft] in depth, adults are associated with areas of strong current and backwaters (Colorado Division of Wildlife, 2008). This species has been extirpated from Wyoming; however, it can be occasionally found in Sweetwater County (University of Wyoming, 2008).

- Ute Ladies' Tresses Orchid (*Spiranthes diluvialis*)—Populations of Ute ladies'-tresses orchids are known from three broad general areas of the interior western United States—near the base of the eastern slope of the Rocky Mountains in southwestern Wyoming and adjacent Nebraska and north-central and central Colorado; in the upper Colorado River basin, particularly in the Uinta Basin; and in the Bonneville Basin along the Wasatch Front and westward in the eastern Great Basin, in north-central and western Utah, extreme eastern Nevada, and southeastern Idaho. The orchid also has been discovered in southwestern Montana and in the Okanogan area and along the Columbia River in north-central Washington. The orchid occurs along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams. It typically occurs in stable wetland and seepy areas associated with old landscape features within historical floodplains of major rivers. It also is found in wetland and seepy areas near fresh-water lakes or springs (U.S. Fish and Wildlife Service, 2008).

- Western Prairie Fringed Orchid (*Platanthera praeclara*)—The western prairie fringed orchid is a plant of the tallgrass prairie and requires direct sunlight for growth. It is most often found in moist habitats or sedge meadows (U.S. Fish and Wildlife Service, 2008).

- Whooping Crane (*Grus americana*)—The whooping crane prefers fresh-water marshes, wet prairies, shallow portions of rivers and reservoirs, grain and stubble fields, shallow lakes, and lagoons for feeding and loafing during migration. The whooping crane formerly nested from central Illinois west to eastern North Dakota and north through the Canadian prairie provinces. It presently breeds in Wood Buffalo National Park in the Northwest Territories, Canada. It overwinters on the Texas Gulf Coast on and in the vicinity of the Aransas National Wildlife Refuge. A second foster population migrates from Grays Lake National Wildlife Refuge in Idaho to the Bosque del Apache National Wildlife Refuge on the Rio Grande River in New Mexico. In South Dakota, the whooping crane is a predictable spring and fall migrant in the Missouri River drainage and in western South Dakota (Platte River Endangered Partnership, 2008).

- Yellow-Billed Cuckoo (*Coccyzus americanus*)—Candidate—Throughout their range, preferred breeding habitat includes open woodland (especially where undergrowth is thick), parks, and deciduous riparian woodland. In the West, they nest in tall cottonwood and willow riparian woodlands. Nests are found in trees, shrubs, or vines an average of 1 to 3 m [3 to 10 ft] above ground (Harrison, 1979). Western subspecies require patches of at least 10 ha [25 acres] of dense, riparian forest with a canopy cover of at least 50 percent in both the understory and overstory (Montana Natural Heritage Program, 2008).

The state of Wyoming does not maintain a list of threatened or endangered plant or animal species, but has established a nongame bird and mammal plan that includes a list of species of special concern. The state considers all of the federally listed animal species to be species of special concern. Wyoming Species of Concern are described as Wyoming Native Species Status matrix 1 (populations are greatly restricted or declining—extirpation appears possible) and 2 (populations are declining or restricted in numbers and/or distribution—extirpation is not imminent. Wyoming Species of Concern that may be found in the Wyoming West Uranium Milling Region include the following:

- Flannelmouth Sucker (*Catostomus latipinnis*) Native Species Status 1—This species prefers large rivers with deep riffles and runs, they can also be found in smaller streams and sometimes in lakes. Native to the Colorado River drainage basin, in Wyoming it is found in the Green and Little Snake River drainages. In the spring it leaves the large rivers and ascend small tributary streams to spawn; migrations of over 225 km [140 mi] have been documented (Wyoming Game and Fish Department, 2008).

- Boreal Toad (*Bufo boreas*) Native Species Status 1—The southern Rocky Mountain population occurs from south-central Wyoming southward through the mountainous regions of Colorado to extreme north-central New Mexico. The toads inhabit a variety of wet habitats (i.e., marshes, wet meadows, streams, beaver ponds, glacial kettle ponds, and lakes interspersed in subalpine forest) at altitudes primarily between 2,400–3,400 m [8,000–11,500 ft] (U.S. Fish and Wildlife Service, 2008).

- Common Loon (*Gavia Immer*) Native Species Status 1—Lakes that are suitable for breeding are extremely limited in Wyoming and must have the following characteristics (Wyoming Game and Fish Department, 2008):

  — At least 4 ha [10 acres], although reproductive success is better on lakes that are greater than 10 ha [25 acres]

  — Free of human disturbance or in areas that are secluded from human activity

  — Between 1,800 and 2,400 m [1,000 and 8,000 ft] in elevation

  — Have clear water with a minimum visibility of 3 to 4 m [10 to 13 ft], as loons are visual predators

  — Islands or protected shore areas for nesting and raising young

  — Abundant populations of small to mid-sized fish

  — Greater than 2 m [6 ft] deep to prevent winter kill of fish

  — Remain ice free for at least 4 months to allow young to fledge

  — For nesting, lakes with partially forested, rocky shorelines; an area of shallow water with emergent vegetation; and a steep slope adjacent to the shoreline for an underwater approach to the nest

- Burbot (*Lota lota*) Native Species Status 1—The burbot lives in cold, deep lakes and large rivers. Immature fish prefer rubble substrate, while adults remain in deep water to prey on other fish. In Wyoming, the burbot is native to the Big Horn and Tongue River systems. It is found in larger lakes in the Lander and Dubois area, including Boysen Reservoir and Ocean Lake. It also occurs south to Missouri and Kansas and east to New England, as well as throughout Canada (Wyoming Game and Fish Department, 2008).

- Sauger (*Sander canadensis*) Native Species Status 2—The sauger prefers large rivers but may also be found in reservoirs. The fish is tolerant of turbid waters. In rivers the key component of sauger habitat is velocity. In the summer and spring they select low velocity areas having sand or silt substrates. Pool habitats are preferred by sauger especially in winter where they tend to select low velocity pools greater than 2 m [6 ft] deep. Native to streams east of the Continental Divide, today the sauger occurs in Wyoming in the Wind Big Horn River drainage and in the Tongue and Powder River drainages. It has apparently been extirpated from the North Platte River, where it had once been common (Wyoming Game and Fish Department, 2008).

- Yellowstone Cutthroat (*Oncorhynchus clarki bouvieri*) Native Species Status 2—The Yellowstone cutthroat lives in lakes, large rivers, and small tributary streams. Native to the Yellowstone River drainage downstream to the Tongue River, including the Big Horn and Clarks Fork River drainages, this trout is also found in Pacific Creek and other Snake River tributaries. All other occupation by this species east of the Continental Divide is from introductions (Wyoming Game and Fish Department, 2008).

- Cliff Tree Lizard (*Urosaurus ornata wrightii*) Native Species Status 2—This lizard prefers cliffs and rocky canyon slopes in sagebrush desert habitats. It is often found on the vertical surfaces of large boulders or rock cliffs. In Wyoming, the cliff tree lizard occurs in the extreme southwestern part of the state. It also ranges south through Utah and western Colorado to northern Arizona and northern New Mexico (Wyoming Game and Fish Department, 2008).

- Great Basin Gopher Snake (*Pituophis melanoleucas deserticola)*, Native Species Status 1—This snake prefers sagebrush communities and deserts in the plains zone. In Wyoming, it can be found in the south-central counties at lower elevations and west of the Continental Divide in the Wyoming Basin. Elsewhere, it is distributed from the Great Basin to eastern California, Oregon, and Washington (Wyoming Game and Fish Department, 2008).

- Rubber Boa (*Charina bottae)* Native Species Status 2—The rubber boa prefers areas with an abundance of flat rocks and water nearby. It does not inhabit Wyoming's arid regions, but may be found in the foothills and lower mountain zones of the northwestern corner of the state, south into Star Valley and east to the Big Horn Mountains. It is also distributed west of Wyoming to the Pacific Coast from British Columbia to northern California (Wyoming Game and Fish Department, 2008).

- Canada Lynx (*Lynx canadensis*) Native Species Status 1—The Canada lynx inhabits mountain regions, primarily at elevations between 2,356 and 2,869 m [7,730 and 9,413 ft] and on slopes of 8 to 12 percent. It usually occurs in extensive tracts of dense coniferous forest, primarily Engelmann spruce (*Picea englemannii*) and subalpine fir (*Abies lasiocarpa*). It feeds primarily on snowshoe hares (*Lepus americanus*), especially during winter, and the prime consideration for lynx is habitat for snowshoe hares. Older forests with a substantial understory of conifers or small patches of shrubs and young trees provide good quality lynx foraging habitat. The most important component of denning habitat is large woody debris, especially dense tangles of fallen trees and root wads. Such preferred habitat is relatively limited in Wyoming and occurs primarily in multiple use areas of the Shoshone and Bridger-Teton National Forests. The national parks and designated wilderness areas in Wyoming tend to be marginal lynx habitat as they are either dominated by dry even-aged lodgepole pine forests or steep and high elevation (Wyoming Game and Fish Department, 2008).

- Pale Milk Snake (*Lampropeltis triangulum multistrata*), Native Species Status 2—The pale milk snake prefers grasslands, sandhills, and scarp woodlands below 1,800 m [6,000 ft] in elevation. It is distributed throughout the northern Great Plains. In Wyoming, it can be found in the eastern counties and the Big Horn Basin (Wyoming Game and Fish Department, 2008).

- Smooth Green Snake (*Opheodrys vernalis*), Native Species Status 2—This snake occupies forested areas of the foothills and montane zones, preferring to spend much of its time under rocks, logs, and other objects. It is usually associated with lush vegetation. Two subspecies occur in Wyoming. *O. vernalis vernalis*, the eastern smooth green snake, is a relict population that occurs only in the Black Hills of Wyoming and South Dakota. *O. vernalis blanchardi* is the western subspecies and can be found in southeast and south-central Wyoming. Additionally, the smooth green snake occurs in parts of Canada, the northeastern and north-central United States, and as far west as

Utah, Idaho and New Mexico. In the west, the snake's distribution is highly disjointed (Wyoming Game and Fish Department, 2008).

- Yellow-Billed Cuckoo (*Coccyzus americanus*) Native Species Status 2—The yellow-billed cuckoo nests primarily in large stands of cottonwood-riparian habitat below 2,100 m [7,000 ft], including such habitats that occur in urban areas. It is a riparian obligate species that prefers extensive areas of dense thickets and mature deciduous forests near water, and requires low, dense, shrubby vegetation for nest sites (Wyoming Game and Fish Department, 2008).

- Greater Sage-Grouse (*Centrocercus urophasianus*) Native Species Status 2—Sage-grouse depend on a variety of sagebrush community types and associated habitats, including basin-prairie and mountain foothill shrublands and wet-moist meadows. Alfalfa and irrigated meadows also serve as habitat when immediately adjacent to sagebrush. Sage-grouse use different habitats during different times of the year (Wyoming Game and Fish Department, 2008).

- Bald Eagle (*Haliaeetus leucocephalus*) Native Species Status 2—The bald eagle nests near large lakes and rivers in forested habitat where adequate prey and old, large-diameter cottonwood or conifer trees are available for nesting. Highly productive nesting areas in the Greater Yellowstone Area were found to have open water available in winter, low severity of early spring weather, limited human activity, and high sinuosity and an abundance of islands, riffles, runs, and pools in the river. Migrating and wintering eagles congregate near open water areas where concentrations of prey are available, such as carcasses of game animals, and spawning areas for kokanee, trout, and other fish (Wyoming Game and Fish Department, 2008).

- Trumpeter Swan (*Cygnus buccinator*), Native Species Status 2—The trumpeter swan inhabits shallow marshes, ponds, lakes, and river oxbows. It prefers stable, quiet, and shallow waters where small islands, muskrat houses, or dense emergent vegetation provide nesting and loafing sites. Nutrient-rich waters, with dense aquatic plant and invertebrate growth, provide the most suitable habitat. Adequate forage in the prenesting period (April to May) is critical for nesting success. Winter habitat must provide extensive beds of aquatic plants that remain ice free. In Wyoming, cold temperatures and ice restrict trumpeters to sites where geothermal waters, springs, or outflow from dams maintain ice-free areas (Wyoming Game and Fish Department, 2008).

- Fringed Myotis (*Myotis thysanodes*), Native Species Status 2—The fringed myotis is found in a wide range of habitats, including coniferous forests, woodlands, grasslands, and shrublands, although it is probably most common in xeric woodlands, such as juniper, ponderosa pine, and Douglas fir. It typically forages over water, along forest edges, or within forests and woodlands. During summer, it uses a variety of roosts, including rock crevices, tree cavities, caves, abandoned mines, and buildings. During winter, it hibernates in caves, abandoned mines, and buildings (Wyoming Game and Fish Department, 2008).

- Long-Eared Myotis (*Myotis evotis*), Native Species Status 2—The long-eared myotis primarily inhabits coniferous forest and woodland, including juniper, ponderosa pine, and spruce fir. It typically forages over rivers, streams, and ponds within the forest-woodland

environment. During summer, it roosts in a wide variety of structures, including cavities in snags, under loose bark, stumps, buildings, rock crevices, caves, and abandoned mines. During winter, it is thought to hibernate primarily in caves and abandoned mines (Wyoming Game and Fish Department, 2008).

- Long-Legged Myotis (*Myotis volans*), Native Species Status 2—The long-legged myotis inhabits open, mature forest with standing dead trees, including montane and subalpine forest and ponderosa pine and juniper woodlands, primarily from 1,500 m to more than 3,300 m [5,000 to more than 11,000 ft]. It usually forages over open areas such as campgrounds and small forest clearings; over vegetated riparian areas; and within, above, and under the forest canopy. During summer, it roosts in tree cavities, buildings, rock crevices, caves, abandoned mines, and under loose bark. During winter, it hibernates primarily in caves and abandoned mines (Wyoming Game and Fish Department, 2008).

- Pallid Bat (*Antrozous pallidus*), Native Species Status 2—The pallid bat generally inhabits low desert shrublands, juniper woodlands, and grasslands and occasionally cottonwood riparian zones in those habitats. It is most common in low, arid regions with rocky outcroppings, particularly near water. During summer, it usually roosts in rock crevices and buildings, but also uses rock piles, tree cavities, shallow caves, and abandoned mines (Wyoming Game and Fish Department, 2008).

- Spotted Bat (*Euderma maculatum*), Native Species Status 2—The spotted bat occupies a wide variety of habitats, from desert scrub to coniferous forest, although it is most often observed in low deserts and basins and juniper woodlands. It roosts in cracks and crevices in high cliffs and canyons. It also may occasionally roost in buildings, caves, or abandoned mines, although cliffs are the only roosting habitat in which reproductive females have been documented (Wyoming Game and Fish Department, 2008).

- Townsend's Big-Eared Bat (*Plecotus townsendii*), Native Species Status 2—The Townsend's big-eared bat occupies a variety of xeric to mesic habitats, including coniferous forests, juniper woodlands, deciduous forests, basins, and desert shrublands, and is absent only from the most extreme deserts and highest elevations. However, this species requires caves or abandoned mines for roost sites during all seasons and stages of its life cycle, and its distribution is strongly correlated with the availability of these features (Wyoming Game and Fish Department, 2008).

3.2.6 Meteorology, Climatology, and Air Quality

3.2.6.1 Meteorology and Climatology

Wyoming's elevation results in relatively cool temperatures. Much of the temperature variations within the state can be attributed to elevation with average values dropping 1 to 2 °C [1.8 to 3.6 °F] per 300 m [1,000 ft] (National Climatic Data Center, 2005]. Summer nights are normally cool although daytime temperatures may be quite high. The fall, winter, and spring can experience rapid changes with frequent variations from cold to mild periods. Freezes in early fall and late spring are typical and result in long winters and a short growing season. In the mountains and high valleys, freezes can occur any time in the summer. During winter warm spells, nighttime temperatures can remain above freezing. Valleys protected from the wind by mountain ranges can provide ideal pockets for cold air to settle and temperatures in the valley

Table 3.2-6. Information on Two Climate Stations in the Wyoming West Uranium Milling Region*				
Station (Map Number)	**County**	**State**	**Longitude**	**Latitude**
Gas Hills 4 E (042)	Fremont	Wyoming	107°31W	42°50N
Jeffrey City (049)	Fremont	Wyoming	107°50W	42°30N

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.

can be considerably lower than on nearby mountainsides. Table 3.2-6 identifies two climate stations located in the Wyoming West Uranium Milling Region. Climate data for these stations are found in the National Climatic Data Center's Climatography of the United States No. 20 Monthly Station Climate Summaries for 1971–2000 (National Climatic Data Center, 2004). This summary contains climate data for 4,273 stations throughout the United States and some territories. Table 3.2-7 contains temperature data for two stations in the Wyoming West Uranium Milling Region.

Precipitation within Wyoming varies, with spring and early summer being the wettest time for much of the state. Mountain ranges are generally oriented in a north-south direction. This is perpendicular to the prevailing westerlies. Therefore, these mountains often act as moisture barriers. Air currents for the Pacific Ocean rise and drop much of their moisture along the western slopes of the mountains. Summer showers are frequent, but typically result in rainfall amounts of a few hundredths of an inch. Usually several times a year in the state, local thunderstorms will result in 2.5 to 5 cm [1 to 2 in] of rain in a 24-hour period. On rare occasions, rainfall in a 24-hour period can reach 7.5 to 12.5 cm [3 to 5 in] (National Climatic Data Center, 2005). Heavy rains can create flash flooding in headwater streams, and this flooding intensifies if these storms coincide with snowpack melting. Table 3.2-7 contains precipitation data for two stations in the Wyoming West Uranium Milling Region. The wettest month for both stations identified in Table 3.2-7 is May, which based on the snow depth data, coincides with snow pack melting (National Climatic Data Center, 2004). Both of these stations are in Fremont County. Data from the National Climatic Data Center's Storm Events Database from 1950 to 2007 indicate that the vast majority of thunderstorms in Fremont County occur between June and September with the most occurring in July (National Climatic Data Center, 2007).

Table 3.2-7. Climate Data for Stations in the Wyoming West Uranium Milling Region*			
		Gas Hills 4 E	**Jeffrey City**
Temperature (°C)†	Mean—Annual	5.5	5.3
	Low—Monthly Mean	−7.0	−7.0
	High—Monthly Mean	19.5	19.0
Precipitation (cm)‡	Mean—Annual	24.9	27.1
	Low—Monthly Mean	0.86	0.89
	High—Monthly Mean	3.33	5.71
Snowfall (cm)	Mean—Annual	154	143
	Low—Monthly Mean	0	0
	High—Monthly Mean	34.3	26.9

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.
†To convert Celsius (°C) to Fahrenheit (°F), multiply by 1.8 and add 32.
‡To convert centimeters (cm) to inches (in), multiply by 0.3937.

Hailstorms are the most destructive storm event for Wyoming. Most hailstorms pass over open rangeland with minimal impact. When a hailstorm passes over a city or farmland, the property and crop damage can be severe. Most of the severe hailstorms occur in the southeast corner of the state.

Low elevations typically experience light to moderate snowfall from November to May. Snowfall within Wyoming varies by location with the mountain ranges typically receiving the most. Significant storms of 25 to 40 cm [10 to 16 in] of snowfall are infrequent outside of the mountains. Wind often coincides or follows snowstorms and can form snow drifts several meters [feet] deep. Snow can accumulate to considerable depths in the high mountains. Blizzards that last more than 2 days are uncommon. Table 3.2-7 contains snowfall data for two stations in the Wyoming West Uranium Milling Region.

Wyoming is windy and ranks first in the United States with an annual average speed of 6 m/s [12.9 mph]. During winter, Wyoming frequently experiences periods where wind speed reaches 13 to 18 m/s [30 to 40 mph] with gusts to 22 to 27 m/s [50 or 60 mph] (National Climatic Data Center, 2005). Prevailing wind direction varies by location but usually ranges from west-southwest through west to northwest. Because the wind is normally strong and constant from those directions, trees often lean to the east or southeast.

The pan evaporation rates for the Wyoming West Uranium Milling Region range from about 76 to 127 cm [30 to 50 in] (National Weather Service, 1982). Pan evaporation is a technique that measures the evaporation from a metal pan typically 121 cm [48 in] in diameter and 25 cm [10 in] tall. Pan evaporation rates can be used to estimate the evaporation rates of other bodies of water such as lakes or ponds. Pan evaporation rate data is typically available only from May to October. Freezing conditions often prevent collection of quality data during the other parts of the year.

3.2.6.2 Air Quality

As described in Section 1.7.2.2, the permitting process is the mechanism used to address air quality. If warranted, permits may set facility air pollutant emission levels, require mitigation measures, or require additional air quality analyses. Except for Indian Country, New Source Review permits in Wyoming are regulated under the EPA-approved State Implementation Plan. For Indian Country in Wyoming, the New Source Review permits are regulated under 40 CFR 52.21 (EPA, 2007a).

State implementation plans and permit conditions are based in part on federal regulations developed by the EPA. As promulgated in 40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards (NAAQS), the NAAQS define acceptable ambient air concentrations for six common nonradiological air pollutants: nitrogen oxides, ozone, sulfur oxides, carbon monoxide, lead, and particulates. Primary NAAQS are established to protection public health, and secondary NAAQS are established to protect public welfare by safeguarding against environmental and property damage. Primary and secondary NAAQS are presented in Table 3.2-8. Some pollutants have multiple standards. Particulates are divided into two categories: PM_{10} defined as particulate matter smaller than 10 μm [3.9×10^{-4} in], and $PM_{2.5}$, defined as particulate matter smaller than 2.5 μm [9.8×10^{-5} in]. In June 2005, EPA revoked the 1-hour ozone standard nationwide in all locations except certain early action compact areas. None of the 1-hour ozone Early Action Compact Areas are in Wyoming. States may develop

Table 3.2-8. National Ambient Air Quality Standards*

Pollutant	Primary Standards	Averaging Times	Secondary Standards
Carbon Monoxide	9 ppm (10,000 μg/m^3)†	8 hours‡	None
	35 ppm (40,000 μg/m^3)†	1 hour‡	None
Lead	1.5 μg/m^3†	Quarterly average	Same as primary
Nitrogen Dioxide	0.053 ppm (100 μg/m^3)†	Annual (arithmetic mean)	Same as primary
Particulate Matter 10-μm diameter (PM_{10})	150 μg/m^3†	24 hours§	Same as primary
Particulate Matter 2.5-μm diameter ($PM_{2.5}$)	15.0 μg/m^3†	Annual‖ (arithmetic mean)	Same as primary
	35 μg/m^3†	24 hours¶	Same as primary
Ozone	0.08 ppm	8 hours#	Same as primary
	0.12 ppm	1 hour**	Same as primary
Sulfur Oxides	0.03 ppm	Annual (arithmetic mean)	Not applicable
	0.14 ppm	24 hours‡	Not applicable
	Not applicable	3 hours‡	0.5 ppm (1,300 μg/m^3)†

*Modified from U.S. Environmental Protection Agency. "National Ambient Air Quality Standards (NAAQS)." 2007. <http://www.epa.gov/air/criteria.html> (15 October 2007).
†Multiply μg/m^3 value by 2.7 × 10^{-8} to convert units to oz/yd^3.
‡Not to be exceeded more than once per year.
§Not to be exceeded more than once per year on average over 3 years.
‖To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 μg/m^3.
¶To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35.0 μg/m^3 (effective December 17, 2006).
#To attain this standard, the 3-year average of the fourth highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
**(a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤1, as determined by Appendix H. (b) As of June 15, 2005, the U.S. Environmental Protection Agency revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonatttainment Early Action Compact Areas.

standards that are stricter or supplement the NAAQS. Wyoming has a more restrictive annual average standard for sulfur dioxide at 60 μg/m^3 [1.6 × 10^{-6} oz/yd^3] and a supplemental 50 μg/m^3 [1.3 × 10^{-6} oz/yd^3] PM_{10} standard with an annual averaging time (WDEQ, 2008).

As promulgated in 40 CFR Part 52, Prevention of Significant Deterioration requirements identify maximum allowable increases in concentrations for particulate matter, sulfur dioxide, and nitrogen dioxide for areas designated as attainment. Different increment levels are identified for different classes of areas. Table 3.2-9 contains the maximum allowable Prevention of Significant Deterioration increments for Class I and Class II areas. Class I areas are locations with special natural, recreational, scenic, or historic value such as national parks or wilderness areas and have the most stringent set of allowable increments. Most other areas in the United States are categorized as Class II areas and have a less stringent set of allowable increments.

Table 3.2-9. Allowable Prevention of Significant Deterioration Class I and Class II Areas*			
Pollutant	**Class 1 (μg/m³)†**	**Class II (μg/m³)†**	**Measurement**
Nitrogen Dioxide (NO_2)	2.5	25	Annual average
PM_{10}‡	4	17	Annual average
	8	30	24 hours‡
Sulfur Dioxide (SO_2)	2	20	Annual average
	5	91	24 hours§
	25	512	3 hours§

*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40—Protection of the Environment, Part 52. Washington, DC: U.S. Government Printing Office. 2005.
†Multiply μg/m³ value by 2.7×10^{-8} to convert units to oz/yd³.
‡Not to be exceeded on more than 1 day/year on the average over 3 years.
§Not to be exceeded more than once per year.

One goal identified in the Clean Air Act is to address visibility impairment from haze at the Prevention of Significant Deterioration Class I areas in the country. Regional haze is visibility impairment caused by cumulative air pollutant emissions from numerous sources over a wide geographic area (EPA, 1999). Key contributors to regional haze are sulfur dioxide, nitrogen oxides, and particulate matter. One source of particulate matter is soil dust or fugitive dust. EPA, in 40 CFR Part 51, requires states to address regional haze in their implementation plans.

The Wyoming West Uranium Milling Region air quality description focuses on two topics: NAAQS attainment status and Prevention of Significant Deterioration classifications in the region.

NAAQS compliance attainment status is typically determined at the county level. Each NAAQS pollutant is designated into one of the following categories: attainment, nonattainment, or maintenance. Areas are designated as attainment for a particular pollutant if atmospheric concentrations meet NAAQS. If atmospheric concentrations of a pollutant do not meet NAAQS, that area is designated as nonattainment for that pollutant. The maintenance category describes areas formerly designated as nonattainment, but that now meet NAAQS requirements. Figure 3.2-15 identifies counties in Wyoming and surrounding areas that are partially or entirely designated as nonattainment or maintenance for NAAQS at the time this GEIS was prepared (EPA, 2007b). All of the area within the Wyoming West Uranium Milling Region is classified as attainment. In fact, Wyoming only has one area that is not in attainment. The city of Sheridan in Sheridan County is designated as nonattainment for PM_{10}. Portions of several Colorado counties along the southern Wyoming border are classified as not in attainment. However, the southern boundary of the Wyoming West Uranium Milling Region is north of the Wyoming/Colorado border.

Table 3.2-10 identifies the Prevention of Significant Deterioration Class I areas in Wyoming. These areas are shown in Figure 3.2-16. There are no Class I areas in the Wyoming West Uranium Milling Region (40 CFR Part 81).

EPA also encourages states to work with tribes and federal agencies in regional partnerships to address the regional haze issue. Wyoming is a member of the Western Regional Air Partnership. Also, specific provisions in 40 CFR Part 51 allow nine western states, including Wyoming, to implement the recommendations of the Grand Canyon Visibility Transport Commission within the regional haze program.

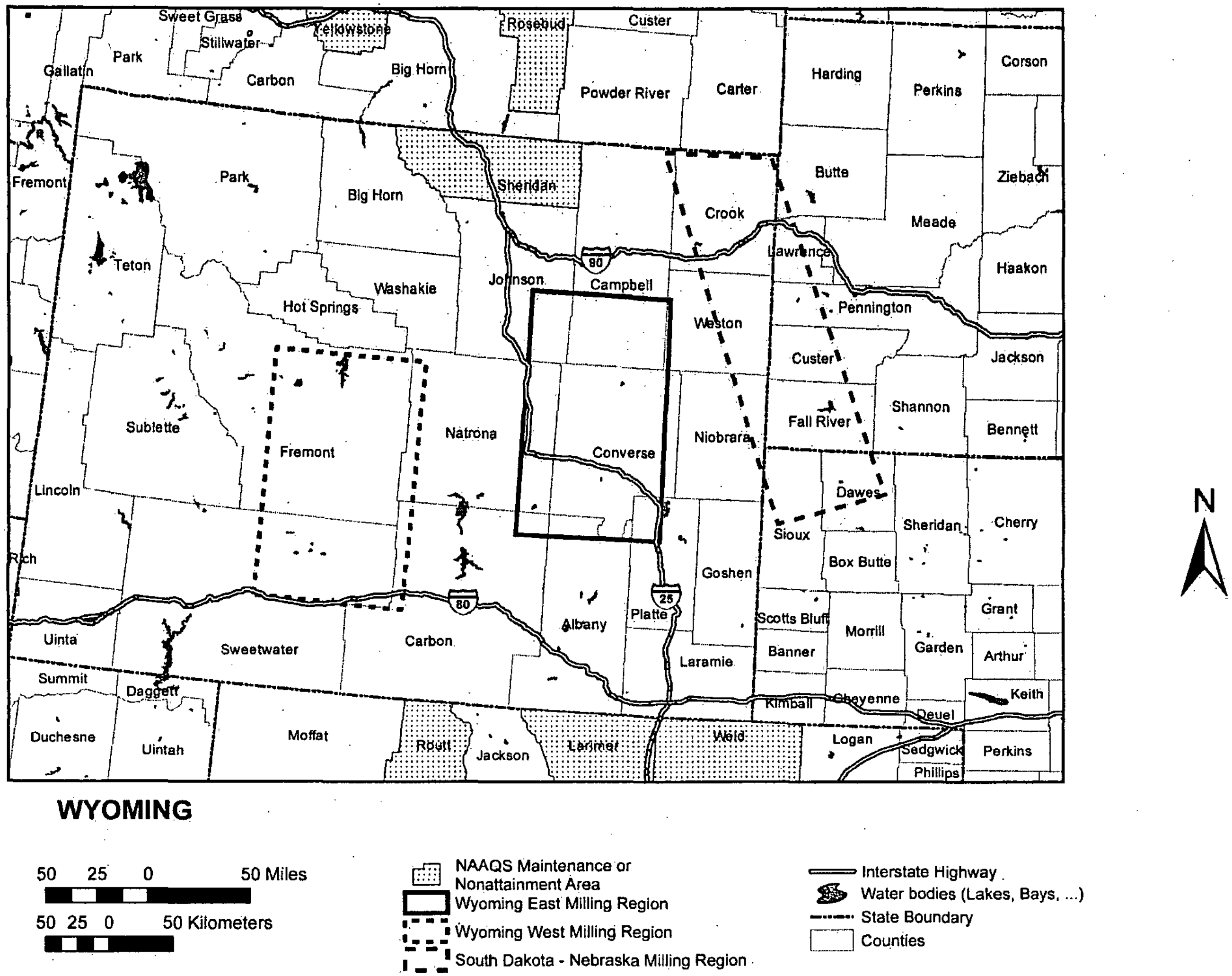


Figure 3.2-15. Air Quality Attainment Status for Wyoming and Surrounding Areas (EPA, 2007)

Table 3.2-10. U.S. Environmental Protection Agency Class I Prevention of Significant Deterioration Areas in Wyoming*
Bridger Wilderness
Fitzpatrick Wilderness
Grand Teton National Park
North Absaroka Wilderness
Teton Wilderness
Washakie Wilderness
Yellowstone National Park
*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40—Protection of the Environment, Part 81. Washington, DC: U.S. Government Printing Office. 2005.

3.2.7 Noise

Noise is technically defined as unwanted sound. Noise is a potential occupational hazard because prolonged exposure to noise may cause long-term hearing loss. In the United States, noise levels are regulated at the federal level by the Occupational Health and Safety Administration and the Mining Safety and Health Administration (Bauer and Kohler, 2000). To provide a sense of magnitude, noise levels associated with common activities are presented in Figure 3.2-17.

What are Sound and Noise?

When an object vibrates, some of the energy causes air molecules to vibrate. Nearby people or animals translate these vibrations into sound using the eardrum and brain. Noise is simply unwanted sound. Sound waves are characterized by frequency and measured in hertz (Hz); sound pressure is expressed as decibels (dB). Noises that are perceptible to human hearing range vary from 31 to 20,000 Hz. Audible sounds (those that can be heard) range from about 60 dB at a frequency of 31 Hz to less than about 1 dB between 900 and 8,000 Hz. Noise levels for perceptible frequencies are typically reported in A-weighted decibels to account for the way people respond to noise; this type of measurement assumes a human receptor to a particular noise-producing activity.

Existing ambient noise levels can be used to establish baseline conditions and determine potential site-specific disturbances associated with ISL milling activities. The Wyoming West Uranium Milling Region is predominantly rural and undeveloped. Rural areas tend to be quiet, open sagebrush-grass and forested areas where natural phenomena such as wind, rain, insects, birds, and other wildlife account for most natural background sounds. Baseline noise levels for typical undeveloped desert or arid environments range from day-night sound levels of 22 dB on calm days to 38 dB on windy days (Brattstrom and Bondello, 1983; DOE, 2007).

Larger communities in the region include Riverton and Lander, with populations of between 5,000 and 10,000. Fort Washakie (population about 1,500), the location of the headquarters for the Wind River Indian Reservation, is within the region. In addition, Rawlins (population about 8,500) is just east of the southeast corner of the region on Interstate 80 (see Section 3.2.10). In these more urbanized areas, ambient noise levels would be expected to be influenced by noise-generating activities such as street noise, traffic, emergency vehicles, and construction equipment. Noise levels in these types of suburban residential/urban areas range from 45 to about 78 dB, with lower noise levels at night (Washington State Department of Transportation, 2006).

As described in Section 2.8, several highways cross the region, including U.S. Highways 20, 26, and 287, as well as Interstate 80. A summary of noise effects on wildlife populations (Federal Highway Administration, 2004) includes reference to measured average traffic noise levels at 15 m [50 ft] of 54–62 dBA for passenger cars and 58–70 dBA for heavy trucks

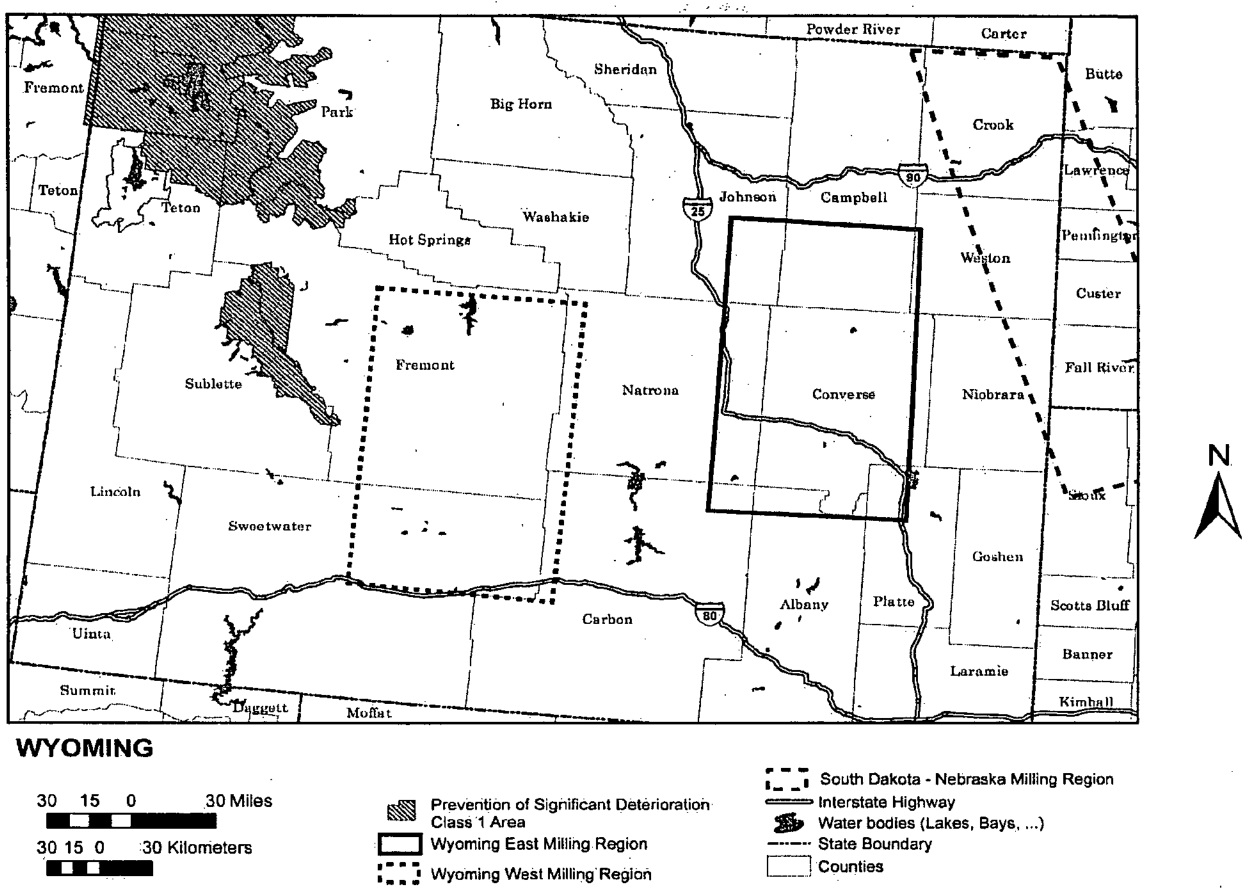


Figure 3.2-16. Prevention of Significant Deterioration Class I Areas in the Wyoming West Uranium Milling Region and Surrounding Areas (40 CFR Part 81)

COMMON SOUNDS	DECIBELS*	EFFECT
Jet Operation	140	Painfully Loud
	130	
Jet Takeoff Thunder Rock Concert	120	Maximum Vocal Effort
Pile Drivers	110	
Garbage Truck	100	
Heavy Truck (50 ft)	90	Very Annoying Hearing Damage at 8 hr
Alarm Clock Hair Dryer	80	Annoying
Freeway Traffic Man's Voice (3 ft)	70	Telephone Use Difficult
Air Conditioning Unit (20 ft)	60	Intrusive
Light Auto Traffic (100 ft)	50	Quiet
Living Room Quiet Office	40	
Library Soft Whisper (15 ft)	30	Very Quiet
Broadcasting Studio	20	
	10	Just Audible

*To the ear, each 10 dB increase seems twice as loud. 70 dB is the point at which noise begins to harm hearing.

Figure 3.2-17. Comparison of Noise Levels Associated with Common Activities (After EPA, 1981)

(Federal Highway Administration, 2004) along Interstate 80. Baseline ambient noise levels would be similar to or less than those for the U.S. and state highways in the region, as they are mostly undivided highways and tend to carry less traffic (particularly heavy trucks) than a major interstate highway like Interstate 80. For example, a 2005 traffic analysis at Interstate 80 milepost 208.65 just west of Rawlins indicates an average traffic count of about

12,400 vehicles per day. Of this, almost 50 percent was heavy truck traffic (Wyoming Department of Transportation, 2005). In comparison, for U.S. Highway 26 milepost 125.75 northwest of Riverton, the 2005 traffic count was about 3,700 vehicles with almost 90 percent passenger truck and car traffic (Wyoming Department of Transportation, 2005).

The two principal uranium districts in the Wyoming West Uranium Milling Region (the Great Divide Basin in the southeast part of the region and the Wind River Basin in the northeast part of the region) are located more than about 30 to 80 km [20 to 50 mi] from the larger communities, in rural undeveloped areas where the ambient noise levels would be expected to be low. There are a number of smaller communities along highways and roads through the uranium districts, including Jeffrey City and Bairoil near U.S. Highway 287 in the Great Divide Basin and Ervay and Sand Draw in the Wind River Basin, where noise levels would be expected to be slightly higher as a result of human activities. Areas of special sensitivity may be located on the Wind River Indian Reservation in the northwest corner of the region, but the reservation boundary is more than 16 km [10 mi] from the closest potential uranium ISL facility near Sand Draw, and more than 50 km [30 mi] from the center of the two uranium districts.

How Is Sound Measured?

The human ear responds to a wide range of sound pressures. The range of sounds people normally experience extends from low to high pressures by a factor of 1 million. Sound is commonly measured using decibels (dB). Another common sound measurement is the A-weighted sound level (dBA). The A-weighting measures different sound frequencies and the variation of the human ear's response over the frequency range. Higher frequencies receive less A-weighting than lower ones. Noise levels are often reported as the equivalent sound level (DOE, 2007). The equivalent sound level is expressed as an A-weighted sound level over a specified period of time—usually 1 or 24 hours. The equivalent sound level is an equivalent steady sound level that, if it continued during a specified time period, would contain the same total energy as the actual time-varying sound over the monitored or modeled time period. Noise levels are also expressed as day-night sound levels: the average of the day and nighttime A-weighted sound level with a built-in penalty of 10 dBA at night when noise levels are likely lower. The day-night sound level is particularly useful for evaluating community-level noise effects. If noise is regulated, municipalities often have local ordinances specifying upper limits on evening noise levels, with specific hours for residential and commercial zones.

3.2.8 Historical and Cultural Resources

The following sections summarize the historical and cultural resources background and legislation and authorities regarding historical and cultural resources for the Uranium GEIS regions in the states of Nebraska, New Mexico, South Dakota, and Wyoming. The information is provided on a state-by-state basis rather than by the regions of interest as the historical and cultural resource information and agencies are organized at the state level. A brief discussion of NHPA cultural and historical resource management processes is included in Appendix D.

3.2.8.1 Cultural Resources Overview

The Wyoming State Historic Preservation Office (SHPO) administers and is responsible for oversight and compliance with the National Register of Historic Places (NRHP), compliance and review for Section 106 of NHPA, traditional cultural properties review, enforcement of the Native American Graves Protection and Repatriation Act (NAGPRA), and compliance with other federal and state historic preservation laws, regulations, and statutes. The Wyoming SHPO and BLM have also entered into a programmatic agreement that describes the manner in which the Wyoming SHPO and the Wyoming BLM would interact and cooperate under the BLM national Programmatic Agreement. State level agreements between Wyoming and the National Resource Conservation Service (NRCS) and the U.S. Forest Service (USFS) are in draft form.

Wyoming SHPO's webpage with links to all of their resources can be found at: (http://wyoshpo.state.wy.us/). The state of Wyoming also has a law pertaining to archaeological sites and human remains, entitled Archaeological Sites (Wyoming Statute Ann. §36-1-114, et seq).

The following provides a brief overview of prehistoric and historical cultures recognized in the central and northern plains region, which includes the Wyoming West Uranium Milling Region. *Figure 3.2-18 illustrates the division of the plains into regional subdivisions. The dating of* cultural periods for the prehistoric period is provided in years before present (B.P.). Most prehistoric and historical period Native American archaeological sites are concentrated along major river systems and their tributaries, but can also be found along many drainage basins in the eastern and central portions of the state. In addition, historical period sites such as the Oregon-California National Historic Trail and the Bozeman National Historic Trail cross the Wyoming West and Wyoming East Regions.

Paleoindian Big Game Hunters (12,000 to 6,500 B.P.). The earliest well-defined cultural tradition in the northern and central plains region is the Paleoindian. Early humans entered the area shortly after deglaciation allowed movement onto the northern and central plains sometime after 14,000 B.P. A variety of cultures, each defined by the presence of distinctive, lanceolate projectile points, are recognized during the Paleoindian period: Clovis, Goshen, Folsom, Hell Gap-Agate Basin, Alberta, Cody Complex, and the late Paleoindian-Early Archaic Foothills/Mountain Complex. Most post-Clovis Paleoindian sites on the northern and upper central plains are known from bison kill sites. The Clovis culture (12,000 to 10,000 B.P.) is recognized by a distinctive projectile point style and a subsistence mode heavily reliant on hunting large, now-extinct mammals, notably mammoth, which became extinct at the end of the Clovis period, and ancient bison. The poorly defined Goshen Complex is found at the Carter/Kerr-McGee site in northeastern Wyoming and the Jim Pitts site in the Black Hills at the Wyoming-South Dakota border. Goshen is technologically similar to Clovis and may be contemporary with Clovis and perhaps Folsom. The Folsom culture (ca. 10,000 to 8,500 B.P.) is also known for a distinctive fluted, projectile point style, and evidence of the culture has been found at the Carter/Kerr-McGee site associated with bison and red ochre deposits. Folsom subsistence is also characterized by reliance on large game (the ancient bison). Folsom sites consist of campsites and kill sites. The latter tend to be located near cliffs and around water, such as ponds and springs.

The Hell Gap-Agate Basin Complex, Alberta Complex, and Cody Complex are widely distributed in the northern and central portions of the southern plains region at the Agate Basin, Hell Gap, and Carter/Kerr-McGee archaeological sites in eastern Wyoming. These late Paleoindian cultural complexes are, in their earliest forms, a continuation of preceding Paleoindian hunting traditions. The distinctive projectile point forms that define these cultural complexes in central and eastern Wyoming and western South Dakota are, in comparison to earlier Clovis, Goshen, and Folsom, much more restricted in geographic distribution. Toward the end of the Paleoindian period, however, there is a transition in subsistence modes following the extinction *of the ancient bison, and the transition to hunting the modern form of bison ultimately leading to* the transition to Archaic broad-spectrum foraging. Post molds and stone circles suggesting the presence of ephemeral shelters are sometimes found, primarily toward the end of the period.

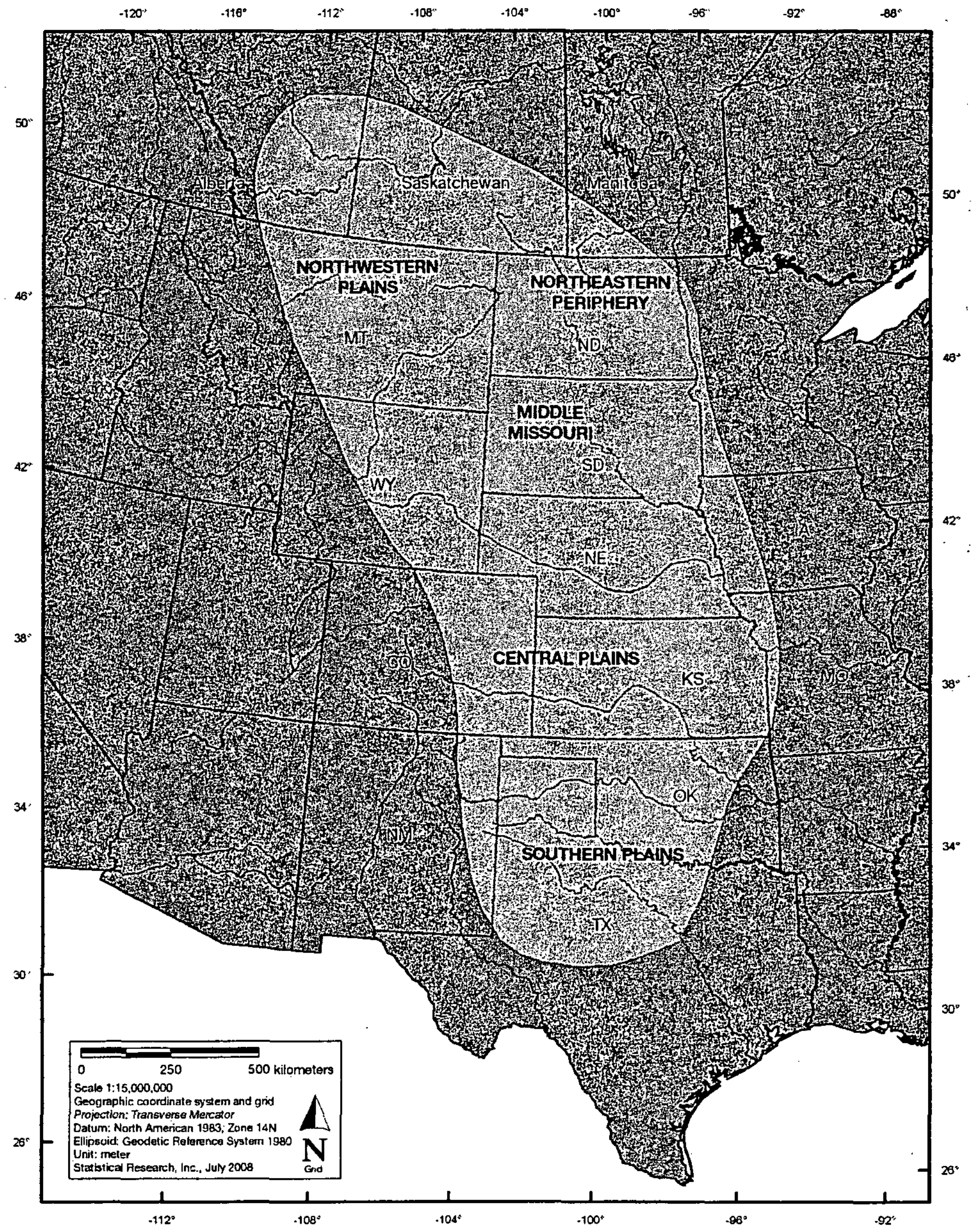


Figure 3.2-18. General Divisions of the American Plains

The late Paleoindian Foothills/Mountain Complex is characterized by a reliance on medium-sized game animals rather than big game hunting. Sites are found in upland, mountainous regions, leading some to suggest that Paleoindian groups may have split into lowland big game hunters and upland/mountain small- and medium-game hunters (Frison, 1991). The upland/mountain sites show increased use of small seed-bearing plants as indicated by the presence of groundstone implements and suggests the presence of an early archaic lifestyle. Habitation sites of this complex are found in rock shelters and caves such as Mummy Cave in the Absaroka Mountains of northwestern Wyoming.

Archaic Foragers (6,500 to 2,500 B.P.). The Plains Archaic period represents the continuation of change in subsistence and settlement linked to an increasingly arid environment that occurs in the latter portion of the preceding late Paleoindian cultures. At the end of the Paleoindian period there is also a change in projectile point styles from lanceolate to somewhat smaller corner- and side-notched projectile points, suggesting that the atlatl (spearthrower) was in use. Distinctive Archaic cultures, from early to late, include Mummy Cave, Oxbow, McKean, and Pelican Lake complexes and are found throughout the northern plains. Large bison kill sites, characteristic of the preceding Paleoindian period are virtually absent. Hunting and gathering wild plant foods is the primary mode of subsistence. Dietary breadth, indicated by increasing diversity and numbers of subsistence items, is believed to expand significantly with more medium and small mammals being hunted and the introduction of seed-bearing plants, dietary staples indicated by the introduction of stone seed-grinding implements. The Early Archaic Medicine House site in southeastern Wyoming contained evidence of structures, hearths, storage pits, and milling basins. At the McKean site in the Black Hills of Wyoming, a shallow pithouse was found. Through time, settlement is increasingly tethered to highly productive resource areas and sites tend to become larger and increasingly complex, indicating the presence of somewhat more sedentary lifestyles relative to earlier periods. Settlement is focused on river valleys and elevated areas. Artifact styles, principally projectile points, become increasingly diversified, suggesting increasing regionalization and cultural differentiation. In southeastern Wyoming, Pelican Lake projectile points are sometimes found in association with stone circles, firepits, and pithouses.

Late Prehistoric/Plains Woodland (2,500 to 300 B.P.). Early in the period, the preceding late Archaic broad-spectrum foraging subsistence and settlement patterns continue with little change. In the Northern Plains, the Besant and Avonlea Complexes continued virtually unchanged Archaic lifestyles until contact with European and American cultures. A significant technological change from atlatl to bow and arrow occurs during the Late Prehistoric period. Subsistence focused on scheduled small- and medium-game hunting, plant food gathering, and bison hunting according to a seasonal round. In central and northeastern Wyoming, a basic hunting and gathering lifestyle differing little from the preceding Late Archaic period predominates. Although eastern Wyoming is considered peripheral to the eastern Woodland tradition, Woodland pottery is sometimes found in association with Besant points in the northern plains. The Butler-Risser site south of Casper, Wyoming, contained both Besant points and pottery. Food procurement and site location during this period appears to be focused primarily on elevated landforms near larger riverine systems and tributaries with increasing utilization of upland resources later in time. The Late Prehistoric/Plains Woodland of Wyoming is also characterized by the appearance of ceramics late in the period (Besant and Avonlea Complexes), introduced from the Eastern Woodland cultural area. The late Avonlea Complex and later Old Woman Complex sites in northern Wyoming contain artifact types that suggest a high degree of specialization in hunting large, upland game animals, primarily bison.

In the eastern portions of Wyoming, the Upper Republican phase (ca. 1000–300 B.P.) is characterized by the presence of seasonal or permanent sedentary villages. These sites are usually on ridges and bluffs and have evidence of domesticated plants (corn, beans, squash, and sunflowers). Although horticulture was an important part of the subsistence base, wild plants and game animals formed a substantial part of the diet. Storage pits for food and other items are located within the structures, and grinding tools are common. Pottery was diverse with globular jars, and decorated exterior rims are common. The later Dismal River Aspect (ca. 500–300 B.P.) in southeastern Wyoming is focused primarily on hunting and gathering with only limited evidence of horticultural pursuits and a distinctive form of pottery.

In the 1500s to early 1700s A.D., large migrations by Native American tribes occurred. The ancestors of modern Apache, Arapaho, Comanche, Apache-Kiowa, and Kiowa migrated southward through western Wyoming in the 1500s and 1600s.

Post-Contact Tribes (300 to 100 B.P.). The post-contact period on the northern plains is that period after initial contact with Europeans and Americans. Although Euro-American trade goods may have appeared as early as the mid-1600s, the earliest documented contact in the northern and central plains is by Spanish and French explorers in the early 1700s A.D. The horse appears to have been introduced at about the same time. The lifeways of the late Avonlea and post-Avonlea/Old Woman nomadic bison-hunting cultural complexes in central and northeastern Wyoming and the Upper Republican and Dismal River horticulturalists of eastern and southeastern Wyoming appear to have continued well into the mid to late 1700s A.D. At the time of European exploration, the Dakota and Nakota moved into eastern Wyoming from what is now Minnesota. The Shoshone were present in southeastern Wyoming in the 1600s and 1700s. About this time, the Crow moved into northeastern and north-central Wyoming and the Apache-Kiowas moved out of the Black Hills into southeastern Wyoming. The Apache-Kiowa migration through the Black Hills was followed by that of the Cheyenne who moved through western South Dakota and then into central Wyoming where they were joined by the Arapaho who settled in southern Wyoming (Reher, 1977). By the mid-1800s, much of the eastern and central portions of the state was occupied by nomadic Siouan-speaking tribes, primarily the Hunkpapa, Minneconjou, Brule, and Oglala.

Europeans and Americans (300 to 100 B.P.). The earliest European presence in Wyoming was by French explorers of the de la Vénendrye family in 1743. In 1803, the United States completed the purchase of the Louisiana Territory from France. Early expeditions and trappers provide descriptions of varying quality for some of the early historical tribes in the region. In the later 1700s and early 1800s, more intensive contact and settlement occurred first through missionaries and the fur trade period in the 1810s through the 1840s. In 1807, Manuel Lisa of St. Louis established a trading post on the Bighorn River. Others, including Jedediah Smith, began fur trading companies that quickly spread along the major river systems of Wyoming. Each year the fur traders and trappers would establish a rendezvous site where they would gather. Rendezvous sites are known throughout much of central and western Wyoming. By the late 1830s, the fur trade in Wyoming was in decline. By the mid-1800s, missionary, settler, and military contacts led to increasing conflict with the Siouan tribes of Wyoming. The slowly increasing number of settlers passing through traditional tribal use areas on well-established trails in the mid-1800s led to increasing conflict over time. The establishment of military forts on tribal lands to protect the settlers was yet another irritant to tribes.

Treaties, notably the Fort Laramie Treaty of 1851, were signed with the intent of removing tribes from along the emigrant trails and allowing for the building of trails and forts to protect settlers moving west on the Texas, Oregon, California, Mormon, Bozeman, and Bridger Trails in central

and eastern Wyoming. Continued conflict resulted in the creation of the Great Sioux Reservation bounded by the Missouri River on the east, the Big Horn Mountains on the west, and the 46th and 43rd parallels to the north and south, respectively. Continued conflict with the U.S. military over the failure of the government to abide by treaty obligations led to several punitive expeditions to return tribes to reservations. In 1874, General George Armstrong Custer led an expedition to the Black Hills of Wyoming and South Dakota where the presence of gold, previously only rumored, was confirmed. The intense interest by Americans to go to the Black Hills to mine for gold led to numerous treaty violations; the Black Hills regions was, by treaty, part of the Sioux reservation. The continued conflict over the Black Hills, along with reduction of the buffalo herds, led to the final military conquest of the Great Sioux Nation and their confinement to small reservations. In November 1875, President Grant ordered the Indians of the Powder River and Big Horn country in eastern and central Wyoming to return to their tribal agencies. The Sioux refused and were forced militarily onto their reservations. The Black Hills gold rush facilitated the subsequent settlement of much of Wyoming and the development of towns and cattle ranching.

Ranching, a livelihood well suited to the grassland plains of Wyoming, was practiced by settlers by the early 1870s. Most of the early ranching occurred in well-watered areas along existing trail systems to facilitate moving cattle to market. The arrival of the railroads in 1868 (first the Union Pacific in southern Wyoming, then branch lines in other parts of Wyoming) led to increased settlement and opened Wyoming to a flood of new settlers. In the 1880s, farmers began homesteading much of the open range leading to conflict with ranchers over fencing. They settled mostly around well-watered regions, with many of the new farmers pursuing newly developed dry-land farming techniques. These homestead farmers began a period of extensive agriculture throughout the state that lasted from the 1880s to the 1930s. The Great Depression and the droughts that occurred at the same time led to the abandonment of many farms and the outmigration of a significant portion of Wyoming's population. Many of the individual homesteads were bought out in the 1930s and 1940s to create larger farms that used mechanized equipment.

3.2.8.2 National Register of Historic Properties and State Registers

Table 3.2-11 includes a summary of sites in the Wyoming West Uranium Milling Region that are listed on the Wyoming state and/or NRHP. Most of the sites are located in Fremont County, at least 32 km [20 mi] west of the two uranium districts in the Gas Hills and near Crooks Gap.

Table 3.2-11. National Register Listed Properties in Counties Included in the Wyoming West Uranium Milling Region

County	Resource Name	City	Date Listed YYYY-MM-DD
Carbon	Duck Lake Station Site	Wamsutter	1978-12-06
Fremont	BMU Bridge Over Wind River	Ethete	1985-02-22
Fremont	Decker, Dean Sites (48FR916; 48SW541)	Honeycomb Buttes	1986-03-12
Fremont	Delfelder Schoolhouse	Riverton	1978-03-29
Fremont	ELY Wind River Diversion Dam Bridge	Morton	1985-02-22
Fremont	Fort Washakie Historic District	Fort Washakie	1969-04-16
Fremont	Green Mountain Arrow Site (48FR96)	Stratton Rim	1986-03-12
Fremont	Jackson Park Town Site Addition Brick Row	Lander	2003-02-27
Fremont	King, C.H., Company, and First National Bank of Shoshoni	Shoshoni	1994-09-08

Table 3.2-11. National Register Listed Properties in Counties Included in the Wyoming West Uranium Milling Region (continued)

County	Resource Name	City	Date Listed YYYY-MM-DD
Fremont	Lander Downtown Historic District	Lander	1987-05-05
Fremont	Quien Sabe Ranch	Shoshoni	1991-04-18
Fremont	Riverton Railroad Depot	Riverton	1978-05-22
Fremont	Shoshone-Episcopal Mission	Fort Washakie	1973-04-11
Fremont	South Pass	South Pass City	1966-10-15
Fremont	South Pass City	South Pass City	1970-02-26
Fremont	St. Michael's Mission	Ethete	1971-06-21
Fremont	Union Pass	Unknown	1969-04-16
Fremont	U.S. Post Office and Courthouse—Lander Main	Lander	1987-05-19
Fremont	Wind River Agency Blockhouse	Ft. Washakie	2000-12-23
Natrona	Archaeological Site No. 48NA83	Arminto	1994-05-13
Natrona	Big Horn Hotel	Arminto	1978-12-18
Natrona	Bishop House	Casper	2001-03-12
Natrona	Bridger Immigrant Road—Waltman Crossing	Casper	1975-01-17
Natrona	Casper Army Air Base	Casper	2001-08-03
Natrona	Casper Buffalo Trap	Casper	1974-06-25
Natrona	Casper Federal Building	Casper	1998-12-21
Natrona	Casper Fire Department Station No. 1	Casper	1993-11-04
Natrona	Casper Motor Company—Natrona Motor Company	Casper	1994-02-23
Natrona	Chicago and Northwestern Railroad Depot	Powder River	1988-01-07
Natrona	Church of Saint Anthony	Casper	1997-01-30
Natrona	Consolidated Royalty Building	Casper	1993-11-04
Natrona	DUX Bessemer Bend Bridge	Bessemer Bend	1985-02-22
Natrona	Elks Lodge No. 1353	Casper	1997-01-30
Natrona	Fort Caspar	Casper	1971-08-12
Natrona	Fort Caspar (Boundary Increase)	Casper	1976-07-19
Natrona	Independence Rock	Casper	1966-10-15
Natrona	Martin's Cove	Casper	1977-03-08
Natrona	Masonic Temple	Casper	2005-08-24
Natrona	Midwest Oil Company Hotel	Casper	1983-11-17
Natrona	Natrona County High School	Casper	1994-01-07
Natrona	North Casper Clubhouse	Casper	1994-02-18
Natrona	Ohio Oil Company Building	Casper	2001-07-25
Natrona	Pathfinder Dam	Casper	1971-08-12
Natrona	Rialto Theater	Casper	1993-02-11
Natrona	Roosevelt School	Casper	1997-01-30
Natrona	South Wolcott Street Historic District	Casper	1988-11-23
Natrona	Split Rock, Twin Peaks	Muddy Gap	1976-12-22
Natrona	Stone Ranch Stage Station	Casper	1982-11-01
Natrona	Townsend Hotel	Casper	1983-11-25
Natrona	Tribune Building	Casper	1994-02-18
Sweetwater	Eldon—Wall Terrace Site (48SW4320)	Westvaco	1985-12-13

3.2.8.3 Tribal Consultation

There are several Native American tribes located within or immediately adjacent to the state of Wyoming that have interests in the state and in the Wyoming West Uranium Milling Region (Figure 3.2-19). These include the

- Arapaho Tribe of the Wind River Reservation
- Shoshone Tribe of the Wind River Reservation
- Cheyenne River Sioux
- Flandreau Santee Sioux
- Lower Brulé Sioux
- Oglala Sioux
- Rosebud Sioux
- Sisseton-Whapeton Oyate
- Standing Rock Sioux
- Yankton Sioux
- Crow Tribe of Montana

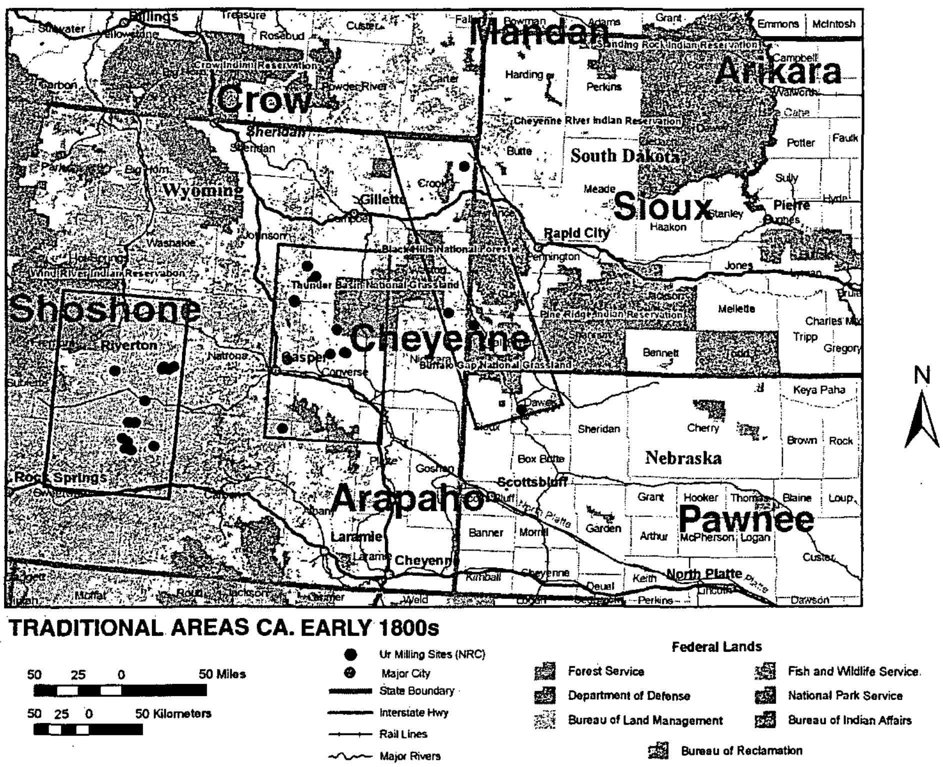


Figure 3.2-19. Regional Distribution of Native American Tribes in the Early 1800s in Wyoming, South Dakota, and Nebraska

The Siouan tribes are located throughout South and North Dakota, and the Crow are located in Montana but have interests in Wyoming. Other Siouan-speaking tribes as well as other tribes in North Dakota, Wyoming, Montana, and Nebraska may have traditional land use claims in the Wyoming West Uranium Milling Region.

The U.S. government and the State of Wyoming recognize the sovereignty of certain Native American tribes. These tribal governments have legal authority for their respective reservations. Executive Order 13175 requires executive branch federal agencies to undertake consultation and coordination with Native American tribal governments on a government-to-government basis. NRC, as an independent federal agency, has agreed to voluntarily comply with Executive Order 13175.

In addition, the NHPA provides these tribal groups with the opportunity to manage cultural resources within their own lands under the legal authority of a Tribal Historic Preservation Officer (THPO). To date, the Northern Arapaho Tribe is the only tribe in Wyoming to have attained status as a THPO as provided for in the NHPA. Some tribes have historic and cultural preservation offices that are not recognized as THPOs, but they should be consulted where they exist. NRC, in meeting its responsibilities under the NHPA, contacts tribal cultural resources personnel as part of the consultation process, along with consulting with the Wyoming SHPO.

3.2.8.4 Places of Cultural Significance

Traditional cultural properties are places of special heritage value to contemporary communities because of their association with cultural practices and beliefs that are rooted in the histories of those communities and are important in maintaining the cultural identity of the communities (Parker and King, 1998; King, 2003). Religious places are often associated with prominent topographic features like mountains, peaks, mesas, springs, and lakes. In addition, shrines may be present across the landscape to denote specific culturally significant locations and vision quest sites where an individual can place offerings.

Information on traditional land use and the location of culturally significant places is often protected information within the community (e.g., King, 2003). Therefore, the information presented on religious places is limited to those that are identified in the published literature and is therefore restricted to a few highly recognized places on the landscape within southwestern South Dakota.

There are no culturally significant places in the NRHP or state register located in the Wyoming West Uranium Milling Region. However, the Lakota Sioux or other Sioux bands (Cheyenne River Sioux, Lower Brulé Sioux, Oglala Sioux, Rosebud Sioux) along with the Crow Tribe, the Arapaho, the Kiowa, and Wind River Shoshone who once occupied portions of the Wyoming West Uranium Milling Region consider the Black Hills in Wyoming and South Dakota, Devil's Tower in northeastern Wyoming, and Bear Butte in southwestern South Dakota to be culturally significant; these were once used for personal rituals and the Sun Dance and are the source of origin legends.

Areas of central and eastern Wyoming once used by these tribes may contain additional, undocumented culturally significant sites and traditional cultural properties. Mountains, peaks, buttes, prominences, and other elements of the natural and cultural environment are often considered important elements of a traditional culturally significant landscape.

Traditional cultural properties are those that have been passed down over the generations and that refer to beliefs, customs, and practices of a living community. Native American traditional cultural properties are often not found on the state or national registers of historic properties nor described in the extant literature or in SHPO files. There is, however, a range of cultural property types of religious or traditional use that might be identified during the tribal consultation process. These might include

- Sites of ritual and ceremonial activities and related features
- Shrines
- Marked and unmarked burial grounds
- Traditional use areas
- Plant and mineral gathering areas
- Traditional hunting areas
- Caves and rock shelters
- Springs
- Trails
- Prehistoric archaeological sites

The U.S. Bureau of Indian Affairs website contains a list, current as of May 2007, of tribal leaders and contact information <http://www.doi.gov/bia/Tribal%20Leaders-June%202007-2.pdf>. The National Organization of Tribal Historic Preservation Officers also maintains a list of THPOs on its website at http://www.nathpo.org/THPO/state_list.htm. These tribal groups should be contacted for consultations associated with ISL milling activities in their respective states (see Table 3.2-12). Additional tribal contact information may be obtained from the respective SHPO in Nebraska, Montana, South Dakota, and Wyoming.

Table 3.2-12. List of Tribal Contacts for Tribes With Interests in Nebraska, Montana, South Dakota, and Wyoming
Nebraska
Santee Sioux Nation, 108 Spirit Lake Ave. West, P(402) 857-2772 F(402) 857-2307, Roger Trudell, Chairman, Niobrara, NE 68760-7219
Ponca Tribe of Nebraska, P.O. Box 288, P(402) 857-3391 F(402) 857-3736, Larry Wright, Jr., Chairman, Niobrara, NE 68760
Omaha Tribal Council, P.O. Box 368, P(402) 837-5391 F(402) 837-5308, Mitchell Parker, Chairperson, Macy, NE 68039
Iowa Tribe of Kansas & Nebraska, 3345 Thrasher Rd., P(785) 595-3258 F(785) 595-6610, Leon Campbell, Chairman, White Cloud, KS 66094
Sac and Fox Nation of Missouri, 305 N. Main Street, P(785) 742-7471 F(785) 742-3785, Fredia Perkins, Chairperson, Reserve, KS 66434
Ponca Tribe of Nebraska, P.O. Box 288, P(402) 857-3391 F(402) 857-3736, Larry Wright, Jr., Chairman, Niobrara, NE 68760
Montana
Blackfeet Tribal Business Council, P.O. Box 850, P(406) 338-7276 F(406) 338-7530, Earl Old Person, Chairman, Browning, MT 59417 <btbc@3rivers.net>
Chippewa Cree Business Committee, RR 1, P.O. Box 544, P(406) 395-4282 F(406) 395-4497, John "Chance" Houle, Chairman, Box Elder, MT 59521
Crow Tribal Council, P.O. Box 169, P(406) 638-3715 F(406) 638-3773, Carl Venne, Chairman, Crow Agency, MT 59022

Table 3.2-12. List of Tribal Contacts for Tribes With Interests in Nebraska, Montana, South Dakota, and Wyoming (continued)
Montana (continued)
Fort Belknap Community Council, RR 1, Box 66, P(406) 353-2205 F(406) 353-4541, Julia Doney, President, Harlem, MT 59526
Fort Peck Tribal Executive Board, P.O. Box 1027, P(406) 768-5155 F(406) 768-5478, John Morales, Chairman, Poplar, MT 59255
Northern Cheyenne Tribal Council, P.O. Box 128, P(406) 477-6284 F(406) 477-6210, Eugene Littlecoyote, President, Lame Deer, MT 59043
Confederated Salish & Kootenai Tribes, Tribal Council, Box 278, P(406) 675-2700 F(406) 675-2806, James Steele, Jr., Chairman, Pablo, MT 59855 <csktadmn@ronan.net>
South Dakota
Cheyenne River Sioux Tribe, P.O. Box 590, P(605) 964-4155 F(605) 964-4151, Joseph Brings Plenty, Chairman, Eagle Butte, SD 57625
Crow Creek Sioux Tribal Council, P.O. Box 50, P(605) 245-2221 F(605) 245-2470, Lester Thompson, Chairman, Fort Thompson, SD 57339
Flandreau Santee Sioux Executive Committee, P.O. Box 283, P(605) 997-3891 F(605) 997-3878, Joshua Weston, President, Flandreau, SD 57028 <president@fsst.org>
Lower Brule Sioux Tribal Council, 187 Oyate Circle, P(605) 473-5561 F(605) 473-5606, Michael Jandreau, Chairman, Lower Brule, SD 57548
Oglala Sioux Tribal Council, P.O. Box 2070, P(605) 867-6074 F(605) 867-6076, John Yellow Bird Steele, President, Pine Ridge, SD 57770
Rosebud Sioux Tribal Council, P.O. Box 430, P(605) 747-2381 F(605) 747-2905, Rodney Bordeaux, President, Rosebud, SD 57570 <www.rosebudsiouxtribe.org>
Sisseton-Wahpeton Oyate of the Lake Traverse Reservation, P.O. Box 509, P(605) 698-3911 F(605) 698-7907, Michael Selvage, Sr., Chairman, Agency Village, SD 57262 <http://swcc.cc.sd.us/>
Standing Rock Sioux Tribal Council, P.O. Box D, P(701) 854-8500 F(701) 854-7299, Ron His Horse Is Thunder, Chairman, Fort Yates, ND 58538
Yankton Sioux Tribal Business & Claims Committee, P.O. Box 248, P(605) 384-3641 F(605) 384-5687, Robert Cournoyer, Chairman, Marty, SD 57361-0248 <bobbycournoyer@yahoo.com> <www.yanktonsiouxtribe.org/index.html>
Wyoming
Arapaho Business Committee, P.O. Box 396, P(307) 332-6120 F(307) 332-7543, Richard B. Brannon, Chairman, Fort Washakie, WY 82514
Shoshone Business Committee, P.O. Box 217, P(307) 332-3532 F(307) 332-3055, Ivan D. Posey, Chairman, Fort Washakie, WY 82514

3.2.9 Visual/Scenic Resources

Assigning values to visual and scenic resources is subjective, but basic design elements such as form, line, color, and texture can be used to describe and evaluate landscapes.

Modifications that repeat the landscape's basic elements tend to match the surroundings well. Modifications that do not match basic landscape features can look out of place and jar the

viewer. Potential visual impacts can be evaluated based on likely features that may result from anticipated activities (drilling masts, well heads, header houses, satellite ion exchange facilities, and centralized milling facilities) from the perspective of both design (space, height, color) and time (permanent versus temporary structures).

Federal land management agencies such as the BLM and the USFS have established guidelines to inventory and manage visual resources. Because there are a variety of visual values, different levels of management are necessary. These activities are typically part of a visual resource management (VRM) system.

The BLM guidelines for VRM are identified in BLM Manual 8400 (BLM, 2007a). The VRM system identifies and inventories existing scenic values (BLM, 2007a–c) and establishes management objectives for those values. These area-specific objectives provide the standards for planning, designing, and evaluating the potential visual resource impacts resulting from future management projects. The VRM system also provides for mitigation measures that can reduce potentially adverse visual impacts.

In practice, the VRM system as described by BLM consists of two stages:

- Inventory—Visual Resource Inventory (BLM, 2007b)
- Analysis—Visual Resource Contrast Rating (BLM, 2007c)

Objectives for Visual Resource Classes (After BLM, 2007a,b)

Class I: To preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

Class II: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV: To provide for management activities that require major modifications of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Landscape inventories are determined by taking scenic quality, visual sensitivity, and distance from the existing travel routes and dividing these factors into as many as four classes. The final VRM class determinations are typically established in the resource management plans developed by BLM field offices. The USFS system for VRM is slightly different from that used by the BLM, with five classifications based on visual quality and scenic integrity objectives (USFS, 1974, 1995).

Based on the BLM Visual Resource Handbook, the uranium districts in the Wyoming West Uranium Milling Region are located in the Wyoming Basin physiographic province (BLM, 2007a). Although BLM does not manage all of the land in the Wyoming West Uranium Milling Region, the BLM resource management plans prepared by the regional field offices establish VRM classifications for all of the region, including private land or land managed by other agencies. The regional management plans that cover the Wyoming West Uranium Milling

Region include the Casper (BLM, 2007d; Bennett, 2003), Lander (BLM, 1987), Rock Springs (BLM, 2007e), and Rawlins (BLM, 2008b) field offices (see the BLM Wyoming website at http://www.blm.gov/wy/st/en.html). The VRM classifications assigned within these resource plans are presented in Figure 3.2-20. The Lander resource management plan is in the process of being revised; as a result, the current VRM classification for the northern part of the Wyoming West Uranium Milling Region is not available at this time (BLM, 2007f). Public concerns expressed to BLM include visual and scenic resources relating to the quality of recreational experiences on public lands and the protection of landscapes along sensitive resources such as the National Historic Trails (BLM, 2007d).

Visual Quality and Scenic Integrity Objectives of the USFS
(From USFS, 1974, 1995)

The USFS established visual quality objectives as part of a visual management system in its 1974 forest landscape management handbook. These objectives described the different degrees of alteration associated with a proposed management strategy that the USFS would find acceptable in terms of visual contrast with the surrounding natural landscape. The visual quality objectives have been updated and replaced by scenic integrity objectives as part of the USFS scenery management system (USFS, 1995). There has been some overlap in their application, and both systems have been used by the USFS to define visual resources.

Preservation: This visual quality objective represents essentially unaltered landscape with only minute if any deviations. This is equivalent to an area with very high scenic integrity.

Retention: This visual quality objective represents landscape that appears to be intact to the casual viewer. Alterations may be present, but are consistent with the form, line, color, and texture of the landscape. It is equivalent to a classification of high scenic integrity.

Partial Retention: This visual quality objective represents landscape that appears slightly altered. New form, line, color, or texture may be introduced as long as it remains visually subordinate. This objective is equivalent to a classification of moderate scenic integrity.

Modification: This visual quality objective represents landscape that appears moderately altered. Changes may be introduced that visually dominate the characteristic landscape, but must reflect naturally established form, line, color, and texture to be compatible with natural surroundings. This objective is equivalent to a classification of low scenic integrity.

The bulk of the southern part of the Wyoming West Uranium Milling Region is categorized by BLM as VRM Class III (along highways) and Class IV (open grassland, oil and natural gas, urban areas) (Figure 3.2-20). The BLM resource management plans do not identify any VRM Class I (most sensitive) resources that fall entirely within the Wyoming West Uranium Milling Region. Located in the northwestern corner of Carbon County, however, the Ferris Mountains Wilderness Study Area is identified as Class I (BLM, 2008b) and borders the eastern boundary of the region, about 72 km [45 mi] north of Rawlins. The closest potential uranium ISL facility, however, is located about 24 km [15 mi] from the closest boundary of the Ferris Mountains Wilderness Study Area. VRM Class II areas are generally identified in ranges such as the Granite Mountains, and the Rock Springs field office identifies Red Lake, Alkali Basin, Alkali Draw, South Pinnacles, and Honeycomb Buttes Wilderness Study Areas in the southwestern corner of the region as Class II (Figure 3.2-20). These Class II areas, however, are more than 32 km [20 mi] from the closest point in either of the two uranium districts located within the Wyoming West Uranium Milling Region. In addition, scenic areas along the Sweetwater and Powder Rivers provide unique viewsheds (USFS, 2005). One potential facility may be located near Jeffrey City, within a few kilometers [miles] of the Sweetwater. All of the other potential facilities are located 24 km [15 mi] or more from these two rivers. As described in Section 3.2.6.2, there are no areas identified by EPA as Class 1 Prevention of Significant Deterioration areas in the Wyoming West Uranium Milling Region (see Figure 3.2-16). In addition, the state of Wyoming Environmental Quality Council also has developed two

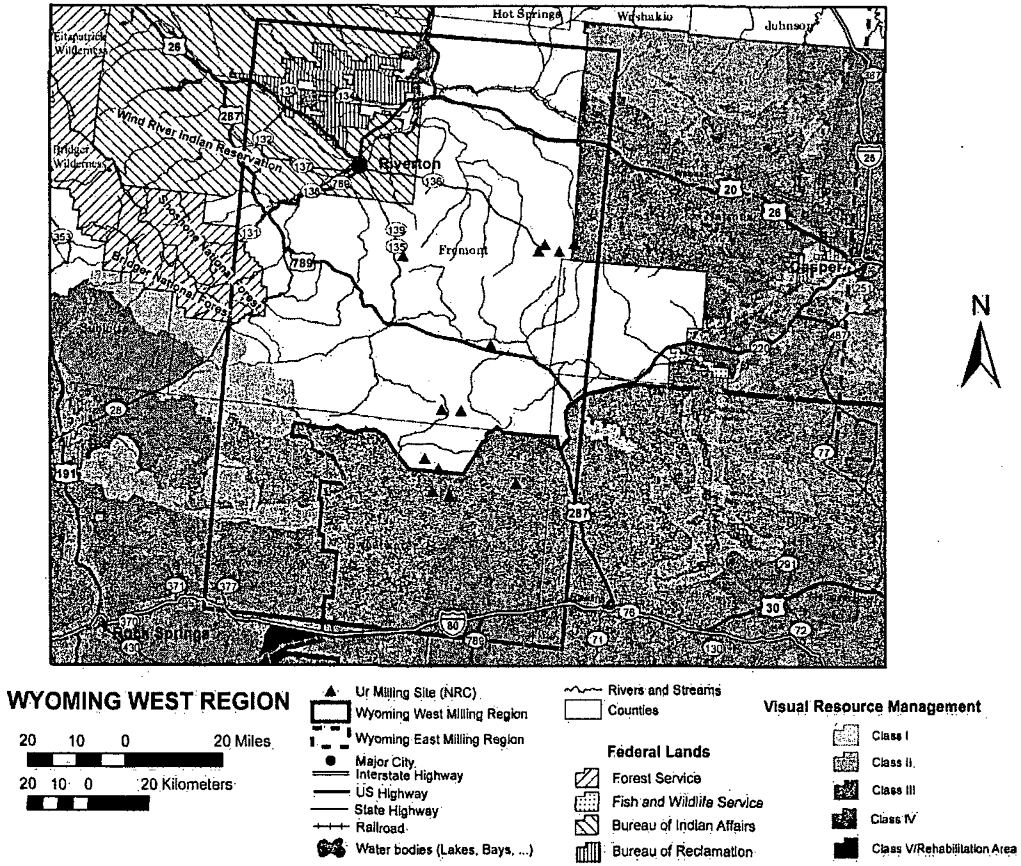


Figure 3.2-20 BLM Visual Resource Classifications for the Wyoming West Uranium Milling Region (BLM, 2008b, 2007d,e)

designations for scenic resources: (1) Unique and Irreplaceable and (2) Rare or Uncommon. These designations are limited to a small number of locations (seven), and none are located within the two uranium districts in the Wyoming West Uranium Milling Region (Girardin, 2006).

The Wind River Indian Reservation occupies the northwestern corner of the region, including the Boysen and Pilot Reservoirs managed by the U.S. Bureau of Reclamation. These areas fall within the area covered by the BLM Lander field office, and VRM classifications are not available. These regions are more than 16 km [10 mi] northwest from the closest potential ISL facility at Sand Draw, however, and more than 50 km [30 mi] from the center of the two uranium districts at Gas Hills and Crooks Gap.

3.2.10 Socioeconomics

For the purpose of this GEIS, the socioeconomic description for the Wyoming West Uranium Milling Region includes communities within the region of influence for a potential ISL facility. Communities that have the highest potential for socioeconomic impacts are considered the affected environment. These potentially affected communities are defined by (1) proximity to an ISL facility {generally within 48 km [30 mi]}; (2) economic profile, such as potential for income growth or destabilization; (3) employment structure, such as potential for job placement or displacement; and (4) community profile, such as potential for growth or destabilization to local emergency services, schools, or public housing. The affected environments are listed in Table 3.2-13.

The following subsections describe areas most likely to have implications to socioeconomics. In some sub-sections, Core-Based Statistical Areas (CBSAs) and Metropolitan Areas are also discussed. A CBSA, according to the U.S. Census Bureau, is a collective term for areas ranging from a population of 10,000 to 50,000. A Metropolitan Area is greater than 50,000, and a town is considered less than 10,000 in population (U.S. Census Bureau, 2008). A number of small towns with populations less than 1,000 exist in the affected environment but are not called out by name in Table 3.2-13 or in data presented in this section. Towns such as Moneta, Jeffrey City, Bairoil, Lamont, Wamsutter, and others are represented collectively by the applicable county-level socioeconomic information provided in this section.

Table 3.2-13. Summary of the Affected Environment Within the Wyoming West Uranium Milling Region

Counties Within Wyoming West	Towns Within Wyoming West	Native American Communities Within Wyoming West
Carbon	Arapaho	Wind River Indian Reservation
Fremont	Ethete	
Natrona		
Sweetwater	Ft. Washakie	
	Lander	
	Riverton	
	St. Stephens	

3.2.10.1 Demographics

For the GEIS, demographics are based on 2000 U.S. Census data on population and racial characteristics of the affected environment (Table 3.2-14), Figure 3.2-21 illustrates the populations of communities within the Wyoming West Uranium Milling Region. Most 2006 data compiled by the U.S. Census Bureau was not available for the region at the time of writing.

The most populated county in the Wyoming West Uranium Milling Region is Natrona County and the most sparsely populated county is Carbon County. Riverton has the largest population in the region, and and the smallest populated town is Ethete (Wind River Indian Reservation). The county with the largest percentage of nonminorities is Natrona County with a white population of 94.2 percent, and Lander has a white population of 90.8 percent. The largest minority-based county is Fremont County with a white population of 76.5 percent. The largest minority-based town is Ethete, with a white population of only 4.9 percent.

Although not listed in Table 3.2-14, the 2000 U.S. Census total population count for the Wind River Indian Reservation was 23,250. The Wind River Indian Reservation is shared by the Eastern Shoshone and Northern Arapaho tribes and is located in Fremont and Hot Springs Counties, Wyoming. Riverton is the largest town on the reservation (U.S. Census Bureau, 2008).

3.2.10.2 Income

Income information from the 2000 U.S. Census including labor force, income, and poverty levels for the affected environment, is based on data collected at the state and county levels. Data collected at the state level also includes information on towns, CBSAs, or Metropolitan Areas and considers an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than 48 km [greater than 30 mi]} for income opportunities or may be a workforce needed to fulfill specialized positions (if local workforce is unavailable or does not have the appropriate skill set). In Wyoming, the workforce frequently commutes long distances to work. For example, in the Wyoming West Uranium Milling Region, all of the affected counties experienced net inflows of workers during the fourth quarter of 2005. Net inflows ranged from 370 for Carbon County to 10,600 for Natrona County, predominantly for jobs related to the energy industry (Wyoming Workforce Development Council, 2007). Data collected at the county level is generally the same as for the affected environment presented in Table 3.2-13 and also includes information on Native American communities. State-level information for the surrounding region is provided in Table 3.2-15 for comparison, and county data is listed in Table 3.2-16.

For the surrounding region, the state with the largest labor force population is Montana. The population with the largest labor force is Billings, Montana, 320 km [200 mi] to the nearest potential ISL facility. The population in the surrounding region with the highest per capita income is Cheyenne, Wyoming, 225 km [140 mi] from the nearest potential ISL facility. The lowest per capita income population is Laramie, Wyoming, 160 km [100 mi] to the nearest potential ISL facility. The population with the highest percentage of individuals and families below poverty level is in Billings, Montana.Based on review of Table 3.2-16, the county in the Wyoming West Uranium Milling Region with the largest labor force population is Natrona County and the smallest labor force population is in Carbon County. The town with the largest labor force population in the region is Riverton (Wind River Indian Reservation), and the smallest labor force population is in Ethete (Wind River Indian Reservation). Sweetwater County has the highest per capita income, and the smallest per capita income is in Fremont County. Per capita

Table 3.2-14. 2000 U.S. Bureau of Census Population and Race Categories of the Wyoming West Uranium Milling Region*									
Affected Environment	**Total Population**	**White**	**African American**	**Native American**	**Some Other Race**	**Two or More Races**	**Asian**	**Hispanic Origin†**	**Native Hawaiian and Other Pacific Islander**
Wyoming	493,782	454,670	3,722	11,133	12,301	8,883	2,771	31,669	302
Percent of total		92.1%	0.8%	2.3%	2.5%	1.8%	0.6%	6.4%	0.1%
Carbon County	15,639	14,092	105	9	808	321	105	2,163	9
Percent of total		90.1%	0.7%	0.1%	5.2%	2.1%	0.7%	13.8%	0.1%
Fremont County	35,804	27,388	44	7,047	417	793	106	1,566	9
Percent of total		76.5%	0.1%	19.7%	1.2%	2.2%	0.3%	4.4%	0.0%
Natrona County	66,533	62,644	505	686	1,275	1,121	277	3,257	25
Percent of total		94.2%	0.8%	1.0%	1.9%	1.7%	0.4%	4.9%	0.0%
Sweetwater County	37,613	34,461	275	380	1,349	892	240	3,545	16
Percent of total		91.6%	0.7%	1.0%	3.6%	2.4%	0.6%	9.4%	0.0%
Lander	6,867	6,236	10	411	48	140	22	239	0
Percent of total		90.8%	0.1%	6.0%	0.7%	2.0%	0.3%	3.5%	0.0%
Arapaho (Wind River Indian Reservation)	1,766	318	2	1,423	9	13	0	91	1
Percent of total		18.0%	0.1%	80.6%	0.5%	0.7%	0.0%	5.2%	0.1%
Ethete (Wind River Indian Reservation)	1,455	72	0	1,371	1	10	1	30	0
Percent of total		4.9%	0.0%	94.2%	0.1%	0.7%	0.1%	2.1%	0.0%

Table 3.2-14. 2000 U.S. Bureau of Census Population and Race Categories of the *Wyoming West* Uranium Milling Region (continued)*

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
Fort Washakie (Wind River Indian Reservation)	1,477	87	1	1,368	10	11	0	48	0
Percent of total		5.9%	0.1%	92.6%	0.7%	0.7%	0.0%	3.2%	0.0%
Riverton (Wind River Indian Reservation)	9,310	8,082	16	752	173	240	44	660	3
Percent of total		86.8%	0.2%	8.1%	1.9%	2.6%	0.5%	7.1%	0.0%
St. Stephens (Wind River Indian Reservation)	NA‡	NA	NA	NA	NA	NA	NA	NA	NA
Percent of total		NA	NA	NA	NA	NA	NA	NA	NA

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100 percent).
‡NA—not available.

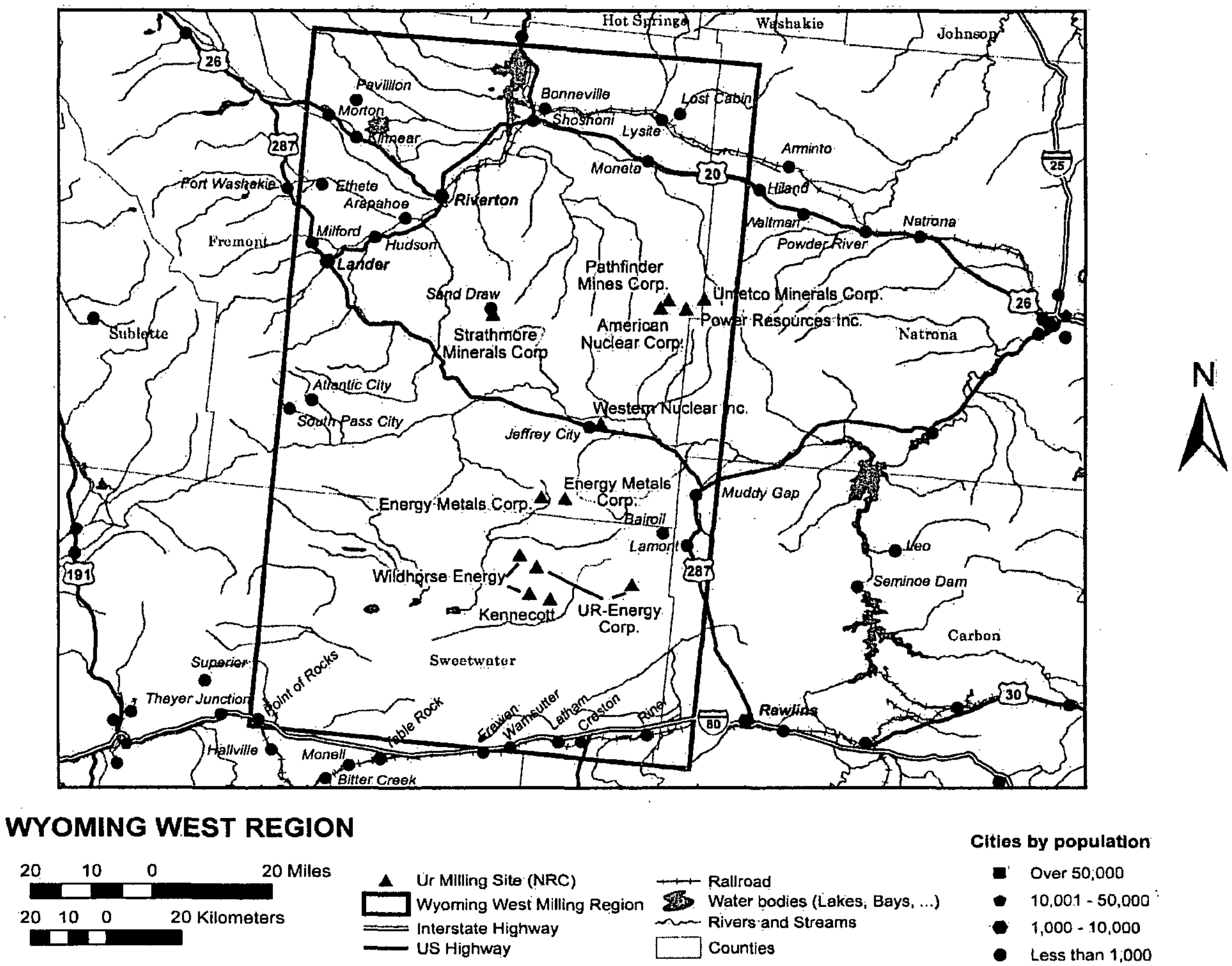


Figure 3.2-21. Wyoming West Uranium Milling Region With Population

Table 3.2-15. U.S. Bureau of Census State Income Information for the Region Surrounding the Wyoming West Uranium Milling Region*

Affected Environment	2000 Labor Force Population (16 years and over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Montana	458,306	$33,024	$40,487	$17,151	25,004	128,355
Wyoming	257,808	$37,892	$45,685	$19,134	10,585	54,777
Billings, Montana	47,584	$35,147	$45,032	$19,207	2,130	10,402
Percent of total†	67.7%	NA	NA	NA	9.2%	12.0%
Cheyenne, Wyoming	27,647	$38,856	$46,771	$19,809	891	4,541
Percent of total†	66.7%	NA	NA	NA	6.3%	8.8%
Lander, Wyoming	3,337	$32,397	$41,958	$18,389	178	859
Percent of total†	62.5%	NA	NA	NA	9.95%	13.2%
Laramie, Wyoming	15,504	$27,319	$43,395	$16,036	633	5,618
Percent of total†	67.2%	NA	NA	NA	11.1%	22.6%

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 25 February 2008, and 15 April 2008).
†Percent of total based on a population of 16 years and over.

Table 3.2-16. U.S. Bureau of Census County and Native American Income Information for the Wyoming West Uranium Milling Region*

Affected Environment	2000 Labor Force Population (16 years and over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Carbon County, Wyoming	7,744	$36,060	$41,991	$18,375	411	1,879
Percent of total†	62.5%	NA‡	NA	NA	9.8%	12.9%
Fremont County, Wyoming	17,637	$32,503	$37,983	$16,519	1,267	6,155
Percent of total†	64.9%	NA	NA	NA	13.3%	17.6%
Natrona County, Wyoming	35,081	$36,619	$45,575	$18,913	1,548	7,695
Percent of total†	68.3%	NA	NA	NA	8.7%	11.8%
Sweetwater County, Wyoming	20,022	$46,537	$54,173	$19,575	548	2,871
Percent of total†	70.6%	NA	NA	NA	5.4%	7.8%
Arapaho (Wind River Indian Reservation)	636	$22,679	$24,659	$8,943	134	784
Percent of total†	58.1%	NA	NA	NA	35.5%	45.0%
Ethete (Wind River Indian Reservation)	517	$24,130	$24,762	$7,129	95	453
Percent of total†	60.5%	NA	NA	NA	33.9%	34.4%

Table 3.2-16. U.S. Bureau of Census County and Native American Income Information for the Wyoming West Uranium Milling Region* (continued)

Affected Environment	2000 Labor Force Population (16 years and over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Fort Washakie (Wind River Indian Reservation)	567	$18,906	$20,658	$7,700	151	636
Percent of total†	57.6%	NA‡	NA	NA	42.9%	42.7%
St. Stephens (Wind River Indian Reservation)	na	na§	na	na	na	na
Percent of total†	na	NA	NA	NA	na	na
Riverton (Wind River Indian Reservation)	4,694	$31,531	$37,079	$16,720	267	1,400
Percent of total†	64.5%	NA	NA	NA	11.0%	15.7%

* U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Percent of total based on a population of 16 years and over.
‡NA—Not applicable.
§na—not available.

income ranges from Lander ($18,389) to the town of Ethete ($7,129). The county with the highest percentage of individuals and families below poverty level is Fremont County. The town with the highest percentage of individuals and families below poverty level is Fort Washakie (Wind River Indian Reservation).

3.2.10.3 Housing

Housing information from the 2000 U.S. Census is provided in Table 3.2-17. Housing information for the Wind River Indian Reservation was only available for the town of Riverton (U.S. Census Bureau, 2008).

The availability of housing within the immediate vicinity of the potential ISL facilities in the Wyoming West Uranium Milling Region is limited. The majority of housing is available in larger populated areas such as the towns of Riverton (20 miles to nearest ISL facility) and Casper {97 km [60 mi] to nearest ISL facility}. Temporary housing such as apartments, lodging, and trailer camps within the immediate vicinity of the proposed ISL facilities is not as limited. The majority of apartments are available in larger populated areas such as the towns of Lander, Riverton, and Rawlins with a total of 18 apartment complexes (MapQuest, 2008). There are also five hotels/motels along major highways or towns near potential ISL facilities in the two uranium districts in the Wyoming West Uranium Milling Region. In addition to apartments and lodging, there are trailer camps situated near potential ISL facilities (along major roads or near towns) in this region (MapQuest, 2008).

Table 3.2-17. U.S. Bureau of Census Housing Information for Wyoming*

Affected Environment	Single Family Owner-Occupied Homes	Median Value in Dollars	Median Monthly Costs With a Mortgage	Median Monthly Costs Without a Mortgage	Occupied Housing Units	Renter-Occupied Units
Wyoming	95,591	$96,600	$825	$229	193,608	55,793
Carbon County	7,744	$76,500	$685	$196	6,129	1,708
Fremont County	6,281	$89,300	$714	$217	13,545	3,496
Natrona County	15,250	$84,600	$746	$218	26,819	7,993
Sweetwater County	7,283	$104,200	$953	$231	14,105	3,488
Lander	1,479	$97,300	$701	$226	2,777	833
Riverton (Wind River Indian Reservation)	2,146	$83,200	$683	$203	3,792	1,221

*U.S. Census Bureau. "American FactFinder." 2000. <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).

3.2.10.4 Employment Structure

Employment structure from the 2000 U.S. Census including employment rate and type is based on data collected at the state and county level. Data collected at the state level also includes information on towns, CBSAs, or Metropolitan Areas and considers an outside workforce. An outside workforce includes workers willing to commute long distances {more than 48 km [30 mi]} for employment opportunities or external labor necessary to fulfill specialized positions (if the local workforce is unavailable or does not have the necessary skill sets). Data collected at the county level is the same as for the affected environment presented in Table 3.2-13 and also includes information on Native American communities.

Based on review of state-level information, Wyoming has a low unemployment rate (3.5 percent).

Unemployment at the county level ranges from 3.3 percent (Carbon County) to 5.7 percent (Fremont County). The town with the highest percentage of employment is Lander, and the town with the highest unemployment rate is Arapaho on the Wind River Indian Reservation.

3.2.10.4.1 State Data

3.2.10.4.1.1 Montana

The state of Montana has an employment rate of 60.8 percent and unemployment rate of 4.1 percent. The largest sector of employment is management, professional, and related occupations at 33.1 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

<u>Billings</u>

Billings has an employment rate of 64.8 percent and unemployment rate of 2.8 percent. The largest sector of employment is sales and office occupations at 31.9 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.2.10.4.1.2 Wyoming

The state of Wyoming has an employment rate of 63.1 percent and unemployment rate of 3.5 percent. The largest sector of employment is sales and office occupations. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

<u>Cheyenne</u>

Cheyenne has an employment rate of 59.2 percent and unemployment less than the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 33.0 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Lander

Lander has an employment rate of 59.4 percent and an unemployment rate lower than that of the state at 2.8 percent. The largest sector of employment is management, professional, and related occupations at 39.3 percent. The largest type of industry is educational, health, and social services at 37.9 percent. The largest class of worker is private wage and salary workers at 62.6 percent (U.S. Census Bureau, 2008).

Laramie

Laramie has an employment rate of 63.4 percent and unemployment less than the state at 3.7 percent. The largest sector of employment is management, professional, and related occupations at 40.5 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.2.10.4.2 County Data

Carbon County, Wyoming

Carbon County has an employment rate of 59.2 percent and an unemployment rate lower than that of the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 23.4 percent followed by sales and office occupations at 21.9 percent. The largest type of industry is educational, health, and social services at 17.1 percent. The largest class of worker is private wage and salary workers at 65.6 percent (U.S. Census Bureau, 2008).

Fremont County, Wyoming

Fremont County has an employment rate of 59.0 percent and an unemployment rate relatively high at 5.7 percent when compared to the state average. The largest sector of employment is management, professional, and related occupations at 33.9 percent followed by sales and office occupations at 22.5 percent. The largest type of industry is educational, health, and social services at 28.5 percent. The largest class of worker is private wage and salary workers at 64.1 percent (U.S. Census Bureau, 2008).

Natrona County, Wyoming

Natrona County has an employment rate of 64.6 percent and an unemployment rate similar to that of the state at 3.5 percent. The largest sector of employment is sales and office occupations at 29.9 percent followed by management, professional, and related occupations at 28.5 percent. The largest type of industry is educational, health, and social services at 21.2 percent. The largest class of worker is private wage and salary workers at 76.2 percent (U.S. Census Bureau, 2008).

Sweetwater County, Wyoming

Sweetwater County has an employment rate of 66.4 percent and an unemployment rate slightly higher than that of the state at 4.0 percent. The largest sector of employment is sales and office occupations at 23.4 percent followed by management, professional, and related occupations at 23.3 percent. The largest type of industry is educational, health, and social services at

18.2 percent. The largest class of worker is private wage and salary workers at 76.5 percent (U.S. Census Bureau, 2008).

Native American Communities

Information on labor force and poverty levels for the Wind River Indian Reservation is based on 2003 Bureau of Indian Affairs data and is provided in Table 3.2-18. The Northern Arapaho Tribe reports unemployment rates much higher than the statewide levels (U.S. Department of the Interior, 2003).

3.2.10.5 Local Finance

Local finance such as revenue and tax information for the affected environment is provided in this section. Table 3.2-19 shows 2007 annual sales and use tax distribution of the affected counties (including cities and towns) in the Wyoming West Uranium Milling Region.

Wyoming

The State of Wyoming does not have an income taxnor does it assess tax on retirement income received from another state. . Wyoming has a 4 percent state sales tax, 2 percent to 4 percent county lodging tax, and 4 percent use tax. Counties have the option of collecting an

Table 3.2-18. Employment Structure of the Wind River Indian Reservation Within the Affected Area*

Affected Environment	2003 Labor Force Population	Unemployed as Percent of Labor Force	Employed Below Poverty Guidelines	
Arapaho Tribe of the Wind River Indian Reservation	1,386	72%	106	8%

* U.S. Department of the Interior. "Affairs American Indian Population and Labor Force Report 2003." <http://www.doi.gov/bia/labor.html>. Washington, DC: U.S. Department of the Interior, Bureau of Indian Affairs, Office of Tribal Affairs. 2003.

Table 3.2-19. 2007 State and Local Annual Sales and Use Tax Distribution of Affected Counties Within the Wyoming West Uranium Milling Region*

Affected Counties	Use Tax		Sales Tax		Gross Revenue
	State	Local	State	Local	
Carbon County	$3,778,037	$4,328,728	$15,087,797	$16,953,793	$40,812,784
Fremont County	$1,520,637	$734,665	$20,205,131	$9,710,326	$32,624,896
Natrona County	$4,135,490	$3,322,747	$51,551,636	$41,420,622	$102,046,519
Sweetwater County	$9,856,907	$11,435,504	$51,423,220	$59,342,366	$133,613,150

*Wyoming Department of Revenue. "State of Wyoming Department of Revenue 2007 Annual Report." <http://revenue.state.wy.us/PortalVBVS/uploads/2007%20DOR%20Annual%20Report.pdf>. (7 April 2009).

additional 1 percent tax for general revenue and 2 percent tax for specific purposes. Wyoming also imposes "ad valorem taxes" on mineral extraction properties. Taxes levied for uranium production were 10.0 percent in 2007 (6.0 percent "ad valorem" and 4 percent severance) totaling $1.7 million dollars (Wyoming Department of Revenue, 2007). For 2007, in the Wyoming West Uranium Milling Region a small portion of this uranium tax revenue ($715.90) was generated in Sweetwater County. Annual sales and use tax distribution information for the affected counties (including cities and towns) in the Wyoming East Uranium Milling Region are presented in Table 3.3-14.

Native American Communities

The Wind River Indian Reservation's largest sources of revenue come from the Northern Arapaho and Eastern Shoshone Tribal Governments; the Bureau of Indian Affairs; the Ethete, Fort Washakie, and Arapaho School Districts; the Indian Health Service; and Native American household income (University of Wyoming, 1997).

3.2.10.6 Education

Based on review of the affected environment, the county with the largest number of schools is Natrona County and the county with the smallest number of schools is Carbon County. The town with the largest number of schools is Lander and the towns with the smallest number of schools (Ethete, Aropaho) are located on the Wind River Indian Reservation.

Lander

Lander has one school district, Fremont County School District No. 1, with a total 2007 enrollment of approximately 1,930 students. There are five elementary schools, four middle schools, three high schools, seven public schools, and one private school. The majority of schools provide bus services (Greatschools.com, 2008).

Carbon County

Carbon County has two school districts, Carbon County School Districts #1 and #2, with a combined total 2007 enrollment of approximately 2,650 students. There are a total of nine elementary schools, two middle school, two high school, and two private schools. The majority of schools within each school district provide bus services (Carbon County School District No.1 and No. 2, 2008a,b).

Fremont County

Fremont County has over eight school districts, with a combined total 2007 enrollment of approximately 7,125 students. There are more than 25 public and private elementary, middle, and high schools. The majority of school districts provides bus services (Schoolbug.org, 2007).

Natrona County

Natrona County has one school district: Natrona County School District No. 1, with a total enrollment of approximately 11,500 students in 2007. There are more than 30 public and private elementary and secondary schools. The majority of schools provide bus services (Natrona County School District No. 1, 2007).

Sweetwater County

Sweetwater County has 2 school districts with a total of 10 elementary schools, 3 intermediate/middle schools, 4 high schools, and 4 private or parochial schools. There are a total of about 7,175 students. The majority of schools within each district provides bus services (Sweetwater County School District No.1, 2007; Sweetwater County School District No. 2, 2005).

Native American Communities

The Wind River Indian Reservation has several school districts in the towns of Arapaho, Ethete, Fort Washakie, and Saint Stephens. There are a total of approximately 1,060 students. Schools are the Arapaho School, Wyoming Indian School, Fort Washakie School, and Saint Stephens Indian School. All four schools accommodate elementary through 12th grades. There is no information available as to whether bus services are provided by any of these schools (Easternshoshone.net, 2008).

3.2.10.7 Health and Social Services

Health Care

The majority of the health care facilities that provide service in the vicinity of the Wyoming West Uranium Milling Region is located within the larger population centers. The closest health care facilities within the vicinity of the potential ISL facilities are located in Riverton, Lander, Casper, Cheyenne, Laramie, and Thermopolis with a total of 14 facilities (MapQuest, 2008). These consist of hospitals, clinics, emergency centers, and medical services. Hospitals located within the vicinity of the potential ISL facilities include Lander (one), Riverton (one), Rock Springs (one), Rawlins (one), Casper (one), Laramie (one), and Thermopolis (one).

Local Emergency

Local police in the Wyoming West Uranium Milling Region are under the jurisdiction of each county. There are 16 police, sheriff, or marshals offices within the region: Carbon County (6), Fremont County (3), Natrona County (4), and Sweetwater County (3) (USACops, 2008a).

Fire departments within the Wyoming West Uranium Milling Region are comprised at the county, town, CBSA, or city level. There are 7 fire departments within the milling region: Lander (one), Natrona County (one), Dubois (one), Rawlins (two), Fort Washakie (one), and Riverton (one) (50States, 2008).

> **How Is Radiation Measured?**
>
> Radiation dose is measured in units of either sievert or rem and often referred to in either milliSv/mSv or millirem/mrem where 1,000 mSv=1 Sv and 1,000 mrem=1 rem. The conversion for sieverts to rem is Sv=100 rem. These units are used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation. Total effective dose equivalent, or TEDE, refers to the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). See Table 3.2-20 for public radiation doses from common activities.

3.2.11 Public and Occupational Health

3.2.11.1 Background Radiological Conditions

For a U.S. resident, the average total effective dose equivalent from natural background radiation sources is approximately 3 mSv/yr [300 mrem/yr] but varies by location and elevation (National Council of Radiation Protection and Measurements, 1987). In addition, the

Table 3.2-20. Public Radiation Doses*	
Activity or Event	**Dose**
Flying from NY to LA	2.5 mrem/trip
Chest x-ray	10 mrem/exam
Full mouth dental x-ray	9 mrem/exam
U.S. average background	360 mrem/yr
* Voss, J.T. "Los Alamos Radiation Monitoring Notebook." LA–UR–00–2584. Los Alamos, New Mexico: Los Alamos National Laboratory. 2000.	

average American receives 0.6 mSv/yr [60 mrem/yr] from man-made sources including medical diagnostic tests and consumer products (National Council of Radiation Protection and Measurements, 1987). Therefore, the total from natural background and man-made sources for the average U.S. resident is 3.6 mSv/yr [360 mrem/yr]. For a breakdown of the sources of this radiation, see Figure 3.2-22.

The total effective dose equivalent is the total dose from external sources and internal material released from licensed operations. Doses from sources in the general environment (such as terrestrial radiation, cosmic radiation, and naturally occurring radon) are not included in the dose calculation for compliance with 10 CFR Part 20, even if these sources are from technologically enhanced naturally occurring radioactive material, such as preexisting radioactive residues from prior mining (Atomic Safety and Licensing Board, 2006).

Background dose varies by location primarily because of elevation changes and variations in the dose from radon. As elevation increases so does the dose from cosmic radiation and hence the total dose. Radon is a radioactive gas produced from the decay of U-238, which is naturally found in soil. The amount of radon in the soil/bedrock depends on the type, porosity, and moisture content. Areas that have types of soils/bedrock like granite have higher radon levels than those with other types of soils/bedrock (EPA, 2006). For the Wyoming West Uranium

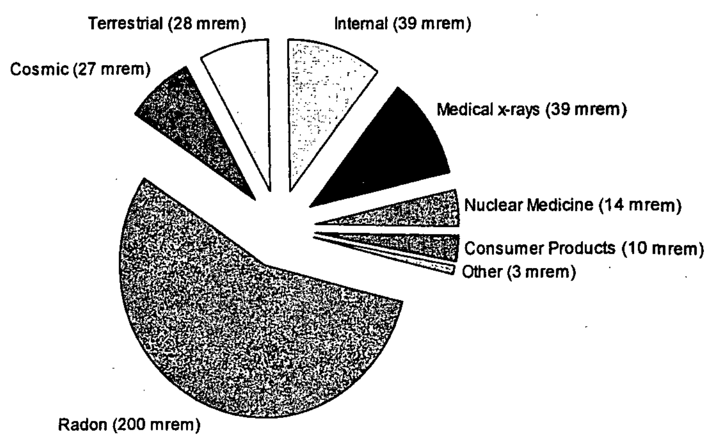


Figure 3.2-22 Average Annual Background Radiation in the United States {Units of mrem [1 mSv=100 mrem]} (NRC, 2006)

Milling Region, the average background radiation dose for the state of Wyoming is used, which is 3.16 mSv/yr [316 mrem/yr] (EPA, 2006). This value includes natural and man-made sources. This dose is slightly lower than the U.S. average primarily because the radon dose is lower {U.S. average of 2 mSv/yr [200 mrem/yr] versus Wyoming average of 1.33 mSv/yr [133 mrem/yr]}. Because of the higher elevation, the dose from cosmic radiation is slightly higher than the U.S. average: 0.515 mSv/yr [51.5 mrem/yr] versus 0.27 mSv/yr [27 mrem/yr]. The remaining contributions from terrestrial, internal, and man-made radiation combined are the same as the U.S. average of 1.318 mSv/yr [131.8 mrem/yr].

Outdoor radon concentrations are generally a small fraction of the average indoor concentrations. Outdoor radon concentrations can also be influenced by prior mining of any mineral (e.g., uranium, copper) in the area. To develop an open-pit or underground mine, soil and rock need to be excavated to reach the ore. This excavated rock, or overburden, can naturally contain higher levels of uranium and thorium than was present on the surface. Additionally, low grade ore may be left in the area around the mine, especially in the case of abandoned mines. Also, ore processed to extract elements other than uranium and thorium (such as copper, titanium, ruthenium, and other rare earth elements) could result in concentrating the natural uranium or thorium that was in the ore. The process of removing the rock or processing these ores could also change the physical and chemical characteristics controlling radon release, thus allowing additional radon to be released. The overburden and any ore left around the mine could elevate the local outdoor radon concentrations above the levels seen in other parts of the region. In close proximity to the mines, the level of terrestrial radiation could be elevated by the presence of mine waste. The overburden, low grade ore, and tailings from ore processed for other than uranium or thorium is called technologically enhanced naturally occurring radioactive material. Technologically enhanced naturally occurring radioactive material is not regulated by NRC. Radiation from these sources is considered part of the background for compliance with NRC regulations.

3.2.11.2 Public Health and Safety

NRC has the statutory responsibility, under the Atomic Energy Act of 1954, as amended, to protect the public health and safety and the environment. NRC's regulations in 10 CFR Part 20 specify annual dose limits to members of the public of 1 mSv [100 mrem] total effective dose equivalent and 0.02 mSv/hr [2 mrem/hr] from any external sources.

3.2.11.3 Occupational Health and Safety

Occupational health and safety risks to workers include exposure to radioactive materials. Radiation safety practices for workers at uranium ISL facilities should be such that the dose to the workers is kept as low as is reasonably achievable. Radiation exposure limits are specified in 10 CFR Part 20. Occupational dose is determined by the more limiting of (1) 0.05 Sv [5 rem] total effective dose equivalent or (2) sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 0.5 Sv [50 rem]. The lens of the eye is limited to a dose equivalent of 0.15 Sv [15 rem] and the skin (of the whole body or any extremity) is limited to a shallow dose equivalent of 0.5 Sv [50 rem]. The monitoring requirements for occupational dose are covered in greater detail in Section 2.9 and Chapter 8.

3.2.12 References

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3.3 Wyoming East Uranium Milling Region

3.3.1 Land Use

As shown in Figure 3.3-1, the Wyoming East Uranium Milling Region encompasses parts of eight counties (Albany, Campbell, Carbon, Converse, Johnson, Natrona, Platte, and Weston), although it predominantly lies within Converse and Campbell Counties. This region straddles portions of the Wyoming Basin to the west and the upper part of the Missouri Plateau to the north (U.S. Geological Survey, 2004). In this region, past, current, and potential uranium milling operations are generally found in the four-corner area of Campbell, Converse, Natrona, and Johnson Counties (known as the Pumpkin Buttes District) and in the northern-central part of Converse County (known as the Monument Hill District). The Shirley Basin Uranium District located south of Casper is the past site of a conventional uranium milling facility (Figures 3.3-1 and 3.3-2). The geology and soils of these three uranium districts are detailed in Section 3.3.3.

While 53.3 percent of the land in Wyoming is federal and state public land, surface land ownership in this region is predominantly private (68 percent) (Table 3.3-1). Within the Wyoming East Uranium Milling Region there are portions of two large tracts of federal land that are managed by the USFS:

- The Thunder Basin National Grassland, which straddles Campbell, Converse, and Weston Counties in the Powder River Basin between the Big Horn Mountains to the west and the Black Hills to the east, represents 15 percent of the region.

- The Medicine Bow National Forest, which occupies the southern part of Converse County and extends farther south into Albany County, represents almost 6 percent of the region.

Although federal grasslands and forests occupy an important portion of the region (approximately 21 percent), most rangeland is privately owned (68 percent) and is primarily used for grazing cattle and sheep. Campbell County, for example, has more private land ownership than any other county in Wyoming. Other federal lands managed by BLM, the U.S. Bureau of Reclamation, and the Department of Defense (Table 3.3-1) comprise scattered tracts mixed with state and private lands and represent only approximately 10 percent of the land in the Wyoming East Uranium Milling Region (Figure 3.3-1). As described for the Wyoming West Uranium Milling Region in Section 3.1.1, there are also in this region privately owned surface rights and publicly owned subsurface mineral rights resulting in split estate situations (BLM, 2008a) (Section 3.1.2.2).

The open rangelands of this region consist of gently rolling hills covered by sagebrush and short grass prairies capable of supporting year-round cattle and sheep grazing. Compared to the productivity of the open rangeland, farmland is marginal. It consists of dry or locally irrigated grain, hay, and pasture crops for livestock grazing or for preparing livestock feed. Agriculture is limited in the region due to low precipitation and because other water resources are insufficient for irrigation.

In addition to providing forage for livestock and grazing, the Thunder Basin National Grassland provides a variety of recreational activities, such as sightseeing, hiking, camping, hunting, and fishing (USFS, 2008). The historic Bozeman, Oregon, and Bridger Trail Corridors (see

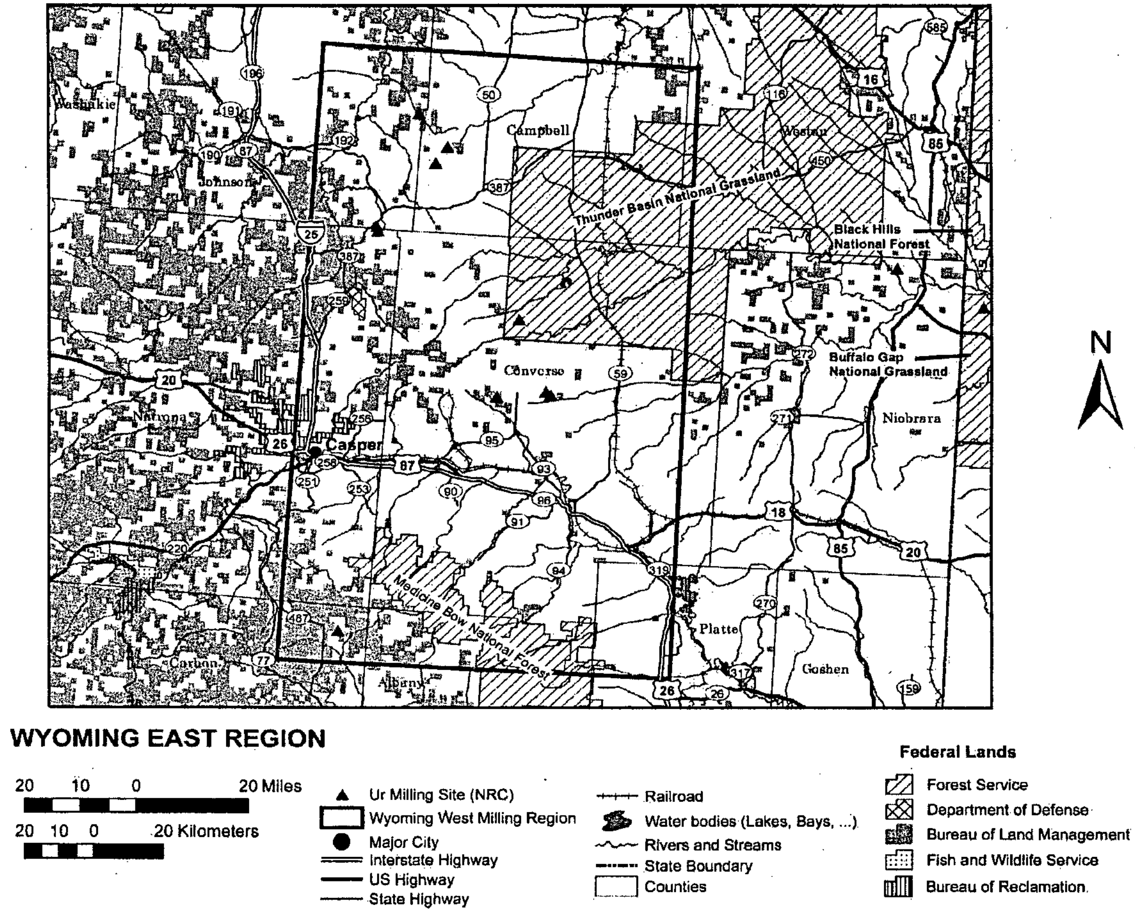


Figure 3.3-1. Wyoming East Uranium Milling Region General Map With Past, Current, and Future Uranium Milling Site Locations

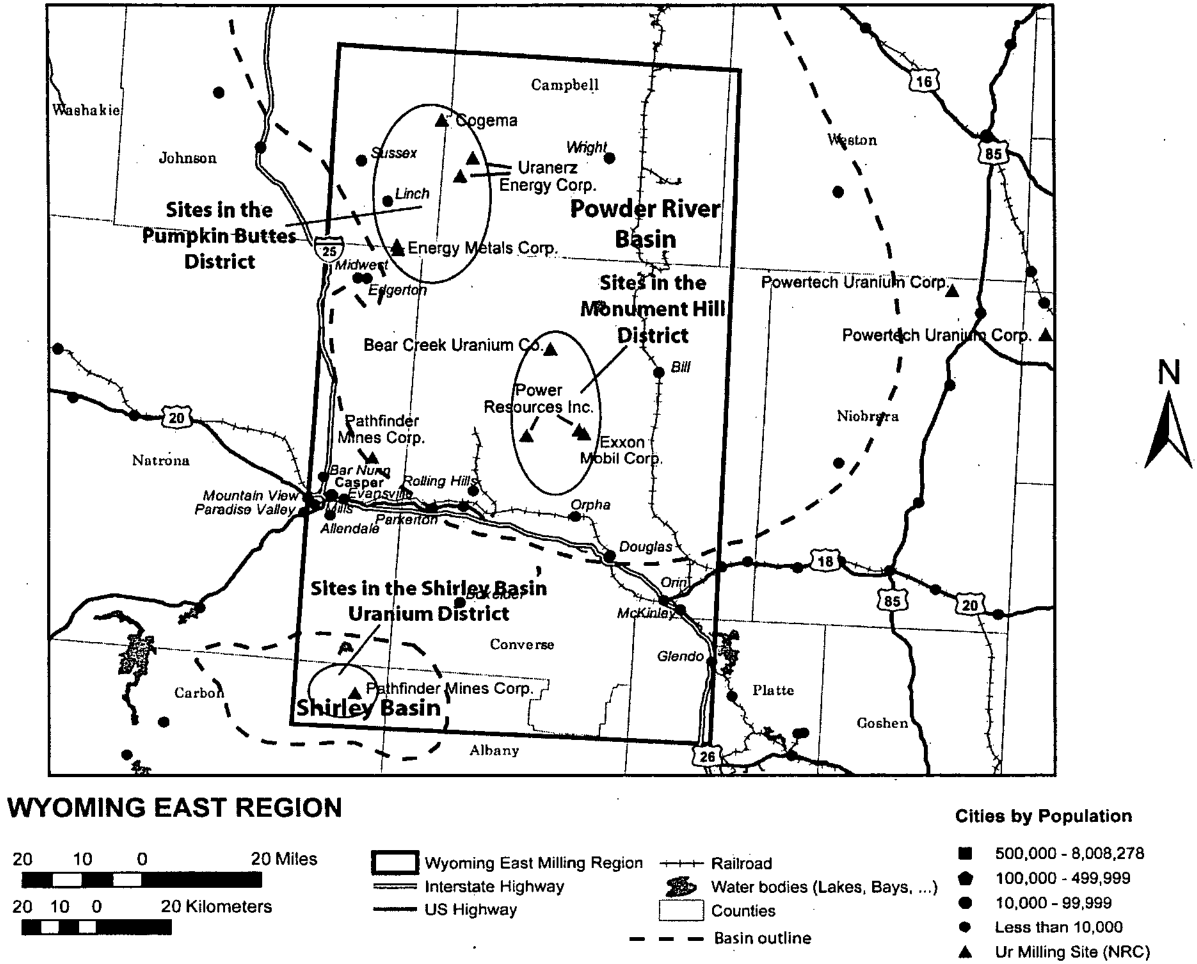


Figure 3.3-2. Map Showing Outline of the Wyoming East Region and Locations of the Pumpkin Buttes and Monument Hill Districts in the Powder River Basin and the Shirley Basin Uranium District in the Shirley Basin

Table 3.3-1. Land Surface Ownership and General Use in the Wyoming East Uranium Milling Region			
Land Surface Ownership and General Use	Area (mi^2)	Area (km^2)	Percent
Private Lands	5,503	14,252	68.3
U.S. Forest Service, National Grassland	1,238	3,207	15.4
U.S. Bureau of Land Management, Public Domain Land	797	2,064	9.9
U.S. Forest Service, National Forest	466	1,208	5.8
Bureau of Reclamation	36	92	0.4
U.S. Department of Defense (Navy)	14	35	0.2
Totals	8,054	20,859	100

Figure 3.1-2), extending north and north-northeast through Natrona and Johnson Counties along the western edge of the Wyoming East Uranium Milling Region, also offer a variety of recreational activities, including sightseeing, museums, historic sites, and small state parks (Fort Phil Kearny/Bozeman Trail Association, 2008).

Oil and gas production facilities, coal mines, and coal bed methane facilities have been, and continue to be, developed throughout the federal and private rangeland of the Powder River Basin. These coal, coal bed methane, and oil and gas facilities are more prevalent and concentrated in the central and northern part of the Powder River Basin in Campbell and Johnson Counties. Given the abundance and density of coal bed methane facilities in these counties, current and future permitted areas of ISL facilities of the Pumpkin Buttes District would be likely near or intermixed with such coal bed methane sites. In the southern part of the Powder River Basin in the Monument Hill District, there are only a few scattered coal bed methane sites (U.S. Geological Survey, 2001). Future ISL facilities in the Monument Hill District therefore would not interfere with land use for coal bed methane facilities.

3.3.2 Transportation

Past experience at NRC-licensed ISL facilities indicates these facilities rely on roads for transportation of goods and personnel (Section 2.8). As shown in Figure 3.3-3, the Wyoming East Uranium Milling Region is accessible from the west by Interstate 25, U.S. Highway 20, and State Route 220. From the north, the region is accessible via Gillette by State Route 59 or State Route 50. Travel from the east reaches the Wyoming East Uranium Milling Region using State Route 450 in the northern portion of the region and U.S. Highway 18 or U.S. Highway 26 farther to the south. Southern access is from U.S. Highway 26 in the southeastern corner near Glendo and State Route 487 from the southwestern corner of the region. Rail lines traverse the southern part of the region following the path of Interstate 25. A rail spur forks north of Orin and generally follows State Route 59 north in the direction of Gillette.

Areas of interest in uranium milling in the region are shown in Figure 3.3-3. For discussion purposes, these areas are located in four main subregions when considering site access by local roads. Areas of milling interest that are located in the northwestern part of the region between Edgerton and Wright are accessed from Gillette to the north or from Casper to the south. A cluster of northernmost sites is accessed by local roads leading east to State Route 50 and then south to State Route 387 and either north to Gillette or south to Casper and Interstate 25. Along State Route 387, north of Edgerton, is another subregion of uranium milling

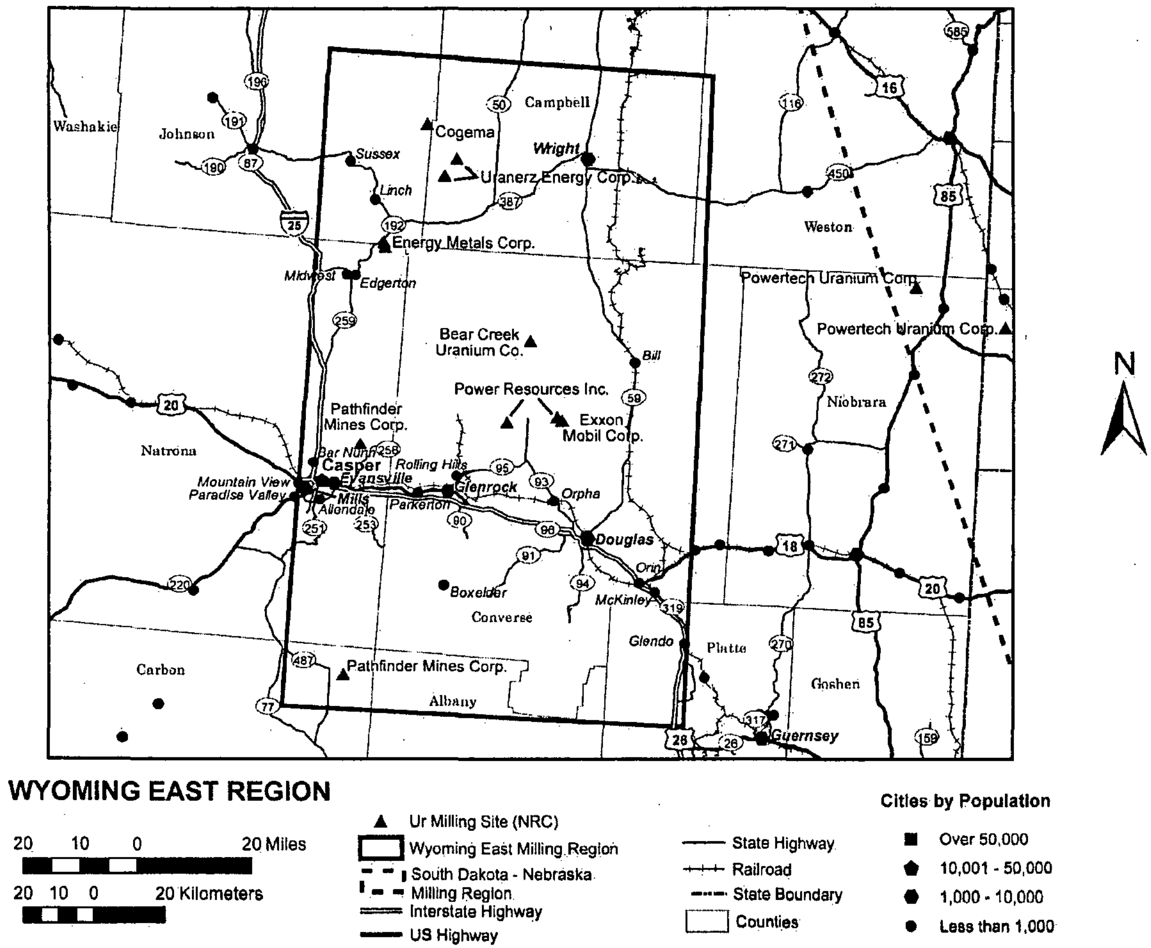


Figure 3.3-3. Wyoming East Uranium Milling Region General Map With Current and Future Uranium Milling Site Transportation Corridor

interest. The midsection of the Wyoming East Uranium Milling Region, north of Douglas, Orpha, and Rolling Hills, is the third subregion of concentrated milling interest. Local roads including Ross Road provide access to this subregion from the south using State Routes 93 and 95 that connect to Interstate 25. A rail spur runs north and dead ends into this area from the main line that follows Interstate 25. Further to the west in the direction of Casper, State Route 256 from Interstate 25 provides access for another milling site. The fourth subregion of interest is in the southwestern corner of the Wyoming East Uranium Milling Region. This is the location of the Shirley Basin conventional milling site, which is accessed using State Route 487 and 251 from Casper (and Interstate 25) to the north, or from the south on State Route 487 and U.S. Highway 30 from Laramie.

Table 3.3-2 provides available traffic count data for roads that support areas of past or future milling interest in the Wyoming East Uranium Milling Region. Counts are variable with the minimum all-vehicle count at 340 vehicles per day on State Route 93 at Orpha and the

Table 3.3-2. Average Annual Daily Traffic Counts for Roads in the Wyoming East Uranium Milling Region*

Road Segment	Distance (mi)	Trucks		All Vehicles	
		2005	2006	2005	2006
State Route 59 at Reno Junction (north of intersection with State Route 387)	—	690	750	3,630	3,930
State Route 387 at Pine Tree Junction (between State Routes 50 and 59)	20	210–410	220–410	970–3,130	970–3,130
State Route 387 at Edgerton North	—	380	440	2,110	2,140
Interstate 25 at Casper North (between Casper and State Route 259)	20	570–690	610–690	2,460–3,760	2,560–3,800
State Route 487 at Shirley Basin North (at intersection with State Route 251)	—	70	80	710	700
State Route 256 North of Interstate 25	—	140	140	2,270	2,290
U.S. Highway 20/26 at Casper East (between Evansville and Parkerton)	0.5	200	230	2,900	2,900
Interstate 25 Casper to State Route 95	21	570–1,030	610–1,030	2,610–10,220	2,710–10,220
State Route 95 at Rolling Hills	—	50	50	1,800	1,810
State Route 93 at Orpha	—	50	50	340	340
State Route 59 Douglas to Bill	35	380–450	410–440	1,940–3,690	1,940–3,690

*Wyoming Department of Transportation. "Wyoming Department of Transportation Vehicle Miles." Data for Calendar Year 2005 and 2006 Provided on Request. District 2 Office, Casper, Wyoming: Wyoming Department of Transportation. April 18, 2008.
1 mi = 1.61 km

maximum on Interstate 25 at Casper to State Route 95 at 10,220 vehicles per day. Most all-vehicle counts in the Wyoming East Uranium Milling Region are above 900 vehicles per day.

Yellowcake product shipments are expected to travel from the milling facility to a uranium hexafluoride production (conversion) facility in Metropolis, Illinois (the only facility currently licensed by NRC in the United States for this purpose). Major interstate transportation routes are expected to be used for these shipments, which are required to follow NRC packaging and transportation regulations in 10 CFR Part 71 and U.S. Department of Transportation hazardous material transportation regulations at 49 CFR Parts 171–189. Table 3.3-3 describes representative routes and distances for shipments of yellowcake from locations of uranium milling interest in the Wyoming East Uranium Milling Region. Representative routes are considered owing to the number of routing options available that could be used by a future ISL facility. Because transportation risks are dependent on shipment distance, identification of representative routes is used to generate estimates of shipment distances for evaluation of transportation impacts in Chapter 4 (Section 4.2.2). An ISL facility could use a variety of routes for actual yellowcake shipments, but the shipment distances for alternate routes are not expected to differ significantly from those estimated for the representative routes.

Table 3.3-3. Representative Transportation Routes for Yellowcake Shipments From the Wyoming East Uranium Milling Region

Origin	Destination	Major Links	Distance* (mi)
West of Savageton, Wyoming	Metropolis, Illinois	Local access road east to State Route 50 State Route 50 south to Route 387 State Route 387 south to Edgerton, Wyoming State Route 259 south to Interstate 25 Interstate 25 south to Casper, Wyoming Interstate 25 south to Denver, Colorado Interstate 70 east to St. Louis, Missouri Interstate 64 east to Interstate 57	1,420
		Interstate 57 south to Interstate 24 Interstate 24 south to U.S. Highway 45 U.S. Highway 45 west to Metropolis, Illinois	
Northwest of Douglas, Wyoming	Metropolis, Illinois	Ross Road south to State Route 93 State Route 93 south to Interstate 25 Interstate 25 south to Denver, Colorado Denver, Colorado, to Metropolis, Illinois (as above)	1,300
Shirley Basin Area, Wyoming	Metropolis, Illinois	Local access roads west to State Route 487 State Route 487 north to State Route 251 State Route 251 north to Casper, Wyoming Interstate 25 south to Denver, Colorado Denver, Colorado, to Metropolis, Illinois (as above)	1,370

*American Map Corporation. "Road Atlas of the United States, Canada, and Mexico." Long Island City, New York: American Map Corporation. p. 144. 2006.
1 mi = 1.61 km

3.3.3 Geology and Soils

As noted in Section 3.2.3, Wyoming contains the largest known reserves of uranium in the United States and has been the nation's leading producer of uranium ore since 1995 (Wyoming State Geological Survey, 2005). Sandstone-hosted uranium deposits account for the vast majority of the ore produced in Wyoming (Chenoweth, 1991). In the Wyoming East Uranium Milling Region, uranium mineralization is found in fluvial sandstones in two major areas: the Powder River Basin and the Shirley Basin (Figure 3.3-2). Uranium mineralization in sandstones in these two districts is in a geologic setting favorable for recovery by ISL milling. Since 1991, all uranium produced from sandstones in the Wyoming East Uranium Milling Region has been by the ISL method (Wyoming State Geological Survey, 2005).

The Powder River Basin encompasses an area of about 31,000 km^2 [12,000 mi^2] in Converse and Campbell Counties. Uranium was first discovered in the Powder River Basin in 1951 near Pumpkin Buttes in the central part of the basin (Davis, 1969). Other uranium deposits were found along a 97-km [60-mi] northwest-southeast trend in the southwest part of the Powder River Basin, and production began in 1953. Prior to 1968, total production from the Powder River Basin was slightly over 455,000 metric tons [500,000 tons] of U_3O_8 (Davis, 1969). The most important uranium deposits are in the Monument Hill District, which produced over 90 percent of the ore from the basin prior to 1968.

The Shirley Basin uranium area is mainly in the northeastern part of Carbon County (Figure 3.3-4). Uranium was discovered in the Shirley Basin in 1955 (Melin, 1969). Production began in 1960 from underground and open-pit mines. Milling by ISL began in 1964. Prior to 1970, approximately 1,500 metric tons [1,600 tons] of U_3O_8 was produced from mines in the Shirley Basin (Chenoweth, 1991). The dominant source of sediment in the Powder River Basin and the Shirley Basin was Precambrian (greater than 540-million-year old) granitic rock of the Sweetwater Arch and northern Laramie Range (Rackley, 1972; Harris and King, 1993). The Sweetwater Arch is also referred to as the Granite Mountains (Bailey, 1969; Anderson, 1969; Lageson and Spearing, 1988). The Sweetwater Arch and northern Laramie Range are mountain ranges composed of uraniferous granitic rock. The Powder River Basin formed during the Laramide Orogeny (mountain-building era) during the Paleocene to early Eocene (50 to 65 million years ago). Uplift of the Sweetwater Arch and Laramie Range began to affect sedimentation in the adjacent Powder River Basin and Shirley Basin in Late Cretaceous time (65 to 99 million years ago). Rapidly subsiding portions of these basins received thick clastic wedges (i.e., wedges made of fragments of other rocks) of predominantly arkosic sediments (i.e., sediments containing a significant fraction of feldspar), while larger, more slowly subsiding portions of the basins received a greater proportion of paludal (marsh) and lacustrine (lake) sediments.

Sediment in the west Shirley Basin was deposited on an alluvial fan, but in the east Shirley Basin and in the Powder River Basin, sedimentation was channel and floodplain deposits of a meandering stream (Rackley, 1972). Beginning in the middle Eocene (41 to 49 million years ago) and increasing in the Oligocene (23.8 to 33.7 million years ago), regional volcanic activity contributed a significant amount of tuffaceous materials (i.e., materials made from volcanic rock and mineral fragments in a volcanic ash matrix) to local sediments. Deposition within the basins probably continued through the Miocene (5.3 to 23.8 million years ago). With the exception of the Pumpkin Buttes in the Powder River Basin, which are capped by remnants of the Oligocene White River Formation, post-Miocene erosion has removed most Oligocene and Miocene units.

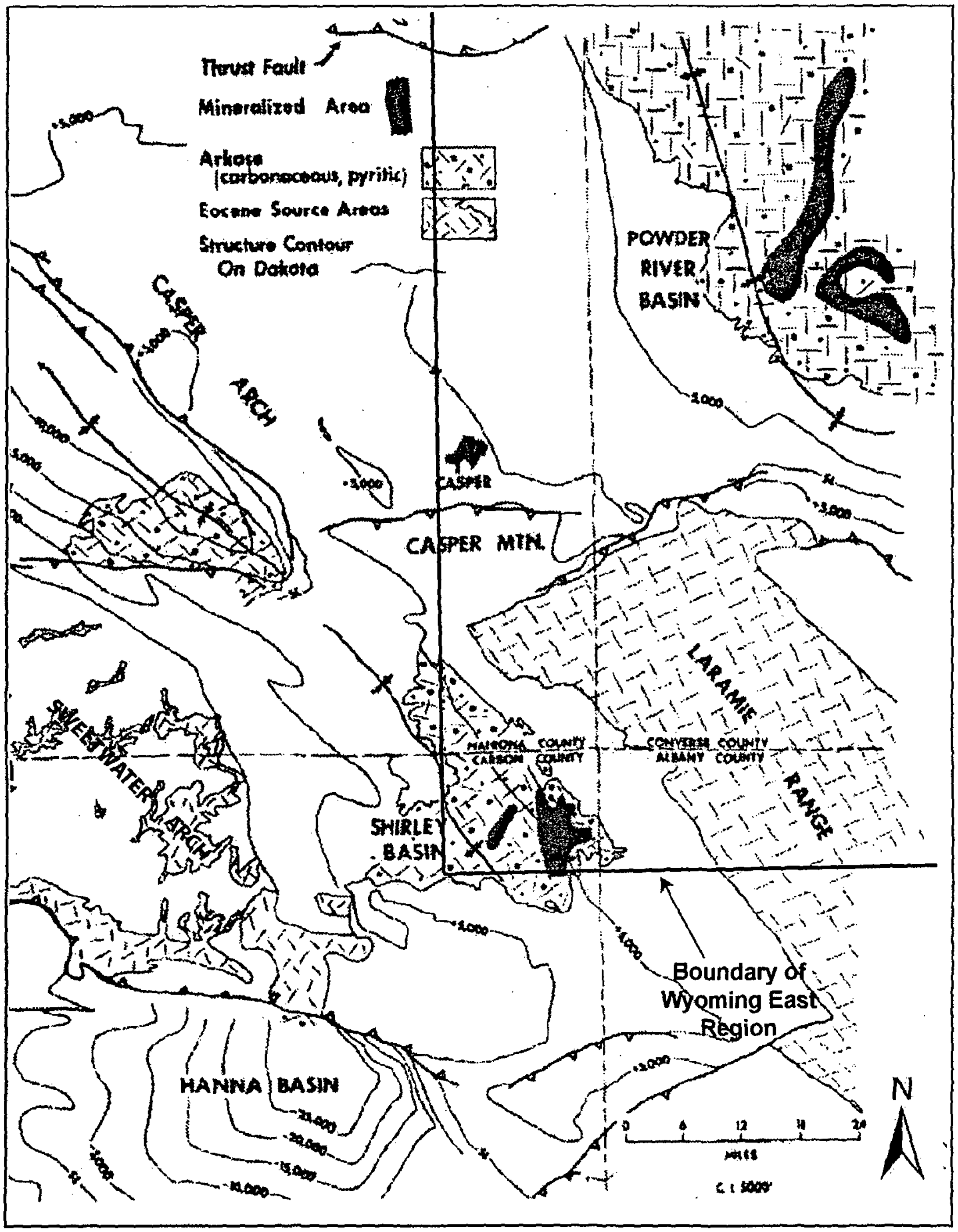


Figure 3.3-4. Index and Structure Map of East-Central Wyoming Showing Relation of the Sweetwater Arch and Laramie Range to the Powder River Basin and the Shirley Basin. The Distribution of Arkosic, Carbonaceous Sediments and Mineralized Areas in the Powder River and Shirley Basins Are Also Shown (Modified From Rackley, 1972).

A generalized stratigraphic section of Tertiary (1.8- to 65-million-year old) formations in the Shirley Basin and the Powder River Basin is shown in Figure 3.3-5. Stratigraphic descriptions presented here are limited to formations that may be involved in potential milling operations or formations that may have environmental significance, such as important aquifers and confining units above and below potential milling zones.

Formations hosting major sandstone-type uranium deposits in the Wyoming East Uranium Milling Region are the Wasatch Formation in the Powder River Basin and the Wind River Formation in the Shirley Basin. Both the Wasatch and Wind River are lower Eocene (49 to 54.8 million years old) in age (Houston, 1969) and consist of interbedded, arkosic sandstone, conglomerate, siltstone, mudstone, and carbonaceous shale, all compacted but poorly cemented (Harshman, 1968). The Wasatch Formation in the Powder River Basin also contains thick coal beds. In the Powder River Basin, recoverable ore that can be exploited by ISL milling is located in parts of the Wasatch Formation extending from depths of 120 to 300 m [400 to 1,000 ft] below the surface (Davis, 1969). Uranium deposits in the Shirley Basin lie at depths of 30 to 150 m [100 to 500 ft], almost entirely in the lower 90 m [300 ft] of the Wind River Formation (Melin, 1969; Bailey, 1969).

The Wagon Bed Formation conformably overlies the Wind River Formation in the Shirley Basin, but is absent in the Powder River Basin. The Wagon Bed comprises a series of interbedded arkosic sandstones and silicified claystones. In the central part of the Shirley Basin, the Wagon Bed Formation may not be present, having been removed by erosion. In the Shirley Basin, the White River Formation unconformably overlies the Wagon Bed Formation of the Wind River

Central Wyoming				
System	Series		Formation	
Tertiary	Pliocene		Moonstone Formation	
	Miocene		Split Rock Formation	Arikaree Formation
	Oligocene		White River Formation	
	Eocene	Upper	Wagon Bed Formation	
		Middle		
		Lower	Wind River Formation	Wasatch Formation
	Paleocene		Fort Union Formation	
Cretaceous	Upper		Lance Formation	

Figure 3.3-5. Stratigraphic Section of Tertiary Age Formations in the Powder River Basin and Shirley Basin of Wyoming. Major Sandstone-Type Uranium Deposits Are Hosted in the Wasatch Formation in the Powder River Basin and the Wind River Formation in the Shirley Basin (Modified From Harshman, 1968).

Formation where the Wagon Bed has been removed by erosion. In the Powder River Basin, the White River Formation overlies the Wasatch Formation. White River consists of tuffaceous siltstone, claystone, and conglomerate with subordinate amounts of tuff. In the Shirley Basin, the White River overlaps older Tertiary formations and wedges out against pre-Tertiary rocks on the flanks of the basin. The White River Formation has been removed by erosion throughout most of the Powder River Basin, but remnants cap the Pumpkin Buttes. The White River Formation is overlain by the Split Rock Formation in the Shirley Basin. The Split Rock consists of tuffaceous siltstone and sandstone beds that sometimes cap prominent ridges (Harshman, 1968).

The Fort Union Formation underlies the Wasatch and Wind River formations in the Powder River and Shirley Basins and, to a limited extent, is also a host to sandstone-type uranium deposits (Davis, 1969; Langden, 1973). The Fort Union is a fluvial deposit consisting of alternating and discontinuous mudstones, siltstones, carbonaceous shales, and coarser arkosic sandstone. In the Powder River Basin, the Fort Union also contains thick, continuous coal beds. The Fort Union is unconformably underlain by sediments of the Lance Formation, which is in turn underlain by a thick sequence of older sandstones, mudstones, and shales.

The uranium deposits in the Wyoming East Uranium Milling Region are stratabound and genetically related to geochemical interfaces, or roll fronts (see Section 3.1.2). The roll-front ore deposits in the Powder River Basin are usually multiple C-shaped rolls distorted by variations in gross lithology (Davis, 1969). The principal ore minerals are uraninite, coffinite, metatyuyamunite, and carnotite. Gangue minerals (i.e., low-value minerals intermixed with ore minerals) are calcite, gypsum, pyrite, iron oxide, and barite (Mrak, 1968). Although most of the uranium in the Shirley Basin is in roll-front deposits, important amounts also occur in tabular bodies near the rolls. Tabular sandstone-hosted uranium deposits are found as blanketlike, roughly parallel ore bodies along sandstone trends. The uranium mineralization in both the roll-front and tabular deposits consists of disseminations and impregnations of uraninite, calcite, pyrite, and marcasite in arkosic sandstones.

The source of uranium in sandstone-type uranium deposits in central Wyoming is a topic of conjecture. Four theories on the source of uranium in these occurrences have been suggested: (1) leached uranium from overlying ash-fall tuffs, (2) leached uranium from igneous and metamorphic rocks in the highlands surrounding the basins, (3) leached uranium from the host sandstones themselves, and (4) hydrothermal uranium from a magma source at depth (Harris and King, 1993). Combinations of these theories have been proposed as well (Boberg, 1981). The most popular theories are the (1) tuff leach and (2) highland leach. The tuff leach theory is supported by extensive geochemical studies on uranium removal from tuff (Zielinski, 1983, 1984; Trentham and Orajaka, 1986). Further, it was the tuff leach theory that led to the discovery of most of the large uranium deposits in Wyoming (Love, 1952). On the other hand, many sandstone-hosted uranium deposits in Wyoming are found adjacent to crystalline rocks, especially the uraniferous granites of the northern Laramie and Granite Mountains (Harris and King, 1993). Oxidized uranium leached from these crystalline terrains could have been transported to the sites of present mineralization.

Soils within the Wyoming East Uranium Milling Region are diverse and can vary substantially in terms of characteristics over relatively short distances. The distribution and occurrence of soils in east-central Wyoming can vary both on a regional basis (mountains, foothills, basins) and locally with changes in slope, geology, vegetation, climate, and time. In the Powder River Basin and Shirley Basin, old, tilted sedimentary rocks occur in bands along the margins of the basins,

whereas younger sediments showing varying degrees of incision by erosion are found in the basin centers.

The topographic position and texture of typical soils in the Powder River Basin and Shirley Basin areas of east-central Wyoming were obtained from tMunn and Arneson (1998). This map was designed primarily for statewide study of ground water vulnerability to contamination and would not be expected to be used for site-specific soil interpretations at proposed ISL milling facilities. For site-specific evaluations, detailed soils information would be expected to be obtained from published county soil surveys or the NRCS.

In the Powder River and Shirley Basins, shallow loamy-skeletal (stony) soils with little or no subsoil development occupy ridge crests along the margins of the basins. These soils contain hard clasts (i.e., rock fragments) and tend to be much coarser than soils on the adjacent lower slopes. Loamy-skeletal soils with little subsoil development are also found in the foothills along the margins of the basin and along eroded drainageways. Fine to fine-loamy soils with moderate- to well-developed soil horizons are found on gently sloping to moderately steep slopes associated with alluvial fans and alluvial terraces. These soils are generally light colored and depleted in moisture. Moderately deep soils with well-developed soil horizons occur on low relief surfaces, such as stream terraces and floodplains, across broad expanses of the basins. Fine loamy over sandy and coarse loamy soils occurs on stream terraces. Soils found on floodplains include fine loamy and fine-sand loams. Dark-colored, base-rich soils formed under grass are generally associated with floodplains along streams with permanent high water.

3.3.4 Water Resources

3.3.4.1 Surface Waters

The Wyoming East Uranium Milling Region (Figure 3.3-6) includes portions of Albany, Campbell, Carbon, Converse, Johnson, Natrona, Platte, and Weston Counties in east-central Wyoming. Surface runoff to streams, in terms of average annual flow per unit area of a watershed, in the Wyoming East Uranium Milling Region varies from more than 13 cm/yr [5 in/yr] to less than 1 cm/yr [0.5 in/yr] in the mountains to less than 1.3 cm/yr [0.5 in/yr] in the intermontane valleys and on the plains (Gebert, et al., 1987). The potential uranium milling sites are located in the intermontane areas and on the plains. The watersheds within the Wyoming East Uranium Milling Region are listed in Table 3.3-4 along with the range of designated uses of surface water bodies assigned by the State of Wyoming (WDEQ, 2001). Because surface water uses are designated for specific water bodies (such as stream segments and lakes) within a watershed and the specific locations of future uranium milling activities are not known at this time, the range of designated uses is provided rather than a listing of designated uses for each water body within a watershed. Not all water bodies within a watershed may have all of the designated uses listed in Table 3.3-4. For example, a watershed may contain perennial streams, intermittent streams that flow only during portions of the year, and ephemeral streams that flow only because of surface runoff from local precipitation events. The perennial streams and possibly portions of intermittent streams may be designated as "fisheries" whereas ephemeral streams are unlikely to be designated as fisheries. The descriptions of the water bodies and their classifications in this section focus on perennial streams that generally have higher designated uses than the intermittent and ephemeral streams. For information regarding specific water bodies, refer to the Wyoming Department of Environmental Quality Surface Water Standards webpage (deq.state.wy.us/wqd/watershed/surfacestandards).

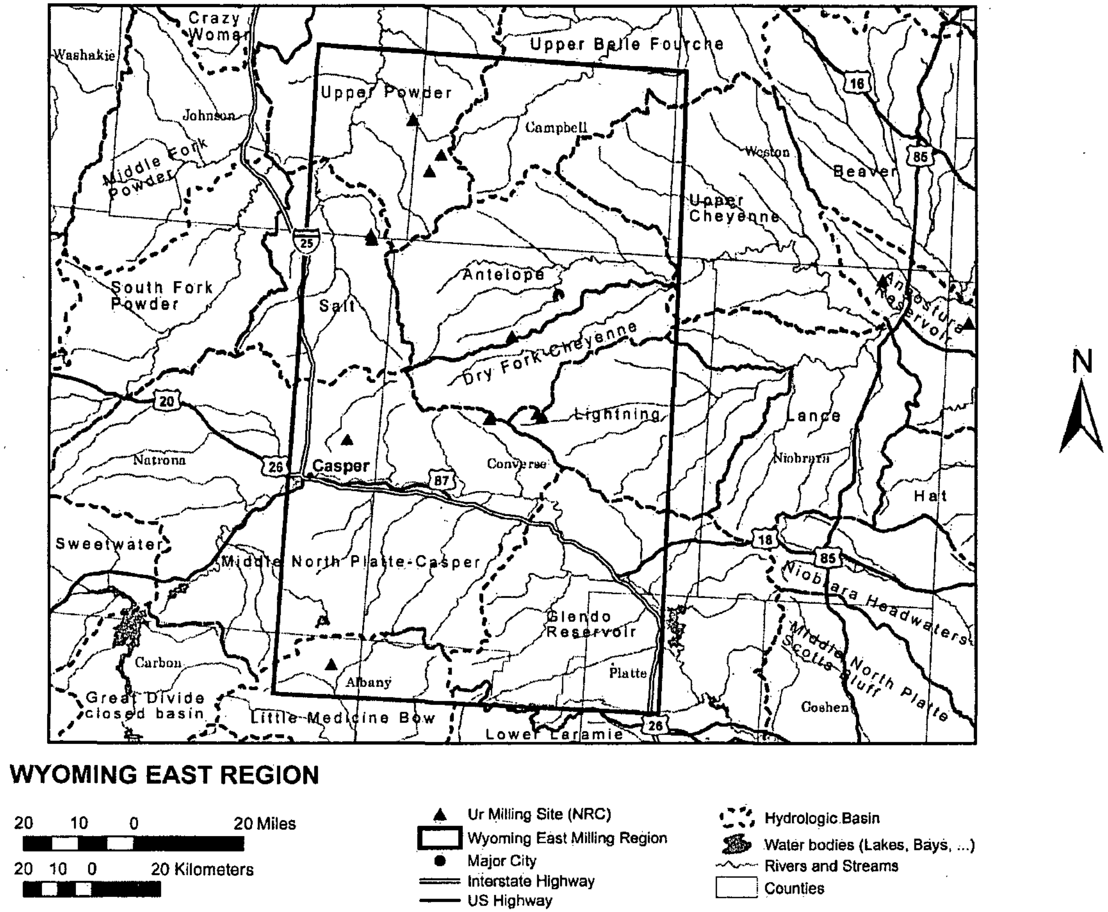


Figure 3.3-6. Watersheds Within the Wyoming East Uranium Milling Region

Table 3.3-4. Primary Watersheds in the Wyoming East Uranium Milling Region Range of Designated Uses of Water Bodies Within Each Watershed	
Watershed	**Range of State Classification of Designated Uses***
Little Medicine Bow River and Tributaries	Generally 2AB with some tributaries 2B and 3C
Glendo Reservoir and Tributaries	2AB and 3B
Middle North Platte River	2AB with some tributaries 3B
Salt Creek	2C with some tributaries 3B
Lightning Creek	3B
Dry Fork Cheyenne River	3B
Antelope Creek	3B
Upper Cheyenne River	3B
Upper Powder River	2ABww with some tributaries 3B
Upper Belle Fourche River and Tributaries	2ABww and 3B

*Class 2AB waters have designated uses including Drinking Water, Game Fish, Non-Game Fish, Fish Consumption, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2A waters have designated uses including Drinking Water, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2B waters exclude Drinking Water from the Class 2AB uses. Class 2C waters exclude drinking water and game fish from the Class 2AB uses.
Class 3A, 3B and 3C waters have designated uses including Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Classes 4A, 4B and 4C waters have designated uses including Recreation, Wildlife Agriculture, Industry, Scenic Value.
Classes 2ABww and 2Bww are warm water fisheries.
Official definitions of surface water classes and uses are in Wyoming Department of Environmental Quality Water Quality Rules and Regulations, <http://soswy.state.wy.us/Rules/RULES/6547.pdf> (29 January 2009).

The historical uranium milling districts included in the Wyoming East Uranium Milling Region are the Shirley Basin within the Little Medicine Bow River Watershed in the southwest and uranium deposits in the area known as the Powder River Basin that actually includes watersheds in addition to those contributing to the Powder River. Watersheds containing historical or potential uranium milling sites are Middle North Platte-Casper, Lightning Creek, Dry Fork Cheyenne River, Antelope Creek, Salt Creek, and Upper Powder River.

The Shirley Basin uranium district is located within the Little Medicine Bow River Watershed (Figure 3.3-6) in Carbon and Albany counties. In addition to the Little Medicine Bow River, other significant surface water features associated with the Shirley Basin are Sand Creek and Muddy Creek. Several small reservoirs are located on these streams. Several unnamed springs are also shown on the topographic maps covering the Shirley Basin. The Little Medicine Bow River and most of its tributaries are generally Class 2AB waters with some classified as 2C and 3B (Table 3.3-4). The difference between Class 2AB and Class 2C waters is that Class 2C waters do not have drinking water supply or game fish as designated uses. Class 3B also excludes nongame fish and fish consumption as designated uses. Although the Little Medicine Bow River flows directly through an area of historic uranium mining and milling, it is not listed as an impacted or threatened water body (WDEQ, 2008). The average flow of the Little Medicine Bow River at Boles Spring, Wyoming, is 1.1 m^3/s [38 ft^3/s] (U.S. Geological Survey, 2008).

The Powder River Basin contains the most extensive uranium deposits in Wyoming, covering a large portion of east-central Wyoming in Converse, Campbell, and Johnson Counties. Principal watersheds within the Powder River Basin uranium district are (from south to north), Glendo Reservoir (on the North Platte River), Middle North Platte-Casper, Lightning Creek, Dry Fork of the Cheyenne River, Antelope Creek, Salt Creek, Upper Cheyenne River, Upper Belle Fourche, and Upper Powder River. The Lightning Creek, Antelope Creek, Dry Fork of the Cheyenne River, and Upper Cheyenne River watersheds contain ephemeral and intermittent streams that flow to the Cheyenne River east of the uranium districts in the Powder River Basin. Other surface water features in these watersheds include stock ponds. The ephemeral and intermittent water bodies are generally Class 3B. These watersheds include areas of oil and natural gas as well as coal bed methane development.

The Middle North Platte-Casper watershed is drained by the North Platte River, which is fed by numerous small tributaries. The North Platte River and most of its tributaries are classed as 2AB (Table 3.3-4). Portions of the North Platte River and some tributaries are impacted by elevated selenium concentrations (WDEQ, 2008). The flow of the North Platte River is not measured in this watershed. The Middle North Platte-Casper watershed is located within the area covered by the Platte River Recovery Implementation Program. The purpose of this program is to manage the land and water resources within the Platte River Basin to support the U.S. Fish and Wildlife Service recovery plan for four target species (interior least tern, whooping crane, piping plover, and pallid sturgeon) listed as threatened or endangered species (Platte River Recovery Implementation Program, 2006). The cooperative agreement between the federal agencies and the states of Colorado, Nebraska, and Wyoming requires that federal agencies consult with the U.S. Fish and Wildlife Service on federally licensed or permitted water projects within the Platte River Recovery Implementation Program area.

The Salt Creek watershed is located north of Casper, Wyoming, in Natrona County, upstream from the Upper Powder River watershed. Salt Creek is a Class 2C water body (Table 3.3-4). The water quality of Salt Creek is impaired due to elevated chloride and threatened by oil and grease attributed to oil and natural gas production in the watershed. Flow in Salt Creek is not measured.

The Upper Belle Fourche River watershed is located in the northeastern portion of the Wyoming East Uranium Milling Region in Campbell County (Figure 3.3-6). The Upper Belle Fourche River in Wyoming is classed as 2ABww where "ww" indicates "warm water fishery" (Table 3.3-4). Water quality in some portions of the Upper Belle Fourche River is listed as impaired due to fecal coliform from livestock grazing east of the Wyoming East Uranium Milling Region (WDEQ, 2008). Average flow in the Upper Belle Fourche River at Moorcroft, Wyoming (just east of the Wyoming East Uranium Milling Region), for water years 1991 through 2008 is 0.62 m^3/s [22 ft^3/min] (U.S. Geological Survey, 2008).

The Upper Powder River watershed is located downstream of the Salt Creek watershed in Johnson and Campbell Counties. The Upper Powder River is classified as 2ABww with its smaller tributaries classified as 3B (Table 3.3-4). The Upper Powder River is listed as impacted by high chloride (WDEQ, 2008). Annual average flow in the Upper Powder River at Sussex, Wyoming, varied between 2.4 and 14 m^3/s [86 and 487 ft^3/s] between 1939 and 2007 (U.S. Geological Survey, 2008).

3.3.4.2 Wetlands and Waters of the United States

The majority of waterways in this region are composed of ephemeral and intermittent streams. Some perennial slow moving rivers are also present in the region. Regulatory guidance and jurisdictional determination are the same as those found in Section 3.2.4.2 for the Wyoming West Uranium Milling Region.

Freshwater emergent marshes are found in depressions, as fringes around lakes, and sloughs along slow-moving streams. These wetlands maybe temporarily to permanently inundated and are typically dominated by floating-leaved plants in deeper areas (e.g., *Lemna*, *Potamogeton*, *Brasenia*, *Nuphar*) and sedges (*Carex, Cyperus, Rhynchospora*), bulrushes (*Scirpus*, *Schoenoplectus*), spikerushes (*Eleocharis*), cattails (*Typha*), rushes, (*Juncus*), and grasses (e.g., *Phalaris*, *Spartina*) in seasonal wetlands (USACE, 2006).

Floodplain and riparian systems occur along rivers and streams across the Wyoming East Uranium Milling Region. Common woody species in riparian and floodplain wetlands in the region include plains cottonwood (*Populus deltoides* ssp. *monilifera*), narrowleaf cottonwood (*P. angustifolia*), various willows, green ash (*Fraxinus pennsylvanica*), cedar elm, eastern swampprivet (*Forestiera acuminata*), and the introduced saltcedar (*Tamarix ramosissima*) (USACE, 2006).

Waters of the United States and special aquatic sites that include wetlands would need to be identified and the impact delineated upon individual site selection. Based on impacts and consultation with each area, appropriate permits would be obtained from the local USACE district. Section 401 state water quality certification is required for work in Waters of the United States. Within this region, the State of Wyoming regulates isolated wetlands and waters. Cumulative total project impacts greater than .4 ha [1 acre] would require a general permit for wetland mitigation by the WDEQ.

3.3.4.3 Groundwater

Groundwater resources in the Wyoming East Uranium Milling Region are part of regional aquifer systems that extend well beyond the areas of uranium milling interest in this part of Wyoming. Uranium-bearing aquifers exist within these regional aquifer systems in the Wyoming East Uranium Milling Region. This section provides a general overview of the regional aquifer systems to provide context for a more focused discussion of the uranium-bearing aquifers in the Wyoming East Uranium Milling Region, including hydrologic characteristics, level of confinement, groundwater quality, water uses, and important surrounding aquifers.

3.3.4.3.1 Regional Aquifer Systems

The location of the Wyoming East Uranium Milling Region is shown in Figures 3.3-1 and 3.3-2. The Northern Great Plains aquifer system is the major regional aquifer system in the Wyoming East Uranium Milling Region. The Northern Great Plains aquifer system extends over one-third of Wyoming (Whitehead, 1996).

Whitehead (1996) grouped the Northern Great Plains aquifer system into five major aquifers. These aquifers, from shallowest to deepest, are the Lower Tertiary, Upper Cretaceous, Lower Cretaceous, Upper Paleozoic, and Lower Paleozoic aquifers. The Lower Tertiary aquifers consist of sandstone beds within the Wasatch Formation and the Fort Union Formation. Both formations consist of alternating beds of sandstone, siltstone, and claystone and beds

containing lignite and subbituminous coal, but most water is stored in and flows through the more permeable sandstone beds. In the Powder River Basin, the Fort Union Formation and the Wasatch Formation are as thick as 1,095 and 305 m [3,600 and 1,000 ft], respectively. In the Lower Tertiary aquifers, the regional groundwater flow direction is northward and northeastward from recharge areas in northeastern Wyoming. Recharge to the aquifer is by precipitation in outcrop areas, water seeps from streambeds, and local irrigation. Discharge from the aquifer system is mainly by upward leakage of water into the shallower aquifers. The clinker layers that consist of fractured rocks along the coal outcrop appear to be a recharge area to the coal beds.

The Upper Cretaceous aquifers consist of sandstone beds interbedded with siltstone and claystone in the Lance and the Hell Creek Formations and the Fox Hills Sandstone, which are 105 to 1,035 m [350 to 3,400 ft] and 90 to 135 m [300 to 450 ft thick]. The Fox Hills Sandstone is one of the most continuous water-yielding formations in the Northern Great Plains aquifer system. Groundwater in the Upper Cretaceous aquifers moves from aquifer recharge areas at higher altitudes toward discharge areas along major rivers. The general groundwater flow direction is northward in the Powder River Basin. In Wyoming, the potentiometric surface of the Lower Tertiary aquifers is locally 122 m [400 ft] higher than that of the underlying upper Cretaceous aquifers. Hence, groundwater moves locally vertically downward from the lower Tertiary aquifers into the Upper Cretaceous aquifers through the confining layer separating these two aquifers.

The Lower Cretaceous aquifers are separated from the overlying Upper Cretaceous aquifers by several thick confining units. The Pierre Shale, the Lewis Shale, and the Steele Shale are the regionally thickest and most extensive confining units. Water across the Pierre Shale can leak into the underlying Lower Cretaceous aquifers where the Pierre Shale is fractured.

The Lower Cretaceous aquifers are the most widespread aquifers in the Northern Great Plains aquifer system and contain several sandstones. The principal water-yielding units are the Muddy Sandstone and the Inyan Kara Group in the Powder River Basin. The Lower Cretaceous aquifers contain little freshwater. The water becomes saline in the deep parts of the Powder River Basin. Locally, the Sundance, Swift, Rierdon, and Piper Formations yield small to moderate quantities of water.

The Paleozoic aquifers cover a larger area, but they are deeply buried in most places and contain little freshwater. They are divided into Upper Paleozoic aquifers and Lower Paleozoic aquifers. In much of the Powder River Basin, the Upper and Lower Paleozoic aquifers are hydraulically connected and locally are called the Madison Aquifer System.

The Upper Paleozoic aquifers are confined everywhere except in recharge areas. They consist primarily of the Madison Limestone, the Tensleep Sandstone in the western parts of the Powder River Basin, and sandstone beds of the Minnelusa Formation in the eastern part of the Powder River Basin. The Pennsylvanian sandstones yield less water than the Madison Limestone and contain freshwater locally at the outcrop areas. Pennsylvanian rocks are not usually considered to be a principal aquifer. In the Upper Paleozoic aquifers, the regional groundwater flow direction is northeastward from recharge areas where the aquifers crop out adjacent to structural uplifts near the southern and western limits of the aquifer system.

Lower Paleozoic aquifers consist of sandstone and carbonate rocks. The principal geologic units that compose the Lower Paleozoic aquifers are the Flathead Sandstone, sandstone beds of the Winnipeg Formation, limestones of the Red River and the Stonewall Formations, and the

Bighorn and the Whitehead Dolomites. The groundwater flow direction is generally northeastward. Lower Paleozoic aquifers contain freshwater only in a small area in north-central Wyoming. These aquifers contain slightly saline to moderately saline water throughout the southern half of their extent.

The Madison Limestone exhibits karst features (features formed by the dissolution of a layer or layers of soluble bedrock, usually carbonate rock such as limestone or dolomite) at the outcrop areas in north-central Wyoming (Wyoming East Uranium Milling Region). Several large springs formed from some of the solution conduits in the Madison Limestone, including the Thermopolis hot springs system in central Wyoming with a discharge rate of about 11,355 L/min [3,000 gal/min] of geothermal water.

Recharge to the aquifers in most of the area is likely small, due to low annual precipitation and high evaporation. The mean annual precipitation in the Wyoming East Uranium Milling Region is typically in the range of 28–38 cm/yr [11–15 in/yr], but at high elevations, it locally exceeds 50 cm/year [20 in/year] based on precipitation data from 1971 to 2000. The evaporation rate was estimated to be 105.9±7.1 cm/year [41.7±2.8 in/year] using the Kohler-Nordenson-Fox equation with data from the station in Lander, Wyoming (Curtis and Grimes, 2004).

3.3.4.3.2 Aquifer Systems in the Vicinity of Uranium Milling Sites

The hydrogeological system in areas of uranium milling interest in the Wyoming East Uranium Milling Region consists of a thick sequence of primarily sandstone aquifers and shale aquitards. Uranium-bearing sandstone aquifers in the Fort Union Formation at the active uranium milling sites are also important for water supplies in the milling region.

Areas of uranium milling interest at the Reynolds and Smith Ranch areas are underlain, from shallowest to deepest, by the alluvium, the Wasatch Formation, the Fort Union Formation, the Lance Formation, and the Fox Hills Formation. The alluvium has a thickness of 0–9 m [0–30 ft] and has small yields in stream valleys. The Wasatch Formation and the Fort Union Formation contain important sandstone aquifers for water supplies. Groundwater production from the Lance and the Fox Hills Formations is largely unknown at the ISL facilities in the Reynolds and Smith Ranch areas in Converse County (Power Resources, Inc., 2004).

As discussed in Section 3.3.4.3.1, this aquifer system is separated from the underlying aquifers including, from shallowest to deepest where they are continuous, the Muddy Sandstone, the Inyan Kara Group, and the Paleozoic aquifers by shale layers. The Paleozoic aquifers are deeply buried in most places and contain little freshwater (Whitehead, 1996).

3.3.4.3.3 Uranium-Bearing Aquifers

Uranium mineralization at locations of milling interest is typically hosted by Paleocene-age confined sandstone aquifers (at the Smith Ranch and Reynolds Ranch ISL sites) or Eocene-age confined sandstone aquifers (at the Irigaray and Christensen Ranch ISL sites) in the Wyoming East Uranium Milling Region.

Confined sandstone beds in the Fort Union Formation are the uranium-bearing aquifers at the Smith Ranch and Reynolds Ranch ISL sites in Converse County. The Fort Union Formation contains multiple confined sandstone aquifers in the eastern and northeastern parts of the permit area at the Smith Ranch and Reynolds Ranch ISL sites, but it is unconfined in the southwestern and western parts. Among the confined sandstone aquifers, the U- and

S-Sandstones are the primary uranium mineralization zone, and they are referred to as the U/S sand. O-Sandstone aquifers also contain economic uranium mineralization in the Fort Union Formation (NRC, 2006). Confined sandstone units in the Wasatch Formation are the uranium-bearing units at the Irigaray and Christensen Ranch ISL sites. These units are L, K, and J fluvial units in an ascending order at the Christensen Ranch ISL site and these fluvial units correspond to the Lower Irigaray sandstone, the Upper Irigaray sandstone, and the Unit 1 sandstone at the Irigaray Ranch ISL site. The K unit is the primary uranium mineralization zone (Cogema Mining, Inc., 1998).

For ISL operations to begin, portions of the uranium-bearing sandstone aquifers in the Fort Union Formation in the Wyoming East Uranium Milling Region would need to be exempted by the UIC program administered by WDEQ (Section 1.7.2.1).

Hydrogeological characteristics: In the Wyoming East Uranium Milling Region, the production aquifer system typically consists of confined sandstone aquifers. Aquifer properties (e.g., transmissivity, thickness, storage coefficient) vary spatially in the region.

At the Smith Ranch and Reynolds Ranch areas, the mean effective transmissivity of the U/S sandstone aquifer and O-sandstone aquifer is 6,700 L/day/m {8.2 m^2/day [540 gal/day/ft} and 7,900 L/day/m {9.7 m^2/day} [640 gal/day/ft]}, respectively. The storage coefficient for the U/S sandstone aquifer and O-sandstone aquifer ranges between 1.5×10^{-5} and 1.7×10^{-5} and 6.3×10^{-5} and 7.8×10^{-5}, respectively, indicating the confined nature of the production aquifer (typical storage coefficients for confined aquifers range from 10^{-5} to 10^{-3} (Driscoll, 1986, p. 68). The average groundwater velocities through the U/S-sandstone aquifer and O-sandstone aquifer were reported to be 2.4 and 0.17 m/yr [8 and 0.56 ft/yr] (NRC, 2006). The approximate thickness of the Fort Union Formation is 910–1,100 m [3,000–3,600 ft] in the Powder River Basin (PRI, 2004; Whitehead, 1996). Groundwater production from the Fort Union Formation is generally good with water yields as high as 2,080 L/min [550 gal/min] (PRI, 2004; NRC, 2006).

The average thickness of the K unit is 54 m [180 ft]. The K unit has a mean hydraulic conductivity of 0.13 m/day [0.42 ft/day] (Cogema Mining, Inc., 1998).

Level of confinement: The production aquifer is typically confined in the Wyoming East Uranium Milling Region. The thickness of the confinement varies spatially.

At the Smith Ranch and Reynolds Ranch ISL sites, the U/S sandstone is confined above by a 6- to 20-m [20- to 70-ft]-thick shale aquitard (V Shale). It is confined below by a 45-m [150-ft]-thick shale aquitard (R Shale) (NRC, 2006). Aquifer tests revealed that the confining shale members would be effective aquitards to the vertical movement of leaching solution (Power Resources Inc., 2006, 2005).

At the Irigaray and Christensen Ranch ISL sites, the K unit is confined above by a 23-m [76-ft]-thick aquitard. It is confined below by a 27-m [90-ft]-thick aquitard. The vertical hydraulic conductivity of the upper confining layer ranges from 8.2×10^{-6} to 1.1×10^{-4} m/day [27×10^{-6} to 3.6×10^{-4} ft/day]. The vertical hydraulic conductivity of the lower confining layer ranges from 7.4×10^{-6} to 1.2×10^{-3} m/day [24×10^{-6} to 3.9×10^{-3} ft/day]. The confining strata are continuous over the commercial area of the Irigaray and Christensen Ranch ISL sites (Cogema Mining, Inc., 1998).

As discussed in Section 3.3.4.3.1, the aquifer sequence that includes, from the shallowest to deepest, the Wasatch Formation, the Fort Union Formation, the Lance Formation, and the Fox Hills Formation are confined below by regionally extensive and thick low permeability layers that include the Pierre Shale, the Lewis Shale, and the Steele Shale. The vertical hydraulic conductivity of the Pierre Shale is reported to be 1.5×10^{-8} to 1.5×10^{-4} m/day [5×10^{-8} to 5×10^{-4} ft/day] outside the Wyoming East Uranium Milling Region (Kansas Geological Survey, 1991). The Pierre Shale is fractured in some parts of the region and may leak water to the underlying lower Cretaceous aquifers (Whitehead, 1996). Hence, where the Pierre Shale is fractured, the aquifer sequence may not be effectively confined below.

Groundwater quality: In some parts of the Wyoming East Uranium Milling Region, the total dissolved solids (TDS) levels in the uranium-bearing aquifers exceed the EPA's drinking water standards. The uranium and radium-226 concentrations in the uranium-bearing aquifers typically exceed their respective EPA Maximum Contaminant Levels.

At the Smith Ranch and Reynolds Ranch ISL area, the water quality is usually good in the U/S-sandstone and O-sandstone aquifers and meets the EPA's drinking water standards except for radium-226. Radium-226 naturally exists in the U/S sandstone and O-sandstone aquifers at a level of 296 pCi/L and 86 pCi/L, respectively, which exceeds the EPA's primary drinking water standard of 5 pCi/L. Both aquifers have TDS ranging from 234–952 mg/L [234–952 ppm] {the limit of dissolved solids recommended by the EPA for drinking water is 500 mg/L [500 ppm]} (NRC, 2006).

At the Irigaray and Christensen Ranch ISL sites, the TDS concentrations are usually below the drinking water standard, but groundwater is not considered as potable in the ore production zone due to elevated concentrations of radium-226 in excess of the EPA primary drinking standards of 5 pCi/L.

Current groundwater uses: In the vicinity of the Smith Ranch and Reynolds Ranch ISL area permit area, groundwater is largely pumped for livestock watering, and to a lesser extent, for domestic water supply (NRC, 2006).

3.3.4.3.4 Other Important Surrounding Aquifers for Water Supply

At the regional scale, the Wasatch Formation and the Fort Union Formation are important aquifers for water supplies. The Fox Hills Sandstone is one of the most continuous water-yielding formations in the Northern Great Plains aquifer system. Except at outcrop areas, the Paleozoic aquifers are not usually used for water production, because they are either deeply buried or contain saline water (Whitehead, 1996).

At the ISL facilities in the Reynolds and Smith Ranches, the Wasatch Formation and the Fort Union Formation contain important sandstone aquifers for water supplies. The thickness of the Wasatch Formation ranges from 0–150 m [0–500 ft] and yields as high as 530 L/min [140 ga/min]. Water yields from the Lance Formation and the Fox Hills Formation are largely unknown at the Reynolds and Smith Ranch areas. The thickness of the Lance Formation is about 915 m [3,000 ft], and its water yield is estimated to not exceed 75 L/min [20 gal/min]. The thickness of the underlying Fox Hills Formation is about 150–210 m [500–700 ft], and its water yield is estimated to not exceed 380 L/min [100 gal/min] (PRI, 2004 and the references therein).

3.3.5 Ecology

3.3.5.1 Terrestrial

Wyoming East Uranium Milling Flora

According to the EPA, the identified ecoregions in the Wyoming East Uranium Milling Region primarily consist of Wyoming Basin, Northern Great Plains, Southern Rockies, and the Western High Plains ecoregions (Figure 3.3-7). Uranium milling districts in this region are generally found in the Rolling Sagebrush Steppe and the Powder River Basin of the Wyoming Basin. Habitat types and species found in these areas are based on the Wyoming Gap Analysis project (Wyoming Geographic Information Science Center, 2007) as described in Section 3.2.5.

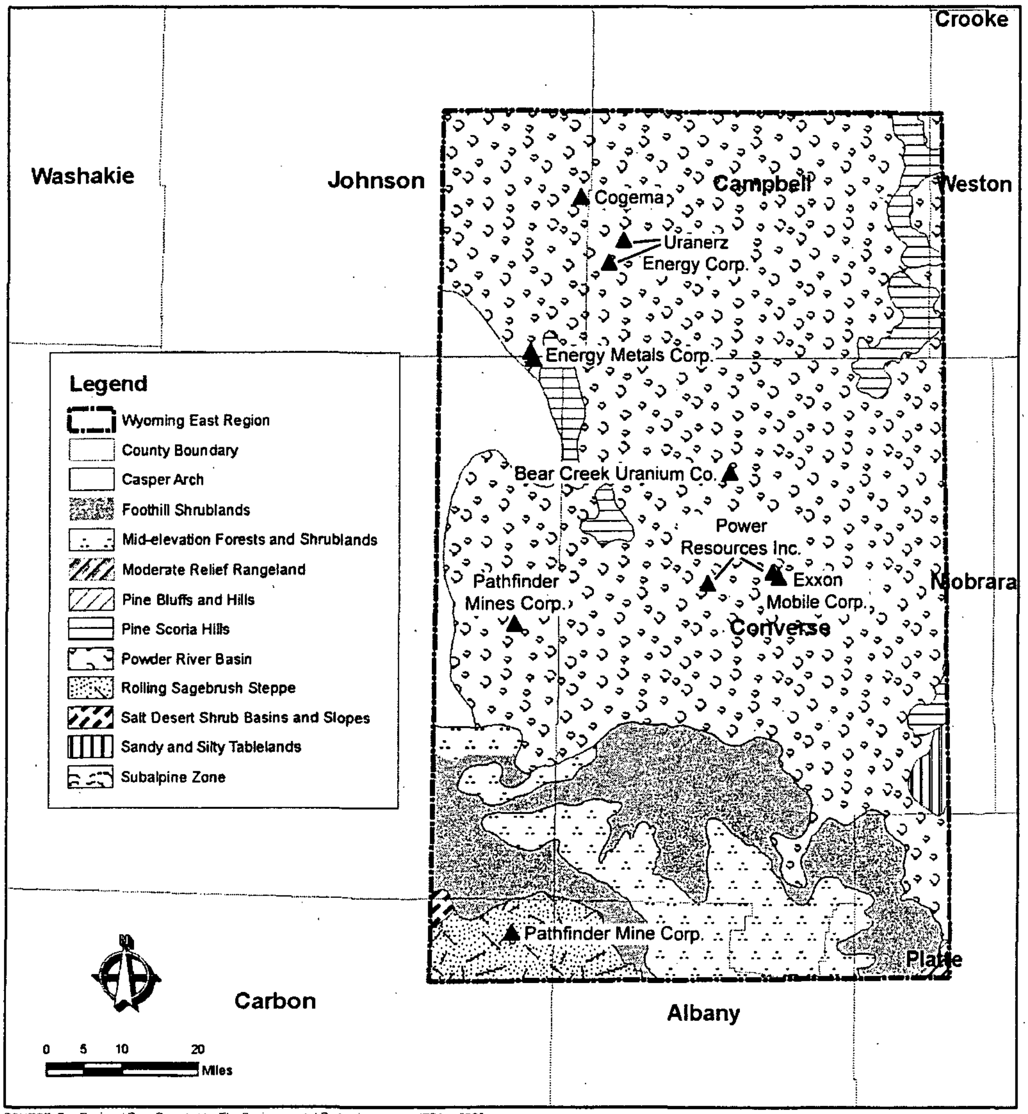
The Rolling Sagebrush Steppe and the Salt Desert Shrub Basin ecoregions of the Wyoming Basin have been described in the Wyoming West Uranium Milling Region (Section 3.2.5). An excellent description of the Wyoming East Uranium Milling Region Fauna is provided by Chapman, et al. (2004) and is summarized next.

The Southern Rockies are characterized by rugged, steep mountains, intermontane depressions and open meadows, and high-elevation plateaus. Ponderosa pines are found at lower elevations with pinyon-juniper woodlands below that grasslands are located in the lowest areas. Lodgepole pine is more common in the Middle Rockies region; white pine (*Pinus* spp.), grand fir (*Abies grandis)*, and cedar, prevalent in the Northern Rockies region, are absent from the alpine zone. A greater portion of the Middle Rockies is used for summer grazing of livestock (Chapman, et al., 2004).

The Subalpine Forests ecoregion of the Southern Rockies is a forested area found on the steep forested slopes of the Medicine Bow and Sierra Madre Mountains with a greater extent on the north slopes. The dense forests are dominated by lodgepole pine, Englemann spruce and subalpine fir; some areas are locally dominated by aspen (*Populus tremula*). Whortleberry dominates the forest understory. Subalpine meadows also occur in some areas (Chapman, et al., 2004).

The Mid-Elevation Forests and Shrublands ecoregion of the Southern Rockies is found in the 2,300 to 2,750 m [7,500 to 9,000 ft] elevation range within the Laramie, Medicine Bow, and Sierra Madre mountains. Vegetation located in the region from the southwest to northeast are composed of aspen, Douglas fir, lodgepole pine, limber pine (*Pinus flexilis*), and ponderosa pine. Due to the increased availability of moisture ponderosa pine grows mainly on the eastern slopes of the Laramie Mountains, as it does on the eastern Bighorn Mountains. The understory is composed of grasses and shrubs. Perennial streams are diverted for irrigation in lower elevations and are often dry in their lower reaches in the summer (Chapman, et al., 2004).

The Foothill Shrublands ecoregion of the Southern Rockies is a transition between the higher elevation forests of the Laramie, Medicine Bow, and Sierra Madre Mountains and the more arid grassland and sagebrush regions in the Wyoming Basin and the High Plains. On the east side of the Laramie Mountains, this ecoregion is a continuation of high plains prairie grasslands of blue grama, prairie junegrass, and western wheatgrass interspersed with mountain big sagebrush and mountain mahogany shrubland. Pockets of aspen, limber pine, and Douglas fir are often found on north-facing slopes. Riparian vegetation along the water courses originating in higher mountains include willow species and narrowleaf cottonwood, with boxelder (*Acer*



SOURCE: Eco Regional Data Provided by The Environmental Protection Agency (EPA) - 2005

Figure 3.3-7. Ecoregions of the Wyoming East Uranium Milling Region

negundo) and wild plum in the north. Land use is mainly livestock grazing and some irrigated hayland adjacent to perennial streams (Chapman, et al., 2004).

The High Plains ecoregion consists of rolling plains and tablelands formed by uplift and the erosion of the Rocky Mountains. Due to the rainshadow of the Rocky Mountains drought resistant shortgrass and mixed-grass prairie dominate the plains vegetation. Seasonal precipitation in this region generally falls during the growing season. This region occupies the southeastern corner of Wyoming where the Southern Rockies, Wyoming Basin, and the Northwestern Great Plains ecoregions meet. The boundaries of these regions fade into one another and some characteristics of each region can be found near the borders, making the boundary of the High Plains in Wyoming a transitional area.

The Moderate Relief Rangeland ecoregion of the High Plains consists of mixed-prairie vegetation dominated by grass species such as blue grama, western winter wheatgrass, junegrass, Sandberg blue grass needle-and-thread grass, prairie junegrass, and winter fat (*Ceratoides lanata*). Other species found in the prairie include rabbitbrush, fringed sage, scattered yucca, and other various forbs. Patches of mountain mahogany (*Cercocarpus* spp.) and skunkbush sumac (*Rhus trilobata*) grow on bluffs and hilltops. The plains surface steadily increases in elevation as it rises to a subtle boundary transition with the Laramie Mountains (Chapman, et al., 2004).

The Pine Bluffs and Hills ecoregion of the High Plains is composed of escarpments, bluffs, and badlands. Ponderosa pine woodland and open grasslands alternate along the rocky outcrops. Common species found in this region include little bluestem, common juniper, and bearberry (*Arctostaphylos uva-ursi*). Areas of limber pine and silver sagebrush may also be present (Chapman, et al., 2004).

The Sandy and Silty Tablelands ecoregion of the High Plains is characterized by tablelands with areas of moderate relief. This region consists of mixed-grass prairies dominated by blue grama, western wheatgrass, june grass, needle-and-thread grass, rabbit brush, fringed sage, and various forbs. Since the 1880s the ecoregion has been mainly used for livestock grazing (Chapman, et al., 2004).

The Northwestern Great Plains encompass the Missouri Plateau section of the Great Plains. This area includes semiarid rolling plains of shale and sandstone derived soils punctuated by occasional buttes and badlands. For the most part, it has not been influenced by continental glaciation. Cattle grazing and agriculture with spring wheat and alfalfa farming are common land uses. Agriculture is affected by erratic precipitation and limited opportunities for irrigation. In Wyoming, mining for coal and coal-bed methane production is prevalent, with a large increase in the number of coal-bed methane wells drilled in recent years. Native grasslands and some woodlands persist, especially in areas of steep or broken topography (Chapman, et al., 2004).

The Pine Scoria Hills ecoregion is composed of rugged broken land and stony rough hills covered by open ponderosa pine-Rocky Mountain juniper forest or ponderosa pine savannas. Coal, sandstone, and shale bedrock underlie the region. Savannas and extensive open grassland are found in areas with less available moisture. Species found in this region include little bluestem (*Schizachyrium scoparium*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), western wheatgrass, blue grama, and Sandberg bluegrass. Skunkbush sumac and western snowberry (*Symphoricarpos occidentalis*) are common shrubs.

Land use includes woodland grazing and areas of historical small-scale coal mining (Chapman, et al., 2004).

The Casper Arch ecoregion of the Northwestern Great Plains is a transitional region between the Northern Great Plains and the Wyoming Basin. Soils are weathered from sodic Cody shale; they are generally well drained to slowly permeable, and are moderately to very shallow. Shrubland dominated by sagebrush steppe, which may include Wyoming big sagebrush, Gardner saltbush (*Atriplex gardneri*), Indian ricegrass (*Oryzopsis hymenoides*), birdfoot sagebrush (*Artemisia pedatifida*), western wheatgrass, bluebunch wheatgrass, needle-and-thread grass, blue grama, Sandberg bluegrass, junegrass, rabbitbrush, fringed sage, and other grasses, forbs, and shrubs (Chapman, et al., 2004).

The Powder River Basin ecoregion of the Northwestern Great Plains covers rolling prairie and dissected river breaks surrounding the Powder, Cheyenne, and Upper North Platte Rivers. The Powder River Basin has less precipitation and less available water than the neighboring regions. Vegetation within this region is composed of mixed-grass prairie dominated by blue grama, western wheatgrass, junegrass, Sandberg bluegrass, needle-and-thread grass, rabbitbrush, fringed sage, and other forbs, shrubs and grasses (Chapman, et al., 2004).

Wyoming East Uranium Milling Region Fauna

The animal species that may occur in the Wyoming Basin and the Middle/Southern Rockies have been discussed previously in the Wyoming West Uranium Milling Region (see Section 3.2.5.1)

The Northwest Great Plains/Northern short grasslands region of Wyoming is home to approximately 337 different species. Many of these species are found in the adjacent Wyoming Basin Shrub Steppe (World Wildlife Fund, 2007d,e). Many of the animals in this region are associated with prairie potholes. Birds include the Ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), golden eagle, sharp tailed grouse (*Tympahuchus phasinellus*), sage-grouse, the greater prairie chicken (*Tympanuchus cupido*), numerous migratory birds such as ducks and song birds, and one of the largest breed populations of the endangered piping plover (*Charadrius melodus*). Blacktail and white tailed deer, pronghorns, bighorn sheep, American bison (*Bison bison*), bobcat (*Lynx rufus*), and cougars (*Felis concolor*) are typical large animals. This region is also known for its abundance of white-tailed prairie dog towns, which the black-footed ferret uses as a habitat (World Wildlife Fund, 2007a–e).

The Western High Plains/Western Short Grasslands is home to approximately 431 different species. Many of these spices can be found in the adjacent Northwest Great Plains region to the north. Rodents are the most numerous type of mammals of this region. These include Desert and Eastern cotton tail rabbits, gophers (*Thomonys* sp.), shrews (*Sorex* sp.), voles (*Microtus* sp.), kangaroo rats (*Dipodomys* sp.), black-tailed prairie dogs, and numerous rat and mouse species. Larger mammals include the pronghorns, elk, big horn sheep, coyote, beaver, porcupine, bobcats, and foxes. The largest diversity of animals of the region is birds. Birds include the Ferruginous hawk, Swainson's hawk, golden eagle, sharp tailed grouse, prairie chickens, wrens, kingbirds, vireos sparrows, flycatchers (*Tyrannidae* spp.), and ducks. This region contains numerous reptile and amphibians. Amphibian species include the northern cricket frog (*Acris crepitans*), leopard frog (*Rana* spp.), bull frog (*Rana catesbeiana*), Rio Grande frog (*Rana berlandieri*), narrowmouth toad (*Gastrophryne* spp.), great plains toad (*Bufo cognatus*), green toad (*Bufo debilis* spp.), tiger salamander, and Woodhouse toad. Western rattle snake ringneck snake (*Diadophis punctatus* ssp.), king snake (*Lampropeltis*

spp.), hog-nose snake (*Heterodon platirhinos*), and garter snake can be found in the region. Numerous lizards and turtles are also found within the region (World Wildlife Fund, 2007 a–e).

According to the Wyoming Game and Fish Department, crucial wintering habitats are found within this region for large game mammals and nesting leks for the sage-grouse. Figures 3.3-8 to 3.3-14 show the crucial winters and yearlong ranges for large mammal found in this region. Most of the crucial areas are located either in the Thunder Basin National Grassland in the northeast portion of the region, the Medicine Bow National Forest in the Laramie Mountains, or along the North Platte River and its tributaries that traverse west-east across the lower half of the region. Within this region, the area of milling interest nearest to Casper is situated in close proximity to a crucial wintering area for antelopes. Numerous sage-grouse leks are clustered near the Pumpkin Buttes Uranium District in the northwestern part of the study region. In addition, a large concentration of leks is found in the southwestern corner of the study region in the vicinity of the Shirley Basin Uranium District.

3.3.5.2 Aquatic

Within the Wyoming East Uranium Milling Region, watersheds identified as aquatic habitat areas include the Lower Salt Creek Basin; the middle North Platte River Corridor, the La Bonte Creek and Horseshoe Creek Watersheds; and the North Platte River, Bolton Creek; and Bates Creek Watersheds. Additional information on watersheds in the region is provided in Section 3.3.4.1. The three uranium districts within the Wyoming West Uranium Milling Region are located in the following regional watersheds: Salt Creek, Middle North Platte-Casper, Lightning Creek, Dry Fork Cheyenne River, Antelope Creek, and Upper Powder River.

The Lower Salt Creek Basin located in the northeastern portion of the Wyoming West Uranium Milling Region (near theh Pumpkin Buttes Uranium District) is a relatively dry basin with little vegetation. This basin includes intermittent streams with few perennial streams. Many of the stream channels are degraded or actively degrading. Small reservoirs in the basin are dewatered for live stock and have diminished water storage capacity from sedimentation due to erosion. Native species like the fathead minnow, flathead chub, longnose dace, plains minnow, sand shiner, and white sucker are found in this watershed (Wyoming Game and Fish Department, 2007a,b).

The La Bonte Creek and Horseshoe Creek watersheds are located in the southeastern portion of the Wyoming West Uranium Milling Region. These watersheds are subject to short periods of high water flow that contribute to the scouring of stream channels leaving wide channels that decrease during low flow periods during the summer, winter and fall seasons thus limiting habitat. Native species found in the watersheds include the brassy minnow, fathead minnow, longnose dace, sand shiner, longnose sucker, stonecat and plains killifish. Sport fish that can be found in the systems include rainbow and brown trout (Wyoming Game and Fish Department, 2007a,b).

The middle North Platte River Corridor (near the Monument Hill Uranium District) is discussed for the Wyoming West Uranium Milling Region (Section 3.2.5.2).

The North Platte River, Bolton Creek, and Bates Creek watersheds are located in the southwestern portion of the Wyoming East Uranium Milling Region (in the vicinity of the Shirley Basin Uranium District). Soil erosion and sediment loading to these waterways have diminished the potential for fish to naturally reproduce. Sedimentation is further increased by erosive soils,

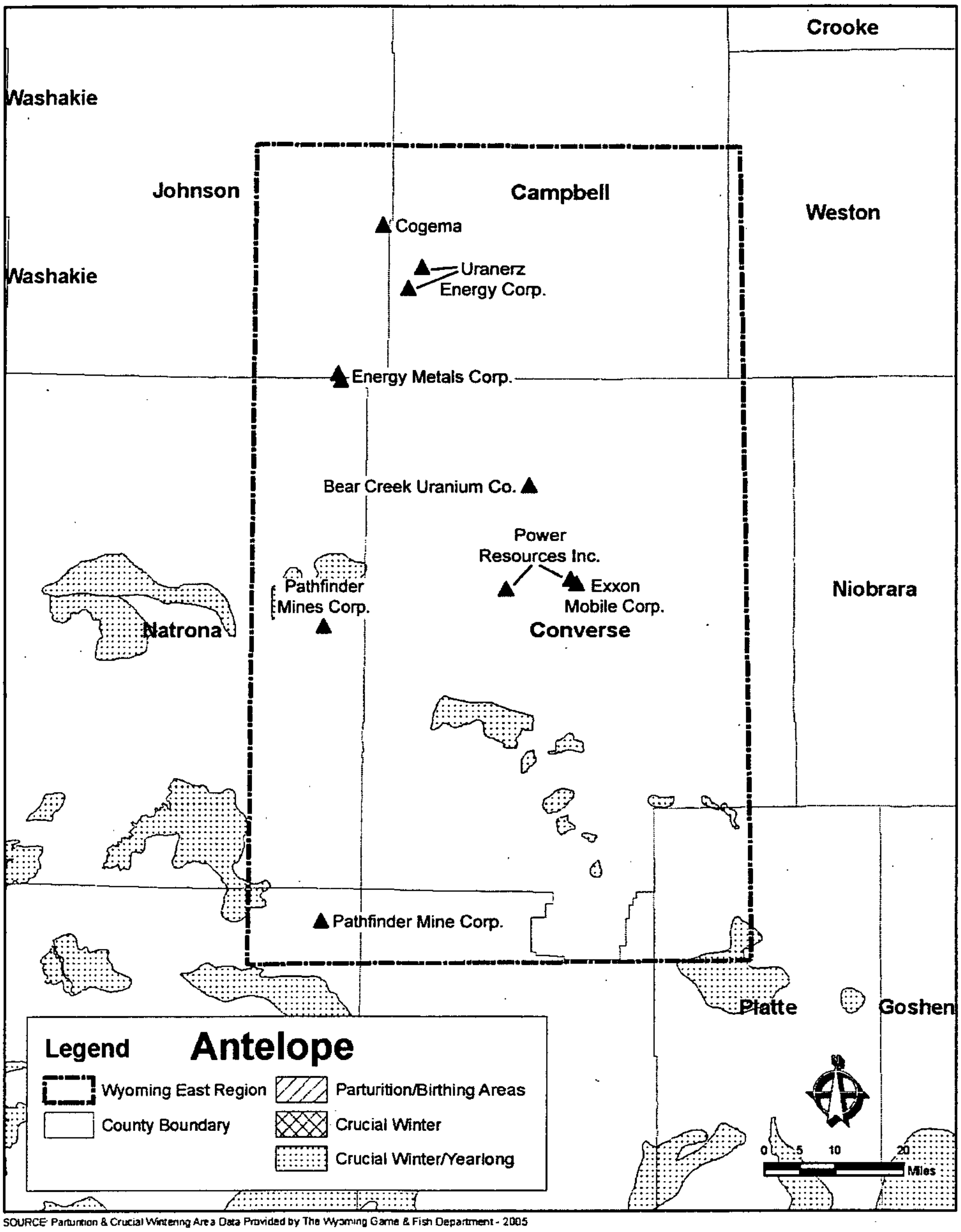


Figure 3.3-8. Antelope Wintering Area for the Wyoming East Uranium Milling Region

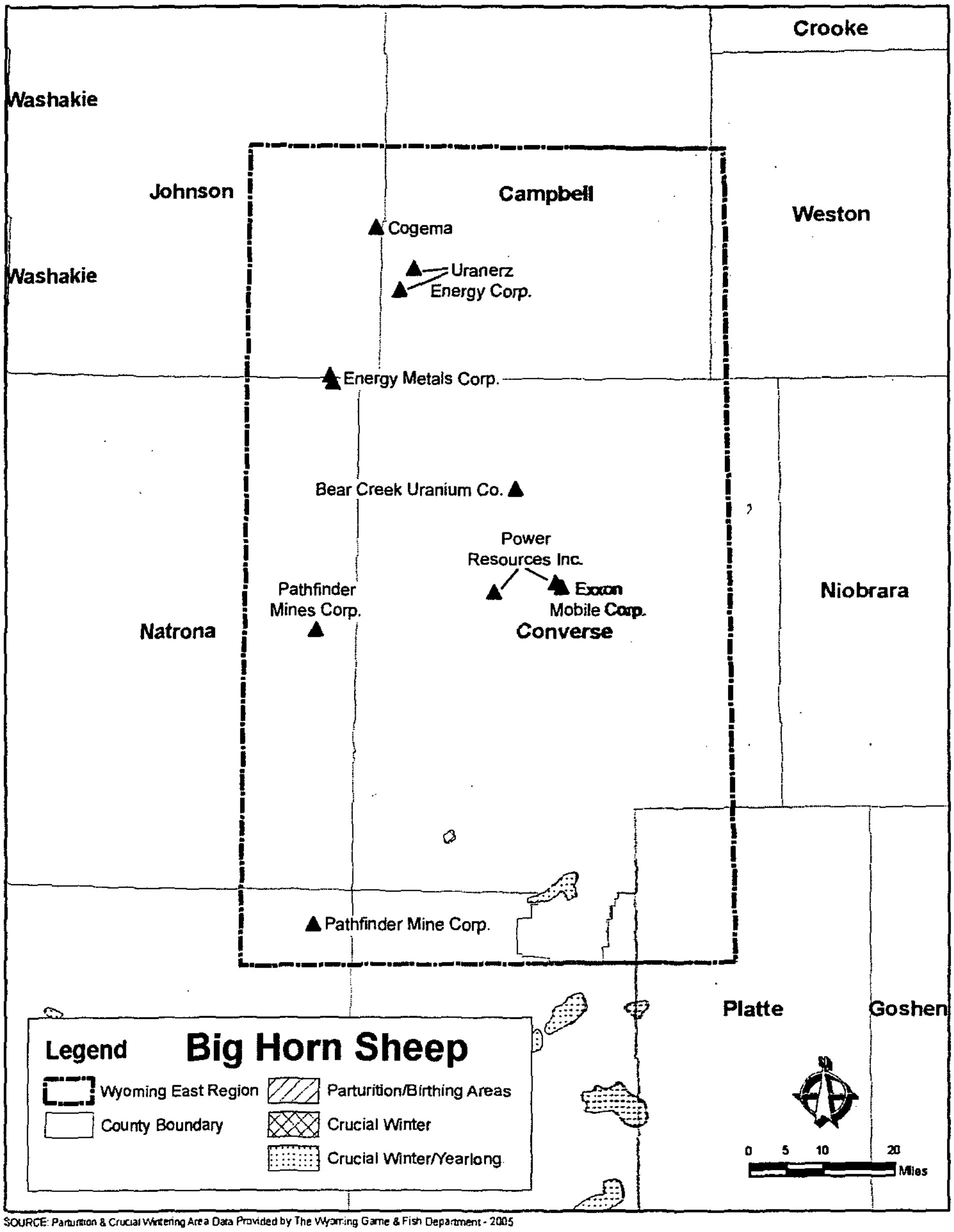


Figure 3.3-9. Big Horn Wintering Area for the Wyoming East Uranium Milling Region

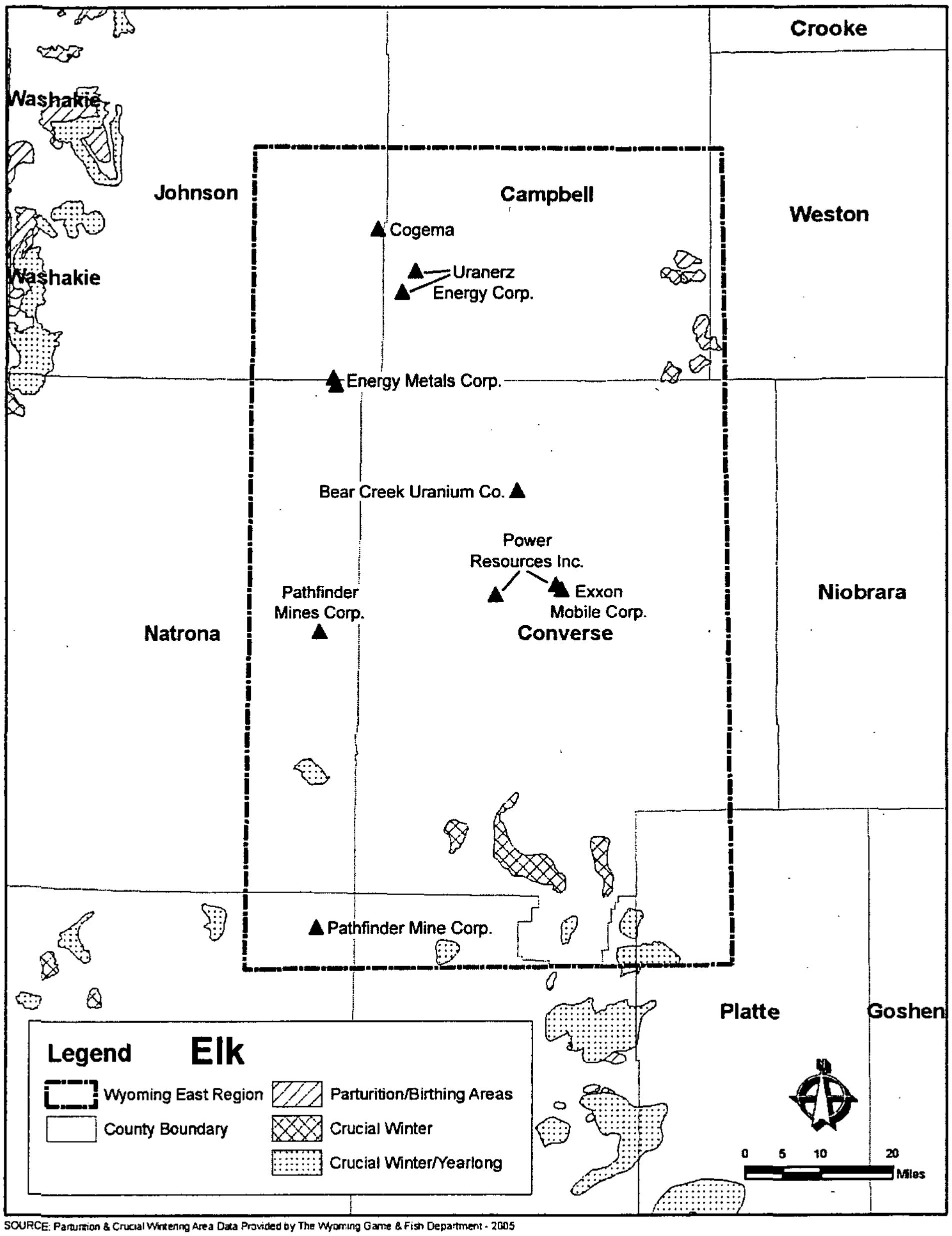


Figure 3.3-10. Elk Wintering Area for the Wyoming East Uranium Milling Region

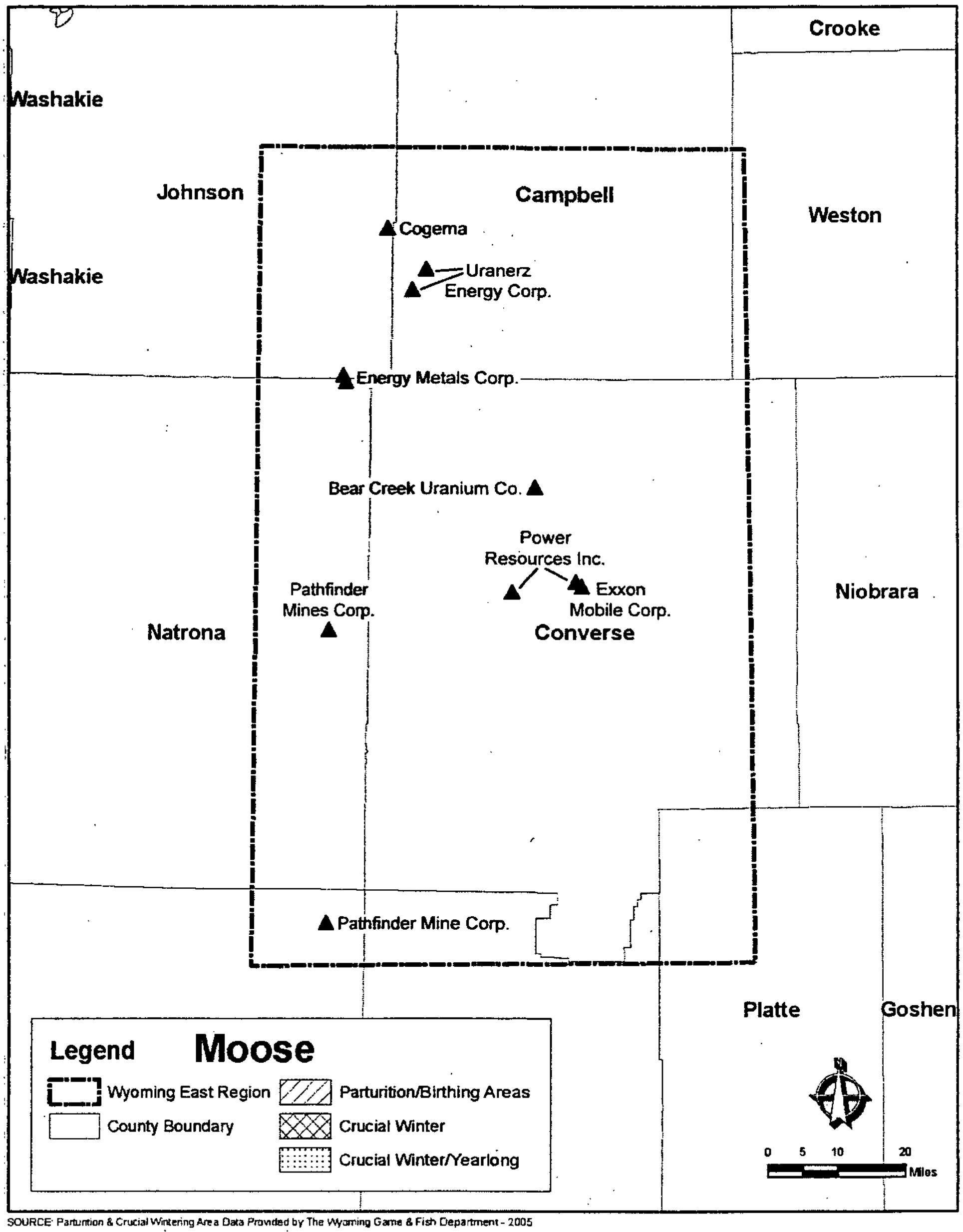


Figure 3.3-11. Moose Wintering Area for the Wyoming East Uranium Milling Region

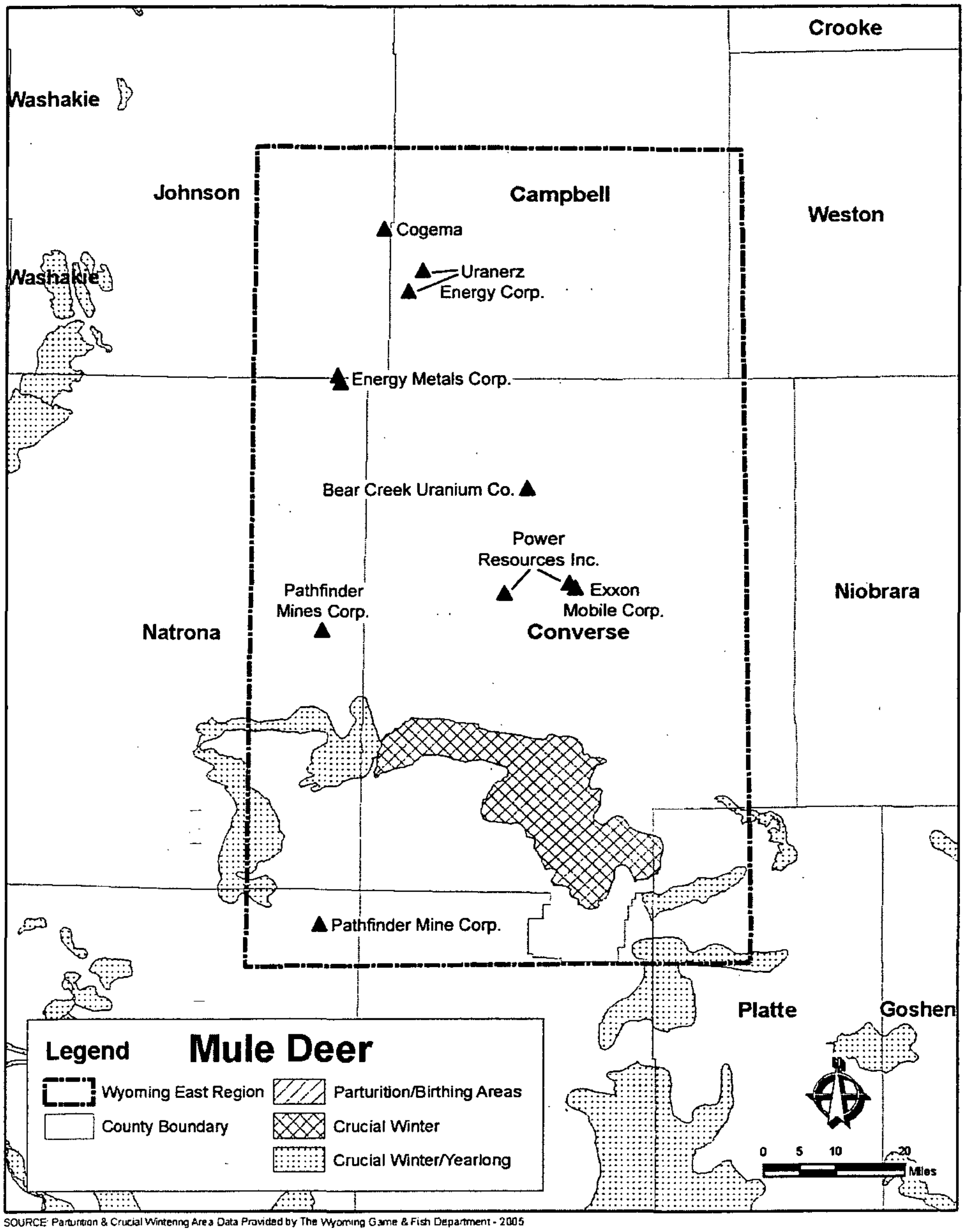
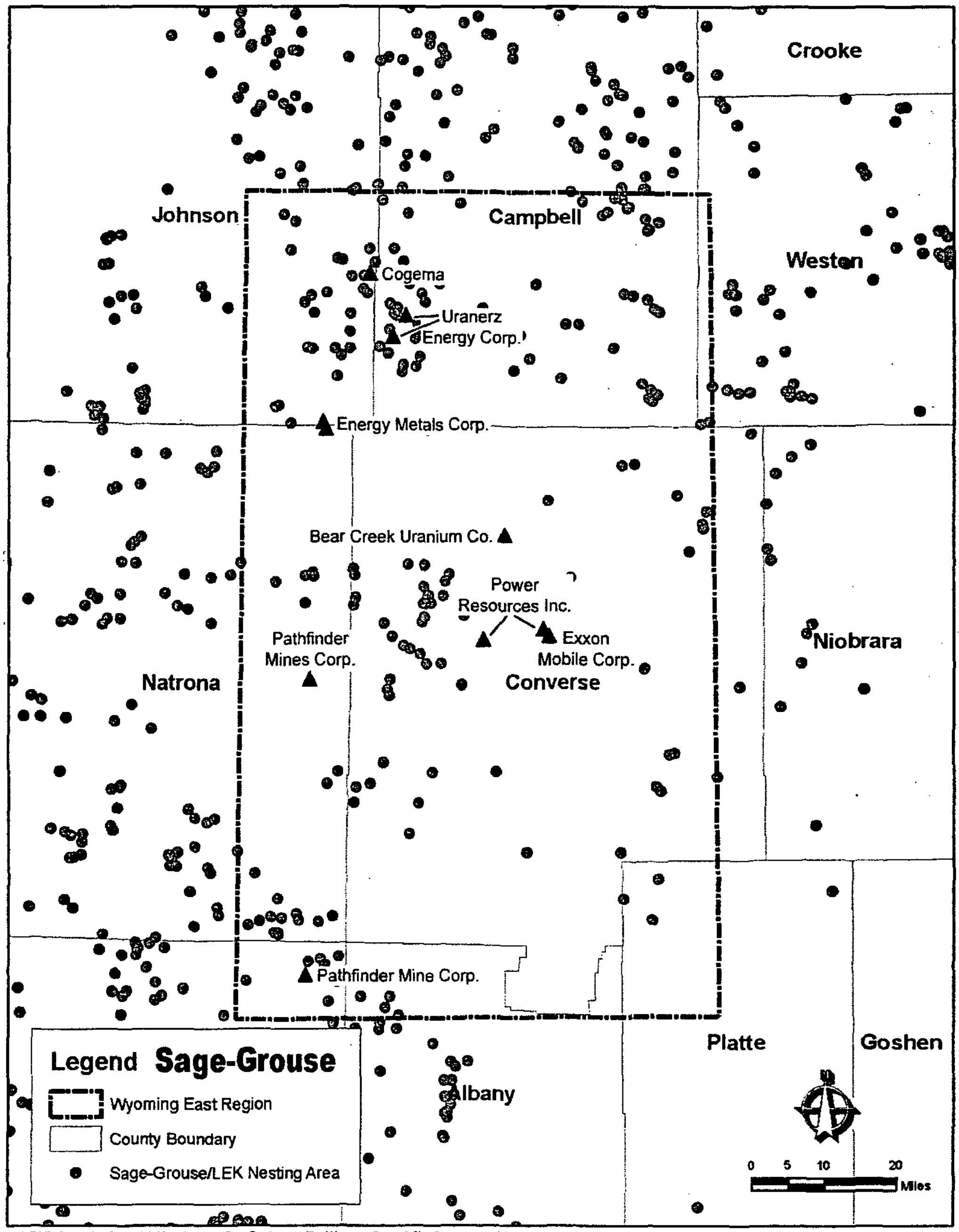
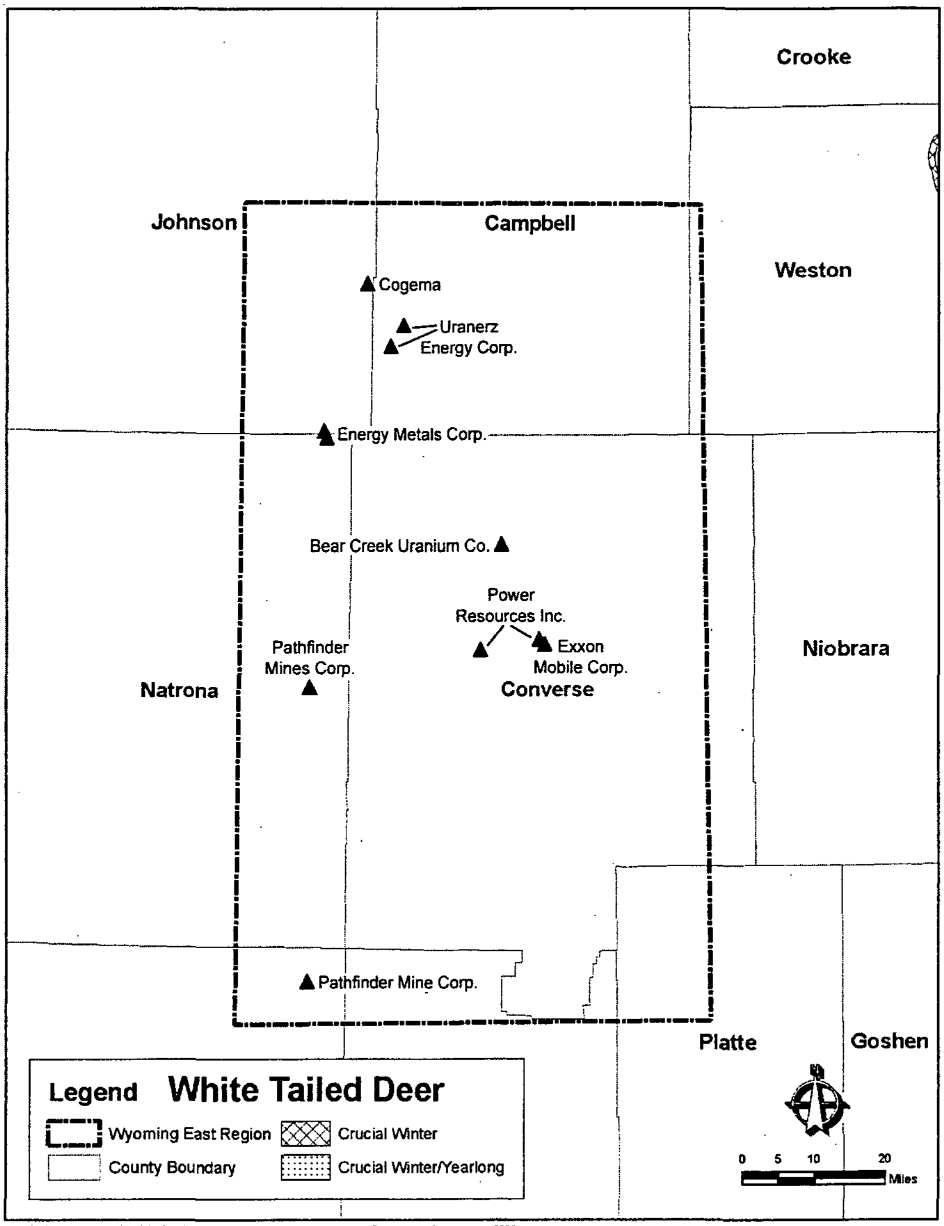


Figure 3.3-12. Mule Deer Wintering Area for the Wyoming East Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.3-13. Sage-Grouse/Leks Nesting Areas for the Wyoming East Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.3-14. White Tailed Deer Wintering Area for the Wyoming East Uranium Milling Region

intense grazing, road density, and poorly engineered stream crossings. Native fish within these watersheds include the big mouth shiner, brassy minnow (*Hybognathus hankinsoni*), common shiner (*Notropis cornutus*), creek chub, fathead minnow, longnose dace, sand shiner, stoneroller, longnose sucker, white sucker, and the plains killifish. Sports fish in the watershed include rainbow trout, cutthroat trout, brook trout, and green sunfish (*Lepomis cyanellus*) (Wyoming Game and Fish Department, 2007a,b).

3.3.5.3 Threatened and Endangered Species

A number of federally listed threatened and endangered species that are known to exist within habitats found with in the region have been discussed previously for the Wyoming West Uranium Milling Region in Section 3.2.5.3.

- Black Footed Ferret—discussed in Section 3.2.5.3
- Blowout Penstemon—discussed in Section 3.2.5.3
- Bonytail Chub—discussed in Section 3.2.5.3
- Canada Lynx—discussed in Section 3.2.5.3
- Colorado Butterfly Plant (*Gaura neomexicana* ssp. *Coloradensis*)—The Colorado butterfly plant typically occurs on subirrigated, stream deposited soils on level floodplains and drainage bottoms. Subpopulations are often found in low depressions or along bends in wide, active, meandering stream channels just a short distance upslope of the active channel. The plant occurs on soils derived from conglomerates, sandstones and tufaceous mudstones and siltstones of the Tertiary White River, Arikaree, and Ogalalla Formations. Average annual precipitation within its range is 33–41 cm [13–16 in] primarily in the form of rainfall. The Colorado butterfly plant requires early- to mid-succession riparian habitat experiencing periodic disturbance. It commonly occurs in communities including redtop and Kentucky bluegrass (*Poa pratensis*) on wetter sites, or wild licorice (*Aralia nudicaulis*), Flodmans's thistle (*Cirsium flodmanii*), curlytop gumweed (*Grindelia squarrosa*), and smooth scouring rush (*Equisetum laevigatum*) on drier sites (U.S. Fish and Wildlife Service, 2008).
- Colorado Pikeminnow—discussed in Section 3.2.5.3.
- Humpback Chub—discussed in Section 3.2.5.3.
- Interior Least Tern—discussed in Section 3.2.5.3.
- Pallid Sturgeon—discussed in Section 3.2.5.3.
- Piping Plover—discussed in Section 3.2.5.3.
- Preble's Meadow Jumping Mouse—discussed in Section 3.2.5.3.
- Razor Sucker—discussed in Section 3.2.5.3.
- Ute Ladies's Tresses—discussed in Section 3.2.5.3.

- Western Prairie Fringed Orchid—discussed in Section 3.2.5.3.

- Whooping Crane—discussed in Section 3.2.5.3.

- Wyoming Toad (*Bufo baxteri*)—This toad is a glacial relict found only in Albany County, Wyoming. It formerly inhabited flood plains, ponds, and small seepage lakes in the shortgrass communities of the Laramie Basin. The diet of this species includes ants, beetles, and a variety of other arthropods. Adults emerge from hibernation in May or June, after daytime maximum temperatures reach 21 °C [70 °F] (U.S. Fish and Wildlife Service, 2008).

- Yellow Billed Cuckoo—(candidate) discussed in Wyoming West Uranium Milling Region

Wyoming Species of Concern are described as Wyoming Native Species Status Matrix 1 (populations are greatly restricted or declining—extirpation appears possible) and 2 (populations are declining or restricted in numbers and/or distribution–extirpation is not imminent). Wyoming state species of concern may be found in the Wyoming East Uranium Milling Region include the following:

- Kendall Warm Spring Dace (*Rhinichthys osculus thermalis*), Native Species Status 1—It resides solely in a warm spring tributary to the Green River within the Bridger-Teton National Forest. Kendall warm springs dace are found well distributed throughout all but the upper portion of the 300-m [984-ft]-long spring creek. Kendall Warm Springs has a near constant temperature of 29 °C [85 °F]. Habitat consists of moderate to fast riffles, several man-made pools less than 1 m [3 ft] deep and shallower boggy areas. Adults are seen in the main current and pools while juveniles are seen in vegetated lateral habitats (Wyoming Game and Fish Department, 2008).

- Bluehead Sucker (*Catostomus discobolus*) Native Species Status 1—Bluehead suckers are usually found in the main current of streams, although their streamlined bodies form a narrow caudal peduncle, which indicates adaptation to living in the strong currents of larger rivers. Bluehead suckers prefer turbid to muddy streams with often high alkalinity and are rarely found in clear water (Wyoming Game and Fish Department, 2008).

- Black Footed Ferret (*Mustela nigripes*), Native Species Status 1—The black-footed ferret is found almost exclusively in prairie dog colonies in basin-prairie shrublands, sagebrush-grasslands, and grasslands. It is dependent on prairiedogs for food and all essential aspects of its habitat, especially prairie dog burrows where it spends most of its life underground (Wyoming Game and Fish Department, 2008).

- Bonneville Cutthroat (*Oncorhynchus clarki utah*), Native Species Status 2—Cutthroat trout prefer gravel-bottomed creeks and small rivers as well as lakes. The Bonneville cutthroat trout is well known for its ability to survive in harsh and often degraded (by man) habitats. In Wyoming, the Bonneville cutthroat is found in the Smith Fork and Thomas Fork drainages of the Bear River system. It is also native to some drainages in Idaho, Utah and Nevada with the bulk of its historic range within Utah (Wyoming Game and Fish Department, 2008).

- Western Silvery Minnow (*Hybognathus argyritis*), Native Species Status 2—This minnow prefers large to medium sized rivers with sluggish flow and silted bottoms. It is typically found in shallow backwaters and slow pools with sand or gravel substrates. It is more abundant in clear water and show intolerance for turbidity and pollution. Western silvery minnows occur in the Belle Fourche, Little Powder, and Little Missouri Rivers. It is believed to persist in the Powder River but recent surveys did not find them. They are believed extirpated from the Big Horn River. The western silvery minnow is associated with the more common plains minnow (Wyoming Game and Fish Department, 2008).

- Swift Fox (*Vulpes velox*), Native Species Status 4—The Swift fox historically inhabited Montana and the Dakotas through the Great Plains states to northwestern Texas and eastern New Mexico. In Wyoming, it occurs primarily east of the Continental Divide and is considered common in Wyoming. Its habitat consists of shortgrass and mixed grass prairies, although it often uses highway and railroad right-of-ways, agricultural areas, and sagebrush-grasslands. Closely associated with prairie dog colonies, the swift fox uses underground dens year round. It selects habitat with low growing vegetation, relatively flat terrain, friable soils, and high den availability. Although expected to be stable, Wyoming classifies it as Native Species Status 4 because habitat is vulnerable though there is no ongoing significant loss of habitat (Wyoming Game and Fish Department, 2008).

- Plains Topminnow (*Fundulus sciadicus*), Native Species Status 2—The plains topminnow is considered to be of special concern in Minnesota, Missouri, Kansas, Nebraska, and Colorado. In Wyoming plains topminnows are considered rare and their distribution appears to be declining. The plains topminnow occupies habitats that are impacted by natural and anthropogenic dewatering. Introductions of western mosquito fish have been implicated in the current restricted distribution of plains topminnow in Nebraska (Wyoming Game and Fish Department, 2008).

- Great Basin Gopher Snake—discussed in Section 3.2.5.3.

- Canada Lynx—discussed in Section 3.2.5.3.

- Pale Milk Snake Native Species Status 2—discussed in Section 3.2.5.3.

- Smooth Green Snake—discussed in Section 3.2.5.3.

- Yellow-Billed Cuckoo—discussed in Section 3.2.5.3.

- Greater Sage-Grouse—discussed in Section 3.2.5.3.

- Bald Eagle—discussed in Section 3.2.5.3.

- Trumpeter Swan—discussed in Section 3.2.5.3.

- Fringed Myotis—discussed in Section 3.2.5.3.

- Long-Legged Myotis—discussed in Section 3.2.5.3.

- Pallid Bat—discussed in Section 3.2.5.3.
- Spotted Bat—discussed in Section 3.2.5.3.

3.3.6 Meteorology, Climatology, and Air Quality

3.3.6.1 Meteorology and Climatology

Wyoming's elevation results in relatively cool temperatures. Much of the temperature variations within the state can be attributed to elevation with average values dropping 1 to 2 °C [1.8 to 3.6 °F] per 300 m [1,000 ft] (National Climatic Data Center, 2005]. Summer nights are normally cool although daytime temperatures may be quite high. The fall, winter, and spring can experience rapid changes with frequent variations from cold to mild periods. Freezes in early fall and late spring are typical and result in long winters and a short growing season. In the mountains and high valleys, freezes can occur any time in the summer. During winter warm spells, nighttime temperatures can remain above freezing. Valleys protected from the wind by mountain ranges can provide ideal pockets for cold air to settle and temperatures in the valley can be considerably lower that on nearby mountainsides. Tables 3.3-5 and 3.3-6 provide information on two climate stations located in the Wyoming East Uranium Milling Region.

Precipitation within Wyoming varies, with spring and early summer being the wettest time for much of the state. Mountain ranges are generally oriented in a north-south direction. This is perpendicular to the prevailing westerlies. Therefore, these mountains often act as moisture barriers. Air currents for the Pacific Ocean rise and drop much of their moisture along the

Table 3.3-5. Information on Two Climate Stations in the Wyoming East Uranium Milling Region*

Station (Map Number)	County	State	Longitude	Latitude
Glenrock 5 ESE (044)	Converse	Wyoming	105°47W	42°50N
Midwest (062)	Natrona	Wyoming	106°17W	43°25N

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.

Table 3.3-6. Climate Data for Stations in the Wyoming East Uranium Milling Region*

		Glenrock 5 ESE	Midwest
Temperature (°C)†	Mean—Annual	8.8	7.5
	Low—Monthly Mean	−3.1	−5.7
	High—Monthly Mean	22.4	21.5
Precipitation (cm)‡	Mean—Annual	31.0	35.0
	Low—Monthly Mean	0.90	1.4
		Glenrock 5 ESE	Midwest
	High—Monthly Mean	6.1	6.5
Snowfall (cm)	Mean—Annual	58.4	135
	Low—Monthly Mean	0	0
	High—Monthly Mean	13.5	22.6

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.
†To convert Celsius (°C) to Fahrenheit (°F), multiply by 1.8 and add 32.
‡To convert centimeters (cm) to inches (in), multiply by 0.3937.

western slopes of the mountains. Summer showers are frequent, but typically result in rainfall amounts of a few hundredths of an inch. Usually several times a year in the state, local thunderstorms will result in 2.5 to 5 cm [1 to 2 in] of rain in a 24-hour period. On rare occasions, rainfall in a 24-hour period can reach 7.5 to 12.5 cm [3 to 5 in] (National Climatic Data Center, 2005). Heavy rains can create flash flooding in headwater streams, and this flooding intensifies if these storms coincide with snowpack melting. Table 3.3-6 contains precipitation data for two stations in the Wyoming East Uranium Milling Region. The wettest month for both stations identified in Table 3.3-6 is May, which based on the snow depth data, coincides with snowpack melting (National Climatic Data Center, 2004). One of the stations is in Converse County and the other is in Natrona County. Data from the National Climatic Data Center's Storm Events Database from 1950 to 2007 indicate that the vast majority of thunderstorms in Converse and Natrona Counties occurs between June and August with the most occurring in June (National Climatic Data Center, 2007).

Hailstorms are the most destructive storm event for Wyoming. Most hailstorms pass over open rangeland with minimal impact. When a hailstorm passes over a city or farmland, the property and crop damage can be severe. Most of the severe hailstorms occur in the southeast corner of the state.

Low elevations typically experience light to moderate snowfall from November to May. Snowfall within Wyoming varies by location with the mountain ranges typically receiving the most. Significant storms of 25 to 40 cm [10 to 16 in] of snowfall are infrequent outside of the mountains. Wind often coincides or follows snowstorms and can form snow drifts several meters [feet] deep. Snow can accumulate to considerable depths in the high mountains. Blizzards that last more than 2 days are uncommon. Table 3.3-6 contains snowfall data for two stations in the Wyoming East Uranium Milling Region.

Wyoming is windy and ranks first in the United States with an annual average speed of 6 m/s [12.9 mph]. During winter, Wyoming frequently experiences periods where wind speed reaches 13 to 18 m/s [30 to 40 mph] with gusts to 22 to 27 m/s [50 or 60 mph] (National Climatic Data Center, 2005). Prevailing wind direction varies by location but usually ranges from west-southwest through west to northwest. Because the wind is normally strong and constant from those directions, trees often lean to the east or southeast.

The pan evaporation rates for the Wyoming East Uranium Milling Region range from about 102 to 127 cm [40 to 50 in] (National Weather Service, 1982). Pan evaporation is a technique that measures the evaporation from a metal pan typically 121 cm [48 in] in diameter and 25 cm [10 in] tall. Pan evaporation rates can be used to estimate the evaporation rates of other bodies of water such as lakes or ponds. Pan evaporation rate data is typically available only from May to October. Freezing conditions often prevent collection of quality data during the other part of the year.

3.3.6.2 Air Quality

The air quality general description for the Wyoming East Uranium Milling Region is similar to the description in Section 3.2.6 for the Wyoming West Uranium Milling Region.

As described in Section 1.7.2.2, the permitting process is the mechanism used to address air quality. If warranted, permits may set facility air pollutant emission levels, require mitigation measures, or require additional air quality analyses. Except for Indian Country, New Source

Review permits in Wyoming are regulated under the EPA-approved State Implementation Plan. For Indian Country in Wyoming, the New Source Review permits are regulated under 40 CFR 52.21 (EPA, 2007a).

State implementation plans and permit conditions are based in part on federal regulations developed by the EPA. The NAAQS are federal standards that define acceptable ambient air concentrations for six common nonradiological air pollutants: nitrogen oxides, ozone, sulfur oxides, carbon monoxide, lead, and particulates. In June 2005, EPA revoked the 1-hour ozone standard nationwide in all locations except certain Early Action Compact Areas. None of the 1-hour ozone Early Action Compact Areas are in Wyoming. States may develop standards that are stricter or supplement the NAAQS. Wyoming has a more restrictive annual average standard for sulfur dioxide at 60 $\mu g/m^3$ [1.6×10^{-6} oz/yd^3] and a supplemental 50 $\mu g/m^3$ [1.3×10^{-6} oz/yd^3] PM_{10} standard with an annual averaging time (WDEQ, 2006).

Prevention of Significant Deterioration requirements identify maximum allowable increases in concentrations for particulate matter, sulfur dioxide, and nitrogen dioxide for areas designated as attainment. Different increment levels are identified for different classes of areas, and Class I areas have the most stringent requirements.

The Wyoming East Uranium Milling Region air quality description focuses on two topics: NAAQS attainment status and PSD classifications in the region.

All of the area within the Wyoming East Uranium Milling Region is classified as attainment for NAAQS. Figure 3.3-15 identifies counties in Wyoming and surrounding areas that are partially or entirely designated as nonattainment or maintenance for NAAQS at the time this GEIS was prepared (EPA, 2007b). All of the area within the Wyoming East Uranium Milling Region is classified as attainment. In fact, Wyoming only has one area that is not in attainment. The city of Sheridan in Sheridan County is designated as nonattainment for PM_{10}. Portions of several Colorado counties along the southern Wyoming border are classified as not in attainment. However, the southern boundary of the Wyoming East Uranium Milling Region is north of the Wyoming/Colorado border.

Table 3.3-7 identifies the Prevention of Significant Deterioration Class I areas in Wyoming. These areas are shown in Figure 3.3-16. There are no Class I areas in the Wyoming East Uranium Milling Region (40 CFR Part 81).

3.3.7 Noise

The existing ambient noise levels in the undeveloped rural and more urban areas of the Wyoming East Uranium Milling Region would be 22 to 38 dB, similar to those described in Section 3.2.7 for the Wyoming West Uranium Milling Region. The largest community is Casper, the second largest city in Wyoming, with a population near 50,000. Smaller communities include Glenrock and Douglas, with populations between 2,000 and about 6,000 (see Section 3.3.10). Ambient noise levels in these communities would be expected to be similar to other urban areas (up to 78 dB) (Washington State Department of Transportation, 2006).

As described in Section 3.3.2, major highways in the region include Interstate 25 and U.S. Highways 20, 26, 18, and 87. Sections of these highways are multilane, limited access freeways, and traffic is highest to the east (about 7,200 vehicles per day) and north (about 5,300 vehicles per day) of Casper on Interstate 25 (Wyoming Department of Transportation,

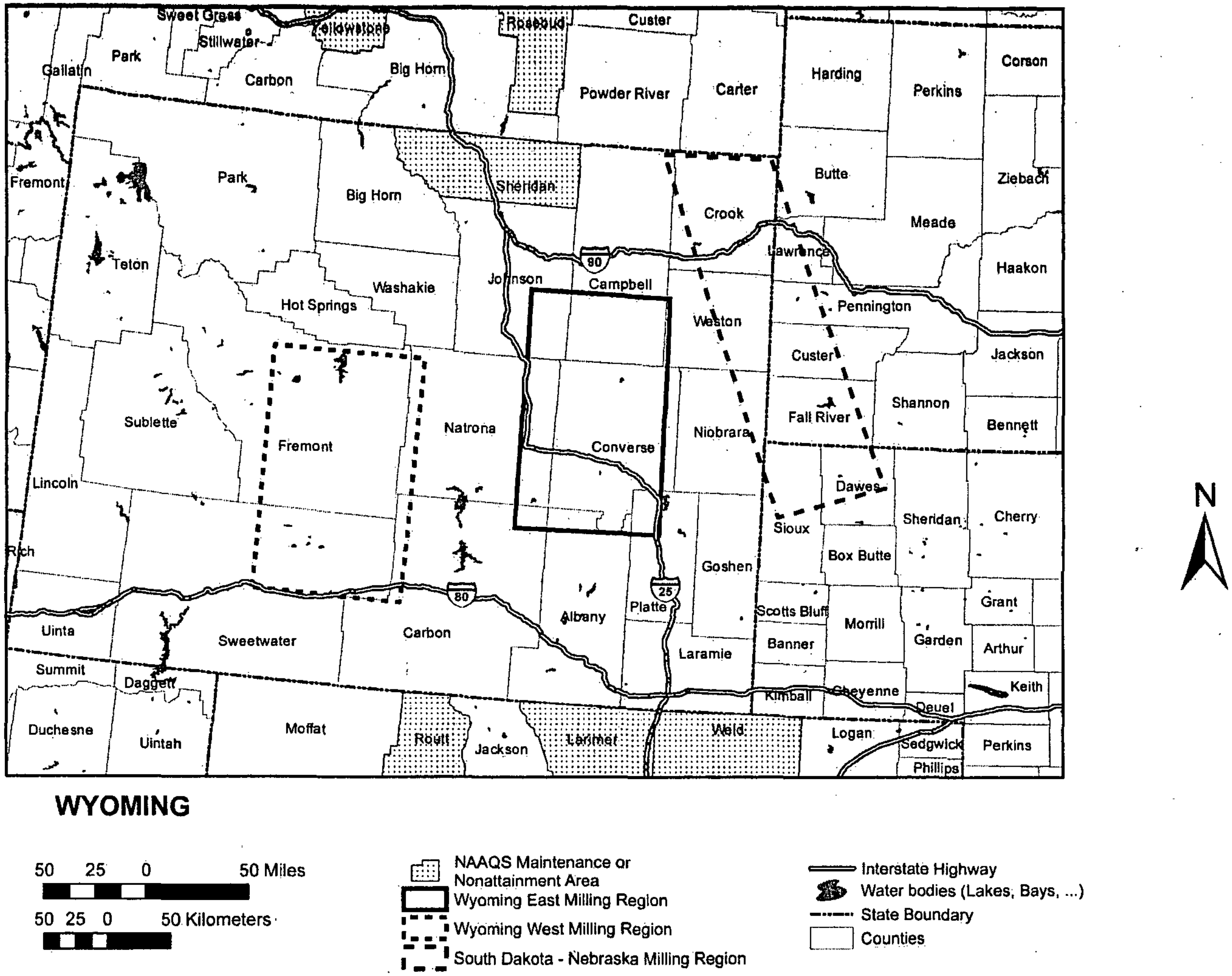


Figure 3.3-15. Air Quality Attainment Status for Wyoming and Surrounding Areas (EPA, 2007a)

Table 3.3-7. U.S. Environmental Protection Agency Class I Prevention of Significant Deterioration Areas in Wyoming*
Bridger Wilderness
Fitzpatrick Wilderness
Grand Teton National Park
North Absaroka Wilderness
Teton Wilderness
Washakie Wilderness
Yellowstone National Park
*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40, Protection of the Environment, Part 81. Washington, DC: U.S. Government Printing Office. 2005.

2005). Passenger cars make up about 75 percent of the traffic count on Interstate 25, indicating that ambient noise levels would likely be less than those measured at up to 70 dBA along Interstate 80 where traffic count and heavy truck traffic is higher (Federal Highway Administration, 2004; see also Section 3.2.7).

The current ISL uranium facilities (Smith Ranch-Highland and Reynolds Ranch) and those that are anticipated for the Wyoming East Uranium Milling Region are located at least 16 km [10 mi] from the larger communities in the region. For the three uranium districts in the Wyoming East Uranium Milling Region, most of the ambient noise levels would therefore be anticipated to be similar to rural, undeveloped areas. As in the Wyoming West Uranium Milling Region, a number of small communities are located along the highways and roads that run through the region. For example, Linch, Savageton, and Sussex are located in the Pumpkin Buttes Uranium District in the northwest corner of the region. In the central uranium district, the closest small communities include Orpha and Bill, and Shirley Basin is located in the uranium district in the southeast corner of the region. Noise levels in these areas would be anticipated to be higher than the undeveloped areas (22 to 38 dB), but less than the larger urban areas like Casper and Douglas.

3.3.8 Historical and Cultural Resources

3.3.8.1 Cultural Resources Overview

A general overview of historical and cultural resources for the Wyoming East Uranium Milling Region is provided in Section 3.2.8.1. As described in Section 3.2.8.1, the Wyoming SHPO administers and is responsible for oversight and compliance with the NRHP, compliance and review for Section 106 of the NHPA traditional cultural properties review, enforcement of NAGPRA, and compliance with other federal and state historic preservation laws, regulations, and statutes.

3.3.8.2 National Register of Historic Properties and State Registers

Table 3.3-8 includes a summary of the historic properties in the Wyoming East Uranium Milling Region that are listed on the Wyoming state and/or the NRHP. Many of the sites are located in Casper, Glenrock, and Douglas, at least 16 km [10 mi] from potential and existing uranium ISL facilities. Several sites near Sussex in Johnson County are located near the uranium district in the northwest corner of the Wyoming East Uranium Milling Region.

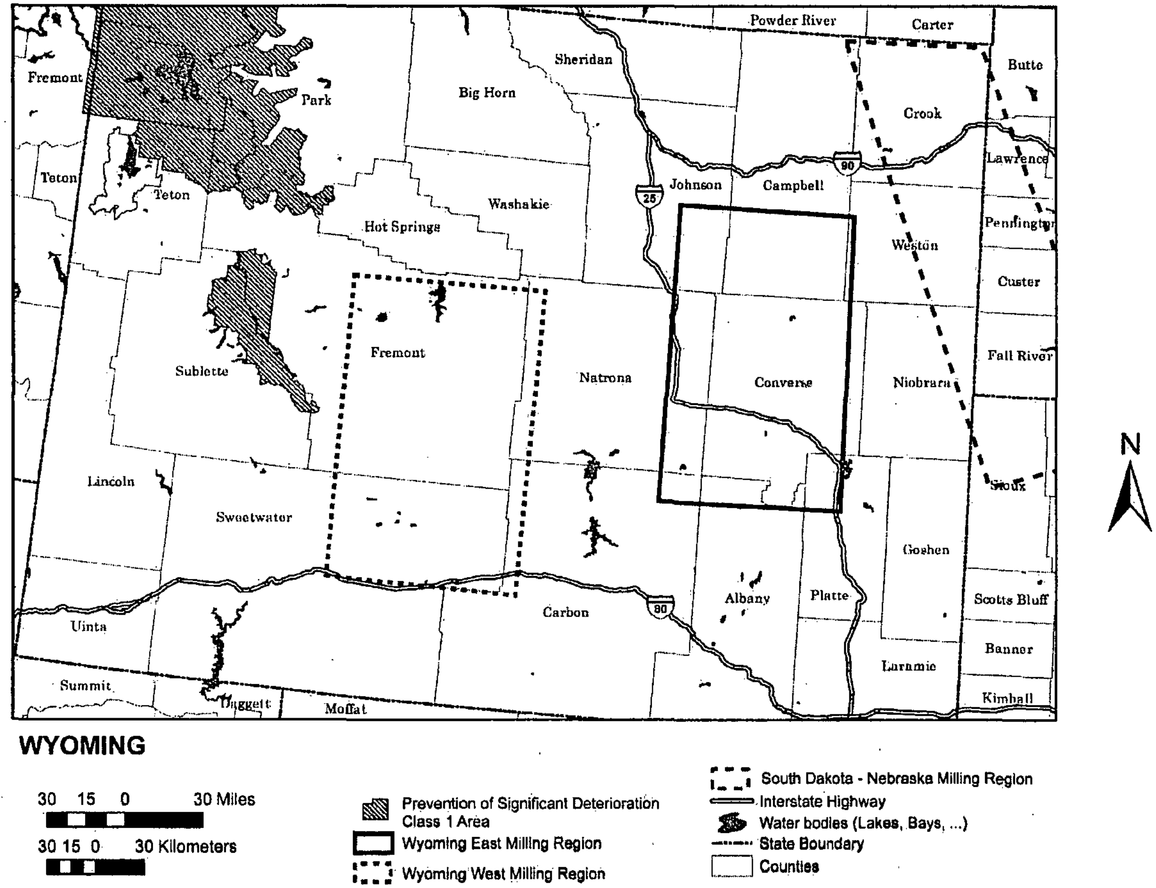


Figure 3.3-16. Prevention of Significant Deterioration Class I Areas in the Wyoming East Uranium Milling Region and Surrounding Areas (40 CFR Part 81)

Table 3.3-8. National Register Listed Properties in Counties Included in the Wyoming East Uranium Milling Region

County	Resource Name	City	Date Listed YYYY-MM-DD
Campbell	Basin Oil Field Tipi Rings (48CA1667)	Piney	1985-12-13
Campbell	Bishop Road Site (48CA1612)	Piney	1985-12-13
Campbell	Nine Mile Segment, Bozeman Trail (48CA264)	Pine Tree Junction	1989-07-23
Converse	Antelope Creek Crossing (48CO171 and 48CO165)	City Unavailable	1989-07-23
Converse	Braehead Ranch	Douglas	1995-09-07
Converse	Christ Episcopal Church and Rectory	Douglas	1980-11-17
Converse	College Inn Bar	Douglas	1979-07-10
Converse	Commerce Block	Glenrock	2005-01-21
Converse	Douglas City Hall	Douglas	1994-03-17
Converse	Fort Fetterman	Orpha	1969-04-16
Converse	Fremont, Elkhorn & Missouri Valley Railroad Passenger Depot	Douglas	1994-08-03
Converse	Glenrock Buffalo Jump	Glenrock	1969-04-16
Converse	Holdup Hollow Segment, Bozeman Trail (48CO165)	City Unavailable	1989-07-23
Converse	Hotel Higgins	Glenrock	1983-11-25
Converse	Jenne Block	Douglas	1998-01-06
Converse	La Prele Work Center	Douglas	1994-04-11
Converse	Morton Mansion	Douglas	2001-01-11
Converse	North Douglas Historic District	Douglas	2002-11-25
Converse	Officer's Club, Douglas Prisoner of War	Douglas	2001-09-08
Converse	Ross Flat Segment, Bozeman Trail (48C0165)	City Unavailable	1989-07-23
Converse	Sage Creek Station (48CO104)	Glenrock	1989-07-23
Converse	Stinking Water Gulch Segment, Bozeman Trail (48CO165)	City Unavailable	1989-07-23
Converse	U.S. Post Office—Douglas Main	Douglas	1987-05-19
Johnson	AJX Bridge over South Fork and Powder Rivers	Kaycee	1985-02-22
Johnson	Cantonment Reno	Sussex	1977-07-29
Johnson	Dull Knife Battlefield	Barnum	1979-08-15
Johnson	EDZ Irigaray Bridge	Sussex	1985-02-22
Johnson	Fort Reno	Sussex	1970-04-28
Johnson	Lake Desmet Segment, Bozeman Trail	City Unavailable	1989-07-23
Johnson	Powder River Station—Powder River Crossing (48JO134 and 48JO801)	Sussex	1989-07-23
Johnson	Sussex Post Office and Store	Kaycee	1998-11-12
Natrona	Archaeological Site No. 48NA83	Arminto	1994-05-13
Natrona	Big Horn Hotel	Arminto	1978-12-18
Natrona	Bishop House	Casper	2001-03-12
Natrona	Bridger Immigrant Road—Waltman Crossing	Casper	1975-01-17
Natrona	Casper Army Air Base	Casper	2001-08-03
Natrona	Casper Buffalo Trap	Casper	1974-06-25
Natrona	Casper Federal Building	Casper	1998-12-21
Natrona	Casper Fire Department Station No. 1	Casper	1993-11-04
Natrona	Casper Motor Company—Natrona Motor Company	Casper	1994-02-23
Natrona	Church of Saint Anthony	Casper	1997-01-30
Natrona	Consolidated Royalty Building	Casper	1993-11-04
Natrona	DUX Bessemer Bend Bridge	Bessemer Bend	1985-02-22
Natrona	Elks Lodge No. 1353	Casper	1997-01-30

Table 3.3-8. National Register Listed Properties in Counties Included in the Wyoming East Uranium Milling Region (continued)			
County	Resource Name	City	Date Listed YYYY-MM-DD
Natrona	Fort Casper	Casper	1971-08-12
Natrona	Fort Casper (Boundary Increase)	Casper	1976-07-19
Natrona	Independence Rock	Casper	1966-10-15
Natrona	Martin's Cove	Casper	1977-03-08
Natrona	Masonic Temple	Casper	2005-08-24
Natrona	Midwest Oil Company Hotel	Casper	1983-11-17
Natrona	Natrona County High School	Casper	1994-01-07
Natrona	North Casper Clubhouse	Casper	1994-02-18
Natrona	Ohio Oil Company Building	Casper	2001-07-25
Natrona	Pathfinder Dam	Casper	1971-08-12
Natrona	Rialto Theater	Casper	1993-02-11
Natrona	Roosevelt School	Casper	1997-01-30
Natrona	South Wolcott Street Historic District	Casper	1988-11-23
Natrona	Split Rock, Twin Peaks	Muddy Gap	1976-12-22
Natrona	Stone Ranch Stage Station	Casper	1982-11-01
Natrona	Teapot Rock	Midwest	1974-12-30
Natrona	Townsend Hotel	Casper	1983-11-25
Natrona	Tribune Building	Casper	1994-02-18

3.3.8.3 Tribal Consultation

Section 3.2.8.3 includes a discussion on Native American tribes located within or immediately adjacent to the state of Wyoming that have interests in the state, including

- Arapaho Tribe of the Wind River Reservation
- Shoshone Tribe of the Wind River Reservation
- Northern Cheyenne Tribe of Montana
- Cheyenne River Sioux
- Flandreau Santee Sioux
- Lower Brulé Sioux
- Oglala Sioux
- Rosebud Sioux
- Sisseton-Whapeton Oyate
- Standing Rock Sioux
- Yankton Sioux
- Crow Tribe of Montana

The Siouan tribes are located throughout South and North Dakota, and the Crow and Northern Cheyenne are located in Montana and have interests in Wyoming. Other Siouan-speaking tribes, as well as other tribes in North Dakota, Wyoming, Montana, and Nebraska may have traditional land use claims in the Wyoming East Uranium Milling Region.

3.3.8.4 Places of Cultural Significance

Section 3.2.8.4 includes a more detailed discussion of culturally significant places and traditional cultural properties in Central and Eastern Wyoming. As described in Section 3.2.8, there are no culturally significant places listed in either the NRHP or state registers in the Wyoming East

Uranium Milling Region. However, the Lakota Sioux or other Sioux bands (Cheyenne River Sioux, Lower Brulé Sioux, Oglala Sioux, Rosebud Sioux) along with the Northern Cheyenne, Crow Tribe, the Arapaho, the Kiowa, and Wind River Shoshone who once occupied or may have utilized portions of the Wyoming East Uranium Milling Region consider the Black Hills in Wyoming and South Dakota, Devil's Tower in northeastern Wyoming, Pumpkin Buttes in eastern Wyoming, and Bear Butte in southwestern South Dakota to be culturally significant. These were once used for personal rituals and the Sun Dance and are the source of origin legends among many of these tribes.

Areas of central and eastern Wyoming once used by these tribes may contain additional, hitherto undocumented or undisclosed culturally significant sites and traditional cultural properties. Mountains, peaks, buttes, prominences, and other elements of the natural and cultural environment are often considered important elements of a traditional, culturally significant landscape.

Traditional cultural properties are those that refer to beliefs, customs, and practices of a living community that have been passed down over the generations. Native American traditional cultural properties are often not found on the state or national registers of historic properties or described in the extant literature or in SHPO files. There are, however, a range of cultural property types of religious or traditional use that might be identified during the tribal consultation process. These might include

- Sites of ritual and ceremonial activities and related features
- Shrines
- Marked and unmarked burial grounds
- Traditional use areas
- Plant and mineral gathering areas
- Traditional hunting areas
- Caves and rock shelters
- Springs
- Trails
- Prehistoric archaeological sites

3.3.9 Visual/Scenic Resources

Based on the BLM Visual Resource Handbook (BLM, 2007a–c), the uranium districts in the Wyoming East Uranium Milling Region are located at the junction of the Northern and Southern Rocky Mountain, Wyoming Basin, and Great Basin physiographic provinces (Bennett, 2003). The BLM resource management plans covering this region include the Casper (BLM, 2007d), Buffalo (BLM, 2001), Rawlins (BLM, 2008b), and Newcastle (BLM, 2000) field offices (see the BLM Wyoming website at http://www.blm.gov/wy/st/en.html). The VRM classifications assigned within these resource plans are presented in Figure 3.3-17.

The bulk of the Wyoming East Uranium Milling Region is categorized as VRM Class III (along highways) and Class IV (open grassland, oil and natural gas, urban areas). The landscape has been extensively modified in urban areas and in several areas of oil, natural gas, and coal production, such as Natrona and Converse Counties near Casper and Douglas (Bennett, 2003; BLM, 2007d) and Johnson and Campbell Counties near Gillette (BLM, 2001). As a result, these areas are predominantly classified as VRM Class IV or as Class V/Rehabilitation. The BLM resource management plans do not identify any VRM Class I resources that fall within the

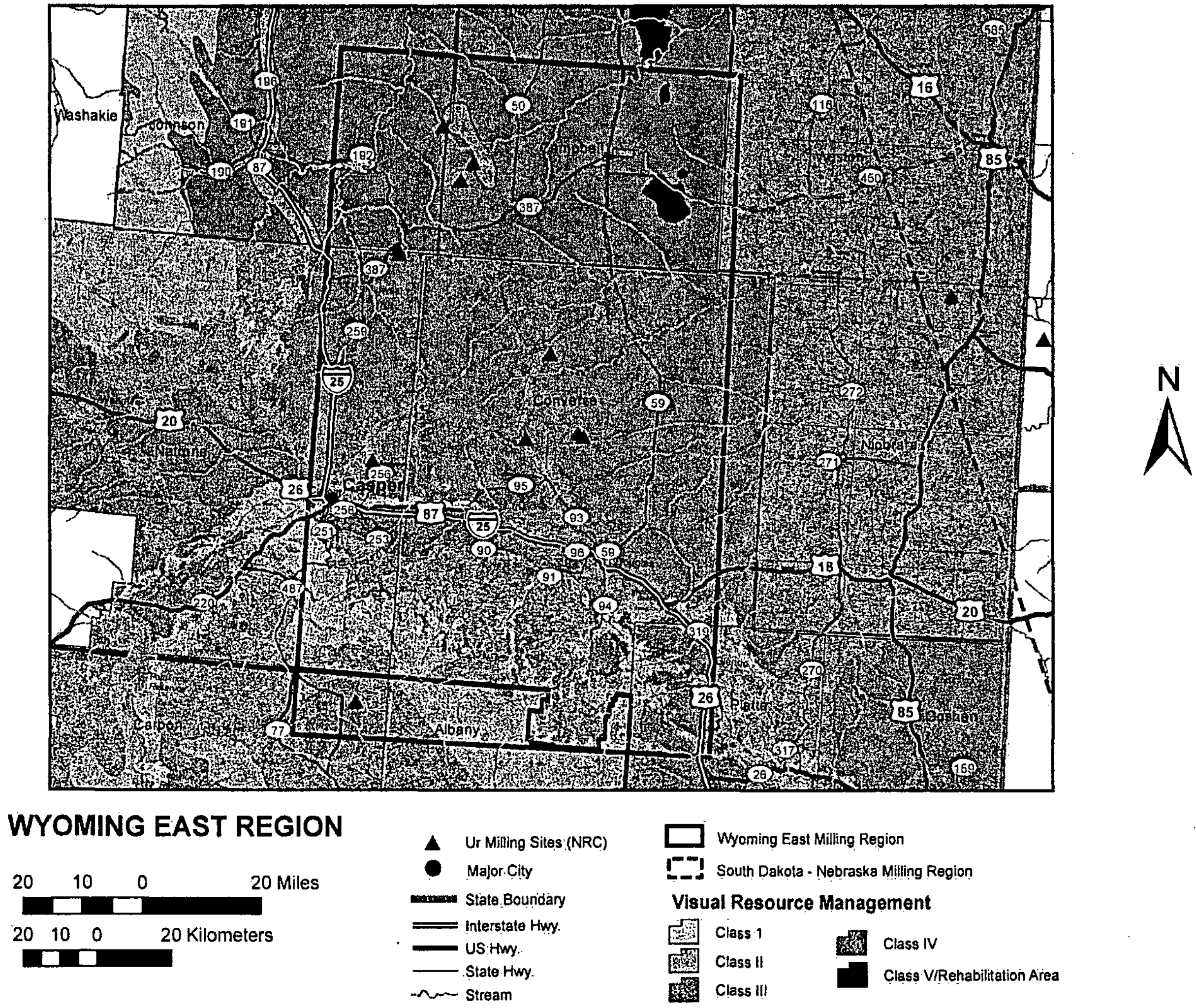


Figure 3.3-17. BLM Visual Resource Classifications for the Wyoming East Uranium Milling Region (BLM, 2008b, 2007d, 2001, 2000)

Wyoming East Uranium Milling Region. VRM Class II areas are generally identified south of Interstate 25 in the region, ranging from the Laramie Mountains in the southwestern portion of the region to the North Platte River and its tributaries across the southern part of the region (BLM, 2007d, 1992). Additional areas of potentially sensitive visual resources include the Bozeman, Oregon, and Bridger Historic Trails that cross the southern part of the region, traveling east to west roughly parallel to the North Platte River (Bennett, 2003; BLM, 2007d, 1992) on the north side of the Laramie Mountains. All of the current and potential ISL facilities identified in the three uranium districts in the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas (Figure 3.3-17). There are no Prevention of Significant Deterioration Class I or Wyoming Unique/Irreplaceable or Rare/Uncommon designated areas within the Wyoming East Uranium Milling Region (Girardin, 2006).

3.3.10 Socioeconomics

For the purpose of this GEIS, the socioeconomic description for the Wyoming East Uranium Milling Region includes communities within the region of influence for potential ISL facilities in the three uranium districts in the region. These include communities that have the highest potential for socioeconomic impacts and are considered the affected environment. Communities that have the highest potential for socioeconomic impacts are defined in the GEIS by (1) proximity to an ISL facility {generally within 48 km [30 mi]}; (2) economic profile, such as potential for income growth or destabilization; (3) employment structure, such as potential for job placement or displacement; and (4) community profile, such as potential for growth or destabilization to local emergency services, schools, or public housing. The affected environment within the Wyoming East Uranium Milling Region consists of counties and CBSAs. A CBSAs, according to the U.S. Census Bureau, is a collective term for both metro and micro areas ranging from a population of 10,000 to 50,000 (U.S. Census Bureau, 2008). The major political divisions of the affected environment are listed in Table 3.3-9. The following subsections describe areas most likely to have implications to socioeconomics and are listed below. In some subsections Metropolitan Areas are also discussed. A Metropolitan Area is greater than 50,000 and a town is considered less than 10,000 in population (U.S. Census

Table 3.3-9. Summary of Affected Environment Within the Wyoming East Uranium Milling Region

Counties Within Wyoming East	Core-Based Statistical Areas Within Wyoming East
Albany	Casper
Campbell	
Carbon	
Converse	
Johnson	
Natrona	
Niobrara	
Platte	
Weston	

Bureau, 2008). Smaller communities such as Bill and Linch are considered as part of the county demographics.

3.3.10.1 Demographics

Demographics are based on 2000 U.S. Census data population and racial characteristics of the affected environment (Table 3.3-10). (Figure 3.3-18 illustrates the populations of communities within the Wyoming East Uranium Milling Region.) Most 2006 data compiled by the U.S. Census Bureau is not yet available for the geographic area of interest.

The most populated county in the Wyoming East Uranium Milling Region is Natrona County, and the most sparsely populated county is Niobrara County. The county with the largest percentage of nonminorities is Niobrara County with a white population of 98.0 percent. The largest minority based county is Carbon County with a white population of 90.1 percent or a minority-based population of 9.9 percent. The CBSAs of Casper is demographically similar to the counties within the Wyoming East Uranium Milling Region.

3.3.10.2 *Income*

Income information from the 2000 U.S. Census including labor force, income, and poverty levels for the affected environment is based on data collected from state and county levels. Data collected at the state level also include information on towns, CBSA, or Metropolitan Areas and considers an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than 48 km [30 mi]} for income opportunities or may be a workforce needed to fulfill specialized positions (if local workforce is unavailable or unspecialized). In Wyoming, the workforce frequently commutes long distances to work. For example, in the Wyoming East Uranium Milling Region, most of the affected counties experienced net inflows of workers during the fourth quarter of 2005. Net inflows ranged from about 160 for Johnson County to about 7,500 for Campbell County. These inflows were predominately for jobs related to the energy industry in the Powder River Basin (Wyoming Workforce Development Council, 2007). Converse (−1,063) and Platte (−228) Counties experienced net outflows during the same period. Data collected at the county level are generally the same as for the affected environment presented in Table 3.3-9. State-level information for the surrounding region is provided in Table 3.3-11, and county data are listed in Table 3.3-12.

For the surrounding region, the state with both the largest labor force population and families and individuals living below poverty level is Colorado. The largest labor force population is Billings, Montana {128 km [80 mi] from the nearest potential ISL facility in the region}, and the smallest labor force population is Laramie, Wyoming {96 km [60 mi] from the nearest potential ISL facility}. The population with the highest per capita income is Fort Collins, Colorado {240 km [150 mi] from the nearest potential ISL facility}, and the lowest per capita income population is Laramie, Wyoming. The population with the highest percentage of individuals and families below poverty levels is Laramie, Wyoming (Table 3.3-11).

The county with the largest labor force is Natrona County, and the smallest labor force is located in Niobrara County. The county with the highest per capita income is Campbell County, and the smallest per capita income at the county level is Niobrara County. The county with the highest percentage of individuals and families living below the poverty level is Albany County (Table 3.3-12).

Table 3.3-10. 2000 U.S. Bureau of Census Population and Race Categories of the Wyoming East Uranium Milling Region*

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
Wyoming	493,782	454,670	3,722	11,133	12,301	8,883	2,771	31,669	302
Percent of total		92.1%	0.8%	2.3%	2.5%	1.8%	0.6%	6.4%	0.1%
Albany County	32,014	29,235	354	18	847	710	545	2,397	18
Percent of total		91.3%	1.1%	0.1%	2.6%	2.2%	1.7%	7.5%	0.1%
Campbell County	33,698	32,369	51	313	378	450	108	1,191	29
Percent of total		96.1%	0.2%	0.9%	1.1%	1.3%	0.3%	3.5%	0.1%
Carbon County	15,639	14,092	105	9	808	321	105	2,163	9
Percent of total		90.1%	0.7%	0.1%	5.2%	2.1%	0.7%	13.8%	0.1%
Converse County	12,052	11,416	18	110	296	177	32	660	3
Percent of total		94.7%	0.1%	0.9%	2.5%	1.5%	0.3%	5.5%	0.0%
Johnson County	7,075	6,865	6	45	39	112	8	148	0
Percent of total		97.0%	0.1%	0.6%	0.6%	1.6%	0.1%	2.1%	0.0%
Natrona County	66,533	62,644	505	686	1,275	1,121	277	3,257	25
Percent of total		94.2%	0.8%	1.0%	1.9%	1.7%	0.4%	4.9%	0.0%
Niobrara County	2,407	2,360	3	12	12	17	3	36	0
Percent of total		98.0%	0.1%	0.5%	0.5%	0.7%	0.1%	1.5%	0.0%
Platte County	8,807	8,471	14	44	149	112	15	465	2
Percent of total		96.2%	0.2%	0.5%	1.7%	1.3%	0.2%	5.3%	0.0%
Weston County	6,644	6,374	8	84	62	102	13	137	1
Percent of total		95.9%	0.1%	1.3%	0.9%	1.5%	0.2%	2.1%	0.0%
Casper	49,644	46,680	428	495	1,011	775	245	2,656	10
Percent of total		94.0%	0.9%	1.0%	2.0%	1.6%	0.5%	5.4%	0.0%

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100 percent).

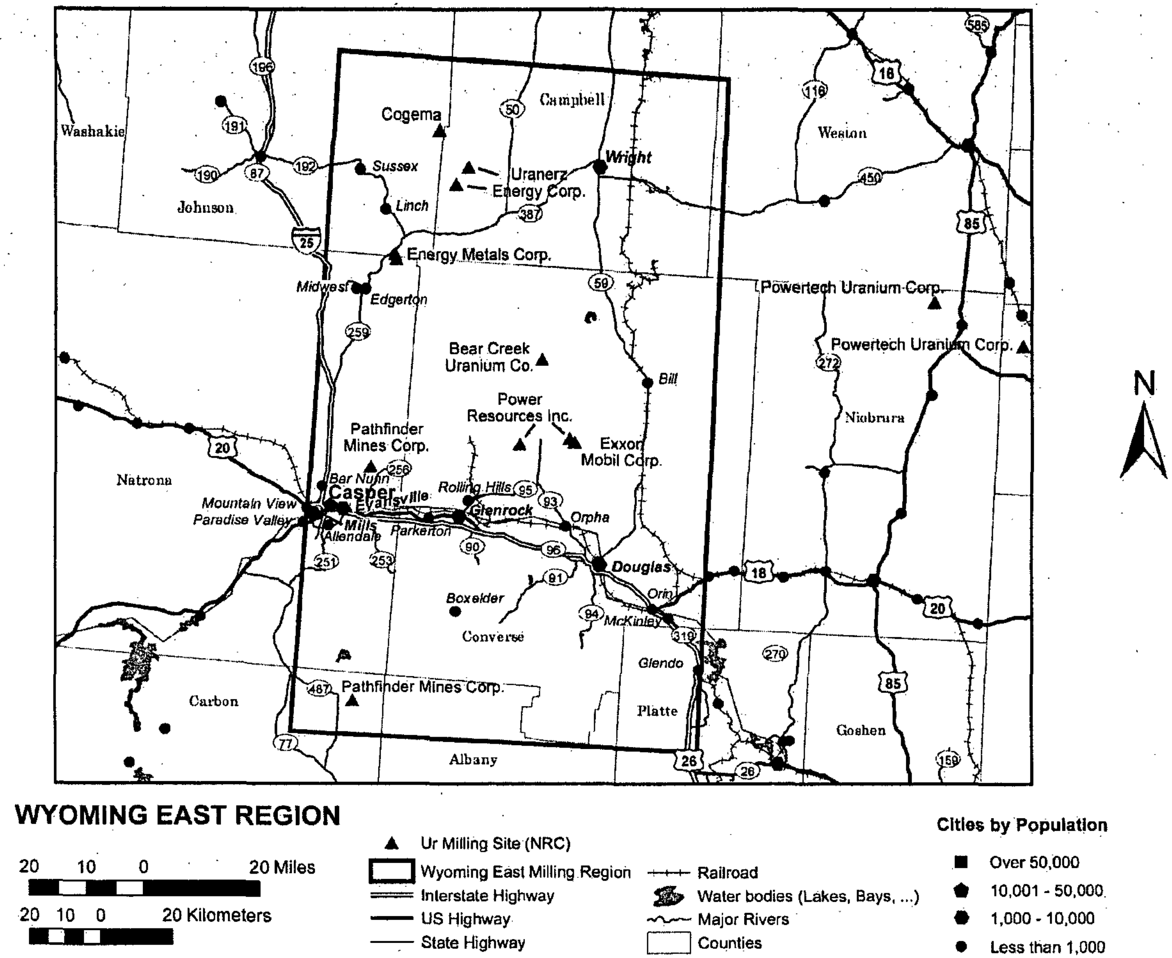


Figure 3.3-18. Wyoming East Uranium Milling Region With Population

Table 3.3-11. U.S. Bureau of Census State Income Information for Wyoming East Uranium Milling Region*

Affected Environment	2000 Labor Force Population (16 years and over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Colorado	2,331,898	$47,203	$55,883	$24,049	67,614	388,952
South Dakota	394,945	$35,282	$42,237	$17,562	18,172	95,900
Wyoming	257,808	$37,892	$45,685	$19,134	10,585	54,777
Casper	26,343	$36,567	$46,267	$19,409	1,122	5,546
Percent of total†	68.4%	NA‡	NA‡	NA‡	8.5%	11.4%
Cheyenne, Wyoming	27,647	$38,856	$46,771	$19,809	891	4,541
Percent of total†	66.7%	NA‡	NA‡	NA‡	6.3%	8.8%
Ft. Collins, Colorado	69,424	$44,459	$59,332	$22,133	1,417	15,835
Percent of total†	72.4%	NA‡	NA‡	NA‡	5.5%	14.0%
Laramie, Wyoming	15,504	$27,319	$43,395	$16,036	633	5,618
Percent of total†	67.2%	NA‡	NA‡	NA‡	11.1%	22.6%
Rapid City, South Dakota	31,948	$35,978	$44,818	$19,445	1,441	7,328
Percent of total†	68.8%	NA‡	NA‡	NA‡	9.4%	12.7%

* U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 25 February 2008, and 15 April 2008).
†Percent of total based on a population of 16 years and over.
‡NA—Not applicable.

3.3.10.3 Housing

Housing information based on 2000 U.S. Census data is provided in Table 3.3-13.

The availability of housing within the immediate vicinity of potential ISL facilities in the Wyoming East Uranium Milling Region is limited. The majority of housing is available in larger populated areas such as the towns of Casper {48 km [30 mi] to the nearest potential ISL facility} and

Table 3.3-12. U.S. Bureau of Census County Income Information for Wyoming East Uranium Milling Region*

Affected Environment	2000 Labor Force Population (16 years and over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Albany County, Wyoming	18,182	$28,790	$44,334	$16,706	763	6,228
Percent of total†	67.7%	NA‡	NA‡	NA‡	10.8%	21.0%
Campbell County, Wyoming	18,805	$49,536	$53,92	$20,063	507	2,544
Percent of total†	76.6%	NA‡	NA‡	NA‡	5.6%	7.6%
Carbon County, Wyoming	7,744	$36,060	$41,991	$18,375	411	1,879
Percent of total†	62.5%	NA‡	NA‡	NA‡	9.8%	12.9%
Converse County, Wyoming	6,244	$39,603	$45,905	$18,744	319	1,379
Percent of total†	68.6%	NA‡	NA‡	NA‡	9.2%	11.6%
Johnson County, Wyoming	3,472	$34,012	$42,299	$19,030	147	712
Percent of total†	61.7%	NA‡	NA‡	NA‡	7.2%	10.1%
Natrona County, Wyoming	35,081	$36,619	$45,575	$18,913	1,548	7,695
Percent of total†	68.3%	NA‡	NA‡	NA‡	8.7%	11.8%
Niobrara County, Wyoming	1,193	$29,701	$33,714	$15,757	74	309
Percent of total†	61.5%	NA‡	NA‡	NA‡	10.7%	13.4%
Platte County, Wyoming	4,540	$33,866	$41,449	$17,530	216	1,021
Percent of total†	66.1%	NA‡	NA‡	NA‡	8.5%	11.7%
Weston County	3,183	$32,348	$40,472	$17,366	119	628
Percent of total†	60.0%	NA‡	NA‡	NA‡	6.3%	9.9%

* U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Percent of total based on a population of 16 years and over.
‡NA—Not applicable.

Table 3.3-13. U.S. Bureau of Census Housing Information for the Wyoming East Uranium Milling Region*

Affected Environment	Single Family Owner-Occupied Homes	Median Value in Dollars	Median Monthly Costs With a Mortgage	Median Monthly Costs Without a Mortgage	Occupied Housing Units	Renter-Occupied Units
Wyoming	95,591	$96,600	$825	$229	193,608	55,793
Albany County	4,987	$118,600	$916	$225	13,269	6,345
Campbell County	5,344	$102,900	$879	$247	12,207	3,174
Carbon County	7,744	$76,500	$685	$196	6,129	1,708
Converse County	2,290	$84,900	$714	$206	4,694	1,142
Johnson County	1,414	$115,500	$849	$227	2,959	677
Natrona County	15,250	$84,600	$746	$218	26,819	7,993
Niobrara County	480	$60,300	$562	$200	1,011	222
Platte County	1,659	$84,100	$698	$205	3,625	800
Weston County	1,174	$66,700	$664	$199	2,624	549
Casper	12,642	$84,500	$744	$220	20,437	6,645

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).

Riverton {193 km [120 mil] to the nearest potential ISL facility}. Temporary housing such as apartments, lodging, and trailer camps within the immediate vicinity of the proposed ISL facilities is not as limited. There are 17 apartment complexes available in larger populated areas such as the CBSAs or towns of Casper, Douglas, Lusk, and Orpha (MapQuest, 2008). There are also 15 hotels/motels along major highways or towns near the uranium districts located within the Wyoming East Uranium Milling Regions. In addition to apartments and lodging, there are more than 25 trailer camps situated along major roads or near towns (MapQuest, 2008).

3.3.10.4 Employment Structure

Employment structure from the 2000 U.S. Census, including employment rate and type, is based on data collected at the state and county levels. Data collected from the state level also includes information on towns, CBSAs, or Metropolitan Areas and considers an outside workforce. An outside workforce may include workers willing to commute long distances {greater than 48 km [30 mil]} for employment opportunities or external labor necessary to fulfill specialized positions (if local workforce is unavailable or unspecialized). Data collected at the county level are generally the same as the affected environment presented in Table 3.3-9.

Based on review of regional state-level information, Colorado has the highest percentage of employment.

At the county level, the county in the Wyoming East Uranium Milling Region with the highest percentage of employment is Campbell County and the county with the highest unemployment rate is Albany County.

3.3.10.4.1 State Data

3.3.10.4.1.1 Colorado

The State of Colorado has an employment rate of 66.3 percent and unemployment rate of 3.0 percent. The largest sector of employment is management, professional, and related occupations at 37.4 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Ft. Collins

Ft. Collins has an employment rate of 68.5 percent and unemployment higher than the state at 3.8 percent. The largest sector of employment is management, professional, and related occupations at 42.9 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.3.10.4.1.2 South Dakota

The state of South Dakota has an employment rate of 64.9 percent and unemployment rate of 3.0 percent. The largest sector of employment is management, professional, and related occupations at 32.6 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Rapid City

Laramie has an employment rate of 63.7 percent and unemployment higher than the state at 3.2 percent. The largest sector of employment is management, professional, and related occupations at 32.8 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.3.10.4.1.3 Wyoming

The State of Wyoming has an employment rate of 63.1 percent and unemployment rate of 3.5 percent. The largest sector of employment is sales and office occupations. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Casper

Casper has an employment rate of 64.9 percent and an unemployment rate lower than that of the state at 3.4 percent. The largest sector of employment is sales and office occupations at 30.6 percent followed by management, professional, and related occupations at 29.7 percent. The largest type of industry is educational, health, and social services at 22.1 percent. The largest class of worker is private wage and salary workers at 76.6 percent (U.S. Census Bureau, 2008).

Cheyenne

Cheyenne has an employment rate of 59.2 percent and unemployment less than the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 33.0 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Laramie

Laramie has an employment rate of 63.4 percent and unemployment less than the state at 3.7 percent. The largest sector of employment is management, professional, and related occupations at 40.5 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.3.10.4.2 County Data

Albany County, Wyoming

Albany County has an employment rate of 63.9 percent and an unemployment rate higher than that of the state at 3.7 percent. The largest sector of employment is management, professional, and related occupations at 40.4 percent. The largest type of industry is educational, health, and social services at 37.1 percent. The largest class of worker is private wage and salary workers at 61.9 percent (U.S. Census Bureau, 2008).

Campbell County, Wyoming

Campbell County has an employment rate of 73.2 percent and an unemployment rate lower than that of the state at 3.4 percent. The largest sector of employment is management, professional, and related occupations at 23.9 percent followed by construction, extraction, and maintenance occupations at 23.7 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 23.3 percent followed by educational, health, and social services at 16.7 percent. The largest class of worker is private wage and salary workers at 78.4 percent (U.S. Census Bureau, 2008).

Carbon County, Wyoming

Carbon County has an employment rate of 59.2 percent and an unemployment rate lower than that of the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 23.4 percent followed by sales and office occupations

at 21.9 percent. The largest type of industry is educational, health, and social services at 17.1 percent. The largest class of worker is private wage and salary workers at 65.6 percent (U.S. Census Bureau, 2008).

Converse County, Wyoming

Converse County has an employment rate of 65.4 percent and an unemployment rate lower than that of the state at 3.2 percent. The largest sector of employment is management, professional, and related occupations at 23.2 percent followed by sales and office occupations at 21.4 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 20.1 percent followed by educational, health, and social services at 18.5 percent. The largest class of worker is private wage and salary workers at 71.1 percent (U.S. Census Bureau, 2008).

Johnson County, Wyoming

Johnson County has an employment rate of 57.6 percent and an unemployment rate slightly higher than that of the state at 3.7 percent. The largest sector of employment is management, professional, and related occupations at 37.5 percent followed by sales and office occupations at 20.3 percent. The largest type of industry is educational, health, and social services at 20.5 percent followed by agriculture, forestry, fishing and hunting, and mining at 19.5 percent. The largest class of worker is private wage and salary workers at 61.1 percent (U.S. Census Bureau, 2008).

Natrona County, Wyoming

Natrona County has an employment rate of 64.6 percent and an unemployment rate similar to that of the state at 3.5 percent. The largest sector of employment is sales and office occupations at 29.9 percent followed by management, professional, and related occupations at 28.5 percent. The largest type of industry is educational, health, and social services at 21.2 percent. The largest class of worker is private wage and salary workers at 76.2 percent (U.S. Census Bureau, 2008).

Niobrara County, Wyoming

Niobrara County has an employment rate of 59.4 percent and an unemployment rate lower than that of the state at 2.1 percent. The largest sector of employment is management, professional, and related occupations at 34.4 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 24.7 percent. The largest class of worker is private wage and salary workers at 62.6 percent (U.S. Census Bureau, 2008).

Platte County, Wyoming

Platte County has an employment rate of 63.1 percent and an unemployment rate lower than that of the state at 2.9 percent. The largest sector of employment is management, professional, and related occupations at 30.3 percent. The largest type of industry is educational, health, and social services at 21.4 percent. The largest class of worker is private wage and salary workers at 64.4 percent (U.S. Census Bureau, 2008).

Weston County, Wyoming

Weston County has an employment rate of 56.6 percent and an unemployment rate lower than that of the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 24.3 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 22.4 percent. The largest class of worker is private wage and salary workers at 68.9 percent (U.S. Census Bureau, 2008).

3.3.10.5 Local Finance

Local finance such as revenue and tax distribution information for the affected counties is presented in Table 3.3-14.

Wyoming

The State of Wyoming does not have an income tax nor does it assess tax on retirement income received from another state. Wyoming has a 4 percent state sales tax, 2 percent to 4 percent county lodging tax, and 4 percent use tax. Counties have the option of collecting an additional 1 percent tax for general revenue and 2 percent tax for specific purposes. Wyoming also imposes "ad valorem taxes" on mineral extraction properties. Taxes levied for uranium production were 10.0 percent in 2007 (6.0 percent "ad valorem" and 4 percent severance) totaling $1.7 million dollars (Wyoming Department of Revenue, 2007). For 2007, in the Wyoming East Uranium Milling Region all of this uranium tax revenue was generated in Converse County. Annual sales and use tax distribution information for the affected counties (including cities and towns) in the Wyoming East Uranium Milling Region are presented in Table 3.3-14.

Casper

Sources of revenue for Casper, the largest city in the Wyoming East Uranium Milling Region, include sales, use, lodging, and property taxes as well as mill levies. The sales and use tax rate is 5 percent and lodging is 3 percent. The largest distribution of property tax is school district tax at a rate of 32.5 percent (Casper Chamber of Commerce, 2007).

Campbell County

Campbell County has 1 school district with 24 schools consisting of 15 elementary schools, 2 junior high schools, 1 junior/senior high school, 1 high school, 1 alternative school, and 1 aquatic center. There are a total of approximately 7,441 students. The majority of schools provides bus services (Campbell County School District No. 1, 2007).

Carbon County

Carbon County has two school districts, Carbon County School District No. 1 and No. 2, with a combined total of approximately 2,647 students. There are a total of nine elementary schools, two middle schools, two high schools, and two private schools. The majority of schools within each school district provides bus services (Carbon County School District No.1, 2008; Carbon County District No. 2, 2008).

Table 3.3-14. 2007 State and Local Annual Sales and Use Tax Distribution of Affected Counties Within the Wyoming East Uranium Milling Region*

Affected Counties	Use Tax		Sales Tax		Gross Revenue
	State	Local	State	Local	
Albany County	$2,712,413	$3,152,059	$12,083,171	$14,042,820	$32,812,196
Campbell County	$9,104,434	$8,130,984	$72,443,855	$64,724,530	$155,316,435
Carbon County	$3,778,037	$4,328,728	$15,087,797	$16,953,793	$40,812,784
Converse County	$1,042,601	$837,455	$8,316,835	$6,682,328	$17,225,640
Johnson County	$795,512	$639,174	$8,502,430	$6,831,523	$17,012,155
Natrona County	$4,135,490	$3,322,747	$51,551,636	$41,420,622	$102,046,519
Niobrara County	$156,916	$182,363	$1,091,293	$1,268,288	$2,745,320
Platte County	$1,100,272	$884,041	$3,040,039	$2,442,613	$7,523,115
Weston County	$630,016	$506,201	$2,572,484	$2,066,940	$5,886,521

* Wyoming Department of Revenue. "State of Wyoming Department of Revenue 2007 Annual Report." 2007. <http://revenue.state.wy.us/PortalVBVS/uploads/2007%20DOR%20Annual%20Report.pdf> (7 April 2009).

<u>Converse County</u>

Converse County has two school districts, Converse County School Districts No. 1 and No. 2, with a total of approximately 2,455 students. There are a total of nine elementary schools, four middle/intermediate schools, and two high schools. The majority of schools within each school district provides bus services (Schoolbug.org, 2007b).

<u>Johnson County</u>

Johnson County has one school district with two elementary schools, one middle school, two high schools, and one learning center. There are a total of approximately 1,257 students. The majority of schools provides bus services (Johnson County School District No. 1, 2007).

<u>Natrona County</u>

Natrona County has one school district, Natrona County School District No. 1, with a total of approximately 11,500 students. There are more than 30 public and private elementary and secondary schools. The majority of schools provides bus services (Natrona County School District No. 1, 2007).

<u>Niobrara County</u>

Niobrara County has one school district, Niobrara County School District No. 1, with a total of approximately 422 students. There is one elementary and middle school, one high school, and one private school. Information as to whether these schools provide bus services is not available (Niobrara County School District No. 1, 2008).

Platte County

Platte County has the Platte County School District No. 1, with a total of approximately 1,571 students. There are two elementary schools, one middle school, one high school, and two private or parochial schools. Information as to whether these schools provide bus services is not available (Platte County School District No.1, 2008).

Weston County

Weston County has one school district, Weston County School District No. 1, with a total of approximately 1,134 students. There are two elementary schools, one middle school, and one high school. Information as to whether these schools provide bus services is not available (Weston County School District No. 1, 2008).

3.3.10.6 Education

Information on education for the affected communities within the region of influence is presented next.

Based on review of the affected environment, the county with the largest number of schools is Natrona County and the county with the smallest number of schools is Niobrara County. The CBSA of Casper was average to the county level when compared to the aforementioned schools.

Casper

Casper has one school district, Natrona County School District No. 1, with a total of approximately 11,500 students. There are more than 25 public and private elementary, middle, and high schools. The majority of schools provides bus services (Schoolbug.org, 2007a).

Albany County

Albany County has one school district, Albany County School District No. 1, with a total of approximately 3,790 students. There are 13 elementary schools, 6 middle schools, and 3 high schools. The majority of schools provides bus services (Greatschools.com, 2008).

Campbell County

Campbell County has 1 school district with 24 schools consisting of 15 elementary schools, 2 junior high schools, 1 junior/senior high school, 1 high school, 1 alternative school, and 1 aquatic center. There are a total of approximately 7,441 students. The majority of schools provides bus services (Campbell County School District No. 1, 2007).

Carbon County

Carbon County has two school districts, Carbon County School Districts No. 1 and No. 2, with a combined total of approximately 2,647 students. There are a total of nine elementary schools, two middle schools, two high schools, and two private schools. The majority of schools within each school district provide bus services (Carbon County School District No.1, 2008; Carbon County School District No. 2, 2008).

Converse County

Converse County has two school districts, Converse County School Districts No. 1 and No. 2, with a total of approximately 2,455 students. There are a total of nine elementary schools, four middle/intermediate schools, and two high schools. The majority of schools within each school district provides bus services (Schoolbug.org, 2007b).

Johnson County

Johnson County has one school district with two elementary schools, one middle school, two high schools, and one learning center. There are a total of approximately 1,257 students. The majority of schools provides bus services (Johnson County School District No. 1, 2007).

Natrona County

Natrona County has one school district, Natrona County School District No. 1, with a total of approximately 11,500 students. There are more than 30 public and private elementary and secondary schools. The majority of schools provides bus services (Natrona County School District No. 1, 2007).

Niobrara County

Niobrara County has one school district, Niobrara County School District No. 1, with a total of approximately 422 students. There is one elementary and middle school, one high school, and one private school. Information as to whether these schools provide bus services is not available (Niobrara County School District No. 1, 2008).

Platte County

Platte County has the Platte County School District No. 1, with a total of approximately 1,571 students. There are two elementary schools, one middle school, one high school, and two private or parochial schools. Information as to whether these schools provide bus services is not available (Platte County School District No.1, 2008).

Weston County

Weston County has one school district, Weston County School District No. 1, with a total of approximately 1,134 students. There are two elementary schools, one middle school, and one high school. Information as to whether these schools provide bus services is not available (Weston County School District No. 1, 2008).

3.3.10.7 Health and Social Services

Health Care

The majority of the health care facilities that provide service in the vicinity of the Wyoming East Uranium Milling Region is located within populated areas of the affected environment. The closest health care facilities within the vicinity of the ISL facilities are located in Riverton, Lander, Casper, Douglas, Wheatland, Cheyenne, and Laramie and have a total of 15 facilities

(MapQuest, 2008). These consist of hospitals, clinics, emergency centers, and medical services. The following hospitals are located proximate to the Wyoming East Milling Region: Riverton (1), Cheyenne (1), Laramie (1), and Wheatland (1).

Local Emergency

Local police within the Wyoming East Uranium Milling Region are under the jurisdiction of each county. There are 28 police, sheriff, or marshals offices within the region: Albany County (2), Campbell County (2), Carbon County (6), Converse County (3), Johnson County (3), Natrona County (4), Niobrara County (2), Platte County (3), and Weston County (3) (USACops, 2008).

Fire departments within the Wyoming East Uranium Milling Region are comprised at the county, town, CBSA, or city level. There are seven fire departments within the milling region: Campbell County (one), Casper (one), Douglas (two), Lusk (one), Natrona County (one), and Wheatland (one) (50states, 2008).

3.3.11 Public and Occupational Health

3.3.11.1 Background Radiological Conditions

For a U.S. resident, the average total effective dose equivalent from natural background radiation sources is approximately 3 mSv/yr [300 mrem/yr] but varies by location and elevation (National Council of Radiation Protection and Measurements, 1987). In addition, the average American receives 0.6 mSv/yr [60 mrem/yr] from man-made sources including medical diagnostic tests and consumer products (National Council of Radiation Protection and Measurements, 1987). Therefore, the total from natural background and man-made sources for the average U.S. resident is 3.6 mSv/yr [360 mrem/yr]. For a breakdown of the sources of this radiation, see Figure 3.2-22.

Background dose varies by location primarily because of elevation changes and variations in the dose from radon. As elevation increases so does the dose from cosmic radiation and hence the total dose. Radon is a radioactive gas produced from the decay of U-238, which is naturally found in soil. The amount of radon in the soil/bedrock depends on the type, porosity, and moisture content. Areas that have types of soils/bedrock like granite and limestone have higher radon levels than those with other types of soils/bedrock (EPA, 2006).

The total effective dose equivalent is the total dose from external sources and internal material released from licensed operations. Doses from sources in the general environment (such as terrestrial radiation, cosmic radiation, and naturally occurring radon) are not included in the dose calculation for compliance with 10 CFR Part 20, even if these sources are from technologically enhanced naturally occurring radioactive material, such as preexisting radioactive residues from prior mining (Atomic Safety and Licensing Board, 2006).
For the Wyoming East Uranum Milling Region, the average background radiation dose for the state of Wyoming is used, which is 3.16 mSv/yr [316 mrem/yr] (EPA, 2006). This value includes natural and man-made sources. This dose is slightly lower than the U.S. average primarily because the radon dose is lower {U.S. average of 2 mSv/yr [200 mrem/yr] versus Wyoming average of 1.33 mSv/yr [133 mrem/yr]}. The cosmic dose is slightly higher than the U.S. average: 0.515 mSv/yr [51.5 mrem/yr] versus 0.27 mSv/yr [27 mrem/yr]. The remaining contributions from terrestrial, internal, and manmade radiation combined are the same as the U.S. average of 1.318 mSv/yr [131.8 mrem/yr].

3.3.11.2 Public Health and Safety

Public health and safety standards are the same regardless of a facility's location. See Section 3.2.11.2 for further discussion of these standards.

3.3.11.3 Occupational Health and Safety

Occupational health and safety standards are the same regardless of facility's location. See Section 3.2.11.3 for further discussion of these standards.

3.3.12 References

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3.4 Nebraska-South Dakota-Wyoming Uranium Milling Region

3.4.1 Land Use

The Nebraska-South Dakota-Wyoming Uranium Milling Region defined in this GEIS is represented by a south-southeast–north-northwest swath of land encompassing parts of Sioux and Dawes Counties in Nebraska; Fall River, Custer, Pennington, and Lawrence Counties in South Dakota; and Niobrara, Weston and Crook Counties in Wyoming (Figure 3.4-1).

This region lies within portions of the Missouri Plateau, the Black Hills and the High Plains sections of the Great Plains province (U.S. Geological Survey, 2004). The locations of past, current, and potential uranium milling operations are found in the Crow Butte Uranium District located in Dawes County, Nebraska; in the Southern Black Hills Uranium District in Fall River County, South Dakota, and Niobrara County, Wyoming; and in the Northern Black Hills Uranium District in Crook County, Wyoming (Figure 3.4-2). Details on the geology and soils of these three districts are provided in Section 3.4.3.

The general land ownership and use statistics for the Nebraska-South Dakota-Wyoming Uranium Milling Region shown next were calculated using the Geographic Information System used to construct the map shown in Figure 3.4-1. Private (surface ownership) lands (59 percent) and national forest and national grassland (38 percent combined) account for 97 percent of this region (Table 3.4-1). As described for the Wyoming West Uranium Milling Region in Section 3.1.1, there are also in this region privately owned surface rights and publicly owned subsurface mineral rights resulting in split estate situations (BLM, 2000a) (Section 3.1.2.2).

In the areas of interest in Dawes and Sioux Counties in Nebraska, the predominant land cover consists of a mix of western shortgrass prairie and western wheatgrass prairie, followed by agricultural fields and ponderosa pine forests and woodlands (Henebry, et al., 2005). A large portion of Dawes and Sioux Counties is occupied by the Oglala National Grassland to the north and west and by the Nebraska National Forest in the center, which are both administered by the USFS (Figure 3.4-1). These federal lands offer general recreational activities, including camping, fishing, and hunting (USFS, 2008b). Chadron, a 394-ha [972-acre] state park in the heart of the Nebraska National Forest, and Fort Robinson, a 8,900-ha [22,000-acre] state park of Pine Ridge scenery west of Crawford, also offer general recreational activities to the public. (Nebraska Game and Parks Commission, 2008). Similar to nearby Niobrara County in Wyoming to the west and Fall River County in South Dakota to the north, the dominant land use in these two northwestern Nebraska counties is cattle grazing on both public and private rangeland and associated livestock feed production. Cultivated lands mixed with the rangeland are used primarily to produce winter wheat and hay, which is both grazed and harvested.

Approximately half of Fall River County in the southwest corner of South Dakota is occupied by the Buffalo Gap National Grassland to the south and by the Black Hills National Forest to the north, which are both managed by the USFS. Higher elevation areas to the north into the Black Hills National Forest create favorable growing conditions for ponderosa pine. The lower elevation areas surrounding the Black Hills to the south are primarily used as rangeland for livestock grazing and as agricultural land. Hay and winter wheat farming are the principal agricultural uses in dry land areas, and alfalfa, corn, and vegetables are typically grown in wetter valley areas and on irrigated land (South Dakota State University, 2001). A large part of

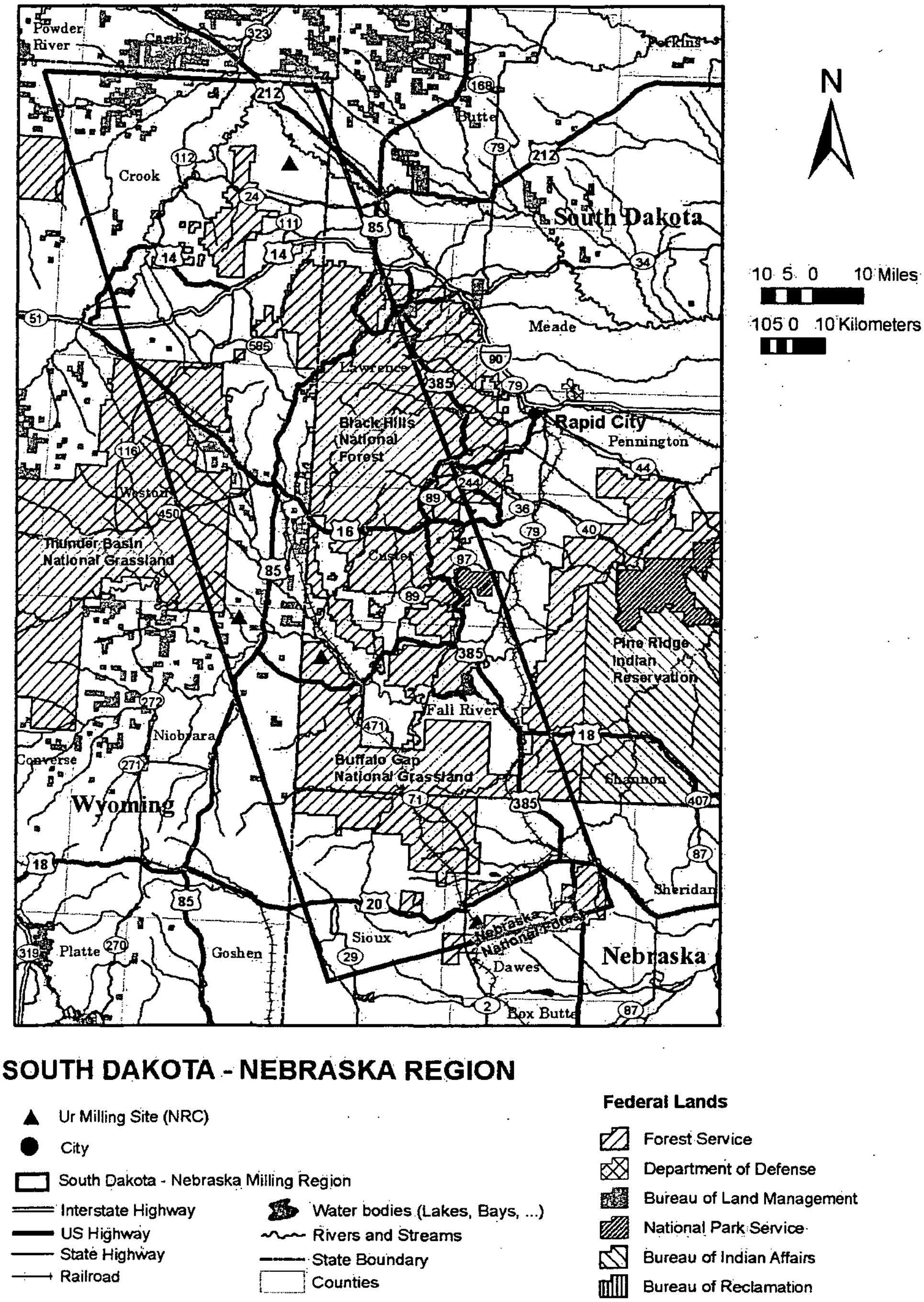


Figure 3.4-1. Nebraska-South Dakota-Wyoming Uranium Milling Region General Map With Current (Crow Butte, Nebraska) and Potential Future Uranium Milling Site Locations

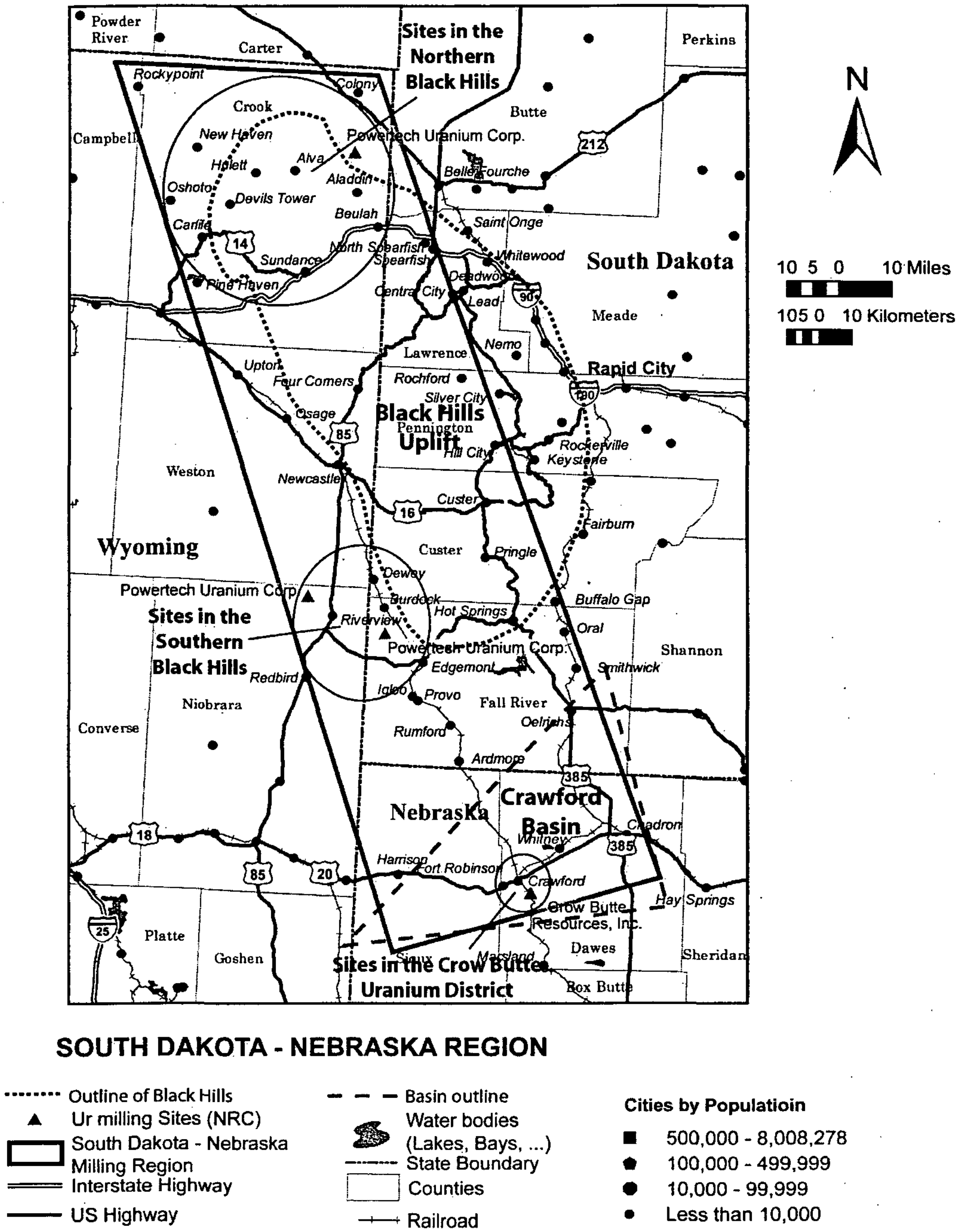


Figure 3.4-2. Map Showing the Nebraska-South Dakota-Wyoming Uranium Milling Region and Uranium Milling Sites in the Black Hills Uranium Districts in South Dakota and Wyoming and in the Crow Butte Uranium District in Nebraska

Table 3.4-1. Land Surface Ownership and General Use in the Nebraska-South Dakota-Wyoming Uranium Milling Region			
Land Surface Ownership and General Use	Area (mi^2)	Area (km^2)	Percent
State and Private Lands	5,379	13,932	58.6
U.S. Forest Service (USFS), National Forest	1,979	5,125	21.5
USFS, National Grassland	1,553	4,022	16.9
U.S. Bureau of Land Management, Public Domain Land	185	480	2
National Park Service, National Park	41	107	0.5
Bureau of Reclamation	16	42	0.2
USFS, Wilderness	22	56	0.2
USFS, National Recreation Area	4	11	0.05
National Park Service, National Monument	4	11	0.05
Totals	9,185	23,788	100

Shannon County, South Dakota, which abuts Fall River County to the east, is occupied entirely by the Pine Ridge Indian Reservation (Figure 3.4-1).

More than half of Custer, Pennington, and Lawrence Counties in South Dakota is also occupied by the Black Hills National Forest (Figure 3.4-1). In these counties, the majority of the land cover consists of ponderosa pine forest associated with short to tall grasslands and agricultural fields (South Dakota State University, 2001).

Historically, the Black Hills have been prospected and mined for many minerals, metals, and materials. Recreational activities provided in the Buffalo Gap National Grassland and in the Black Hills National Forest are similar to those described for USFS lands in Nebraska and in the Wyoming East Uranium Milling Region (USFS, 2008a,b).

In the eastern and northeastern Wyoming Counties of Niobrara and Crook, land ownership is predominantly private as it is in the Wyoming East Uranium Milling Region. BLM-administered lands, which are scattered and mixed with state and private lands, represent less than 10 percent of the land. In Weston County, located between Niobrara and Crook Counties, land ownership is dominated by the USFS Thunder Basin National Grassland. In its eastern half, a large portion of Crook County is occupied by the Black Hills National Forest. To the west of the forest on Route 24, Devils Tower National Monument, administered by the National Park Service, provides additional recreational activities in Crook County (Figure 3.4-1).

The characteristics of open rangeland in these three eastern Wyoming counties are similar to those of the Wyoming East Uranium Milling Region described in Section 3.3.1. Cattle and sheep grazing represent the primary land use on private and federal lands. Recreational activities available on federal lands are also similar to those described previously for parts of Nebraska, South Dakota and the Wyoming East Uranium Milling Region (Section 3.3.1).

3.4.2 Transportation

Past experience at NRC-licensed ISL facilities indicates these facilities rely on roads for transportation of goods and personnel (Section 2.8). As shown in Figure 3.4-3, the

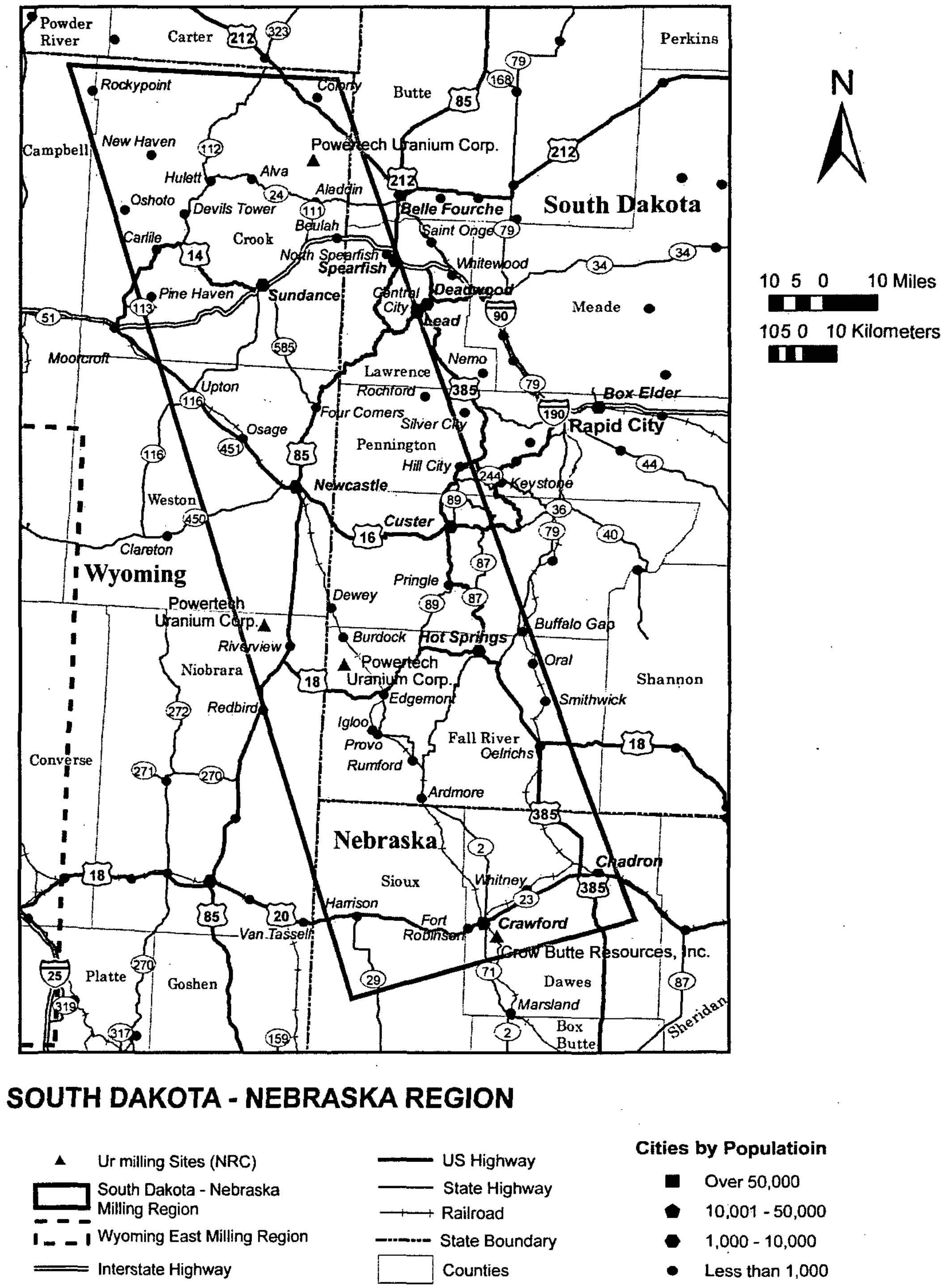


Figure 3.4-3. Nebraska-South Dakota-Wyoming Uranium Milling Region Transportation Corridor

Nebraska-South Dakota-Wyoming Uranium Milling Region is accessible by a variety of highways. In the northern part of the region, Interstate 90 connects Gillette, Wyoming, and Rapid City, South Dakota. U.S. Highway 212 enters the region from Montana to the north intersecting U.S. Highway 85 and then crossing Interstate 90 to the south and traversing the region southbound to intersect U.S. Highway 20. U.S. Highway 20 traverses the south portion of the region and connects with Interstate 25 to the west. A rail line serves the central portion of the South Dakota/Nebraska region along U.S. Highway 16 from the west to the intersection with U.S. Highway 85 at Newcastle and then south to Crawford at the southern boundary of the region.

Areas of past, present, or future uranium milling interest in the region are shown in Figure 3.4-3. These areas are located in three subregions when considering site access by local roads. The area of milling interest in the northeastern part of the region (north of Aladdin, Wyoming) is accessible by local access roads to U.S. Highway 212 southeast to U.S. Highway 85 south, which intersects Interstate 90. Traveling west from Aladdin, State Route 24 connects to U.S. Highway 14 and Interstate 90 continuing west to Gillette. Milling sites farther to the southwest of the region (near Burdock, South Dakota) are served by local access roads and U.S. Highway 18 west to connect with U.S. Highway 85 southbound that exits the region from the southwest. At Lusk, Wyoming, U.S. Highway 20 west provides access to Interstate 25. Areas of milling interest near the southern border of the region (near Crawford, Nebraska) are served by local access roads to U.S. Highway 20, which exits the region to the west to intersect Interstate 25.

Table 3.4-2 provides available traffic count data for roads that support areas of past or future milling interest in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Counts are variable with the minimum all-vehicle count at 333 vehicles per day on U.S. Highway 16 west of Custer (westbound) and the maximum on Interstate 90 east of Spearfish (between Spearfish and Whitewood) at 9,491 vehicles per day. Most of the vehicle counts in the Nebraska-South Dakota-Wyoming Uranium Milling Region are above 400 vehicles per day.

Yellowcake product shipments are expected to travel from the milling facility to a uranium hexafluoride production (conversion) facility in Metropolis, Illinois (the only facility currently licensed by NRC in the United States for this purpose). Major interstate transportation routes are expected to be used for these shipments, which are required to follow NRC packaging and transportation regulations in 10 CFR Part 71 and U.S. Department of Transportation hazardous material transportation regulations at 49 CFR Parts 171–189. Table 3.4-3 describes representative routes and distances for shipments of yellowcake from locations of Uranium milling interest in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Representative routes are considered owing to the number of routing options available that could be used by a future ISL facility. Because transportation risks are dependent on shipment distance, identification of representative routes is used to generate estimates of shipment distances for evaluation of transportation impacts in Chapter 4 (Section 4.2.2). An ISL facility could use a variety of routes for actual yellowcake shipments, but the shipment distances for alternate routes are not expected to differ significantly from those estimated for the representative routes.

3.4.3 Geology and Soils

Sandstone-hosted uranium ore deposits have been identified in western South Dakota, northeastern Wyoming, and in northwestern Nebraska (Figure 3.4-2). In the Nebraska-South

Table 3.4-2. Average Annual Daily Traffic Counts for Roads in the Nebraska-South Dakota-Wyoming Uranium Milling Region*

Road Segment	County, State	All Vehicles
State Route 24 at Devils Tower Junction (intersection with U.S. Highway 14)	Crook, Wyoming	982–1,236
State Route 14 at Devils Tower Junction (west intersection with State Route 24)	Crook, Wyoming	610–675
Interstate 90 at County Border East (near Beulah, Wyoming)	Crook, Wyoming	4,048–5,272
U.S. Highway 85 North of Belle Fourche (southbound in direction of U.S. Highway 212)	Butte, South Dakota	468–905†
Interstate 90 East of Spearfish (between Spearfish and Whitewood)	Lawrence, South Dakota	5,201–9,491†
U.S. Highway 16 West of Custer (westbound)	Custer, South Dakota	333–1,231†
U.S. Highway 385 North of Hot Springs (near north county line)	Fall River, South Dakota	425–1,243†
U.S. Highway 18 at Mule Creek Junction (intersection with U.S. Highway 85)	Niobrara, Wyoming	817–1,192
U.S. Highway 85 at Mule Creek Junction (south of intersection with U.S. Highway 18)	Niobrara, Wyoming	1,327–2,037
U.S. Highway 20 at Van Tassell (at east county line)	Niobrara, Wyoming	415–552
U.S. Highway 20 at Manville South (intersection with State Route 270)	Niobrara, Wyoming	1,418–1,891

*Wyoming Department of Transportation. "Wyoming Department of Transportation Traffic Analysis." 2005. <http://dot.state.wy.us/Default.jsp?sCode=hwyta> (27 December 2005).
South Dakota Department of Transportation. "Automatic Traffic Recorder Data." 2008. <http://gis.sd.gov/dot%5Fctysys/> (January 2008).
†Data for South Dakota are monthly averages of daily counts; Wyoming data are the arithmetic mean of average annual daily counts for each day of the week.

Table 3.4-3. Representative Transportation Routes for Yellowcake Shipments From the Nebraska-South Dakota-Wyoming Uranium Milling Region*

Origin	Destination	Major Links	Distance* (mi)
North of Aladdin, Wyoming	Metropolis, Illinois	Local access road northeast to U.S. Highway 212 U.S. Highway 212 southeast to U.S. Highway 85 U.S. Highway 85 south to Interstate 90 Interstate 90 east to Sioux Falls, South Dakota Interstate 29 south to Kansas City, Missouri Interstate 70 east to St. Louis, Missouri Interstate 64 east to Interstate 57 Interstate 57 south to Interstate 24 Interstate 24 south to U.S. Highway 45 U.S. Highway 45 west to Metropolis, Illinois	1,230

Table 3.4-3. Representative Transportation Routes for Yellowcake Shipments From the Nebraska-South Dakota-Wyoming Uranium Milling Region* (continued)

Origin	Destination	Major Links	Distance* (mi)
Edgemont, South Dakota	Metropolis, Illinois	Local access road south to U.S. Highway 18 U.S. Highway 18 west to U.S. Highway 85 U.S. Highway 85 south to U.S. Highway 20 U.S. Highway 20 west to Interstate 25 Interstate 25 south to Denver, Colorado Interstate 70 east to St. Louis, Missouri Interstate 64 east to Interstate 57 Interstate 57 south to Interstate 24 Interstate 24 south to U.S. Highway 45 U.S. Highway 45 west to Metropolis, Illinois	1,410
Crawford, Wyoming	Metropolis, Illinois	Local access roads north to U.S. Highway 20 U.S. Highway 20 west to Interstate 25 Interstate 25 south to Denver, Colorado Denver, Colorado, to Metropolis, Illinois (as above)	1,360

*American Map Corporation. "Road Atlas of the United States, Canada, and Mexico." Long Island City, New York: American Map Corporation. p. 144. 2006.

Dakota-Wyoming Uranium Milling Region, uranium mineralization is found in fluvial sandstones in two major areas: the Black Hills of western South Dakota and northeastern Wyoming and the Crawford Basin of northwestern Nebraska. Uranium mineralization in the sandstone-hosted uranium deposits in these two areas is in a geologic setting amenable to recovery by ISL milling.

3.4.3.1 The Black Hills (Western South Dakota-Northeastern Wyoming)

The Black Hills are an asymmetrical domal uplift elongated in a northwest direction (Figure 3.4-4). Economically significant uranium discoveries in the Black Hills are contained within strata of the Inyan Kara Group (Chenoweth, 1988). Prior to 1968, the Black Hills produced approximately 1,800 metric tons [2,000 tons] of U_3O_8 (Hart, 1968). The bulk of this production came from the Hulett Creek and Carlile districts of the northern Black Hills and the Edgemont district of the southern Black Hills (Figure 3.4-4).

Stratigraphic units present in the Black Hills area are shown in Figure 3.4-5. Jurassic (144 to 206 million year old) and Cretaceous (65 to 144 million year old) rocks crop out low on the flanks of the Black Hills and form the eroded surface upon which younger rocks were deposited (Harshman, 1968). Sedimentary rocks of Tertiary (1.8 to 65 million year old) age are virtually absent from the Black Hills. However, remnants of Miocene (5.3 to 23.8 million year old) and/or Pliocene (1.8 to 5.3 million year old) age rocks on the flanks of the Black Hills indicate that at one time rocks of middle and late Tertiary age may have extended across the area and at least partially buried the Black Hills uplift. The Tertiary rocks are tuffaceous (i.e., they contain materials made from volcanic rock and mineral fragments in a volcanic ash matrix) and clastic (i.e., they contain fragments or grains of older rocks) and are of fluvial (river), lacustrine (lake), and paludal (marsh) origin.

The Inyan Kara Group is Lower Cretaceous (99 to 144-million-years-old) in age and consists of subequal amounts of complexly interbedded sandstone and claystone (Renfro, 1969). The

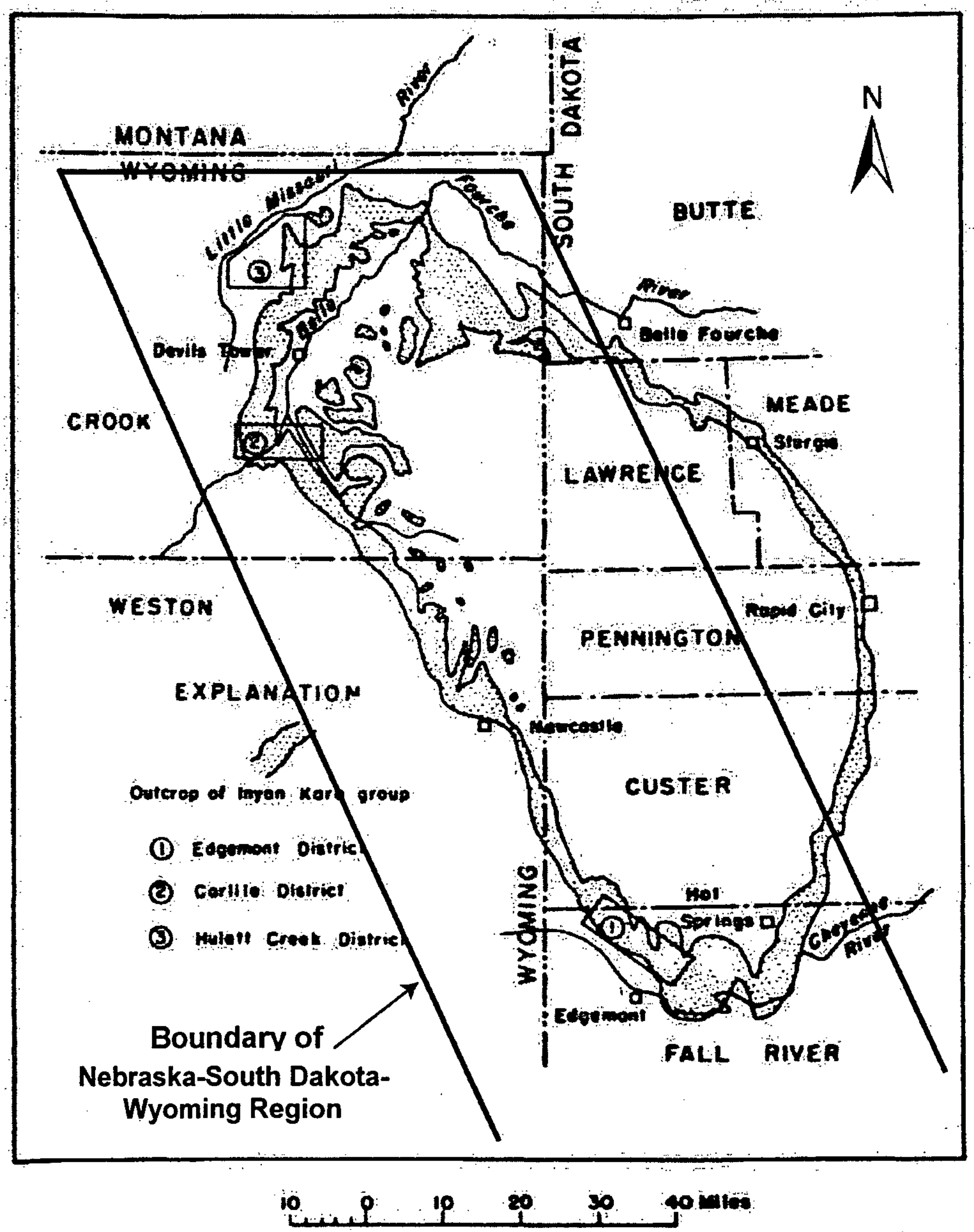


Figure 3.4-4. Outcrop Map of the Inyan Kara Group in the Black Hills of Western South Dakota and Northeastern Wyoming Showing the Locations of Principal Uranium Mining Districts (From Hart, 1968)

<table>
<tr><th colspan="4">Black Hills Area</th></tr>
<tr><th>System</th><th>Series</th><th colspan="2">Formation</th></tr>
<tr><td rowspan="5">Tertiary</td><td>Pliocene</td><td colspan="2">Ogallala Formation</td></tr>
<tr><td>Miocene</td><td colspan="2">Arikaree Formation</td></tr>
<tr><td>Oligocene</td><td colspan="2">White River Formation</td></tr>
<tr><td>Eocene</td><td colspan="2">(Absent)</td></tr>
<tr><td>Paleocene</td><td colspan="2">Fort Union Formation</td></tr>
<tr><td rowspan="8">Cretaceous</td><td rowspan="5">Upper</td><td colspan="2">Hell Creek Formation</td></tr>
<tr><td colspan="2">Fox Hills Sandstone</td></tr>
<tr><td colspan="2">Pierre Shale</td></tr>
<tr><td colspan="2">Niobrara Formation</td></tr>
<tr><td colspan="2">Carlile Shale, Greenhorn Formation, and Belle Fourche Shale</td></tr>
<tr><td rowspan="3">Lower</td><td colspan="2">Mowry Shale</td></tr>
<tr><td colspan="2">Newcastle Sandstone and Skull Creek Shale</td></tr>
<tr><td>Fall River and Lakota Formations</td><td>Inyan Kara Group</td></tr>
<tr><td colspan="2" rowspan="3">Jurassic</td><td colspan="2">Morrison Formation</td></tr>
<tr><td colspan="2">Sundance Formation</td></tr>
<tr><td colspan="2">Gypsum Spring Formation</td></tr>
</table>

Figure 3.4-5. Principal Stratigraphic Units in the Black Hills Area of Western South Dakota and Northeastern Wyoming

Inyan Kara is bounded below by continental Jurassic sediments of the Morrison Formation and is overlain by marine sediments of the Lower Cretaceous Skull Creek Shale. Resistant Inyan Kara sediments form the outermost ring of hogback ridges that crop out in a roughly oval pattern around the flanks of the Black Hills. Major uranium deposits occur from 2 to 8 km [1 to 5 mi] downdip from the main Inyan Kara escarpment at depths ranging from 30 to 180 m [100 to 600 ft].

The Inyan Kara Group is formally subdivided into the Lakota Formation and the Fall River Formation, which are generally accepted to be respectively continental and marginal marine in origin (Robinson, et al., 1964). The source of sediment for the Lakota and Fall River is considered to include all pre-Cretaceous sediments that were exposed to the south and east of the Black Hills (Renfro, 1969).

The Lakota is a sequence of coastal-plain deposits of fine-grained, poorly sorted sandstone and mudstone; channel-fill deposits of cross-bedded sandstone; natural levee and overbank deposits of lenticular (i.e., deposits with a lens-shaped cross section), fine-grained, carbonaceous sandstone and siltstone; and floodplain deposits of bedded siltstone, mudstone, and claystone (Maxwell, 1974). The Lakota Formation is from 15 to 90 m [50 to 300 ft] thick and thickens regionally from northwest to southeast (Chenoweth, 1988).

The oldest Lakota strata are thin, discontinuous dark gray to olive black, humic sandstone and claystone containing sparse subbituminous coal seams (Renfro, 1969). These strata appear to conform with the underlying Morrison Formation. The lowermost Lakota grades upward to a sequence of dark gray, medium- to coarse-grained, cherty and quartzose sandstone containing abundant disseminated carbon and pore-filling, massive pyrite. The uppermost Lakota consists of lenticular greenish gray to dark gray, fine- to medium-grained, quartzose sandstone and varicolored claystone.

Dondanville (1963) divided the Fall River Formation into deltaic and marine facies. The deltaic facies forms approximately 50 percent of the formation and consists of channel sandstone, interchannel sandstone and mudstone, and blanket sandstone formed during erosion of abandoned deltas. The marine and marginal-marine rocks consist of offshore and lagoonal mudstone and shale, and bar and spit sandstone. The Fall River is from 30 to 45 m [100 to 150 ft] thick and thickens regionally from southeast to northwest at the expense of the underlying Lakota Formation.

Renfro (1969) describes the Fall River as a light to dark gray, fine- to medium-grained quartzose sandstone containing traces of glauconite and abundant disseminated carbon, pyrite, and detrital chert. Thin beds of claystone and siltstone are common. The Fall River is in conformable contact and regionally intertongues with the overlying Skull Creek Shale.

Uranium deposits in the Inyan Kara Group are typified by roll-front accumulations (see Section 3.1.1). The geometric complexity of individual roll fronts is governed by the stratigraphic complexity of the Inyan Kara host sediments. Most roll fronts are within tabular sandstones of the Fall River Formation or widespread cherty sandstone facies of the Lakota Formation and have simple C-shaped cross sections that extend laterally for tens of kilometers [tens of miles] (Figure 3.4-6). Roll-front deposits in the more complex sandstone and claystone facies of the upper Lakota Formation are very erratic and generally contain relatively weak mineralization. Mineralization in the roll limbs seldom extends more than 90 to 120 m [300 or 400 ft] up-plunge from the roll fronts. Although roll fronts in the Inyan Kara are common, ore grade

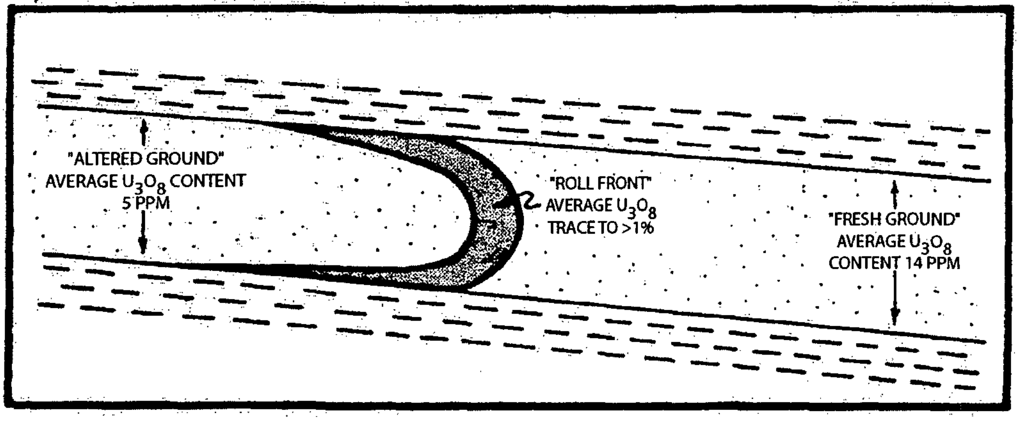


Figure 3.4-6. Schematic Cross Section Through a Typical Inyan Kara Roll-Front Deposit Showing Differences in U_3O_8 Concentration Between "Fresh" (i.e., Unoxidized) and "Altered" Ground (Modified From Renfro, 1969)

mineralization is restricted vertically and laterally. Ore most often occurs in terminal lobes of the roll-front trends. Within Inyan Kara ore bodies, uranium minerals coat sand grains, fill interstices between grains, and are finely disseminated in organic matter (Renfro, 1969). In oxidized deposits, the uranium vanadates, carnotite, tyuyamunite, and meta-tyuyamunite are the principal ore minerals. Uraninite and coffinite are the main minerals in unoxidized ore. Pyrite, marcasite, and calcite are present as gangue minerals (i.e., low-value minerals intermixed with ore minerals).

Tongues of hematite-stained pinkish-red sandstone are present at most of the deposits. This alteration is due to the oxidation of pyrite in the sandstone by migrating groundwater.

The source of uranium in the Inyan Kara deposits is unknown, but two main theories have been proposed. Renfro (1969) proposed that the uranium and other metals indigenous to the Lakota and Fall River sediments were mobilized by oxidizing groundwater and transported downdip, where they were precipitated along an oxidation-reduction boundary. Hart (1968) proposed that uranium was leached by groundwater from tuffaceous beds of the White River Group that were unconformably deposited across the eroded Black Hills uplift. Migrating groundwater carried the uranium into the permeable host rocks where it traveled downdip into reducing environments. Later groundwater movements remobilized and redeposited some of the ore bodies.

The surface of the Black Hills range is still largely mantled by sedimentary rocks that form an outer ring of hogback ridges that crop out in a roughly oval pattern around the flanks of the range. Soils in low lying areas adjacent to the Black Hills of western South Dakota and northeastern Wyoming consist of the weathering products of these sedimentary rocks. The topographic position and texture of typical soils in the Black Hills were obtained from Munn and Arneson (1998). This map was designed primarily for a statewide study of groundwater's vulnerability to contamination and would not be expected to be used for site-specific soil interpretations at proposed ISL milling facilities. For site-specific evaluations, detailed soils information would be expected to be obtained from published county soil surveys or NRCS.

Soils within the Black Hills area of western South Dakota and northeastern Wyoming are mostly fine textured (fine or fine-loamy soils). Shallow fine and fine-loamy soils with little or no subsoil

development are found on ridges and steep slopes on the flanks of Black Hills. On gently sloping to moderately steep slopes adjacent to ridges, moderately deep fine and fine-loamy soils with moderate- to well-developed soil horizons are found. These soils are generally light colored and depleted in moisture. On low gradient surfaces, such as terraces and floodplains, deep fine and fine-loamy soils with well-developed subsoil horizons are found. Dark-colored, base-rich soils formed under grass are generally associated with floodplains along streams with permanent high water tables.

3.4.3.2 The Crawford Basin (Northwestern Nebraska)

Uranium deposits in northwestern Nebraska are located in Dawes and Sioux Counties in what has been named the Crawford Basin (Figure 3.4-2) (DeGraw, 1969). In 1979, an area west of the city of Crawford in Sioux County and an area north of Crawford in Dawes County were identified as having considerable weak uranium mineralization associated with vague oxidation-reduction boundaries (Collings and Knode, 1984). In 1981 and 1982, the Crow Butte mineralized trend was discovered southeast of Crawford in Dawes County. The Crow Butte mineralized trend is about 10 km [6 mi] long and up to 900 m [3,000 ft] wide with ore reserves calculated to be over 13,600 metric tons [15,000 tons] of U_3O_8 having an average grade exceeding 0.25 percent U_3O_8 (Collings and Knode, 1984). Uranium mineralization in the Crow Butte area occurs exclusively within the Chadron Sandstone.

The Crawford Basin is a triangular, asymmetrical basin bounded by the Black Hills Uplift on the northwest, the Chadron Arch to the west, and the Cochran Arch to the south (Figure 3.4-7). As a result of the Black Hills Uplift, formations underlying the uranium milling areas in the Crawford Basin dip gently to the south. The single most prominent structural feature within the Crawford Basin is the White River Fault. It is located north of Crawford and strikes northeast to southwest with the upthrown side to the south. The total vertical displacement is 60 to 120 m [200 to 400 ft].

A generalized stratigraphic section of sedimentary strata in the Crow Butte mining area of northwestern Nebraska is shown in Figure 3.4-8. Stratigraphic descriptions presented here are limited to formations that may be involved in potential milling operations or formations that may have environmental significance, such as important aquifers or confining units above and below potential milling zones.

The Upper Cretaceous (65- to 99-million-year-old) Pierre Shale is a widespread, compositionally uniform, dark gray to black marine shale, which outcrops extensively in Dawes County north of the Crow Butte mining area (Collings and Knode, 1984). In Dawes County, the Pierre Shale is 365 to 460 m [1,200 to 1,500 ft] thick and is essentially impermeable. Due to aerial exposure and subsequent erosion, the top of the present-day Pierre Shale contact marks a major unconformity and exhibits a paleotopography with considerable relief (DeGraw, 1969). As a result of the extended exposure to atmospheric weathering, an ancient soil horizon, or paleosol, from 0 to 10 m [0 to 33 ft] thick, was formed on the surface of the Pierre Shale.

The Oligocene (23.8- to 33.7-million-year-old) White River Group lies unconformably on top of the Pierre Shale. The White River Group consists of the Chadron and Brule Formations. The Chadron comprises three distinct units: the Basal Chadron Sandstone Member, Middle Chadron Member, and Upper Chadron Member.

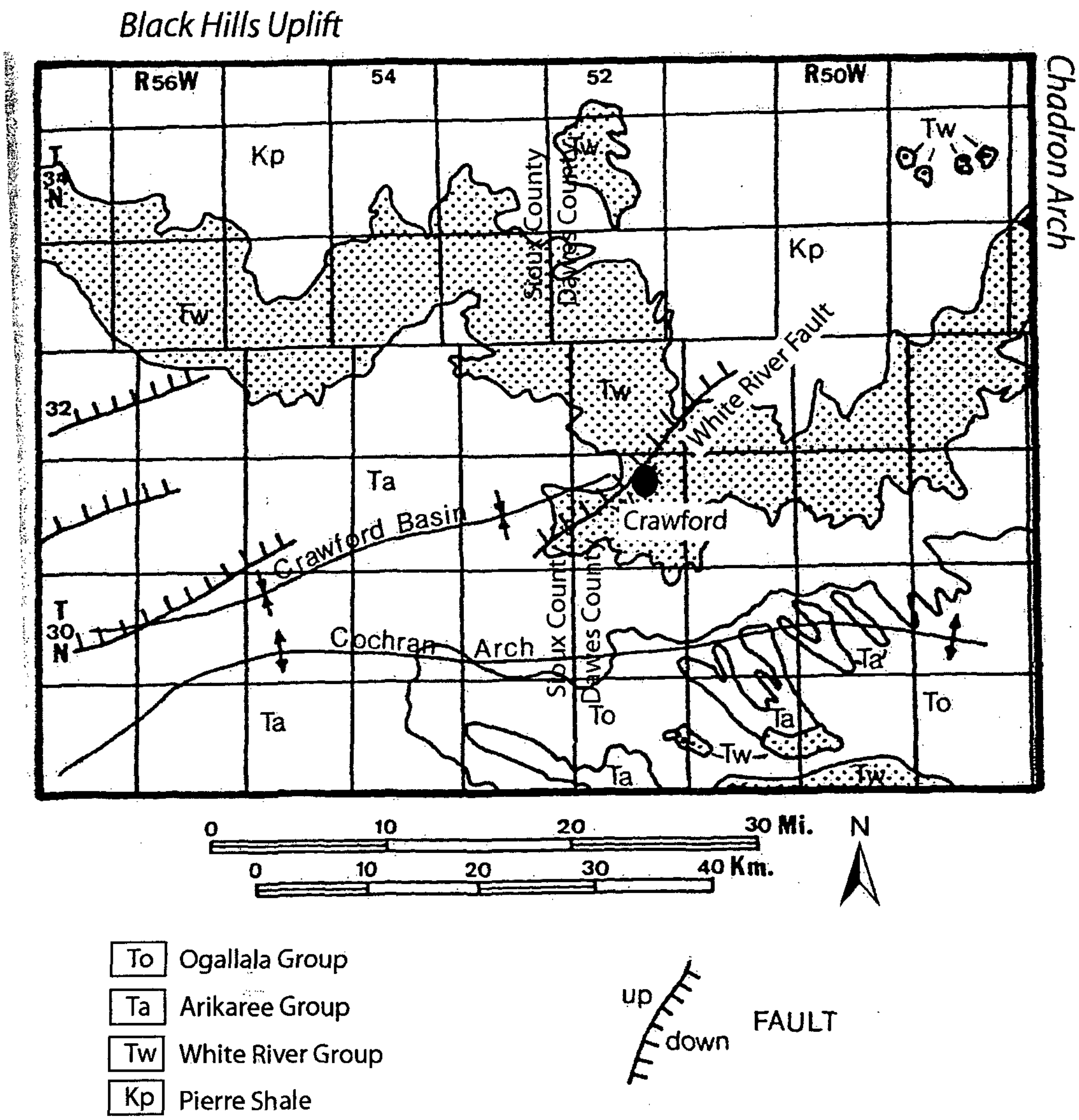


Figure 3.4-7. Bedrock Geology and Major Structural Features of the Crawford Basin (Modified From Gjelsteen and Collings, 1988)

Uranium mineralization in the Crow Butte mineralized trend occurs exclusively within the Basal Chadron Sandstone. The Basal Chadron Sandstone Member consists of coarse-grained arkosic sandstone (i.e., sandstone containing a significant fraction of feldspar) with frequent interbedded thin clay beds. Occasionally, the lower portion of the Basal Member is a very coarse, poorly sorted conglomerate. The Basal Sandstone is the depositional product of a large, braided stream system and ranges from 0 to 105 m [0 to 350 ft] thick.

The Middle Chadron Member overlies the Basal Sandstone Member. The lower part of the Middle Member is impermeable brick-red clay with occasional interbedded gray-green clay. The brick-red clay grades upward to a light green-gray sandy claystone. The upper part of the Middle Member is light gray bentonitic clay. The Middle Member ranges from 12 to 30 m [40 to

<table>
<tr><th colspan="4">Northwestern Nebraska</th></tr>
<tr><th>Age</th><th>Group</th><th>Formation</th><th>Member</th></tr>
<tr><td>Miocene</td><td rowspan="2">Arikaree</td><td>Monroe Creek</td><td rowspan="2"></td></tr>
<tr><td rowspan="6">Oligocene</td><td>Gering</td></tr>
<tr><td rowspan="5">White River</td><td rowspan="2">Brule</td><td>Whitney</td></tr>
<tr><td>Orella</td></tr>
<tr><td rowspan="3">Chadron</td><td>Upper</td></tr>
<tr><td>Middle</td></tr>
<tr><td>Basal</td></tr>
<tr><td>Eocene ?</td><td></td><td>Paleosol</td><td></td></tr>
<tr><td>Cretaceous</td><td></td><td>Pierre Shale</td><td></td></tr>
</table>

Figure 3.4-8. Generalized Stratigraphic Units in the Crow Butte Area of Northwestern Nebraska (Modified From Collings and Knode, 1984)

100 ft] thick. The Upper Chadron Member consists of massive claystones and siltstones, generally considered to be fluvial in origin (Vondra, 1958). The Upper Chadron Member averages 30 m [100 ft] thick throughout the Crow Butte mining area.

The Brule Formation lies conformably on top of the Chadron Formation and consists almost entirely of siltstones with minor sand channels. The Brule is subdivided into two members: the Orella and the Whitney. The Orella lies directly on the Chadron and is composed of buff to brown siltstones. The Whitney comprises massive buff to brown siltstones and contains several volcanic ash horizons.

Uranium deposits in the Basal Chadron Sandstone are associated with oxidation-reduction boundaries or roll fronts (see Section 3.1.1) adjacent to the White River Fault (Figure 3.4-9). Within the Crow Butte uranium ore trend, the Basal Chadron is about 12 m [40 ft] thick (Collings and Knode, 1984). Depth to mineralization varies from 85 to 250 m [275 to 820 ft]. Uranium is present in the matrix and as a coating on grains as coffinite and uraninite, and occurs locally in concentrations as high as 3.0 percent (Gjelsteen and Collings, 1988). The volcaniclastic sediments contained in and overlying the Chadron sandstone are considered to be the most likely source of the uranium of the roll-front deposits in the Crawford Basin because of their abundance, close proximity, and susceptibility to dissolution (Gjelsteen and Collings, 1988).

The distribution and occurrence of soils in Nebraska-South Dakota-Wyoming Uranium Milling Region vary regionally with respect to landform development (e.g., ridges, floodplains, hills) and

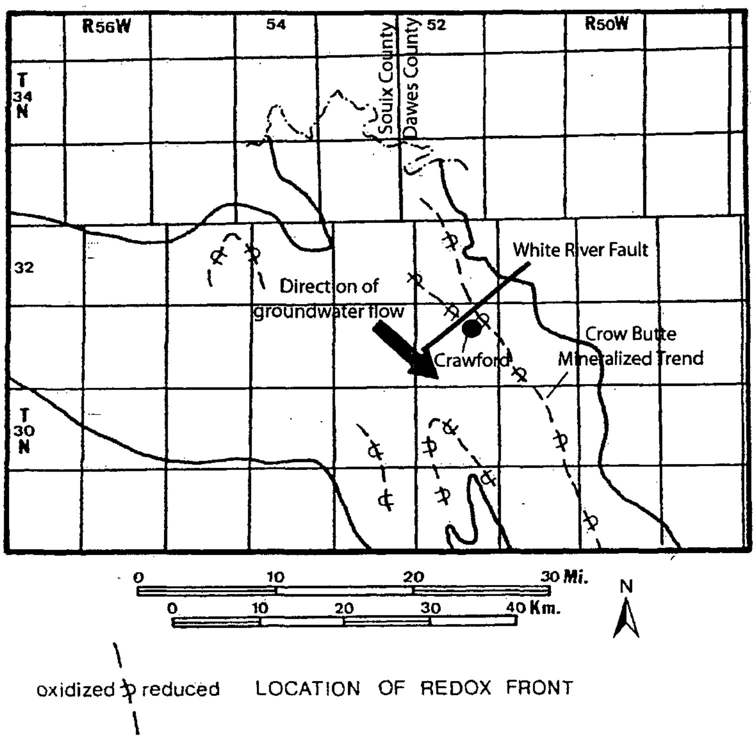


Figure 3.4-9. Location of Oxidation-Reduction Fronts Detected During Exploration Drilling Within the Chadron Sandstone in Northwestern Nebraska. Arrow Shows Direction of Groundwater Flow at the Time of Mineralization as Indicated by Roll-Front Geometry (Modified From Gjelsteen and Collings, 1988).

locally with changes in slope, geology, vegetation, climate, and time. The general characteristics of soils associated with landforms in Dawes County were obtained from the U.S. Department of Agriculture (NRCS, 2007). For site-specific evaluations at proposed ISL milling facilities, more detailed soils information can be obtained from published county soil surveys or the NRCS.

In Dawes County, silt loam and silty clay loam soils having little to moderate horizon development are found on ridges. These shallow to moderately shallow soils occur on steep slopes where erosion activity is greatest. Soils on hillslopes vary from soils having little or moderate horizon development to soils that have well-developed horizons (deep soils). Silty clay and silty clay loam soils having little to moderate horizon development are found on the steeper parts of hillslopes where erosional activity is greatest. Silty clay loam and loamy, very fine sand soils having well-developed horizons are found on gently sloping parts of hillslopes. On plains, which are nearly level or gently sloping, silt loam soils with well-developed clay horizons are found. Soils found on stream terraces and floodplains are generally very deep, with soil textures that are highly variable, depending on the local geology. Silty clay, silty clay loam, silt loam, and loam soils are found on stream terraces. Clay, loamy very fine sand, and sandy loam soils are found on floodplains.

3.4.4 Water Resources

3.4.4.1 Surface Waters

The Nebraska-South Dakota-Wyoming Uranium Milling Region includes portions of northwestern Nebraska, eastern Wyoming, and southwest South Dakota. Average annual surface runoff, in terms of average annual flow per unit area of a watershed in the Nebraska-South Dakota-Wyoming Uranium Milling Region, ranges from approximately 5 cm/yr [2 in/yr] in the higher elevations of the Black Hills to less than 1.3 cm/yr [0.5 in/yr] on the plains surrounding the Black Hills. Watersheds in the Nebraska-South Dakota-Wyoming Uranium Milling Region are shown in Figure 3.4-10. The watersheds within the Nebraska-South Dakota-Wyoming Uranium Milling Region are listed in Table 3.4-4 along with the generic designated uses of surface water bodies in these watersheds. The designated uses of water bodies in these watersheds differ slightly from state to state. Thus, the designated uses for water bodies in watersheds that cross state boundaries may be different. To simplify the discussion of the water quality characteristics of water bodies in each watershed, the designated uses in Table 3.4-4 have been grouped into the following generic categories: fisheries, fish and wildlife propagation, recreation, drinking water supply, agriculture, industrial, and aesthetic. Water bodies with the generic use as a fishery may support either warm-water or cold-water species. More detailed descriptions of the designated uses in each state can be found in the following references

- Wyoming—WDEQ (2001; 2008)
- Nebraska—Nebraska Department of Environmental Quality (2008)
- South Dakota—South Dakota Department of Environmental and Natural Resources (2008)

Not all water bodies within a watershed may have all of the designated uses listed in Table 3.4-4. For example, a watershed may contain perennial streams, intermittent streams that flow only during portions of the year, and ephemeral streams that flow only due to surface runoff from local precipitation events. The perennial streams and possibly portions of

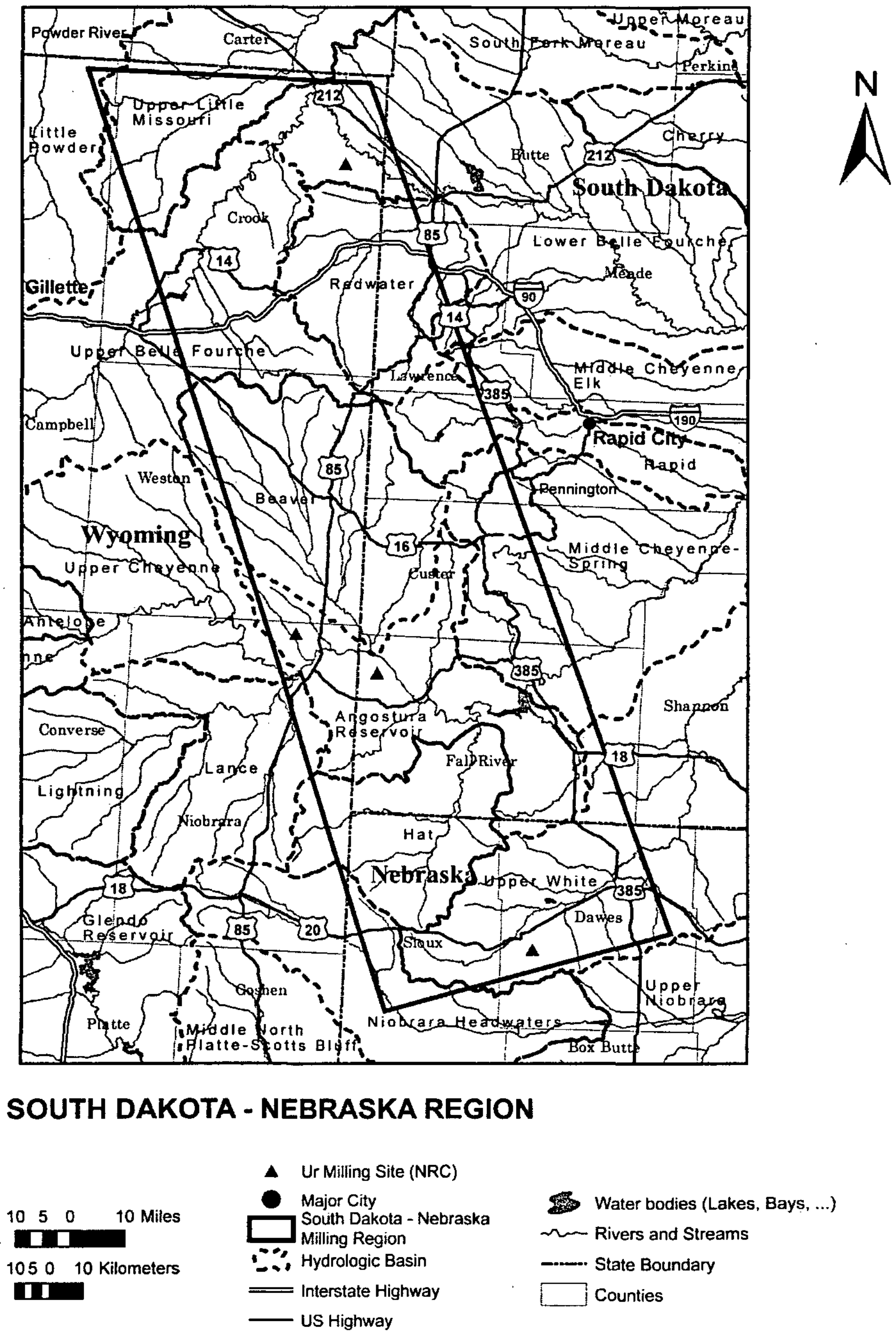


Figure 3.4-10. Watersheds Within the Nebraska-South Dakota-Wyoming Uranium Milling Region

Table 3.4-4. Primary Watersheds in the Nebraska-South Dakota-Wyoming Uranium District and Range of Generic Designated Uses of Water Bodies Within Each Watershed

Watershed	Generic State Designated Uses of Water Bodies in the Watershed	
Upper White River	Nebraska	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Aesthetics
Hat Creek	Nebraska	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Aesthetics
	South Dakota	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Aesthetics
Angostura Reservoir	South Dakota	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Aesthetics
Cheyenne River Above Angostura Reservoir	South Dakota	Fisheries Fish and Wildlife Propagation Recreation Agriculture Aesthetics
	Wyoming	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Industrial Aesthetics

Table 3.4-4. Primary Watersheds in the Nebraska-South Dakota-Wyoming Uranium District and Range of Generic Designated Uses of Water Bodies Within Each Watershed (continued)

Watershed	Generic State Designated Uses of Water Bodies in the Watershed	
Beaver Creek	South Dakota	Fisheries Fish and Wildlife Propagation Recreation Agriculture Aesthetics
	Wyoming	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Industrial Aesthetics
Upper Belle Fourche River and Tributaries	Wyoming	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Industrial Aesthetics
Lower Belle Fourche River and Tributaries	South Dakota	Fisheries Fish and Wildlife Propagation Recreation Agriculture Aesthetics
	Wyoming	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Industrial Aesthetics
Redwater River and Tributaries	South Dakota	Fisheries Fish and Wildlife Propagation Recreation Agriculture Aesthetics
	Wyoming	Fisheries Fish and Wildlife Propagation Drinking Water Recreation Agriculture Industrial Aesthetics

intermittent streams may be designated as "fisheries," whereas ephemeral streams are unlikely to be designated as fisheries. The descriptions of the water bodies and their classifications in this section focus on perennial streams that generally have higher designated uses than the intermittent and ephemeral streams.

Surface water features in specific areas of uranium mineralization within the Nebraska-South Dakota-Wyoming Uranium Milling Region are discussed next.

Nebraska

The area of known uranium mineralization in Nebraska is located in Dawes County within the Upper White River Watershed (Figure 3.4-10). The average annual flow of the White River at the Nebraska-South Dakota state line, near the northern limit of known uranium deposits, was approximately 1.1 m^3/s [40 ft^3/s] for water years 1988 through 2007 (U.S. Geological Survey, 2008a). The state-designated uses for the White River above Chadron, Nebraska, are drinking water supply, aquatic life (cold water), agriculture, and aesthetics (Nebraska Department of Environmental Quality, 2008).

The immediate area of uranium mineralization is drained by White Clay Creek, Squaw Creek, and English Creek, with headwaters in the Nebraska National Forest along Pine Ridge. Small surface impoundments are present along these creeks and are used for stock watering. The state-designated uses for these perennial creeks are aquatic life (cold water), fish consumption, agriculture, and aesthetics (Nebraska Department of Environmental Quality, 2008). These streams are not identified as having impaired water quality.

The Nebraska-South Dakota-Wyoming Uranium Milling Region also includes a portion of Sioux County and the Hat Creek Watershed. Hat Creek is a tributary to the Cheyenne River above Angostura Reservoir in South Dakota. The average flow of Hat Creek at the gauging station near Edgemont, South Dakota, is 0.45 m^3/s [16 ft^3/s] (U.S. Geological Survey, 2008a). The only impaired water body reported in the Hat Creek Watershed is Meng Lake, which has high conductivity and impaired pH (Nebraska Department of Environmental Quality, 2008).

South Dakota and Wyoming

The uranium deposits in the Nebraska-South Dakota-Wyoming Uranium Milling Region of South Dakota and Wyoming occur around the western and northern flanks of the Black Hills. The principal uranium deposits are in Fall River County, South Dakota, within the Angostura Reservoir Watershed and in Niobrara, Weston, and Crook Counties in Wyoming (Hart, 1968) within the Angostura Reservoir and Lower Belle Fourche River Watersheds. Although Custer, Pennington, and Lawrence Counties in South Dakota are included within the Nebraska-South Dakota-Wyoming Uranium Milling Region, uranium deposits are not known to exist in these counties. The primary watersheds in South Dakota and Wyoming that may contain uranium deposits within the Nebraska-South Dakota-Wyoming Uranium Milling Region are listed in Table 3.4-4 along with their generic state-designated uses and any known impairments to these uses. Although the Nebraska-South Dakota-Wyoming Uranium Milling Region shown in Figure 3.4-10 includes small portions of additional watersheds on its periphery, these secondary watersheds are not in areas of anticipated uranium milling activities.

The uranium deposits in South Dakota occur within the watersheds of the Cheyenne River upstream of Angostura Reservoir, Beaver Creek, Redwater River, and Lower Belle Fourche River (Figure 3.4-10). Within South Dakota, the Cheyenne River has generic designated uses of fisheries, fish and wildlife propagation, recreation, irrigation, and aesthetics. According to South Dakota Department of Environment and Natural Resources (2008), the Cheyenne River above Angostura Reservoir is impaired due to high salinity from natural salts. The average flow of the Cheyenne River at Edgemont, South Dakota, is 2.1 m^3/s [75 ft^3/s] (U.S. Geological Survey, 2008a). The upland portions of the uranium district are primarily drained by ephemeral and intermittent streams with the exception of the lower reach of Red Canyon Creek, which is perennial and fed by springs on the flanks of the Black Hills.

The Beaver Creek Watershed includes portions of Custer and Pennington counties in South Dakota and Weston County in Wyoming. The generic designated uses of Beaver Creek and its tributaries are listed in Table 3.4-4. Portions of Beaver Creek and its tributaries within South Dakota are impaired due to elevated temperature, salinity, and turbidity (South Dakota Department of Environment and Natural Resources, 2008). The average flow of Beaver Creek at Mallo Camp, Wyoming, is 0.05 m^3/s [1.8 ft^3/s] for water years 1992 and 2008.

The Upper Belle Fourche Watershed is located in Wyoming northwest of the Beaver Creek Watershed in Weston and Crook Counties. The generic designated uses of the Upper Belle Fourche River and its tributaries are listed in Table 3.4-4. A number of perennial streams flowing from the flanks of the Black Hills, such as Inyan Kara Creek, are also present in this watershed. These streams are fed by springs on the flanks of the Black Hills. Streams in portions of the Upper Belle Fourche Watershed are impacted by elevated fecal coliform from unidentified sources (WDEQ, 2008).

The Lower Belle Fourche Watershed extends from northeastern Crook County in Wyoming (downstream of the Upper Belle Fourche Watershed) into Butte, Meade, and Lawrence Counties in South Dakota. The designated uses of the Lower Belle Fourche Watershed and some of its tributaries are impacted by elevated temperature, salinity, turbidity, and fecal coliform (South Dakota Department of Environment and Natural Resources, 2008). The elevated salinity, turbidity, and fecal coliform are from agricultural livestock grazing activities. Some of the tributaries to the Belle Fourche River drain historical mining districts and are impacted by metals and acidity due to mine drainage. The average flow of the Belle Fourche River at the Wyoming-South Dakota state line is 2.4 m^3/s [85 ft^3/s] for water years 1959 through 2007 (U.S. Geological Survey, 2008a).

The Redwater River watershed straddles the Wyoming-South Dakota state line between the Upper and Lower Belle Fourche Watersheds (Figure 3.4-10) The generic designated uses of the Redwater River and its tributaries are listed in Table 3.4-4. The average flow of the Redwater River at the gauging station above Belle Fourche, South Dakota, is 3.9 m^3/s [139 ft^3/s] for water years 1946 through 2007 (U.S. Geological Survey, 2008a). Water bodies in this watershed are not listed as impaired.

3.4.4.2 Wetlands and Waters of the United States

Wetland areas found in this region are consistent with those found in the Wyoming East Uranium Milling Region (Section 3.3.4.2). Waters of the United States and special aquatic sites that include wetlands would be expected to be identified and the impact delineated upon individual site selection. Based on impacts and consultation with each area, appropriate permits would be obtained from the local USACE district. Section 401 state water quality certification is

required for work in Waters of the United States. Within Wyoming, the State of Wyoming regulates isolated wetlands and waters. Cumulative total project impacts greater than 0.4 ha [1 acre] require a general permit for wetland mitigation by WDEQ. Within Nebraska, waters of the state are under the authority of the Nebraska Department of Environmental Quality. Isolated wetlands are included in Title 117, Nebraska Surface Water Quality Standards. No permitting mechanism is in place to authorize projects in isolated waters; however, state water quality standards apply.

3.4.4.3 Groundwater

Groundwater resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region are part of regional aquifer systems that extend well beyond the areas of uranium milling interest in this part of Nebraska, South Dakota, and Wyoming. Uranium-bearing aquifers exist within these regional aquifer systems in the Nebraska-South Dakota-Wyoming Uranium Milling Region. This section provides a general overview of the regional aquifer systems to provide context for a more focused discussion of the uranium-bearing aquifers in the Nebraska-South Dakota-Wyoming Uranium Milling Region, including hydrologic characteristics, level of confinement, groundwater quality, water uses, and important surrounding aquifers.

3.4.4.3.1 Regional Aquifer Systems

Major regional aquifers in the Nebraska-South Dakota-Wyoming Uranium Milling Region include the Northern Great Plains aquifer system (Whitehead, 1996) and the High Plains aquifer system (Miller and Appel, 1997).

Northern Great Plains Aquifer System (underlying South Dakota): The Northern Great Plains aquifer system underlies most of the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region (Whitehead, 1996). The Upper Cretaceous aquifers (important for uranium mineralization and water supplies) and the Paleozoic aquifers (important only for water supplies) of the Northern Great Plains aquifer system are the most extensive aquifers in the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region.

Groundwater in the upper Cretaceous aquifers (including minor aquifers in the region) contains less than 3,000 mg/L [3,000 ppm] dissolved solids except for small areas in South Dakota where concentrations are as large as 10,000 mg/L [10,000 ppm]. Water with dissolved-solids concentrations of less than 1,000 mg/L [1,000 ppm] is near the Black Hills Uplift (in west South Dakota) and in smaller areas near the boundaries of the aquifers. Groundwater from the upper Cretaceous aquifers provides domestic- and livestock-watering supplies as well as water for several small communities in northwestern South Dakota.

The lower Cretaceous aquifers are composed of several sandstones. The principal water-yielding units are the Newcastle Sandstone (equivalent to the Dakota Sandstone) and the Inyan Kara Group in the Williston Basin. The Newcastle Sandstone is only a few tens of kilometers [tens of feet] thick where it crops out on the flanks of the Black Hills Uplift, but its subsurface equivalent, the Dakota Sandstone, is more than 122 m [400 ft] thick in southeastern South Dakota. In many places, the Newcastle Sandstone is separated from the underlying Inyan Kara Group through the Skull Creek Shale. The Inyan Kara Group merges eastward into the lower part of the Dakota Sandstone in South Dakota.

The Lower Cretaceous aquifers are confined except at outcrop areas that encircle structural uplifts, such as the Black Hills Uplift and the Bighorn Mountains. In South Dakota, the lower Cretaceous aquifers are overlain by poorly permeable till and glacial-lake deposits, and the aquifers behave like a confined to semiconfined aquifer. The regional groundwater flow direction is northeastward from aquifer recharge areas at high altitudes to discharge areas. Although the groundwater in the lower Cretaceous aquifers is slightly saline in most of South Dakota, the aquifers are the principal source of water for livestock watering and domestic use. The water is very saline or a brine in the deep parts of the Williston Basin.

The upper Paleozoic aquifers consist primarily of the Madison Limestone, which is called the Madison Group in the Williston Basin. The Tensleep Sandstone in the western parts of the Powder River Basin and sandstone beds of the Minnelusa Formation in the Williston Basin and the eastern part of the Powder River Basin are treated as separated aquifers at the regional scale. The Pennsylvanian sandstones are not usually considered to be a principal aquifer. The Madison Limestone exhibits karst features in outcrop areas of the Madison in western South Dakota where large springs originate from solution conduits. In the upper Paleozoic aquifers, the regional groundwater flow direction is northeastward from recharge areas near structural uplifts close to the southern and western limits of the aquifer system. Withdrawal of the oil and gas from the hydrocarbon reservoir have resulted in water leaking downward from the upper Paleozoic aquifers through confining units into deeper permeable zones. Groundwater in the upper Paleozoic aquifers is fresh only in small zones near recharge areas, including the area of freshwater encircling the Black Hills Uplift in western South Dakota. The water becomes slightly saline to saline away from the recharge areas into the Williston Basin. Due to the upward leakage of the mineralized water from the upper Paleozoic aquifers into upper Cretaceous aquifers in central South Dakota, the groundwater becomes saline in shallower aquifers.

Lower Paleozoic aquifers are deeply buried for the most part. They consist of sandstone and carbonate rocks. There are great uncertainties in water yield characteristics of these aquifers at the regional scale. The regional groundwater flow direction is northeastward. Lower Paleozoic aquifers contain fresh water only in a small area near the Black Hills Uplift, but contain slightly saline to moderately saline groundwater throughout the southern one-half of their extent. In a large area in central South Dakota, some of the slightly saline water in the Lower Paleozoic aquifers leaks upward into shallower aquifers.

High Plains Aquifer System (underlying Nebraska): The High Plains aquifer underlies the southernmost part of Nebraska-South Dakota-Wyoming Uranium Milling Region. The High Plains aquifer is the principal source of groundwater for the High Plains region. The High Plains aquifer is unconfined for the most part. The water table is usually less than 61 m [200 ft] below the land surface in western Nebraska. However, the water table is between 61 and 91 m [200 and 300 ft] below the land surface in parts of western Nebraska. The regional groundwater flow direction is from west to east at an average velocity of 0.3 m/day [1 ft/day]. The saturated thickness of the High Plains aquifer ranged from 0 to approximately 305 m [0 to 1,000 ft] in 1980 with an average saturated thickness of 104 m [340 ft]. The average specific yield for entire aquifer is 15 percent. Recharge to the aquifer includes precipitation infiltrating through dune sands in western Nebraska, infiltration locally from streams and canals, and infiltration by a small quantity of water moving upward from the underlying bedrock. The rates of recharge are highly variable and range from about 0.3 to 20 percent of the average annual precipitation. Discharge from the aquifer includes water losses to springs, seeps, and streams; evapotranspiration; minor water losses to bedrocks and withdrawals mostly for irrigation.

The High Plains aquifer consists of all or parts of several geologic units of Quaternary and Tertiary age. Clay- to gravel-sized unconsolidated deposits of Quaternary age overlie the Ogallala Formation. These unconsolidated deposits are considered to be part of the High Plains aquifer, if they are saturated as in southeastern Nebraska. The High Plains aquifer is locally confined above by thick loess that consists mostly of silt and clay-sized materials. Highly porous dune sands of Quaternary age, where they are saturated, are also considered to be part of the aquifer (e.g., in west-central Nebraska) and recharge the High Plains aquifers.
The Ogallala Formation is underlain by the Arikaree Group. The Arikaree Group, which is composed of massive sandstone, overlies the Brule Formation. The maximum thickness of the Arikaree Group is about 305 m [1,000 ft] in western Nebraska. The Oligocene-aged Brule Formation of Oligocene, which is the upper unit of the White River Group, underlies much of western Nebraska. It is predominantly composed of massive siltstone and sandstone and is considered to be an aquifer only where it is fractured or it contains solution openings.

In large parts of Nebraska, the High Plains aquifer is underlain by upper Cretaceous rocks that primarily consist of shale, chalk, limestone, and sandstone. Only the chalk, where it is fractured or contains solution openings, yields enough water for irrigation. The Chadron Formation, part of the White River Group, directly underlies the High Plains aquifer in most of western Nebraska. It is predominantly composed of clay and silt units with minimal permeability.

In parts of western Nebraska, the High Plains aquifer is underlain by Jurassic- and Triassic-age rocks that primarily consist of shale and sandstone. The Jurassic and Triassic age rocks generally have low permeability, but some sandstone beds are locally permeable enough to yield water. In other areas, the High Plains aquifer is underlain by Tertiary and Permian rocks that predominantly consist of red shale, siltstone, sandstone, gypsum, anhydrite, and dolomite and locally include limestone and halite (rock salt) as beds or disseminated grains.

During 1990, about 17 million L/day [4.6 million gal/day] of groundwater was pumped from the High Plains aquifer, mostly (97 percent) for agricultural purposes. The potential water yield from wells in most of Nebraska is typically greater than 4.1 million L/day [1.1 million gal/day], although the water yield varies with the geologic formation tapped. For example, water yields from the Brule Formation are typically less than 1.6 million L/day [430,000 million gal/day]. Water yields from the Arikaree Group are not usually large, but locally in Western Nebraska are as large as 1.9 million L/day [500,000 million gal/day]. The water yields from the Brule Formation and the Arikaree Group are relatively larger where these rocks have secondary fractures. Water yields from the Ogallala Formation are 5.5 million L/day [1.4 million gal/day] in many parts of Nebraska.

In most of Nebraska, dissolved-solids concentrations in the High Plains aquifer are less than 500 mg/L [500 ppm], but locally exceed 1,000 mg/L [1,000 ppm] {the limit of dissolved solids recommended by the EPA for drinking water is 500 mg/L [500 ppm]}. Sodium concentrations in the High Plains aquifer are less than 25 mg/L [25 ppm] in most of Nebraska. However, excessive fluoride concentrations are a widespread problem in the High Plains aquifer. High fluoride concentrations in the range of 2–8 mg/L [2–8 ppm] are reported for the High Plains aquifer where the aquifer contains volcanic ash deposits or it is underlain by rocks of Cretaceous age.

The unconfined nature of the High Plains aquifer system along with the shallow water table makes the aquifer vulnerable to contamination by fertilizers and organic pesticides. Elevated concentrations of sodium, alkalinity, nitrate, and triazine (a herbicide) have been found in the

aquifer in Nebraska. For example, during 1984–1985, nearly 33 percent of well samples in Nebraska showed measurable concentrations {greater than 0.04 µg/L [0.04 ppb]} of the herbicide atrazine (Whitehead, 1996).

3.4.4.3.2 Aquifer Systems in the Vicinity of Uranium Milling Sites

An underlying hydrogeological system in past and current areas of uranium milling interest in the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region consists of a thick sequence of primarily sandstone and also limestone aquifers typically separated by shale aquitards. *Uranium-bearing sandstone aquifers in the Inyan Kara Group at the potential* ISL sites are used for local irrigation water supplies.

Areas of uranium milling interest in the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region are underlain by water-bearing layers including, from shallowest to deepest, the alluvial aquifers, the Newcastle sandstone (equivalent to the Muddy Sandstone), the sandstone aquifers in the Inyan Kara Group, the Morrison Formation, the Sundance Formation, the Spearfish Formation, the Minnekahta Limestone, the Minnelusa Formation, the Madison Formation, and the Deadwood Formation. Among these aquifers, the Inyan Kara Group, the Minnekahta Limestone, the Minnelusa Formation, the Madison Formation, and the Deadwood Formation contain important aquifers for water supplies. The *rest of the water-bearing units in the region are pumped for limited local water uses* (Williamson and Carter, 2001).

An underlying hydrogeological system in past and current areas of uranium milling interest in the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region consists of a thick sequence of primarily sandstone and also limestone aquifers typically separated by shale aquitards.

At the Crow Butte ISL sites in Nebraska, only the Basal Chadron sandstone is considered to be an aquifer (NRC, 1998). The Arikaree and Brule Formations are not considered to be important aquifers for water supplies in this region (Miller and Appel, 1997; NRC, 1998).

3.4.4.3.3 Uranium-Bearing Aquifers

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, the sandstone aquifers in the Inyan Kara Group are important aquifers for uranium mineralization (Driscoll, et al., 2002). In this region, uranium may have been introduced into the Inyan Kara Group through upward leakage of uranium-rich water from the Minnelusa aquifer (Gott, et al., 1974). In the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, the Basal Chadron sandstone aquifer (in the Chadron Formation) hosts uranium mineralization (NRC, 1998).

For ISL operations to begin, portions of the uranium-bearing sandstone aquifers in the Inyan Kara Group and the Basal Chadron Sandstone of the Nebraska-South Dakota-Wyoming Uranium Milling Region would need to be exempted by the appropriate EPA- or state-administered underground injection program (Section 1.7.2.1).

Hydrogeological characteristics: In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, the Inyan Kara sandstone aquifers are typically confined except at outcrop areas. Transmissivity of the Inyan Kara aquifer ranges from

0.08–560 m^2/day [0.8–6,000 ft^2/day]. For ISL operations to be practical, the hydraulic conductivity of the production aquifer must be large enough to allow reasonable water flow from injection to production wells. Hence, the portions of the Inyan Kara aquifer with low hydraulic conductivities may not be readily amenable to uranium recovery using ISL techniques. The storage coefficient is in the range of 2.5×10^{-5}–1.0×10^{-4} (Driscoll, et al., 2002), indicating the confined nature of the production aquifer (typical storage coefficients for confined aquifers range from 10^{-5}–10^{-3}) (Driscoll, 1986, p. 68).

In the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling region, the Basal Chadron Sandstone aquifer is confined by a thick sequence of aquitards. Transmissivity of the Basal Chadron Sandstone aquifer ranges from 30 to 45 m^2/day [350 to 480 ft^2/day] and the average aquifer storage coefficient is in the range of 1.3×10^{-5}–8.4×10^{-4} (NRC, 1998), indicating the confined nature of the production aquifer (typical storage coefficients for confined aquifers range from 10^{-5}–10^{-3} (Driscoll, 1986; p. 68).

Level of confinement: The production aquifer is typically confined in the Nebraska-South Dakota-Wyoming Uranium Milling Region. The thickness of the confinement varies spatially.

In South Dakota, the Inyan Kara Group is generally confined by several thick shale layers, except in the outcrop area around structural uplifts, such as the Black Hills. The Inyan Kara Group is confined above by the Skull Creek Shale with a thickness of 46–80 m m [150–270 ft]. The Skull Creek Shale is confined above by the regionally continuous Pierre Shale unit with a thickness of 1,220 m [4,000 ft] in the Black Hills area. The Inyan Kara Group is hydraulically separated from the underlying Minnekahta limestone by low permeability units including, from shallowest to deepest, the Morrison Formation, the Sundance Formation, and the Spearfish Formation. The total thickness of these low permeability layer varies from 190 to 450 m [625 to 1,470 ft] at the Black Hills. Thus, except at the outcrop areas, the sandstone aquifers in the Inyan Kara Group are confined above and below by thick confining units in the Nebraska-South Dakota-Wyoming Uranium Milling Region. A vertical hydraulic conductivity of 0.4×10^{-6} m/day [1.3×10^{-6} ft/day] for the Skull Creek Shale and 1.5×10^{-8}–1.5×10^{-4} m/day [5×10^{-8}–5×10^{-4} ft/day] for the Pierre Shale is estimated in South Dakota (Kansas Geological Survey, 1991).

In Nebraska, the ore-bearing aquifer is confined below by the Pierre Shale with an average thickness of 365 m [1,200 ft] and a vertical hydraulic conductivity of 3.4×10^{-11} to 3.6×10^{-12} m/s [11.2×10^{-11} to 11.8×10^{-12} ft/s]. The upper confinement unit is composed of a red clay bed up to 3–8 m [10–25 ft] thick with a vertical hydraulic conductivity of 3×0^{-8} to 2×0^{-7} m/day [1×10^{-7} to 7×10^{-7} ft/day]. The red clay bed is overlain by another thick confining layer (the Middle Chadron) with an average thickness of 95–100 m [315–325 ft]. The thickness of the upper confining unit is about 60–90 m [200–300 ft] in the permit area. Aquifer testing indicates that movement of lixiviant would be vertically contained by the confining units and horizontally captured in the production zone in the Crow Butte region (NRC, 1998).

Groundwater quality: Water from the Inyan Kara aquifer in South Dakota is locally fresh to slightly saline. However, generally high concentrations of dissolved solids, iron, sulfate, and manganese may hamper the use of water from the Inyan Kara aquifer. Hard water from wells located on or near the outcrop may require special treatment. Suitability for irrigation may be affected by high specific conductance and sodium adsorption ratio [the ratio of the sodium (detrimental element) concentration to the combined concentration of calcium and magnesium (beneficial elements)]. Almost 18 percent of samples collected from the Inyan Kara aquifer

exceed the maximum concentration level for combined radium-226 and radium-228. About 4 percent of these samples exceed the maximum concentration level for uranium. The uranium and radium-226 concentrations ranged from 0.1 to 109 ppm and 7.4×10^{-3}–1.59 Bq/L [0.2–43 pCi/L] in the Inyan Kara aquifer, respectively. In the southern Black Hills, radium-226 and uranium concentrations may preclude use of untreated water from Inyan Kara aquifer for drinking (Williamson and Carter, 2001).

Based on baseline (preoperational) water quality data, the Basal Chadron Sandstone is generally of good quality (with the total uranium less than 3.7×10^{-4}–8.9×10^{-2} Bq/L [0.01–2.40 pCi/L] and the total conductivity in the range of 1,500–2,500 mhos. The State of Nebraska Department of Environmental Quality defines the Basal Chadron sandstone as an underground source of drinking water (NRC, 1998). However, in the vicinity of the mineralized zone, uranium and radium concentrations are elevated. Radium-226 levels range from 3.7×10^{-3} – 22.9 Bq/L [0.1–619 pCi/L], which exceeds the 5 pCi/L EPA primary drinking water standard. As a result, water drawn from Chadron sandstone is not considered potable near the mineralization zone (NRC, 1998).

Current groundwater uses: Groundwater from Inyan Kara aquifer is typically pumped for local irrigation. Groundwater from the Basal Chadron Sandstone is pumped for agricultural and domestic uses.

3.4.4.3.4 Other Important Surrounding Aquifers for Water Supply

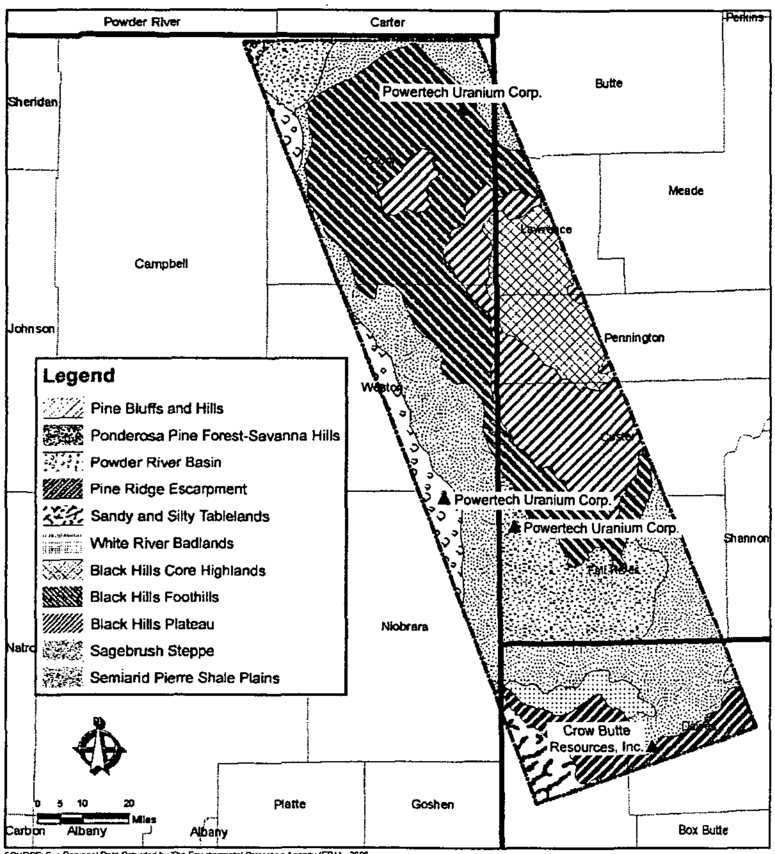
The major aquifers in the hydrologic setting of the Black Hills area all underlie the Inyan Kara Group. The major aquifers include, from shallowest to deepest, the Minnekahta Limestone, the Minnelusa Formation, the Madison Formation, and the Deadwood Formation. These aquifers are separated by relatively impermeable layers, but they are (including the Inyan Kara Group) collectively confined by the underlying Precambrian basement rocks and the overlying the Skull Creek and the Pierre Shales. These aquifers are used extensively for water supplies in the region (Williamson and Carter, 2001). The average saturated thicknesses of the Minnekahta Limestone, the Minnelusa Formation, the Madison Formation, and the Deadwood Formation are 15, 224, 159, and 152 m [50, 736, 521, and 500 ft], respectively. The aquifer transmissivity for the Minnelusa Formation, the Madison Formation, and the Deadwood Formation are estimated to be 2.8–28 m^2/day [30–300 ft^2/day], 9.2×10^{-4}–5,000 m^2/day [0.01–54,000 ft^2/day], and 23–93 m^2/day [250–1,000 ft^2/day], respectively. The storage coefficient for the Minnelusa Formation and the Madison Formation are estimated to be 6.6×10^{-5} through 2.0×10^{-4} and 1.12×10^{-6} through 0.002 (Driscoll, et al., 2002). At the Crow Butte ISL sites in Nebraska, only the Basal Chadron sandstone is considered to be an aquifer (NRC, 1998).

3.4.5 Ecology

3.4.5.1 Terrestrial

Nebraska-South Dakota-Wyoming Uranium Milling Region Flora

According to the EPA, the identified ecoregions in the Nebraska-South Dakota-Wyoming Uranium Milling Region primarily consist of Middle Rockies, Northwestern Great Plains, Western High Plains, and the Nebraska Sand Hills ecoregions (Figure 3.4-11). Uranium districts are located in ecoregions including the Black Hills Foothills, Sagebrush Steppe, the Pine Ridge Escarpment, and the Powder River Basin. The Middle Rockies ecoregion is discussed in the Wyoming West region (Section 3.2.5).



SOURCE: Eco Regional Data Provided by The Environmental Protection Agency (EPA) - 2005

Figure 3.4-11. Ecoregions for the Nebraska-South Dakota-Wyoming Uranium Milling Region

The Black Hills Foothills ecoregion is composed of the Hogback Ridge and the Red Valley. The Hogback Ridge forms a ring of foot hills surrounding the Black Hills. The Red Valley encircles most of the Black Hills dome and acts as a buffer between the Hogback Ridge. Natural vegetation within this region includes ponderosa pine woodlands and open savannas with an understory of western wheat grass, needle-and-thread grass, little bluestem (*Schizachyrium scoparium*), blue grama, buffalo grass (*Hierochloe odorata*), and leadplant (*Amorpha canescens*). In addition, some burr oak (*Quercus macrocarpa*) is found in the north and Rocky Mountain juniper (*Juniperus scopulorum*) occurs in the south (Chapman, et al., 2004).

The Black Hills Plateau ecoregion is a relatively flat, elevated expanse, with broad ridges and entrenched canyons, covering the mid-elevation slopes of the Black Hills. The Black Hills, a mountainous outlier in the Great Plains, has a highly diverse vegetative cover, with an overlap of eastern, boreal, and Rocky Mountain species. The dominant tree spies found in the region is the ponderosa pine; however, it blends with eastern boxelder (*Acer negundo* ssp.), burr oak, and boreal paper birch (*Betula papyrifera*). White spruce and sedges can be found in moist areas. The understory includes grasses like little bluestem and timber oatgrass (*Danthonia intermedia*) and shrubs such as juniper, snowberry, bearberry, and buffaloberry (*Shepherdia argentea*) (Chapman, et al., 2004).

The Black Hills Core Highlands ecoregion includes the higher portions of the limestone plateau above 1,500 m [5,000 ft] and the granitic intrusions that form the major peaks to elevations greater than 2,130 m [7,000 ft]. Due to the high elevation, temperature, and high rainfall boreal species such as white spruce, quaking aspen, and paper birch can be found on the northern slopes and moist canyons. Ponderosa pine forests interspersed with high meadows are predominant in the region. Understory species include sedges in moist areas, bearded wheatgrass, oatgrass, brome grass (*Bromus* spp.), common juniper, snowberry, Oregon bent grass (*Agrostis oregonensis*), bearberry, and iris (*Iris* spp.) (Chapman, et al., 2004)

The Northwestern Great Plains is discussed in Section 3.3.5.1.

The Montana Central Grassland ecoregion is found mostly in Montana with only a small area continuing into northern Wyoming. The dominant vegetation within this region is a mixed grass prairie composed of blue grama, western wheatgrass, junegrass, Sandberg bluegrass, needle-and-thread grass, rabbitbush, fringed sage, and grama-needlegrass-wheatgrass. The shrub or woodland component found in other ecoregions (Sagebrush Steppe) is absent (Chapman, et al., 2004).

The Sagebrush Steppe ecoregion is found in Montana and in the Dakotas with only a small area extending into Wyoming. Vegetation types in this region consist of big sagebrush, Nuttall saltbush (*Atriplex nuttallii*), and short grass prairie. The sparse sagebrush communities consist of dusky gray sagebrush (*Artemisia arbuscula* ssp. *Arbuscula)*, dwarf sage (*Artemisia columbiensis*), and big sagebrush. Prairie vegetation that can be found include western wheatgrass, green needlegrass, blue grama, Sandberg bluegrass, junegrass, rabbit brush, fringed sage, and buffalograss. The shrub vegetation of this ecoregion is transitional between the grasslands of the Montana Central Grassland and the woodland of the Pine Scoria Hills (Bryce, et al., 1996)

The Semiarid Pierre Shale Plains are relatively treeless consisting of rolling hills and grasslands. This is an arid region with rainfall between 38 and 43 cm [15 and 17 in] annually (Bryce, et al., 1996). The natural mixed-grass prairies of the region include shortgrass species such as buffalograss, western wheatgrass, bluebunch wheatgrass, needle-and-thread grass, blue grama, and Sandberg bluegrass. In this ecoregion the sagebrush component found is the neighboring Sagebrush Steppe (Chapman, et al., 2004).

The Powder River Basin and Pine Scoria Hills ecoregions are discussed in Section 3.3.5.1.

The White River Badlands in Nebraska border the northern edges of the Pine Ridge Escarpment and are southern outliers of a more extensive area in South Dakota. The landscape is broken by grass-covered, perched "sod tables" that may be grazed or tilled typical native vegetation found in this region consists of silver sagebrush, western wheatgrass saltbush, and rabbitbrush (Chapman, et al., 2001).

Western High Plains

The Pine Ridge Escarpment forms the boundary between the Missouri Plateau to the north and the High Plains to the south. This escarpment consists of a ponderosa pine woodland composed of Rocky Mountain juniper, western soapberry (*Sapindus drummondii*), skunkbush sumac, choke cherry (*Prunus virginiana*), and Arkansas rose (*Rosa arkansana).* The vegetation found in the mixed-grass prairies of the region consist of little bluestem, western wheatgrass,

reed grass (*Phalaris* spp.), needle-and-thread grass, blue grama, and threadleaf sedges (*Carex filifolia*) in moist areas (Chapman, et al., 2001).

The Pine Bluffs and Hills ecoregion is discussed in Section 3.3.5.1.

The Sandy and Silty Tablelands ecoregion is discussed in Section 3.3.5.1.

The Flat to Rolling Cropland ecoregion has extensive drylands farming, irrigated crops, and rangelands throughout this region. Winter wheat, grain sorgum, corn, and alfalfa are the main cash crops, with smaller acreages in forage crops consisting of grain (Chapman, et al., 2001).

The Dense Clay Prairie differs from the surrounding ecoregions in its relative lack of vegetative cover. The grassland in this ecoregion is missing its short- and midlevel layers; however, it does include tall grasses composed mostly of western wheatgrass. Little to no woodlands are found along waterways (Bryce, et al., 1996).

Nebraska Sand Hills Ecoregions

The Nebraska Sand Hills consist of one of the most distinct and homogeneous ecoregions in North America. With one of the largest areas of grass-stabilized sand dunes in the world, this region is generally devoid of cropland agriculture, and except for some riparian areas in the north and east, the region is treeless. Numerous lakes and wetlands dot the region, and parts of the region are without streams (Chapman, et al., 2001).

The Sand Hills include grass stabilized sand dunes and open sand areas. Dune size, pattern, and alignment generally follow a west-to-east trending axis, with the larger dune hills in the west having local relief as great as about 120 m [400 ft]. Grasses found in the area consist of prairie sandreed (*Calamovilfa longifolia*), little bluestem, sand bluestem (*Andropogon hallii*), switchgrass (*Panicum virgatum*), sand love grass (*Eragrostis trichodes*), needle-and-thread grass, blue grama, and hairy grama (*Bouteloua hirsuta*) (Chapman, et al., 2001).

The Alkaline Lakes Area is dominated by sand dunes and many scattered alkaline lakes. These lakes are located in what is commonly referred to as the "closed basin area." This area is generally devoid of streams. The high alkalinity around lakes restricts wetland vegetation growth with the exception of alkaline tolerant species such as certain alkaline bulrush (*Schoenoplectus maritimus)*, alkali sacaton (*Sporobolus airoides*), and inland saltgrass (*Distichlis stricta*). Grass species found in the region are similar to those found in the Sand Hills region and consist of prairie sandreed, little bluestem, sand bluestem, switchgrass, sand love grass, needle-and-thread grass, blue grama, and hairy grama (Chapman, et al., 2001).

Nebraska-South Dakota-Wyoming Uranium Milling Region Fauna

Animal species that may occur in the Middle/Southern Rockies which include the Black Hills, the Northwest Great Plains/Northern short grasslands, and Western High Plains/Western Short Grasslands have been discussed in the Wyoming East Uranium Milling Region (Section 3.3.5.1). According to the Wyoming Game and Fish Department, crucial wintering habitats are found with this region for large game animals and nesting leks for the sage-grouse. Figures 3.4-12 to 3.4-18 depict the crucial winters, yearlong areas ranges for large game found in this region. Within this region the Northern Black Hills Uranium District, located in the northeastern portion of the region, is near the crucial winter/yearlong area for white-tailed deer.

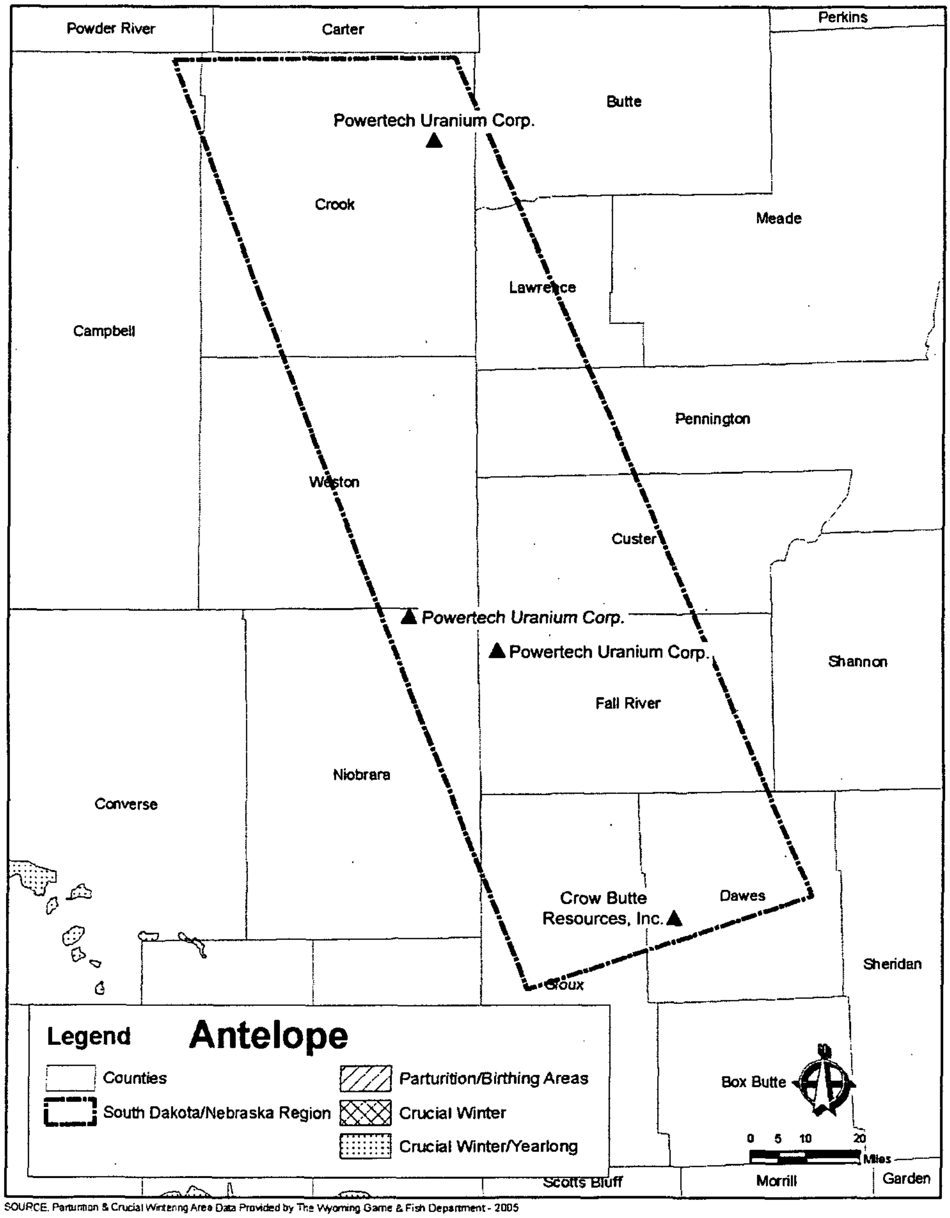


Figure 3.4-12. Antelope Wintering Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region

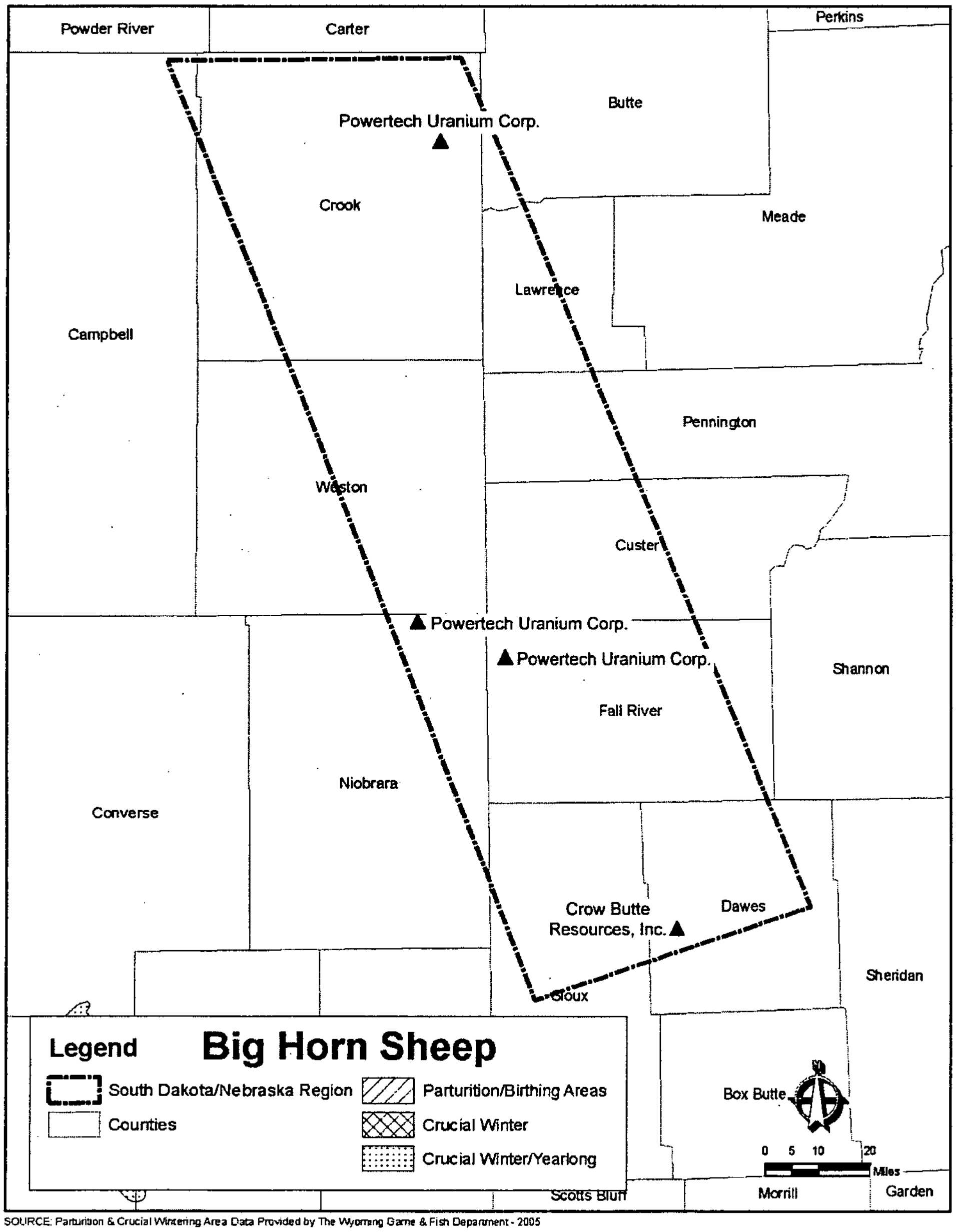


Figure 3.4-13. Big Horn Wintering Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region

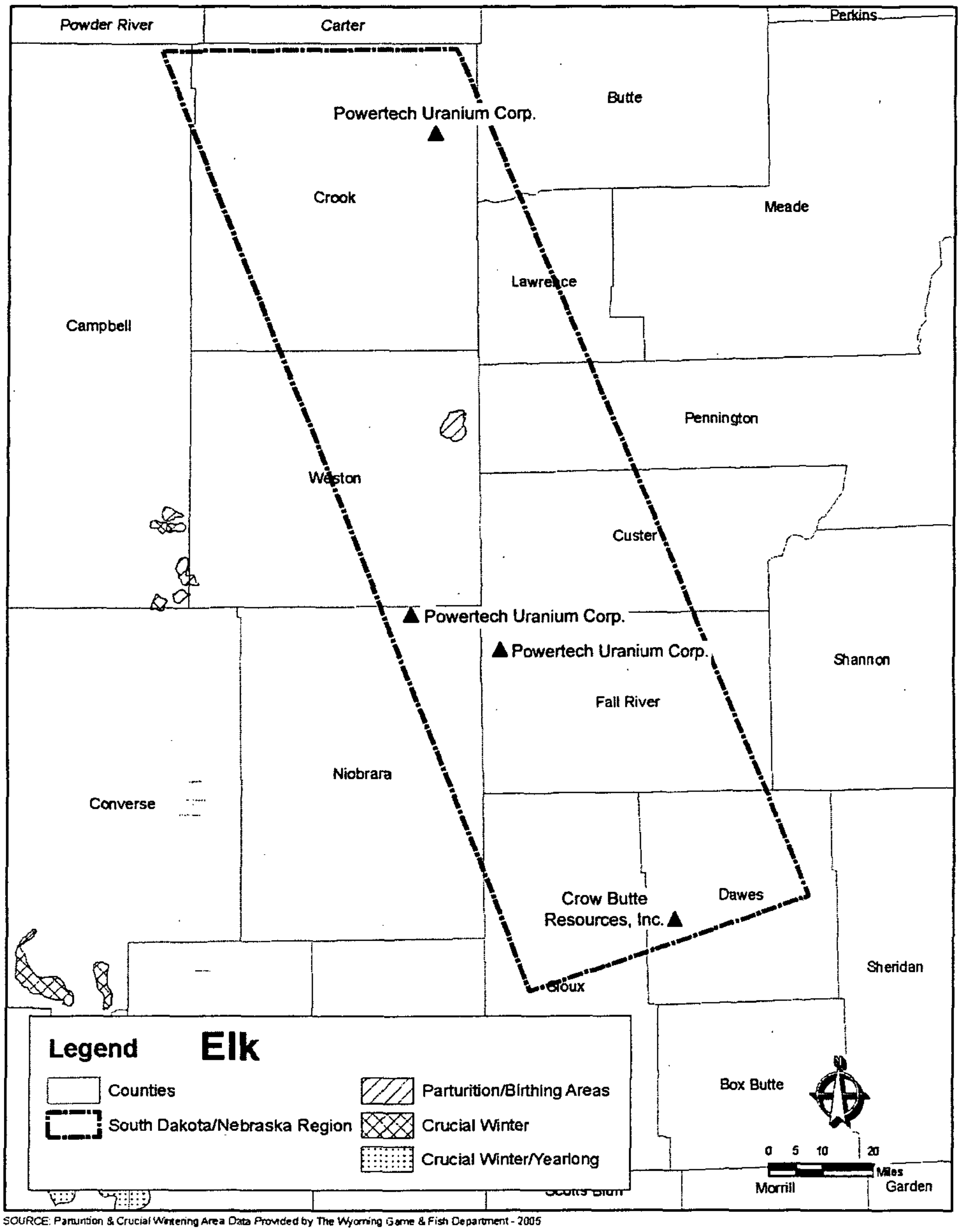
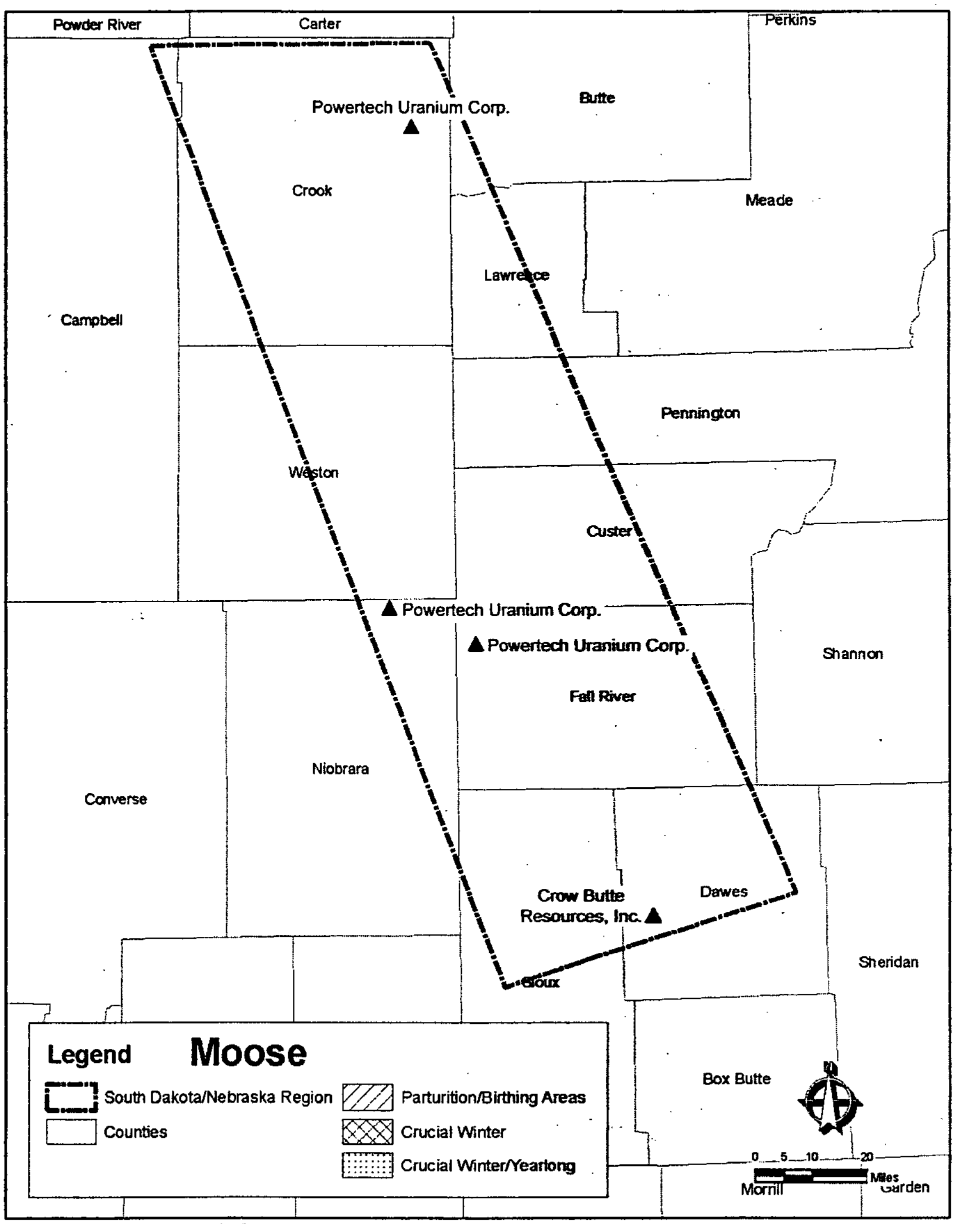
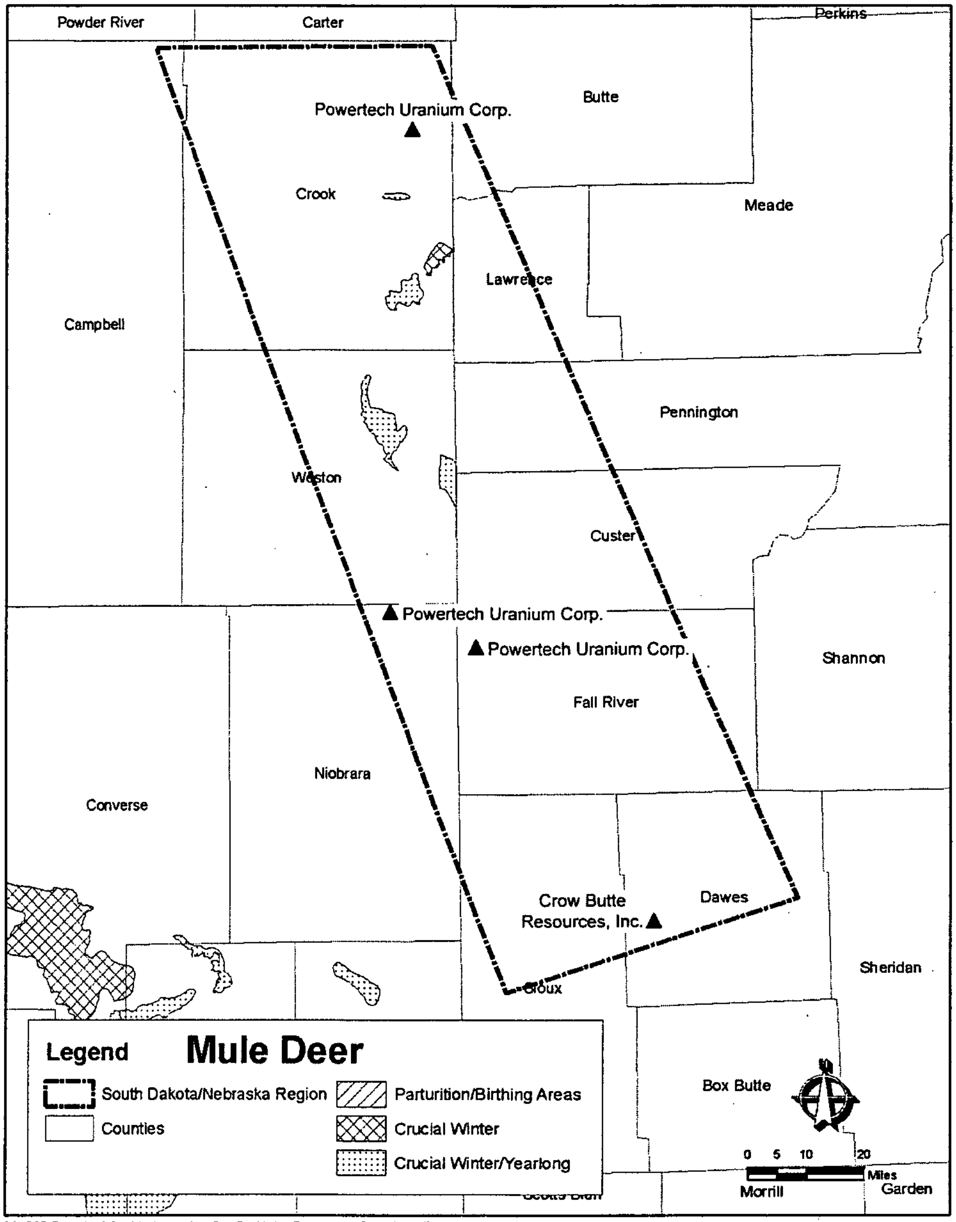


Figure 3.4-14. Elk Wintering Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.4-15. Moose Wintering Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.4-16. Mule Deer Wintering Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region

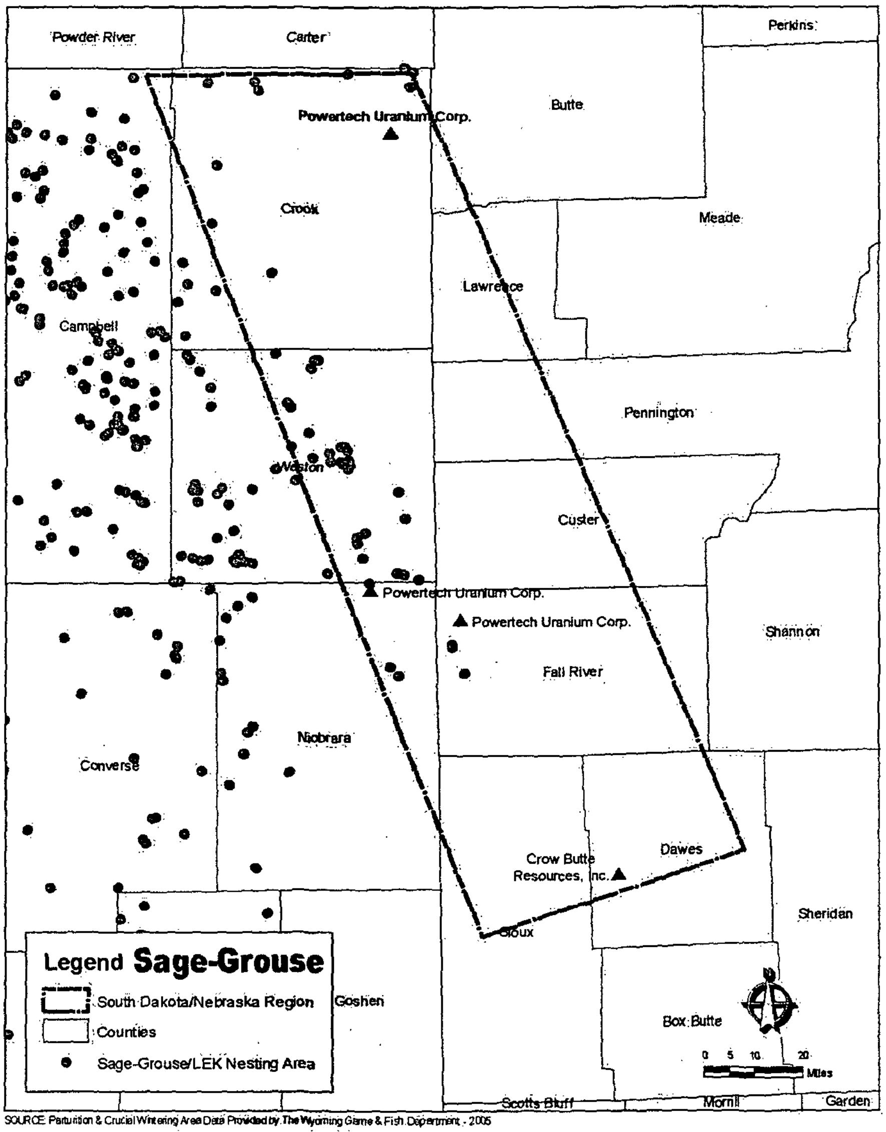
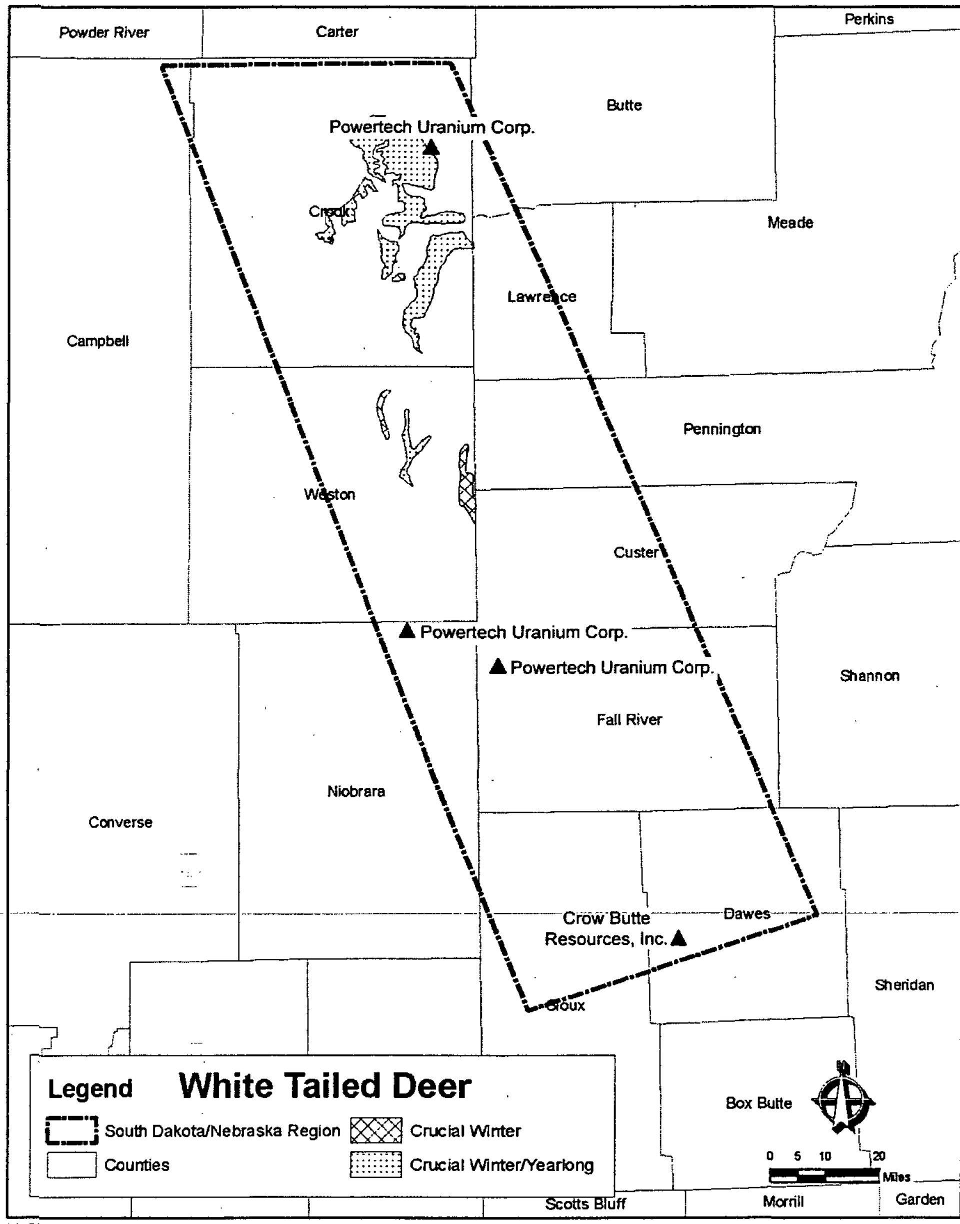


Figure 3.4-17. Sage-Grouse/Lek Nesting Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region



SOURCE: Parturition & Crucial Wintering Area Data Provided by The Wyoming Game & Fish Department - 2005

Figure 3.4-18. White Tailed Deer Wintering Areas for the Nebraska-South Dakota-Wyoming Uranium Milling Region

Sage-grouse leks appear to be located on the western side of the Nebraska-South Dakota-Wyoming Uranium Milling Region in the vicinity of the Southern Black Hills Uranium District.

A comprehensive listing of habitat types and species that have been surveyed within South Dakota are compiled as part of the South Dakota Gap Analysis Project (South Dakota State University, 2007).

According to the Nebraska Game and Parks Commission, Nebraska has approximately 400 bird species, 95 mammal species, and more than 60 reptile and amphibian species.

A comprehensive listing of habitat types and species that have been surveyed within Nebraska are compiled as part of the Gap Analysis Project (University of Nebraska, 2007).

3.4.5.2 Aquatic

Wyoming

As previously discussed, there are approximately 49 native fish species found in the watersheds throughout the state of Wyoming. These species are identified in Table 3.2-5. Current conditions of these watersheds found within the Nebraska-South Dakota-Wyoming Uranium Milling Region have been evaluated, and fish species that would benefit from conservation measures within these watersheds have been identified. These watersheds include the Little Missouri and the Cheyenne River Watersheds.

The Little Missouri Watershed is composed of numerous creeks such as Prairie and Cottonwood Creeks and the north fork of the Little Missouri River. This watershed is located in the northwestern portion of the Nebraska-South Dakota-Wyoming Uranium Milling Region in the vicinity of the Northern Black Hills Uranium District. The game fish habitat in the watershed is restricted to reservoirs and the streamflow in the Little Missouri River. Limiting conditions include small stream size, periods of low flow, high turbidity and sedimentation. Game fish species found in the watershed include brook trout, black bullhead, channel catfish, large mouth bass, rainbow trout, small mouth bass, and stonecat. Nongame species include brassy minnow, flathead chub, fathead minnow, goldeye, green sunfish, lake chub, longnose dace, shorthead redhorse, sand sucker, western silvery minnow, and white sucker (Wyoming Game and Fish Department, 2007).

The Cheyenne River Watershed is composed of the Lower Cheyenne River, Upper Cheyenne River, Bear Creek, Upper and Lower Antelope Creek, Little Thunder Creek, Black Thunder, and the Lodgepole Creek. This watershed is located in the central western portion of the Nebraska-South Dakota-Wyoming Uranium Milling Region in the vicinity of the Southern Black Hills Uranium District. The Cheyenne River is a free-flowing prairie stream until it reaches the Angostura reservoir in South Dakota. Most of the tributaries are intermittent with some perennial stream segments. Most game species are limited to small reservoirs and impoundments. Species found in the watershed include game fish such as the black bull head and channel catfish and nongame fish such as the carp, fathead minnow, green sunfish, longnose dace longnose sucker, plains killi fish, river carpsucker (*Carpiodes carpio*), sand shiner, and white sucker (Wyoming Game and Fish Department, 2007).

South Dakota

The major watersheds in South Dakota include the Red Water, Beaver, Middle Cheyenne-Spring, Rapid Creek, Angostura Reservoir Watershed, which includes the Cheyenne River. The list of fishes present in South Dakota is summarized in Table 3.4-5.

The South Dakota Division of Wildlife (2004) indicates that the Angostura Reservoir Watershed has an area of approximately 23,570 km^2 [9,100 mi^2]. Primary game fish in the watershed include walleye, channel catfish, smallmouth bass (*Micropterus dolomieu*), gizzard shad

Table 3.4-5. Fishes of the Angostura Reservoir, Cheyenne River Watershed*

Common Name	Scientific Name
American Eel	*Anguilla rostrata*
Banded Killifish	*Fundulus diaphanus*
Bighead Carp	*Aristichthys nobilis*
Bigmouth Buffalo	*Ictiobus cyprinellus*
Bigmouth Shiner	*Notropis dorsalis*
Black Buffalo	*Ictiobus niger*
Black Bullhead	*Ameiurus melas*
Black Crappie	*Pomoxis nigromaculatus*
Blackchin Shiner	*Notropis hederdon*
Blacknose Dace	*Rhinichthys atratulus*
Blacknose Shiner	*Notropis hedrolepis*
Blackside Darter	*Percina maculata*
Blackspot Shiner	*Notropis atrocaudalis*
Blue Catfish	*Ictalurus furcatus*
Blue Sucker	*Cycleptus elongatus*
Bluegill	*Lepomis macrochirus*
Bluegill/Green Sunfish Hybrid	*Lepomis macrochirus x L. cyanellus*
Bluntnose Minnow	*Pimephales notatus*
Bowfin	*Amia calva*
Brassy Minnow	*Hybognathus hankinsoni*
Brook Silverside	*Labidesthes sicculus*
Brook Stickleback	*Culaea inconstans*
Brook Trout	*Salvelinus fontinalis*
Brown Bullhead	*Ameiurus nebulosus*
Brown Trout	*Salmo trutta*
Bullhead Minnow	*Pimephales vigilax*
Burbot	*Lota lota*
Central Mudminnow	*Umbri limi*
Central Stoneroller	*Campostoma anomalum*
Channel Catfish	*Ictalurus punctatus*
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Common Carp	*Cyprinus carpio*
Common Shiner	*Luxilus cornutus*
Creek Chub	*Semotilus atromaculatus*
Cutthroat Trout	*Oncorhynchus clarki*
Emerald Shiner	*Notropis atherinoides Rafinesque*

Table 3.4-5. Fishes of the Angostura Reservoir, Cheyenne River Watershed* (continued)

Common Name	Scientific Name
European Rudd	*Scardinius erythrophthalmus*
Fathead Minnow	*Pimephales promelas*
Finescale Dace	*Phoxinus neogaeus Cope*
Flathead Catfish	*Pylodictis olivaris*
Flathead Chub	*Platygobio gracilis*
Freshwater Drum	*Aplodinotus grunniens Rafinesque*
Gizzard Shad	*Dorosoma cepedianum*
Golden Redhorse	*Moxostoma erythrurum*
Golden Shiner	*Notemigonus crysoleucas*
Goldeye	*Hiodon alosoides*
Grass Carp	*Ctenopharyngodon idella*
Greater Redhorse	*Moxostoma valenciennesi*
Green Sunfish	*Lepomis cyanellus*
Hornyhead Chub	*Nocomis biguttatus*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
Kokanee Salmon	*Oncorhynchus nerka*
Lake Chub	*Couesius plumeus*
Lake Herring	*Coregonus artedi*
Lake Sturgeon	*Acipenser flavescens Rafinwsque*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Largemouth Bass	*Micropterus salmoides*
Logperch	*Percina caprodes*
Longnose Dace	*Rhinichthys cataractae*
Longnose Gar	*Lepisosteus osseus*
Longnose Sucker	*Catostomus catostomus*
Mississippi Silvery Minnow	*Hybognathus nuchalis*
Mooneye	*Hiodon tergisus Lesueur*
Mottled Sculpin	*Cottus bairdi*
Mountain Sucker	*Catostomus platyrhynchus*
Muskellunge	*Esox masquinongy*
Northern Hog Sucker	*Hypentelium nigricans*
Northern Pike	*Esox lucius*
Northern Redbelly Dace	*Phoxinus eos*
Orangespotted Sunfish	*Lepomis humilis*
Paddlefish	*Polyodon spathula*
Pallid Sturgeon	*Scaphirhynchus albus*
Pearl Dace	*Margariscus margarita Cope*
Plains Killifish	*Fundulus zebrinus*
Plains Minnow	*Hybognathus placitus*
Plains Topminnow	*Fundulus sciadicus*
Pugnose Shiner	*Notropis anogenus*
Pumpkinseed	*Lepomis gibbosus*
Quillback	*Carpiodes cyprinus*
Rainbow Smelt	*Osmerus mordax*

Table 3.4-5. Fishes of the Angostura Reservoir, Cheyenne River Watershed* (continued)	
Common Name	**Scientific Name**
Rainbow Trout	*Oncorhynchus mykiss*
Red Shiner	*Cyprinella lutrensis*
Redear Sunfish	*Lepomis microlophus*
Ribbon Shiner	*Lythrurus Fumeus*
River Carpsucker	*Carpiodes carpio*
River Darter	*Percina shumardi*
River Shiner	*Notropis blennius*
Rock Bass	*Ambloplites rupestris*
Rosyface Shiner	*Notropis rubellus*
Sand Shiner	*Notropis stramineus*
Sauger	*Stizostedion canadense*
Saugeye	*Stizostedion vitreum x S. canadense*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Shortnose Gar	*Lepisosteus platostomus*
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*
Sicklefin Chub	*Macrhybopsis meeki*
Silver Chub	*Macrhybopsis storeriana*
Silver Lamprey	*Ichthyomyzon unicuspis*
Silverband Shiner	*Notropis shumardi*
Skipjack Herring	*Alosa chrysochloris*
Slender Madtom	*Noturus exilis Nelson*
Slenderhead Darter	*Percina phoxocehpala*
Smallmouth Bass	*Micropterus dolomieu*
Smallmouth Buffalo	*Ictiobus bubalus*
Spotfin Shiner	*Cyprinella spiloptera*
Spottail Shiner	*Notropis hudsonius*
Stonecat	*Noturus flavus*
Sturgeon Chub	*Macrhybopsis gelida*
Suckermouth Minnow	*Phenacobius mirabilis*
Tadpole Madtom	*Noturus gyrinus*
Threadfin Shad	*Dorosoma petenense*
Tiger Muskie	*Esox lucius X E. masquinongy*
Topeka Shiner	*Notropis topeka*
Trout-perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum*
Western Silvery Minnow	*Hybognathus argyritis*
White Bass	*Morone chrysops*
White Crappie	*Pomoxis annularis*
White Perch	*Morone americana*
White Sucker	*Catostomus commersoni*
Wiper (hybrid)	*Morone saxatilis*
Yellow Bullhead	*Ameiurus natalis*
Yellow Perch	*Perca flavescens*

*South Dakota Department of Game, Fish, and Parks. "Fishing in South Dakota." Pierce, South Dakota: South Dakota Game, Fish, and Parks. 2008. <www.sdgfp.info/Wildlife/fishing> (15 February 2008).

(*Dorosoma cepedianum*), largemouth bass, black crappie, and emerald shiner (*Notropis atherinoides*). (South Dakota Game ,Fish, and Parks, 2008)

The Cheyenne River originates in eastern Wyoming flowing on the south side of the Black Hills Uplift in the vicinity of the Southern Black Hills Uranium District. The Cheyenne River Watershed Assessment study area is approximately 4,690 km^2 [1,811 mi^2] in Pennington, Custer, and Fall River Counties in South Dakota. Approximately 45 fish species can be found in the Cheyenne River (South Dakota Game and Fish, 2008).

Nebraska

The White River-Hat Creek Basin is located in northwestern Nebraska above the Niobrara River basin north of the Crow Butte Uranium District. This basin originates in Nebraska and drains in the northeast to the confluence with the Missouri River (White River) and the Cheyenne River (Hat Creek) in South Dakota. The basin encompasses approximately 5,450 km^2 [2,130 mi^2]. Key aquatic species identified in the basin are the brown trout, rainbow trout, and channel catfish (Nebraska Department of Environmental Quality, 2005a).

The Niobrara River Basin located in the vicinity of the Crow Butte Uranium District in northwestern and north-central Nebraska originates in eastern Wyoming. The watershed covers approximately 30,745 km^2 [11,870 mi^2] and has approximately 4,054 km [2,519 mi] of streams. The basin also has watersheds that originate in South Dakota. Streamflow in the basin is a function of surface runoff and groundwater contributions. Major tributaries to the watershed include Ponca Creek, Verdigre Creek, Keya Paha River, Long Pine Creek, Plum Creek, Snake River, and Minnechaduza Creek (Nebraska Department of Environmental Quality, 2005b). Fish species found in the Niobrara Watershed region are listed in Table 3.4-6.

Table 3.4-6. Fishes of the Niobrara River Watershed*

Common Name	Scientific Name
Black Crappie	*Pomoxis nigromaculatus*
Blacknose Shiner	*Notropis hedrolepis*
Blue Catfish	*Ictalurus furcatus*
Bluegill	*Lepomis macrochirus*
Brook Stickleback	*Culaea inconstans*
Brook Trout	*Salvelinus fontinalis*
Brown Trout	*Salmo trutta*
Channel Catfish	*Ictalurus punctatus*
Common Shiner	*Luxilus cornutus*
Finescale Dace	*Phoxinus neogaeus Cope*
Flathead Catfish	*Pylodictis olivaris*
Golden Shiner	*Notemigonus crysoleucas*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
Lake Chub	*Couesius plumeus*
Lake Sturgeon	*Acipenser flavescens Rafinwsque*
Largemouth Bass	*Micropterus salmoides*
Muskellunge	*Esox masquinongy*
Northern Pike	*Esox lucius*
Northern Redbelly Dace	*Phoxinus eos*

Table 3.4-6. Fishes of the Niobrara River Watershed* (continued)	
Common Name	**Scientific Name**
Orange Throat Darter	*Etheostoma spectabile*
Paddlefish	*Polyodon spathula*
Pallid Sturgeon	*Scaphirhynchus albus*
Pearl Dace	*Margariscus margarita Cope*
Pumpkinseed	*Lepomis gibbosus*
Rainbow Trout	*Oncorhynchus mykiss*
Redear Sunfish	*Lepomis microlophus*
Rock Bass	*Ambloplites rupestris*
Sauger	*Stizostedion canadense*
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*
Smallmouth Bass	*Micropterus dolomieu*
Spotted Bass	*Micropterus punctulatus*
Striped Bass	*Morone saxatilis*
Sturgeon Chub	*Macrhybopsis gelida*
Topeka Shiner	*Notropis topeka*
Walleye	*Stizostedion vitreum*
White Bass	*Morone chrysops*
White Crappie	*Pomoxis annularis*
Yellow Perch	*Perca flavescens*
*Nebraska Department of Environmental Quality. "Total Maximum Daily Loads for the Niobrara River Basin." Lincoln, Nebraska: Nebraska Department of Environmental Quality. December 2005.	

3.4.5.3 Threatened and Endangered Species

Federally listed threatened and endangered species that are known to exist within habitats found within the region include the following:

- Black-Footed Ferret—discussed in Section 3.2.5.3
- Blowout Penstemon—discussed in Section 3.2.5.3
- Interior Least Tern—discussed in Section 3.2.5.3
- Piping Plover—discussed in Section 3.2.5.3
- Pallid Sturgeon—discussed in Section 3.2.5.3
- Ute Ladies' Tresses Orchid—discussed in Section 3.2.5.3
- Western Praire Fringed Orchid—discussed in Section 3.2.5.3
- Whooping Crane—discussed in Section 3.2.5.3

State-listed threaten and endangered species for South Dakota, Nebraska, and special Status 1 and 2 species of concern for Wyoming that occur within the region include the following.

South Dakota

- American Dipper (*Cinclus mexicanus*), State Threatened—This bird is found in the cold, fast streams in the Black Hills. American dippers feed on insects found on stream bottoms, swimming underwater to depths of up to 6 m [20 ft] and even walking on the stream bed. Often nests on the underside of bridges over mountain streams (South Dakota Birds and Birding, 2008).

- Osprey (*Pandion haliaetus*), State Threatened—Osprey habitat includes lakes, large rivers and coastal bays. A reversible front toe and spiny nodules under its toes (spicules) to aid in grasping fish captured by plunge-diving feet first. Ospreys nest at the tops of large living or dead trees, on cliffs, on utility poles, or on other tall manmade structures. Clutch size ranges from two to four eggs with hatching in about 30 days. Young fly at 44–59 days and are dependent on parents for 6–12 weeks. This species has a worldwide distribution. In North America, the osprey breeds from northern Saskatchewan, Labrador, and Newfoundland in Canada, to the Great Lakes states and along the Pacific and Atlantic coasts. In South Dakota, it is a historical nester in the southeastern part of the state and an uncommon migrant. Many summer observations and the first modern (1991) successful osprey nest in the state raise hopes for the future of this species in South Dakota (U.S. Geological Survey, 2008b).

- Swift Fox State (*Vulpes velox*), Threatened—discussed in Section 3.3.5.3

- Finescale Dace (*Phoxinus neogaeus*) State Threatened—The finescale dace ranges widely but populations existing in Wyoming and Nebraska are considered glacial relics. Commonly occurs in the Niobrara River and several sites in Crook County where they are native to the North Fork Cow Creek in the Cheyenne River drainage. Typically occur in cool, boggy lakes and sluggish acidic streams. They are commonly found in lakes and ponds and are often associated with beaver ponds. Considered to be widespread, abundant, and globally secure but are considered threatened in South Dakota and of special concern in North Dakota, Nebraska, and Wyoming. Distribution is believed to be stable at drainage or subdrainage scale but is declining on the site and stream scale (Wyoming Game and Fish Department, 2008).

- Longnose Sucker *Catostomus catostomus)*, State Threatened—The longnose sucker is found in cool, spring-fed creeks where it feeds on the bottom on algae, crustaceans, snails, and insect larvae (caddisflies, mayflies, midges). It spawns in lakes or in shallow-flowing streams over gravel, where fry remain until 1–2 weeks old. Longnose suckers do not sexually mature until 4–9 years of age. The longnose is the most widespread sucker species in North America. It is found in Canada and Alaska, south from western Maryland, north to Minnesota, west and north through northern Colorado and through Washington. South Dakota populations are on the edge of its range and are found in the Belle Fourche River drainage north of the Black Hills (U.S. Geological Survey, 2008b).

- Bald Eagle (*Haliaeetus leucocephalus*), State Threatened—discussed in Section 3.2.5.3

- Piping Plover (*Charadrius melodus)*, State Threatened—The piping plover is present on breeding grounds from late March through August. It nests on sandbars and sand and gravel beaches with short, sparse vegetation along inland lakes; on natural and dredge islands in rivers; in gravel pits along rivers; and on salt-encrusted bare areas of sand, gravel or pebbly mud on interior alkali ponds and lakes. Nests are shallow, scraped depressions, occasionally lined with small pebbles, shells, or other material. A clutch of four eggs is usually laid in late May or early June, with hatching in 27–31 days. Both eggs and young are tended by both parents. Piping plovers feed along the water's edge on small insects, crustaceans, and mollusks. In South Dakota, the piping plover is a common breeding associate of the endangered interior least tern. Three North American breeding populations of piping plovers are recognized and have the following distributions: the Atlantic Coast from Newfoundland to Virginia; the Great Lakes,

excluding the rocky north shores of Lakes Superior and Huron; and the northern Great Plains. The greatest number of piping plovers breed in the northern Great Plains. This breeding population occurs in scattered alkaline wetlands of the northern Great Plains and on the Missouri River and its tributaries in the Dakotas and Nebraska. In South Dakota, nesting occurs primarily on the natural stretches of the Missouri River below the Gavins Point and Fort Randall Dams, although some nesting may occur on tributaries. Piping plovers have also been reported from Bitter and Waubay Lakes in Day County and Horseshoe Lake in Codington County in northeastern South Dakota. This species overwinters along the Atlantic coast from North Carolina to Florida, along the Gulf coast, and in the Bahamas and West Indies (U.S. Geological Survey, 2008b).

- Northern River Otter *(Lontra Canadensis)*, State Threatened—The river otter is found in rivers, ponds, lakes and unpolluted waters in wooded areas. Key habitat components are riparian vegetation, temporary den and resting sites (cavities under tree roots, shrub patches, tall grass) and adequate food. It is active all year, mainly at night. Air trapped in the fur insulates the river otter while underwater, where it can stay for up to 4 minutes. Long, stiff whiskers to locate prey and good underwater vision aid in hunting success. The river otter is sexually mature at 2 years, breeding in early spring. The female has two–three pups (range one–six) in a secluded natal den site. Young leave the den at 2 months, are weaned by 3 months, but remain with the female until just prior to the birth of the mother's next litter. It occupies dens built by other animals, log jams and unused human structures. River otters primarily eat fish. Other aquatic foods include frogs, crayfish, and turtles, making the river otter a good barometer of water quality. The river otter is distributed throughout North America north of Mexico, except for the extreme southwestern United States. In South Dakota, it has been reported from Hughes County along the Missouri River, with unverified reports from adjacent counties.

In addition to federal- and state-listed species, South Dakota's Natural Heritage Program has identified species of greatest conservation need. South Dakota's Natural Heritage Program issued conservation modifiers for each species, which are defined as follows:

- G1 S1—Critically imperiled because of extreme rarity (five or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

- G2 S2—Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

- G3 S3—Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences.

- G4 S4—Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long-term concern.

- G5 S5—Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.

- GU SU—Possibly in peril, but status uncertain; more information needed.

- GH SH—Historically known, may be rediscovered.
- GX SX—Believed extinct, historical records only.
- T—Rank of subspecies or variety.
- Q—Taxonomic status is questionable, rank may change with taxonomy.
- SZ—No definable occurrences for conservation purposes, usually assigned to migrants.
- SP—Potential exists for occurrence in the state, but no occurrences.
- SR—Element reported for the state, but no persuasive documentation.
- SA—Accidental or casual.

Subspecies are listed in some cases if the populations are disjunct and may be genetically unique. In addition to being important components of the ecosystems, subspecies can be federally listed if the U.S. Fish and Wildlife Service determines there is justification.

Species of greatest conservation need listed for South Dakota's Comprehensive Management Plan are identified as

- Birds
  - American white pelican (*Pelecanus erythrorhynchos*), G3, S3B, SZN
  - Trumpeter swan (*Cygnus buccinators*), G4, S3
  - Osprey (*Pandion haliaetus*), G5, S1B, SZN
  - Bald eagle (*Haliaeetus leucocephalus*), G4, S1B, S2N
  - Northern goshawk (*Accipiter gentilis*), G5, S3B, S2N
  - Ferruginous hawk (*Buteo regalis*), G4, S4B, SZN
  - Peregrine falcon (*Falco peregrinus*), G4, SXB, SZN
  - Greater sage-grouse (*Centrocercus urophasianus*), G4, S2
  - Greater prairie-chicken (*Tympanuchus cupido*), G4, S4
  - Whooping crane (*Grus americana*), G1, SZN
  - Piping plover (*Charadrius melodus*), G3, S2B, SZN
  - Willet (*Catoptrophorus semipalmatus*), G5, S5
  - Long-billed curlew (*Numenius americanus*), G5, S3B, SZN
  - Marbled godwit (*Limosa fedoa*), G5, S5
  - Wilson's phalarope (*Phalaropus tricolor*), G5, S4
  - Interior least tern (*Sterna antillarum athalassos*), G4, T2Q, S2B, SZN
  - Black tern (*Chlidonias niger*), G4, S3B, SZN
  - Burrowing owl (*Athene cunicularia*), G4, S3S4B, SZN
  - Lewis's woodpecker (*Melanerpes lewis*), G4, S3B,S3N
  - American three-toed woodpecker (*Picoides dorsalis*), G5, S2
  - Black-backed woodpecker (*Picoides arcticus*), G5, S3
  - American dipper (*Cinclus mexicanus*) G5, S2
  - Sprague's pipit (*Anthus spragueii*), G4, S2B, SZN
  - Lark bunting (*Calamospiza melanocorys*), G5, S5
  - Baird's sparrow (*Ammodramus bairdii*), G4 S2B, SZN

- — Le Conte's sparrow (*Ammodramus leconteii*), G4, S1S2B, SZN
- — White-winged junco (*Junco hyemalis aikeni*), G5T4, S5
- — Chestnut-collared longspur *(Calcarius ornatus)*, G5, S4

- Mammals
  - — Fringe-tailed myotis *(Myotis thysanodes pahasapensis)*, G4G5T2, S2
  - — Northern myotis *(Myotis septentrionalis)*, G4 S3
  - — Townsend's big-eared bat *(Corynorhinus townsendii)*, G4, S2S3
  - — Franklin's ground squirrel *(Spermophilus franklinii)*, G5, S5
  - — Richardson's ground squirrel *(Spermophilus richardsonii)*, G5, S5
  - — Northern flying squirrel *(Glaucomys sabrinus)*, G5, S2
  - — Bear lodge meadow jumping mouse *(Zapus hudsonius campestris)*, G5T3, not ranked
  - — Kit or swift fox *(Vulpes velox)*, G3, S1
  - — Black-footed ferret *(Mustela nigripes)*, G1, S1
  - — Northern river otter *(Lontra Canadensis)*, G5, S2

- Freshwater Mussels
  - — Elktoe *(Alasmidonta marginata)*, G4, S1
  - — Rock pocketbook *(Arcidens confragosus)*, G4, S1
  - — Creek heelsplitter *(Lasmigona compressa)*, G5, S1
  - — Higgins eye *(Lampsilis higginsii)*, G1, S1
  - — Scaleshell *(Leptodea leptodon)*, G1, S1
  - — Hickorynut *(Obovaria olivaria)*, G4, S1
  - — Mapleleaf *(Quadrula quadrula)*, G5, S2

- Gastropods
  - — Dakota vertigo *(Vertigo arthuri)*, G2, S2
  - — Mystery vertigo *(Vertigo paradoxa)*, G2G4, S1
  - — Frigid ambersnail *(Catinella gelida)*, G2, S1
  - — Cooper's Rocky Mountain snail *(Oreohelix strigosa cooperi)*, G5T1, S2

- Insects
  - — Ghost tiger beetle *(Cicindela lepida)*, G4, S1
  - — Great Plains tiger beetle *(Amblycheila cylindriformis)*, G5, S1
  - — American burying beetle *(Nicrophorus americanus)*, G2G3, S1
  - — Powesheik skipperling *(Oarisma powesheik)*, G2, S2
  - — Ottoe skipper *(Hesperia ottoe)*, G3G4, S2
  - — Dakota skipper *(Hesperia dacotae)*, G2G3, S2
  - — Iowa skipper *(Atrytone arogos iowa)*, G3G4T3T4, S2
  - — Regal fritillary *(Speyeria idalia)*, G3, S3
  - — Black Hills fritillary *(Speyeria atlantis pahasapa)*, G5T3, S3

- Fishes
  - — Banded killifish *(Fundulus diaphanous)*, G5, S1
  - — Blacknose shiner *(Notropis heterolepis)*, G5, S1
  - — Central mudminnow *(Umbra limi)*, G5, S1
  - — Finescale dace *(Phoxinus neogaeus)*, G5, S1
  - — Longnose sucker *(Catostomus catostomus)*, G5, S1
  - — Northern redbelly dace *(Phoxinus eos)*, G5, S2

- — Pallid sturgeon *(Scaphirhynchus albus),* G1G2, S1
- — Paddlefish *(Polyodon spathula),* G4, S4
- — Pearl dace *(Margariscus margarita),* G5, S2
- — Sicklefin chub *(Macrhybopsis meeki),* G3, S1
- — Sturgeon chub *(Macrhybopsis gelida),* G2, S2
- — Topeka shiner *(Notropis Topeka),* G3, S3
- — Trout-perch *(Percopsis omiscomaycus),* G5, S2
- — Lake chub *(Couesius plumbeus),* G5, S1
- — Mountain sucker *(Catostomus platyrhynchus),* G5, S3
- — Southern redbelly dace *(Phoxinus erythrogaster),* G5, S1
- — Hornyhead chub *(Nocomis biguttatus),* G5, S3
- — Rosyface shiner *(Notropis rubellus),* G5, S2
- — Logperch *(Percina caprodes),* G5, S3
- — Blackside darter *(Percina maculate),* G5, S2

- Reptiles and Amphibians
  - — Blanding's turtle *(Emys blandingii),* G4, S1
  - — False map turtle *(Graptemys pseudogeographica),* G5, S3
  - — Lined snake *(Tropidoclonion lineatum),* G5, S1
  - — Eastern hognose snake *(Heterodon platirhinos),* G5, S2
  - — Black Hills redbelly snake *(Storeria occipitomaculata pahasapae),* G5T3, S3
  - — Cope's gray treefrog *(Hyla chrysoscelis),* G5, S2
  - — Smooth softshell *(Apalone mutica),* G5, S2
  - — Western box turtle *(Terrapene ornate),* G5, S2
  - — Lesser earless lizard *(Holbrookia maculate),* G5, S2
  - — Northern cricket frog *(Acris crepitans),* G5, S1
  - — Many-lined skink *(Eumeces multivirgatus),* G5, S1
  - — Short-horned lizard *(Phrynosoma hernandesi),* G5, S2

Nebraska

- Finescale Dace, State Special Concern—discussed previously for South Dakota
- Swift Fox, State Endangered—discussed in Section 3.3.5.3
- Ute Ladies' Tresses Orchid, State Endangered—discussed in Section 3.2.5.3
- Whooping Crane State Endangered—discussed in Section 3.3.5.3

Wyoming

- Finescale Dace, Native Species Status 1—discussed previously for South Dakota

- Pearl Dace, Native Species Status 1—The pearl dace occurs in cool bogs, ponds, lakes, creeks, and clear streams. It spawns in the spring in clear water with a weak to moderate current over sand or gravel. This species feeds on invertebrates (insects and zooplankton) and algae (U.S. Geological Survey, 2008b).

- Western Silvery Minnow, Native Species Status 1—discussed in Section 3.2.5.3

- Canada Lynx (*Lynx canadensis*), Native Species Status 1—discussed in Section 3.2.5.3

- Plains Topminnow, Native Species Status 2— discussed in Section 3.2.5.3

- Goldeye, Native Species Status 2—In Wyoming, the goldeye can be found in the Powder, Little Powder and Little Missouri Rivers and in Clear and Crazy Woman Creeks. It prefers large rivers and their associated backwaters and marshes, or the shallow waters of large lakes and reservoirs. Young goldeye have never been found in Wyoming; it is thought that populations in the northeastern part of the state are maintained by the migration of adult fish seeking spawning grounds (Wyoming Game and Fish Department, 2008).

- Pale Milk Snake, Native Species Status 2—The pale milksnake prefers grasslands, sandhills, and scarp woodlands below 1,830 m [6,000 ft] in elevation. It is distributed throughout the northern Great Plains. In Wyoming, it can be found in the eastern counties and the Bighorn Basin (Wyoming Game and Fish Department, 2008).

- Smooth Green Snake (*Opheodrys vernalis*), Native Species Status 2—discussed in Section 3.2.5.3

- Yellow-Billed Cuckoo (*Coccyzus americanus*), Native Species Status 2—discussed in Section 3.2.5.3

- Greater Sage-Grouse, Native Species Status 2—discussed in Section 3.2.5.3

- Bald Eagle, Native Species Status 2—discussed in Section 3.2.5.3

- Trumpeter Swan Native, Species Status 2—discussed in Section 3.2.5.3

- Fringed Myotis (*Myotis thysanodes*), Native Species Status 2—discussed in Section 3.2.5.3

- Long-Eared Myotis (*Myotis evotis*), Native Species Status 2—discussed in Section 3.2.5.3

- Long-Legged Myotis (*Myotis volans*), Native Species Status 2—discussed in previous regions.

- Pallid Bat (*Antrozous pallidus*), Native Species Status 2—discussed in Section 3.2.5.3

- Spotted Bat (*Euderma maculatum*), Native Species Status 2—discussed in Section 3.2.5.3

- Townsend's Big-Eared Bat, Native Species Status 2—discussed in Section 3.2.5.3

3.4.6 Meteorology, Climatology, and Air Quality

3.4.6.1 Meteorology and Climatology

The Nebraska-South Dakota-Wyoming Uranium Milling Region contains portions of three states: Wyoming, Nebraska, and South Dakota. This region is characterized by hot summers and cold winters, and rapid temperature fluctuations are common. The Rocky Mountains have a great influence on the climate. As air crosses the Rockies from the west, much moisture is lost on the windward sides of the mountains and becomes warmer as it descends on the eastern slopes.

Table 3.4-7 identifies three climate stations located in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Climate data for these stations are found in the National Climatic Data Center's Climatography of the United States No. 20 Monthly Station Climate Summaries for 1971–2000 (National Climatic Data Center, 2004). This summary contains climate data for 4,273 stations throughout the United States and some territories. Table 3.4-8 contains temperature data for three stations in the Western Nebraska-South Dakota-Wyoming Uranium Milling Region.

Most precipitation in the Nebraska-South Dakota-Wyoming Uranium Milling Region occurs in the spring and summer. Rainstorms, hailstorms, and lighting are most likely to occur in the summer. Heavy rain can accompany thunderstorms and may cause some flooding. This flooding intensifies if these storms coincide with snow pack melting. Table 3.4-8 contains precipitation data for three stations in the Nebraska-South Dakota-Wyoming Uranium Milling Region. The wettest month varies for the stations identified in Table 3.4-8. May is the wettest month for the Newcastle (Weston County, Wyoming) and Ardmore (Fall River County, South Dakota) stations and June is the wettest month for the Colony (Crook County, Wyoming) station. Based on the snow depth data, the wettest months coincide with melting snow pack (National Climatic Data Center, 2004). Data from National Climatic Data Center's Storm Events Database from 1950 to 2007 indicate that the vast majority of thunderstorms in Crook, Weston, and Fall River Counties occurs between May and August with most occurring in July (National Climatic Data Center, 2007).

Table 3.4-7. Information on Three Climate Stations in the Nebraska-South Dakota-Wyoming Uranium Milling Region*

Station (Map Number)	County	State	Longitude	Latitude
Colony	Crook	Wyoming	104°11W	44°55N
Newcastle	Weston	Wyoming	104°13W	43°51N
Ardmore 2 N	Fall River	South Dakota	103°39W	43°03N

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.

Table 3.4-8. Climate Data for Stations in the Nebraska-South Dakota-Wyoming Uranium Milling Region*

		Colony	Newcastle	Ardmore 2 N
Temperature (°C)†	Mean—Annual	8.3	7.9	8.1
	Low—Monthly Mean	−5.3	−5.7	−6.0
	High—Monthly Mean	22.4	22.5	22.5
Precipitation (cm)‡	Mean—Annual	37.8	40.7	43.7
	Low—Monthly Mean	0.9	1.1	1.0
	High—Monthly Mean	6.8	6.5	7.3
Snowfall (cm)	Mean—Annual	93.2	95.5	105
	Low—Monthly Mean	0	0	0
	High—Monthly Mean	19.6	19.8	18.5

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.
†To convert Celsius (°C) to Fahrenheit (°F), multiply by 1.8 and add 32.
‡To convert centimeters (cm) to inches (in), multiply by 0.3937.

The mountains typically receive the most snow. Occasionally snow can accumulate to a considerable depth. During snow periods, there is often wind that may cause a large proportion to collect in gullies and behind windbreaks. Peak snowfall generally occurs in February and early March. Table 3.4-8 contains snowfall data for three stations in the Nebraska-South Dakota-Wyoming Uranium Milling Region.

The pan evaporation rates for the Western Nebraska-South Dakota-Wyoming Uranium Milling Region range from about 102–127 cm [40–50 in] (National Weather Service, 1982). Pan evaporation is a technique that measures the evaporation from a metal pan typically 121 cm [48 in] in diameter and 25 cm [10 in] tall. Pan evaporation rates can be used to estimate the evaporation rates of other bodies of water such as lakes or ponds. Pan evaporation rate data are typically available only from May to October. Freezing conditions often prevent collection of quality data during the other part of the year.

3.4.6.2 Air Quality

The air quality general description for the Western Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to the description in Section 3.2.6 for the Wyoming West Uranium Milling Region. The Nebraska-South Dakota-Wyoming Uranium Milling Region information in Section 3.4.6.2 is limited to the modification, supplementation, or summarization of the Wyoming West Uranium Milling Region information presented in Section 3.2.6.

As described in Section 1.7.2.2, the permitting process is the mechanism used to address air quality. If warranted, permits may set facility air pollutant emission levels, require mitigation measures, or require additional air quality analyses. The Nebraska-South Dakota-Wyoming Uranium Milling Region covers portions of Wyoming, South Dakota, and Nebraska. Except for Indian Country, New Source Review permits in these three states are regulated under the EPA-approved State Implementation Plan except for the Prevention of Significant Deterioration permits in South Dakota, which are regulated by 40 CFR 52.21 (EPA, 2007a). For Indian Country in these three states, the New Source Review permits are regulated under 40 CFR 52.21 (EPA, 2007a).

State implementation plans and permit conditions are based in part on federal regulations developed by the EPA. The NAAQS are federal standards that define acceptable ambient air concentrations for six common nonradiological air pollutants: nitrogen oxides, ozone, sulfur oxides, carbon monoxide, lead, and particulates. In June 2005, EPA revoked the 1-hour ozone standard nationwide in all locations except certain Early Action Compact Areas. None of the 1-hour ozone Early Action Compact Areas is in Wyoming, South Dakota, or Nebraska. States may develop standards that are stricter or supplement the NAAQS. Wyoming has a more restrictive annual average standard for sulfur dioxide at 60 $\mu g/m^3$ [1.6×10^{-6} oz/yd^3] and a supplemental 50 $\mu g/m^3$ [1.3×10^{-6} oz/yd^3] PM_{10} standard with an annual averaging time (Wyoming Department of Environmental Quality, 2006). Nebraska has a 50 $\mu g/m^3$ [1.3×10^{-6} oz/yd^3] PM_{10} standard with an annual averaging time (Nebraska Department of Environmental Quality, 2002). South Dakota standards implement NAAQS straightforward (South Dakota Department of Environment and Natural Resources, 2007).

Prevention of Significant Deterioration requirements identify maximum allowable increases in concentrations for particulate matter, sulfur dioxide, and nitrogen dioxide for areas designated as attainment. Different increment levels are identified for different classes of areas and Class I areas have the most stringent requirements.

The Nebraska-South Dakota-Wyoming Uranium Milling Region air quality description focuses on two topics: NAAQS attainment status and Prevention of Significant Deterioration classifications in the region.

Figure 3.4-19 identifies the counties in and around the Western Nebraska-South Dakota-Wyoming Uranium Milling Region that are partially or entirely designated as nonattainment or maintenance for NAAQS at the time this GEIS was prepared (EPA, 2007b). All of the area within the Nebraska-South Dakota-Wyoming Uranium Milling Region is classified as attainment. Wyoming only has one area that is not in attainment. The City of Sheridan in Sheridan County is designated as nonattainment for PM_{10}. Nebraska only has one area not in attainment. A portion of the city of Omaha in Douglas County is designated as maintenance for lead but this is in eastern Nebraska, about 500 km [311 mi] from the Nebraska-South Dakota-Wyoming Uranium Milling Region. No areas in South Dakota are designated as nonattainment or maintenance. Two counties in southeast Montana are not in attainment. However, the two Montana counties that border the Nebraska-South Dakota-Wyoming Uranium Milling Region are in attainment.

Table 3.4-9 identifies the Prevention of Significant Deterioration Class I areas in Wyoming, South Dakota, Nebraska, and Montana. These areas are shown in Figure 3.4-20. The Nebraska-South Dakota-Wyoming Uranium Milling Region does contain a Class I area for the Wind Cave National Park in South Dakota (40 CFR Part 81).

3.4.7 Noise

The existing ambient noise levels for undeveloped rural and more urban areas in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those described in Section 3.2.7 for the Wyoming West Uranium Milling Region. This is a large region spanning parts of three different states. The largest community within the region, with a population of about 12,500, is Spearfish, South Dakota, in the northeastern portion. Smaller communities with populations from around 1,000 to 6,000 include Sundance and Newcastle, Wyoming; Hot Springs and Custer, South Dakota; and Crawford and Chadron in Dawes County, Nebraska (see Section 3.4.10). Ambient noise levels in these communities would likely be in the range of 45 to about 78 dB (Washington State Department of Transportation, 2006). In addition, the Pine Ridge Indian Reservation is just to the east of the Nebraska-South Dakota-Wyoming Uranium Milling Region.

A number of major highways cross the region, including Interstate 90 in the northern portion and a number of U.S. and state undivided highways. Ambient noise levels near these highways would be similar to or less than those measured at up to 70 dBA for Interstate 80, as the total traffic count and the percentages of heavy truck traffic are less (Wyoming Department of Transportation, 2005; Federal Highway Administration, 2004; see also Sections 3.2.7 and 3.4.2).

A number of scenic byways through the Black Hills could be more sensitive to noise impacts, but these are located more than 16 km [10 mi] east of the areas of interest for ISL uranium recovery.

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, there are several National Park Service and U.S. Forest Service properties, state parks, and other properties (see Figure 3.4-1) that may be sensitive to noise impacts. Much of this

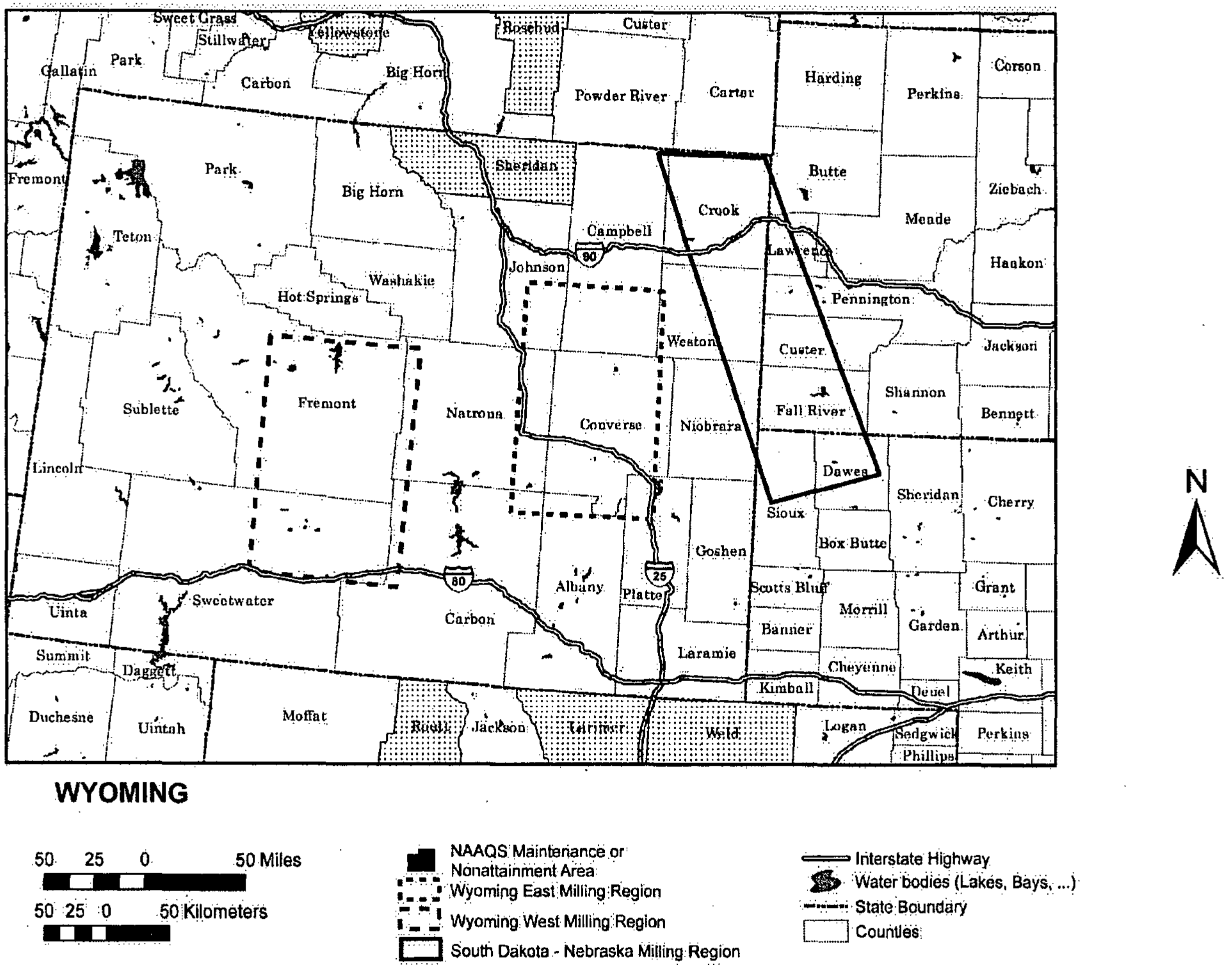


Figure 3.4-19. Air Quality Attainment Status for Nebraska-South Dakota-Wyoming Uranium Milling Region and Surrounding Areas (EPA, 2007b)

Table 3.4-9. U.S. Environmental Protection Agency Class I Prevention of Significant Deterioration Areas in Wyoming, South Dakota, Nebraska, and Montana*

WYOMING Bridger Wilderness Fitzpatrick Wilderness Grand Teton National Park North Absaroka Wilderness Teton Wilderness Washakie Wilderness Yellowstone National Park	MONTANA Anaconda-Pintlar Wilderness Bob Marshall Wilderness Cabinet Mountains Wilderness Gates of the Mountain Wilderness Glacier National Park Medicine Lake Wilderness Mission Mountain Wilderness Red Rock Lakes Wilderness Scapegoat Wilderness Selway-Bitterroot Wilderness U.L. Bend Wilderness Yellowstone National Park
SOUTH DAKOTA Badlands Wilderness Wind Cave National Park	NEBRASKA None

*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40—Protection of the Environment, Part 81. Washington, DC: U.S. Government Printing Office. 2005.

area is protected from extensive development, and the ambient noise levels would be expected to be similar to undeveloped rural areas (up to 38 dB) (DOE, 2007).

Northernmost uranium district (Wyoming)

- Devil's Tower National Monument (Wyoming)
- Black Hills National Forest (Wyoming-South Dakota)

Central uranium district (Wyoming, South Dakota)

- Thunder Basin National Grassland (Wyoming)
- Buffalo Gap National Grassland (South Dakota)

Southern uranium district (Nebraska)

- Oglala National Grassland (Nebraska)
- Nebraska National Forest (Nebraska)
- Fort Robinson State Park (Nebraska)

Small communities are located within and near each of the three uranium districts, including Aladdin, Wyoming, in the northernmost district; Riverview, Wyoming, and Burdock and Edgemont, South Dakota, in the central district; and Crawford, Nebraska, near the Crow Butte ISL facility in the southern district. In general, these small towns are located 8 km [5 mi] or more from the uranium projects.

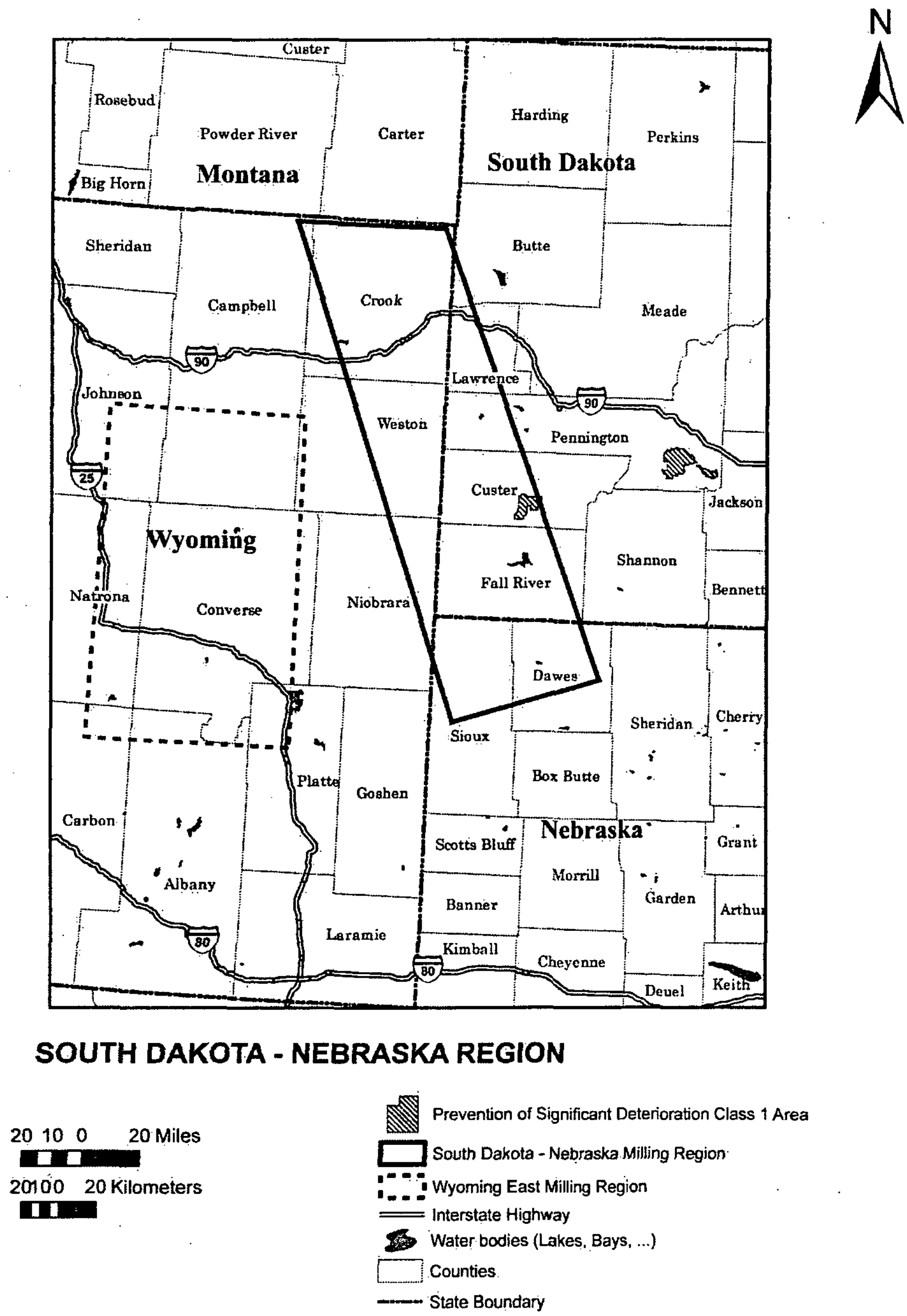


Figure 3.4-20. Prevention of Significant Deterioration Class I Areas in the Nebraska-South Dakota-Wyoming Uranium Milling Region and Surrounding Areas (40 CFR Part 81)

3.4.8 Historical and Cultural Resources of Western South Dakota and Nebraska

Appendix D provides a general overview of historical and cultural resource impact assessment at the federal level. As noted in Section 3.2.8, specific cultural resources in Wyoming, South Dakota, Nebraska, and New Mexico are described at the state level by the responsible state agencies. For the purposes of describing cultural and historical resources for the Nebraska-South Dakota-Wyoming Uranium Milling Region, an overview of Wyoming cultural and historical resources is provided in Section 3.2.8. Cultural and historical resources in South Dakota and Nebraska are described separately in this section (Section 3.4.8).

The South Dakota SHPO is a division of the South Dakota State Historical Society. The director of the South Dakota State Historical Society serves as the state's historic preservation officer. The South Dakota SHPO administers and is responsible for oversight and compliance with the NRHP, compliance and review for Section 106 of the NHPA, Preservation of Historic Property Procedures (South Dakota Codified Law 1-19-11.1), traditional cultural properties, NAGPRA, and archaeological survey through its Archaeology Division as well as compliance with other federal and state historic preservation laws, regulations, and statutes. Their webpage can be found at <http://www.sdhistory.org>. The State of South Dakota also has laws regarding human remains, entitled Cemeteries and Burials (SDCL 1-20-32, Chapter 34-27).

The Nebraska SHPO is a division of the Nebraska State Historical Society. The director of the Nebraska State Historical Society serves as the state's historic preservation officer. The NSHPO administers and is responsible for oversight and compliance with the NRHP, the Nebraska Historic Buildings Survey, compliance and review for Section 106 of the NHPA and traditional cultural properties, NAGPRA, and archaeological survey through its Archaeology Division and compliance with other federal and state historic preservation laws, regulations, and statutes. Their webpage can be found at <http://www.nebraskahistory.org/histpres>. The State of Nebraska also has laws regarding human remains, entitled Unmarked Human Burial Sites {Revised Statutes of Nebraska 1989 Supplement Article 12 [12-1201 to 12-1212]} and Human Skeletal Remains or Burial Goods, Prohibited Acts; Penalty (Article 28-1301).

3.4.8.1 Cultural Resources Overview

3.4.8.1.1 Cultural Resources of Western and Southwestern South Dakota

The following provides a brief overview of prehistoric and historical cultures recognized in the central and northern plains region, which includes western South Dakota. The dating of cultural periods for the prehistoric period is provided in BP. Most prehistoric archaeological sites are concentrated along the James, Missouri, White, Cheyenne and Big Sioux River valleys, but can be found along many drainages in the state. Figures 3.2-18 and 3.2-19 illustrate the division of the plains into regional subdivisions.

Paleoindian Big Game Hunters (12,000 to 6,500 B.P.). The earliest well-defined cultural tradition in the central plains region is the Paleoindian. Early humans entered the areas shortly after deglaciation allowed movement onto the central plains sometime after 14,000 B.P. A variety of cultures, each defined by the presence of distinctive projectile points, are recognized during the Paleoindian period: Clovis, Goshen, Folsom, Hell Gap-Agate Basin, Cody Complex, and Plano. Most post-Clovis Paleoindian sites on the northern and upper central plains are

known from bison kill sites. The Clovis culture (12,000 to 10,000 B.P.) is recognized by a distinctive projectile point style and a subsistence mode heavily reliant on hunting large, now-extinct mammals, notably mammoth and mastodon, which became extinct at the end of the Clovis period. The poorly defined Goshen Complex found at the Jim Pitts site in the Black Hills may be contemporary with Clovis and is technologically similar. The Folsom culture (ca. 10,000 to 8,500 B.P.) is also known for a distinctive projectile point style. Folsom subsistence is also characterized by reliance on large game—the ancient bison. Folsom sites consist of camp sites and kill sites. The latter tend to be located near cliffs and around water, such as ponds and springs. The Plano, Hell Gap-Agate Basin, and Cody Complex cultures (ca. 8,500 to 6,500 B.P.) are, in their earliest forms, a continuation of earlier Paleoindian hunting traditions. The distinctive projectile point forms that define these cultural complexes are, in comparison to earlier Clovis and Folsom, much more restricted in geographic distribution. Toward the middle and end of the period encompassing these cultures, however there is a transition in subsistence modes following the extinction of the ancient bison form to the modern form of bison and ultimately, a transition to Archaic broad-spectrum foraging. Post molds and stone circles suggesting the presence of ephemeral shelters are sometimes found, primarily toward the end of the period.

Archaic Foragers (6,500 to 3,500 B.P.). The Plains Archaic period represents the continuation of change in subsistence and settlement linked to an increasingly arid environment that occurs in the latter portion of the preceding late Paleoindian cultures. Distinctive Archaic cultures, from early to late, include Mummy Cave, Oxbow, McKean, and Pelican Lake complexes. Kill sites, characteristic of the preceding Paleoindian period, are virtually absent. Hunting and gathering wild plant foods is the primary mode of subsistence. Dietary breadth, indicated by increasing diversity and numbers of subsistence items, is believed to expand significantly with more medium and small mammals being hunted and the introduction of seed-bearing plants: dietary staples indicated by the introduction of stone seed-grinding implements. Through time, settlement is increasingly tethered to highly productive resource areas and sites tend to become larger and increasingly complex, indicating the presence of somewhat more sedentary lifestyles relative to earlier periods. Settlement is focused on river valleys and elevated areas. Artifact styles, principally projectile points, become increasingly diversified, suggesting increasing regionalization and cultural differentiation.

Late Prehistoric/Plains Woodland (3,500 to 300 B.P.). Early in the period, the preceding late Archaic broad-spectrum foraging subsistence and settlement patterns continue with little change. In the Northern Plains, the Besant and Avonlea Complexes continued the Archaic, virtually unchanged lifestyles until contact with European and American cultures. Subsistence focused on scheduled small- and medium-game hunting, gathering plant foods, and bison hunting according to a seasonal round. In western South Dakota, a basic hunting and gathering lifestyle differing little from the preceding Late Archaic period predominates. At the very end of the period, some villages located along water courses in western South Dakota may have practiced horticulture, but its contribution to diet among such Northern Plains groups was limited. Food procurement and site location appears to be focused primarily on elevated landforms near larger riverine systems and tributaries with increasing utilization of upland resources later in time. The Late Prehistoric/Plains Woodland of South Dakota is also characterized by the appearance of ceramics late in the period (Avonlea Complex), perhaps introduced from the Eastern Woodland cultural area. The late Avonlea Complex and later Old Woman Complex sites contain artifact types that suggest a high degree of specialization in hunting large, upland game animals, primarily bison.

In the eastern portions of South Dakota along the Missouri River, seasonal or permanent sedentary villages of various sizes occur. These villages were largely reliant on domesticated plants (corn, beans, and squash). Although horticulture was an important part of the subsistence base, wild plants and game animals formed a substantial part of the diet. Villages were primarily located along major river systems and larger tributaries. Most sites consisted of small clusters of rectangular wattle and daub lodges with a few larger village sites. Storage pits for food and other times are located within the structures. Pottery was diverse with globular jars and decorated exterior rims common.

In the 1500s to early 1700s A.D., large migrations occurred. The ancestors of the modern Apache, Arapaho, Comanches, and Kiowa migrated southward through western South Dakota in the 1500s and 1600s. The Crow also resided in western South Dakota for a time. The central portion of the state was occupied by the Arika, Mandan, and Cheyenne while, the Lakota, Omaha, Ponca, Otoe, and Ioway occupied the eastern portion of the state.

Post-Contact Tribes (300 to 100 B.P.). The post-contact period on the northern plains is that period after initial contact with Europeans and Americans. Although Euro-American trade goods may have appeared as early as the mid-1600s, the earliest documented contact in the northern and central plains is by Spanish and French explorers in the early 1700s A.D. The horse appears to have been introduced at about the same time. The lifeways of the late Avonlea and post-Avonlea/Old Woman nomadic bison-hunting cultural complexes appear to have continued well into the mid to late 1700s A.D. At the time of European exploration, Arikara and Mandan farming villages were noted along the Missouri river in central South Dakota. In the 1700s, the Cheyenne moved westward along with the Lakota and displaced the Mandan and Arikara. The Dakota and Nakota moved into eastern South Dakota from Minnesota and displaced the Ponca and the Omaha. By the mid-1800s, the entire state was occupied by nomadic Siouan-speaking tribes, primarily the Santee, Yankton, and Teton.

Europeans and Americans (300 to 100 B.P.). The earliest European presence in South Dakota was by French explorers of the de la Vénendrye family in 1743. In 1803, the United States completed the purchase of the Louisiana Territory from France. A portion of South Dakota was visited by the Lewis and Clark Expedition in 1804–1806. These early expeditions provide descriptions of varying quality for some of the early historical tribes in the region. In the later 1700s and early 1800s, more intensive contact and settlement occurred first through missionaries and then through the fur trade period in the 1830s through the 1860s. The American Fur Company and its fur trading posts located along the Big Sioux, James, Vermillion, Missouri, Cheyenne and White Rivers, and Big Stone Lake formed the foundation for later settlements. By the mid-1800s, missionary, settler, and military contacts led to increasing conflict with the Siouan tribes of South Dakota. The slowly increasing number of settlers passing through traditional tribal use areas in the mid-1800s led to increasing conflict over time and the establishment of military forts in tribal lands—yet another irritant to tribes.

Treaties, notably the Fort Laramie Treaty of 1851, were signed with the intent of removing tribes from along the emigrant trails and allowing for the building of trails and forts to protect settlers moving west. Continued conflict resulted in the creation of the Great Sioux Reservation bounded by the Missouri River on the east, the Bighorn Mountains on the west, and the 46th and 43rd parallels to the north and south, respectively. Continued conflict with the U.S. military over the failure of the government to abide by treaty obligations led to several punitive expeditions to return tribes to reservations. In 1874, General George Armstrong Custer led an expedition to the Black Hills where the presence of gold, previously only rumored, was confirmed. The

intense interest by Americans to go to the Black Hills to mine for gold led to numerous treaty violations; the Black Hills regions was, by treaty, part of the Sioux reservation. The continued conflict over the Black Hills, along with reduction of the buffalo herds, led to the final military conquest of the Great Sioux Nation and their confinement to small reservations. The Black Hills gold rush led to the rapid settlement of much of South Dakota and the development of towns and cattle ranching.

Ranching, a livelihood well suited to the grassland plains of South Dakota, was practiced by settlers by the early 1870s. The arrival of the railroads (the Milwaukee) led to increased settlement and opened South Dakota to a flood of new settlers, most of them recent European immigrants intent on farming. These early settlers began a period of extensive agriculture throughout the state, mostly around well-watered regions, with many of the new farmers pursuing newly developed dry-land farming techniques. The Great Depression and the droughts that occurred at the same time led to the abandonment of many farms and the outmigration of a significant portion of South Dakota's population.

3.4.8.1.2 Cultural Resources of Western Nebraska

The following provides a brief overview of prehistoric and historical cultures recognized in the central plains region, which includes Nebraska. The dating of cultural periods for the prehistoric period are provided in B.P. Figures 3.2-18 and 3.2-19 illustrate the division of the plains into regional subdivisions.

Paleoindian Big Game Hunters (12,000 to 8,000 B.P.). The earliest well-defined cultural tradition in the central plains region is the Paleoindian. Early humans entered the plains shortly after deglaciation allowed movement onto the central plains sometime after 14,000 B.P. Three cultures are recognized during the Paleoindian period: Clovis, Folsom, and Plano. The Clovis culture (12,000 to 10,000 B.P.) is recognized by a distinctive projectile point style and a subsistence mode heavily reliant on big-game hunting, notably mammoth and mastodon, which became extinct at the end of the period. The Folsom culture (ca. 10,000 to 8,500 B.P.) is also known for a distinctive projectile point style. Folsom subsistence is also characterized by reliance on large game—the ancient bison. Folsom sites consist of camp sites and kill sites. The latter tend to be located near cliffs and around water, such as ponds and springs. The Plano culture (ca. 8,500 to 6,500 B.P.) is, in its earliest form, a continuation of earlier Paleoindian hunting traditions. Toward the end of the period, however, there is a transition in subsistence modes with the extinction of the ancient bison to the modern form of bison and a transition to Archaic foragers. Plano sites containing circular rock alignments and post mold circles suggest the present of structures.

Archaic Foragers (6,500 to 2,000 B.P.). The Plains Archaic period represents the continuation of change in subsistence and settlement linked to an increasingly arid environment that occurs in the latter portion of the preceding late Paleoindian Plano culture. Kill sites, characteristic of the preceding Paleoindian period, are virtually absent. Although hunting and gathering is the only mode of subsistence, dietary breadth, indicated by increasing diversity and numbers of subsistence items, is believed to expand significantly with more medium and small mammals being hunted and the introduction of seed-bearing plants as staples. Through time, settlement is increasingly tethered to highly productive resource areas and sites tend to become larger and increasingly complex, indicating the presence of more sedentary lifestyles relative to earlier periods. Artifact styles, principally projectile points, become increasingly diversified, suggesting increasing regionalization and cultural differentiation.

Plains Woodland (2,000 to 1,000 B.P.). The Plains Woodland period is characterized by largely sedentary lifestyles and a mixed subsistence economy consisting of wild game animals and plants and horticulture utilizing the domesticates, maize and beans. The defining settlement pattern of the Woodland Period consists of earth lodge villages, some of which may have been occupied only seasonally. There is variability in the size of Plains Woodland communities. The communities can be small, with as few as two or three structures, to very large (two to three hectares) with numerous contemporary structures. The majority of the larger settlements tended to be located along larger drainages (e.g., Missouri, Republican, Arkansas, and Red Rivers) with permanent water and located near abundant biotic and abiotic resources. The Plains Woodland is also characterized by the appearance of ceramics, perhaps introduced from the Eastern Woodland cultural area.

Plains Village (1,000 to 600 B.P.). The Plains Village period continues the trend toward increasing sedentism and increasing reliance on domesticated plants (corn, beans, and squash). Although horticulture was an important part of the subsistence base, wild plants and game animals formed a substantial part of the Plains Village diet. Villages were primarily located along major river systems and larger tributaries. Most sites, however, consisted of small clusters of rectangular wattle and daub lodges. Storage pits for food and other items are located within the structures. Pottery was diverse with globular jars and decorated exterior rims being common. Small, triangular side- and corner-notched projectile points are common. Early historical Plains Village groups include the Siouan-speaking Omaha, Ponca, Otoe-Missouria, Ioway, and Kansa along with the Caddoan-speaking groups including the Arikara and Pawnee. The Plains Village period is divided into several regional phases and includes the St. Helena, Nebraska, Itskari, and Smokey Hill phases.

Post-Contact Tribes (400 to 100 B.P.). The postcontact period on the central plains is that period after initial contact with Europeans and Americans. The earliest documented contact in the central plains is by Spanish and French explorers in the early 1700s A.D. Tribes present in Nebraska include the Caddoan farming villages of the Pawnee and Arikara in eastern Nebraska. Siouan-speaking tribes were the Omaha, Ponca, Otoe-Missouria, Ioway, and Kansa. Both Caddoan and Siouan-speaking groups lived in permanent earth lodge villages, were agriculturalists, and hunted bison in western Nebraska. Western Nebraska was also home to "nomadic" tribes that resided in tepee villages and were dependent on bison hunting. These tribes include the Apache, Crow, Kiowa, Cheyenne, Teton, Comanche, and Arapaho. The Lakota, Northern Cheyenne, and Arapaho resided in northwestern Nebraska, and the Oglala and Brule Sioux were concentrated around the Black Hills and the upper White and Niobrara Rivers in northern Sioux County. By the mid-1800s, the Oglala and Brule had extended their range to include the Platte River region.

Europeans and Americans (300 to 100 B.P.). The earliest European presence in Nebraska was by French and Spanish explorers in the early 1700s A.D. and possibly earlier in the late 1600s. The Villasur expedition to explore the area was led by Pedro de Villasur out of the Spanish province of New Mexico in 1720 AD. Later explorers included Lewis and Clark and Zebulon Pike. These early expeditions provide descriptions of varying quality for some of the early historical tribes in the region. In the later 1700s and early 1800s, more intensive contact and settlement occurred first through the fur trade in the 1830s and 1840s, and then through missionary and military contacts. By the mid-1800s, emigrant trails, notably the Oregon-California Trail, among others, traversed the Nebraska area.

The large number of settlers moving along the emigrant trails passing through tribal use areas led to increasing conflict over time and the establishment of military forts in tribal lands—yet another irritant to tribes. Treaties, notably the Fort Laramie Treaty of 1851 were signed with the intent of removing tribes from along the emigrant trails and allowing for the building of trails and forts to protect settlers moving west. Continued conflict resulted in the creation of the Great Sioux Reservation bounded by the Missouri River on the east, the Bighorn Mountains on the west, and the 46th and 43rd parallels to the north and south, respectively. Fort Robinson in Dawes County was established in 1874 adjacent to the Red Cloud Agency near the White River. Fort Robinson served as a military outpost to contain the Sioux tribes on the Great Sioux Reservation during the Sioux Wars and the Cheyenne Outbreak. Fort Robinson is important in both Native American and American history because it is the place in which the Oglala Sioux chief, Crazy Horse, was killed and the place where Dull Knife, chief of the Northern Cheyenne, broke free of U.S. military confinement. Use of Fort Robinson continued through World War I, and in World War II, it was a training site for soldiers and a prisoner of war camp. It ceased to be used as a military camp in 1948, and today is a Nebraska state park and historic site.

Ranching, a livelihood well suited to the grassland plains of western Nebraska, was practiced by early settlers by the early 1870s. The arrival of the railroads (Chicago and Northwestern and the Fremont, Elkhorn, and Missouri Valley) in 1885 opened northwestern Nebraska to a flood of settlers, most of them recent European immigrants. These early settlers began a period of extensive agriculture throughout western Nebraska, mostly around well-watered regions, but many of the settlers pursued newly developed dry-land farming techniques. The established ranching community relied on open range cattle grazing. Agricultural practices relied on fencing cattle out of fields. In response, ranchers would often fence off public lands to prevent settlement. This and other issues often led to conflict between farmers and ranchers and the eventual decline of ranching. In 1903, the North Platte irrigation project was authorized by Congress. The project included the construction of five reservoirs, six power plants, and an irrigation canal system (the Interstate Canal).

3.4.8.2 National Register of Historic Properties and State Registers

3.4.8.2.1 Historic Properties in Western South Dakota

In addition to the sites listed in Table 3.4-10, the following sites in western South Dakota are listed on South Dakota state and/or the National Register of Historic Places. There are no historic properties listed in the NRHP or state register in Butte, Fall River, or Pennington Counties as of this writing.

Custer County

- Custer Campsite #1 rural road
- Borglum Ranch & Studio Historic District rural road

Lawrence County

- Thoen Stone & Site
- Frawley Ranch

Table 3.4-10. National Register Listed Properties in Counties Included in the Nebraska-South Dakota-Wyoming Uranium Milling Region			
County	Resource Name	City	Date Listed YYYY-MM-DD
	Wyoming		
Crook	DXN Bridge Over Missouri River	Hulett	1985-02-22
Crook	Entrance Road—Devils Tower National Monument	Devils Tower	2000-07-24
Crook	Entrance Station—Devils Tower National Monument	Devils Tower	2000-07-24
Crook	Inyan Kara Mountain	Sundance	1973-04-24
Crook	Old Headquarters Area Historic District	Devils Tower	2000-07-20
Crook	Ranch A	Beulah	1997-03-17
Crook	Sundance School	Sundance	1985-12-02
Crook	Sundance State Bank	Sundance	1984-03-23
Crook	Tower Ladder—Devils Tower National Monument	Devils Tower	2000-07-24
Crook	Vore Buffalo Jump	Sundance	1973-04-11
Crook	Wyoming Mercantile	Aladdin	1991-04-16
Niobrara	DSD Bridge Over Cheyenne River	Riverview	1985-02-22
Weston	Cambria Casino	Newcastle	1980-11-18
Weston	Jenney Stockade Site	Newcastle	1969-09-30
Weston	U.S. Post Office—Newcastle Main	Newcastle	1987-05-19
Weston	Weston County Courthouse	Newcastle	2001-09-01
Weston	Wyoming Army National Guard Cavalry Stable	Newcastle	1994-07-07
	South Dakota		
Custer	Archaeological Site No. 39CU1619	Custer	1999-06-03
Custer	Archaeological Site No. 39CU70	Custer	1993-10-20
Custer	Archaeological Site No. 39CU890	Hermosa	1993-08-06
Custer	Ayres, Lonnie and Francis, Ranch	Custer	1991-01-25
Custer	Badger Hole	Custer	1973-03-07
Custer	Bauer, Maria, Homestead Ranch	Custer	1992-06-09
Custer	Beaver Creek Bridge	Hot Springs	1984-08-08
Custer	Beaver Creek Rockshelter	Pringle	1993-10-25
Custer	Buffalo Gap Cheyenne River Bridge	Buffalo Gap	1988-02-08
Custer	Buffalo Gap Historic Commercial District	Buffalo Gap	1995-06-30
Custer	CCC Camp Custer Officers' Cabin	Custer	1992-06-09
Custer	Cold Springs Schoolhouse	Custer	1973-03-07
Custer	Custer County Courthouse	Custer	1972-11-27
Custer	Custer State Game Lodge	Custer	1983-03-30
Custer	Custer State Park Museum	Hermosa	1983-03-30
Custer	Fairburn Historic Commercial District	Fairburn	1995-06-30
Custer	First National Bank Building	Custer	1982-03-05
Custer	Fourmile School No. 21	Custer	1991-01-25
Custer	Garlock Building	Custer	2004-01-28
Custer	Grace Coolidge Memorial Log Building	Custer	2001-06-21
Custer	Historic Trail and Cave Entrance	Custer	1995-04-19
Custer	Lampert, Charles and Ollie, Ranch	Custer	1990-07-05
Custer	Mann, Irene and Walter, Ranch	Custer	1990-07-05
Custer	Norbeck, Peter, Summer House	Custer	1977-09-13
Custer	Pig Tail Bridge	Hot Springs	1995-04-07
Custer	Ranger Station	Custer	1995-04-05
Custer	Roetzel, Ferdinand and Elizabeth, Ranch	Custer	1991-01-25
Custer	Site No. 39 Cu 510	City Restricted	1982-05-20
Custer	Site No. 39 Cu 511	City Restricted	1982-05-20

Table 3.4-10. National Register Listed Properties in Counties Included in the Nebraska-South Dakota-Wyoming Uranium Milling Region (continued)			
County	Resource Name	City	Date Listed YYYY-MM-DD
South Dakota (continued)			
Custer	Site No. 39 Cu 512	City Restricted	1982-05-20
Custer	Site No. 39 Cu 513	City Restricted	1982-05-20
Custer	Site No. 39 Cu 514	City Restricted	1982-05-20
Custer	Site No. 39 Cu 515	City Restricted	1982-05-20
Custer	Site No. 39 Cu 516	City Restricted	1982-05-20
Custer	Site No. 39 Cu 91	City Restricted	1982-05-20
Custer	South Dakota Dept. of Transportation Bridge No. 17–289–107	Custer	1993-12-09
Custer	Stearns, William, Ranch	Custer	1990-07-05
Custer	Streeter, Norman B., Homestead	Buffalo Gap	1995-06-30
Custer	Towner, Francis Averill (T.A.) and Janet Leach, House	Custer	1990-06-21
Custer	Tubbs, Newton Seymour, House	Custer	1993-12-09
Custer	Ward, Elbert and Harriet, Ranch	Custer	1990-07-05
Custer	Way Park Museum	Custer	1973-03-07
Custer	Wind Cave National Park Administrative and Utility Area Historic District	Custer	1984-07-11
Custer	Young, Edna and Ernest, Ranch	Custer	1990-07-05
Fall River	Allen Bank Building and Cascade Springs Bath House-Sanitarium	Hot Springs	1984-02-23
Fall River	Archeological 39FA1638	Edgemont	2005-07-14
Fall River	Archeological Site 39FA1336	Edgemont	2005-07-14
Fall River	Archeological Site 39FA1937	Edgemont	2005-07-14
Fall River	Archeological Site No. 39FA1010	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA1013	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA1046	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA1049	Hot Springs	1993-08-06
Fall River	Archeological Site No. 39FA1093	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA1152	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA1154	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA1155	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA1190	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA1201	Edgemont	1993-08-06
Fall River	Archeological Site No. 39FA1204	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA243	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA244	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA316	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA321	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA395	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA446	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA447	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA448	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA542	Edgemont	1993-10-25
Fall River	Archeological Site No. 39FA678	Edgemont	1993-08-06
Fall River	Archeological Site No. 39FA679	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA680	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA682	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA683	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA686	Edgemont	1993-10-20

Table 3.4-10. National Register Listed Properties in Counties Included in the Nebraska-South Dakota-Wyoming Uranium Milling Region (continued)

County	Resource Name	City	Date Listed YYYY-MM-DD
	South Dakota (continued)		
Fall River	Archeological Site No. 39FA688	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA690	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA691	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA767	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA788	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA806	Hot Springs	1993-08-06
Fall River	Archeological Site No. 39FA819	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA86	Edgemont	1993-08-06
Fall River	Archeological Site No. 39FA88	Edgemont	1993-10-20
Fall River	Archeological Site No. 39FA89	Edgemont	1993-08-06
Fall River	Archeological Site No. 39FA90	Hot Springs	1993-10-20
Fall River	Archeological Site No. 39FA99	Edgemont	1993-10-20
Fall River	Bartlett—Myers Building	Edgemont	2006-05-31
Fall River	Chilson Bridge	Edgemont	1993-12-09
Fall River	Flint Hill Aboriginal Quartzite Quarry	Edgemont	1978-07-14
Fall River	Hot Springs High School	Hot Springs	1980-05-07
Fall River	Hot Springs Historic District	Hot Springs	1974-06-25
Fall River	Jensen, Governor Leslie, House	Hot Spring	1987-09-25
Fall River	Log Cabin Tourist Camp	Hot Springs	2004-01-28
Fall River	Lord's Ranch Rockshelter	Edgemont	2005-07-14
Fall River	Petty House	Hot Springs	1999-02-12
Fall River	Site 39FA1303	Edgemont	2005-06-08
Fall River	Site 39FA1639	Edgemont	2005-06-09
Fall River	Site No. 39 FA 277	City Restricted	1982-05-20
Fall River	Site No. 39 FA 389	City Restricted	1982-05-20
Fall River	Site No. 39 FA 554	City Restricted	1982-05-20
Fall River	Site No. 39 FA 58	City Restricted	1982-05-20
Fall River	Site No. 39 FA 676	City Restricted	1982-05-20
Fall River	Site No. 39 FA 677	City Restricted	1982-05-20
Fall River	Site No. 39 FA 681	City Restricted	1982-05-20
Fall River	Site No. 39 FA 684	City Restricted	1982-05-20
Fall River	Site No. 39 FA 685	City Restricted	1982-05-20
Fall River	Site No. 39 FA 687	City Restricted	1982-05-20
Fall River	Site No. 39 FA 7	City Restricted	1982-05-20
Fall River	Site No. 39 FA 75	City Restricted	1982-05-20
Fall River	Site No. 39 FA 79	City Restricted	1982-05-20
Fall River	Site No. 39 FA 91	City Restricted	1982-05-20
Fall River	Site No. 39 FA 94	City Restricted	1982-05-20
Fall River	St. Martin's Catholic Church and Grotto	Oelrichs	2005-05-30
Fall River	Wesch, Phillip, House	Hot Springs	1984-02-23
Lawrence	Ainsworth, Oliver N., House	Spearfish	1990-10-25
Lawrence	Baker Bungalow	Spearfish	1996-10-24
Lawrence	Buskala, Henry Ranch	Dumont	1985-11-13
Lawrence	Cook, Fayette, House	Spearfish	1988-07-13
Lawrence	Corbin, James A., House	Spearfish	1990-10-25
Lawrence	Court, Henry, House	Spearfish	1990-10-25
Lawrence	Dakota Tin and Gold Mine	Spearfish	2005-06-08
Lawrence	Deadwood Historic District	Deadwood	1966-10-15

Table 3.4-10. National Register Listed Properties in Counties Included in the Nebraska-South Dakota-Wyoming Uranium Milling Region (continued)

County	Resource Name	City	Date Listed YYYY-MM-DD
	South Dakota (continued)		
Lawrence	Dickey, Eleazer C. and Gwinnie, House	Spearfish	1989-07-13
Lawrence	Dickey, Walter, House	Spearfish	1988-05-16
Lawrence	Driskill, William D., House	Spearfish	1989-07-13
Lawrence	Episcopal Church of All Angels	Spearfish	1976-04-22
Lawrence	Evans, Robert H., House	Spearfish	1991-11-01
Lawrence	Frawley Historic Ranch	Spearfish	1974-12-31
Lawrence	Halloran-Matthews-Brady House	Spearfish	1976-12-12
Lawrence	Hewes, Arthur, House	Spearfish	1990-10-25
Lawrence	Hill, John, Ranch—Keltomaki	Brownsville	1985-11-13
Lawrence	Homestake Workers House	Spearfish	1991-11-01
Lawrence	Keets, Henry, House	Spearfish	1988-07-13
Lawrence	Knight, Webb S., House	Spearfish	1989-07-13
Lawrence	Kroll Meat Market and Slaughterhouse	Spearfish	1988-05-20
Lawrence	Lead Historic District	Lead	1974-12-31
Lawrence	Lown, William Ernest, House	Spearfish	1976-05-28
Lawrence	Mail Building, The	Spearfish	1988-05-16
Lawrence	McLaughlin Ranch Barn	Spearfish	2002-02-14
Lawrence	Mount Theodore Roosevelt Monument	Deadwood	2005-12-22
Lawrence	Old Finnish Lutheran Church	Lead	1985-11-13
Lawrence	Redwater Bridge, Old	Spearfish	1993-12-09
Lawrence	Riley, Almira, House	Spearfish	1989-07-13
Lawrence	Spearfish City Hall	Spearfish	1990-10-25
Lawrence	Spearfish Filling Station	Spearfish	1988-05-16
Lawrence	Spearfish Fisheries Center	Spearfish	1978-05-19
Lawrence	Spearfish Historic Commercial District	Spearfish	1975-06-05
Lawrence	Spearfish Post Office (Old)	Spearfish	1999-02-12
Lawrence	St. Lawrence O'Toole Catholic Church	Central City	2003-02-05
Lawrence	Tomahawk Lake Country Club	Deadwood	2005-10-26
Lawrence	Toomey House	Spearfish	1997-11-07
Lawrence	Uhlig, Otto L., House	Spearfish	1989-07-13
Lawrence	Walsh Barn	Spearfish	2003-05-30
Lawrence	Walton Ranch	Spearfish	2005-05-30
Lawrence	Whitney, Mary, House	Spearfish	1990-10-25
Lawrence	Wolzmuth, John, House	Spearfish	1988-07-13
Pennington	Archeological Site No. 39PN376	Spearfish	1989-07-13
Pennington	Burlington and Quincy High Line Hill City to Keystone Branch	Spearfish	1990-10-25
Pennington	Byron, Lewis, House	Spearfish	1988-05-16
Pennington	Calumet Hotel	Spearfish	1978-05-19
Pennington	Casper Supply Company of SD	Spearfish	1975-06-05
Pennington	Cassidy House	Spearfish	1999-02-12
Pennington	Church of the Immaculate Conception	Central City	2003-02-05
Pennington	Dean Motor Company	Deadwood	2005-10-26
Pennington	Dinosaur Park	Spearfish	1997-11-07
Pennington	Emmanuel Episcopal Church	Spearfish	1989-07-13
Pennington	Fairmont Creamery Company Building	Spearfish	2003-05-30
Pennington	Feigel House	Spearfish	2005-05-30
Pennington	First Congregational Church	Spearfish	1990-10-25

Table 3.4-10. National Register Listed Properties in Counties Included in the Nebraska-South Dakota-Wyoming Uranium Milling Region (continued)			
County	County	County	County
South Dakota (continued)			
Pennington	Gambrill Storage Building	Spearfish	1988-07-13
Pennington	Harney Peak Hotel	Custer	1993-10-25
Pennington	Harney Peak Tin Mining Company Buildings	Hill City	2003-02-05
Pennington	Otho Mining District	Hermosa	1999-12-17
Pennington	Pennington County Courthouse	Hill City	1977-04-11
Pennington	Quinn, Michael, House	Custer	1983-03-10
Pennington	Rapid City Carnegie Library	Hill City	1977-07-21
Pennington	Rapid City Garage	Keystone	1981-02-22
Pennington	Rapid City Historic Commercial District	Keystone	1982-06-17
Pennington	Rapid City Laundry	Hill City	1994-06-03
Pennington	Site No. 39 PN 108	City Restricted	1982-05-20
Pennington	Site No. 39 PN 438	City Restricted	1982-05-20
Pennington	Site No. 39 PN 439	City Restricted	1982-05-20
Pennington	Site No. 39 PN 57	City Restricted	1982-05-20
Pennington	Von Woehrmann Building	Hill City	1977-04-13
Nebraska			
Dawes	Army Theatre	Crawford	1988-07-07
Dawes	Bordeaux Trading Post	Chadron	1972-03-16
Dawes	Chadron Public Library	Chadron	1990-06-21
Dawes	Co-operative Block Building	Crawford	1985-09-12
Dawes	Crites Hall	Chadron	1983-09-08
Dawes	Dawes County Courthouse	Chadron	1990-07-05
Dawes	Fort Robinson and Red Cloud Agency	Crawford	1966-10-15
Dawes	Hotel Chadron	Chadron	2002-08-15
Dawes	Library	Chadron	1983-09-08
Dawes	Miller Hall	Chadron	1983-09-08
Dawes	Sparks Hall	Chadron	1983-09-08
Dawes	U.S. Post Office—Crawford	Crawford	1992-05-11
Dawes	Wohlers, Henry, Sr., Homestead	Crawford	2004-10-15
Dawes	Work, Edna, Hall	Chadron	1983-09-08
Sioux	Cook, Harold J., Homestead Cabin	Agate	1977-08-24
Sioux	Hudson-Meng Bison Kill Site	Crawford	1973-08-28
Sioux	Sioux County Courthouse	Harrison	1990-07-05

3.4.8.2.2 Historic Properties in Western Nebraska

In addition to the sites listed in Table 3.4-10, the following historic properties in western Nebraska are listed on the Nebraska state and/or the National Register of Historic Places:

Dawes County

- James Bordeaux Trading Post [DW00-002] Listed 1972/03/16
- Henry Wohlers, Sr. Homestead [DW00-043] Listed 2004/10/15
- Chadron Commercial Historic District [DW03] Listed 2007/03/27
- Chadron State College Historic Buildings [DW03] Listed 1983/09/08
- Hotel Chadron [DW03-023] Listed 2002/08/15
- Dawes County Courthouse [DW03-081] Listed 1990/07/05
- Chadron Public Library [DW03-091] Listed 1990/06/21

- Crawford United States Post Office [DW04-007] Listed 1992/05/11
- Co-Operative Block Building [DW04-024] Listed 1985/09/12
- Fort Robinson and Red Cloud Agency [DW07] Listed 1966/10/15

The historic properties listed previously are located within about 5–8 km [3–5 mi] of the existing Crow Butte ISL Facility.

Sioux County

- Hudson-Meng Bison Kill Site [25-SX-115] Listed 1973/08/28
- Harold J. Cook Homestead (Bone Cabin Complex) [SX00-028] Listed 1977/08/24
- Sandford Dugout [SX00-032] Listed 2000/03/09
- Wind Springs Ranch Historic and Archeological District [SX00-033, 25-SX-77, 25-SX-600-655] Listed 2000/11/22
- Sioux County Courthouse [SX04-002] Listed 1990/07/05

3.4.8.3 Tribal Consultations

3.4.8.3.1 South Dakota Tribal Consultation

There are 10 Native American Tribes located within or immediately adjacent to the state of South Dakota. These are the Cheyenne River Sioux, Flandreau Santee Sioux, Lower Brulé Sioux, the Crow Tribe of Montana Oglala Sioux, Rosebud Sioux, Sisseton-Whapeton Oyate, Standing Rock Sioux, Yankton Sioux, and the Ponca Tribe of Nebraska. The Siouan tribes are located throughout South and North Dakota, whereas the Ponca are located in northeastern Nebraska, but have interests in South Dakota. These and other Siouan-speaking tribes in North Dakota, Wyoming, Montana and Nebraska may have traditional land use claims in western South Dakota.

The U.S. government and the State of South Dakota recognize the sovereignty of certain Native America tribes. These tribal governments have legal authority for their respective reservations. Executive Order 13175 requires federal agencies to undertake consultation and coordination with Native Amrican tribal governments on a government-to-government basis. In addition, the NRHP provides these tribal groups with the opportunity to manage cultural resources within their own lands under the legal authority of a THPO. The THPO therefore replaces the South Dakota SHPO as the agency responsible for the oversight of all federal and state historic preservation compliance laws. To date, several tribes in South Dakota have achieved status as a THPO as provided by the NHPA (Oglala Sioux at Pine Ridge, Standing Rock Sioux, Rosebud Sioux, and the Cheyenne River Sioux). Other tribes may have applied for THPO status, but are not yet officially recognized. Projects proponents must, however, contact tribal cultural resources personnel as part of the consultation process along with the South Dakota SHPO. The National Organization of Tribal Historic Preservation Officers also maintains a list of THPOs on its website at <http://www.nathpo.org/THPO/state_list.htm>. The SHPO ensures compliance with applicable federal laws on tribal lands and consults with the tribes and the Bureau of Indian Affairs for undertakings that might occur on tribal reservation lands. Some tribes have historic and cultural preservation offices that are not recognized as THPOs, but must also be consulted where they exist.

3.4.8.3.2 Nebraska Tribal Consultation

There are six Native American tribes located within the state of Nebraska. These are the Omaha, Ponca, Winnebago, Santee Sioux, the Iowa Tribe of Kansas and Nebraska, and the Sac and Fox Nation of Missouri, Kansas, and Nebraska. These tribes are located near the Missouri River in eastern Nebraska. There are no reservation lands in western Nebraska. However, the Oglala Sioux Tribe of the Pine Ridge Reservation is located at the Nebraska-South Dakota border adjacent to the Nebraska-South Dakota-Wyoming Uranium Milling Region. These and other Siouan-speaking tribes in South Dakota, Wyoming, and Nebraska may have traditional land use claims in western Nebraska.

The U.S. government and the State of Nebraska recognize the sovereignty of certain Native America tribes. These tribal governments have legal authority for their respective reservations. Executive Order 13175 requires executive branch federal agencies to undertake consultation and coordination with Native American tribal governments on a government-to-government basis. NRC, as an independent federal agency, has agreed to voluntarily comply with Executive Order 13175.

In addition, the NHRP provides these tribal groups with the opportunity to manage cultural resources within their own lands under the legal authority of a THPO. The THPO therefore replaces the Nebraska SHPO as the agency responsible for the oversight of all federal and state historic preservation compliance laws. To date, no tribes in Nebraska have applied for status as a THPO as provided by the NHPA. In addition, some tribes in South Dakota with THPO offices may have interests in western Nebraska. Some tribes have historic and cultural preservation offices that are not recognized as THPOs, but they should be consulted where they exist. NRC, in meetings its responsibilities under the NHPA, contacts tribal cultural resources personnel as part of the consultation process, along with consulting with the Nebraska SHPO.

3.4.8.4 Places of Cultural Significance

As described in Section 3.2.8.4, traditional cultural properties are places of special heritage value to contemporary communities because of their association with cultural practices and beliefs that are rooted in the histories of those communities and are important in maintaining the cultural identity of the communities (Parker and King, 1998; King, 2003). Religious places are often associated with prominent topographic features like mountains, peaks, mesas, springs, and lakes. In addition, shrines may be present across the landscape to denote specific culturally significant locations and vision quest sites where an individual can place offerings.

Information on traditional land use and the location of culturally significant places is often protected information within the community (King, 2003). Therefore, the information presented on religious places is limited to those that are identified in the published literature and is therefore restricted to a few highly recognized places on the landscape within southwestern South Dakota.

Traditional cultural properties are ones that refer to beliefs, customs, and practices of a living community that have been passed down over the generations. Native American traditional cultural properties are often not found on the state or national registers of historic properties or described in the extant literature or in SHPO files. There is, however, a range of cultural

property types of religious or traditional use that might be identified during the tribal consultation process. These might include

- Sites of ritual and ceremonial activities and related features
- Shrines
- Marked and unmarked burial grounds
- Traditional use areas
- Plant and mineral gathering areas
- Traditional hunting areas
- Caves and rock shelters
- Springs
- Trails
- Prehistoric archaeological sites

The U.S. Bureau of Indian Affairs website contains a list, current as of May 2007, of tribal leaders and contact information at <http://www.doi.gov/bia/Tribal%20Leaders-June%202007-2.pdf>. The National Organization of Tribal Historic Preservation Officers also maintains a list of THPOs on its website at <http://www.nathpo.org/THPO/state_list.htm>. These tribal groups should be contacted for consultations associated with ISL milling activities in their respective states (see Table 3.2-12). Additional tribal contact information may be obtained from the respective SHPO in Nebraska, Montana, South Dakota, and Wyoming.

3.4.8.4.1 Places of Cultural Significance in Southwestern South Dakota

There are no culturally significant historic properties listed in the NRHP or state registers in Butte, Lawrence, Pennington, Custer, or Fall River Counties. However, the Siouan tribes who once occupied portions of South Dakota (Cheyenne River Sioux, Flandreau Santee Sioux, Lower Brule Sioux, Oglala Sioux, Rosebud Sioux, Sisseton-Whapeton Oyate, Standing Rock Sioux, Yankton Sioux, and the Ponca Tribe of Nebraska) consider the Black Hills in Wyoming and South Dakota, Devil's Tower in northeastern Wyoming, Pumpkin Buttes in eastern Wyoming, and Bear Butte in southwestern South Dakota to be culturally significant.

Areas of western South Dakota once used by these tribes may contain additional, undocumented or undisclosed culturally significant places and traditional cultural properties. Mountains, peaks, buttes, prominences, and other elements of the natural and cultural environment are often considered important elements of a traditional, culturally significant landscape.

3.4.8.4.2 Places of Cultural Significance in Western Nebraska

There are no culturally significant historic properties listed in the NRHP or state register in Dawes and Sioux Counties. However, the tribes who once occupied western Nebraska (Lakota, Northern Cheyenne, Arapaho, Oglala, and Brule Sioux, among others) along the upper White and Niobrara Rivers and extending into the Black Hills of South Dakota all consider the Black Hills in Wyoming and South Dakota, Devil's Tower in northeastern Wyoming, Pumpkin Buttes in eastern Wyoming, and Bear Butte in southwestern South Dakota to be culturally significant.

Areas of western Nebraska once used by these tribes and perhaps other tribes in the region may contain additional, undocumented culturally significant sites and traditional cultural properties. Mountains, peaks, buttes, prominences, and other elements of the natural and

cultural environment are often considered important elements of a traditional, culturally significant landscape.

3.4.9 Visual/Scenic Resources

Based on the BLM Visual Resource Handbook, the Nebraska-South Dakota-Wyoming Uranium Milling Region (BLM, 2007a–c) is located within the Great Plains physiographic province, adjacent to the southern end of the Black Hills. The northwestern corner of Wyoming (see Figure 3.3-17) is located within the area managed by the Newcastle BLM field office (BLM, 2000b). Most of the area is categorized as VRM Class III, but there are some Class II areas identified around Devil's Tower National Monument and the Black Hills National Forest along the Wyoming-South Dakota border (see Figure 3.4-1). One potential uranium ISL facility has been identified for development in the northeast corner of Nebraska-South Dakota-Wyoming Uranium Milling Region, about 16 km [10 mi] northeast of the Black Hills National Forest, and about 45 km [28 mi] northeast of Devils Tower. There are no Wyoming (1) Unique and Irreplaceable and (2) Rare or Uncommon designated areas within the Nebraska-South Dakota-Wyoming Uranium Milling Region (Girardin, 2006).

Uranium resources in South Dakota are being evaluated near Fall River County in the southwestern corner of the state. Although it does not assign a VRM classification to the region, the Nebraska and South Dakota BLM field offices resource management plan classifies this region as having natural vegetation of wheatgrass, grama grass, sagebrush, and pine savanna (BLM, 1992, 1985). Similar areas are identified as Class III VRM areas in Wyoming. The USFS has also performed some visual resource classification in association with its forest and grasslands management plans in the region (see text box in Section 3.2.9). The revisions to Northern Great Plains Management Plans (USFS, 2001a) indicate that for the grasslands in Fall River County, almost 95 percent of the area is categorized with a scenic integrity objective of low to moderate (moderately to heavily altered). The Black Hills National Forest land and resource management plan and subsequent amendments (USFS, 1997, 2001b, 2005) identified management plans to maintain about 85 percent of the region for low to moderate scenic integrity objectives. About 15 percent has high (13.6 percent) to very high (1.2 percent) scenic integrity objectives (USFS, 2005). In areas lacking human-caused disturbances, the landscape has attributes that potentially have a high level of scenic integrity (USFS, 2005). There is a Prevention of Significant Deterioration Class 1 area identified for the Wind Cave National Park in South Dakota as described in Section 3.4.6.2 and shown in Figure 3.4-20, but this is at least 40 km [25 mi] east of the closest potential uranium ISL facility.

Similar to South Dakota, uranium resources in Dawes County in northwestern Nebraska are located in the Great Plains physiographic province. The Crow Butte ISL facility in Dawes County is located near the Pine Ridge Unit of the Nebraska National Forest. The revisions to Northern Great Plains Management Plans (USFS, 2001a) indicate that for the Oglala National Grassland and the Pine Ridge Unit of the Nebraska National Forest, about 87 percent of the landscape is classified as having low to moderate scenic integrity objective classification, with the remaining 13 percent roughly divided between high (7.3 percent) and very high (5.4 percent).

3.4.10 Socioeconomics

For the purpose of this GEIS, the socioeconomic description for the Nebraska-South Dakota-Wyoming Region includes communities within the region of influence for potential ISL

facilities in the three uranium districts in the region. These include communities that have the highest potential for socioeconomic impacts and are considered the affected environment. Communities that have the highest potential for socioeconomic impacts are defined by (1) proximity to an ISL facility {generally within 48 km [30 mi]}; (2) economic profile, such as potential for income growth or destabilization; (3) employment structure, such as potential for job placement or displacement; and (4) community profile, such as potential for growth or destabilization to local emergency services, schools, or public housing. The affected environment within the Nebraska-South Dakota-Wyoming Uranium Milling Region consists of counties and Native American communities. The affected environment is listed in Table 3.4-11.

The following subsections describe areas most likely to have implications to socioeconomics and are listed below. A CBSA, according to the U.S. Census Bureau, is a collective term for both metro and micro areas ranging from a population of 10,000 to 50,000. A Metropolitan Area has a population greater than 50,000, and a town is considered to have less than 10,000 in population (U.S. Census Bureau, 2008). Smaller communities are considered as part of the county demographics.

3.4.10.1 Demographics

Demographics for the year 2000 are based on population and racial characteristics of the affected environment and are provided in Tables 3.4-12 through 3.4-14. Figure 3.4-21 illustrates the populations of communities within the Nebraska-South Dakota-Wyoming Uranium Milling Region. Most 2006 data compiled by the U.S. Census Bureau is not yet available for the geographic areas of interest.

Based on review of Tables 3.4-12 through 3.4-14, the most populated county is Campbell County, Wyoming and the most sparsely populated county is Sioux County, Nebraska. For communities located within 48 km [30 mi] of potential ISL facilities, the most populated town is Pine Ridge, South Dakota (Pine Ridge Indian Reservation), and the smallest populated town is Oglala, South Dakota (Pine Ridge Indian Reservation). The county with the largest percentage of nonminorities is Niobrara County, Wyoming, with a white population of 98.0 percent. The town with the largest minority population is Pine Ridge, South Dakota, with a white population of 3.7 percent. The largest minority-based county is Shannon County, South Dakota, with a white population of only 4.5 percent. The largest minority-based town is Oglala, South Dakota, with a white population of only 0.7 percent.

Although not listed in Table 3.4-12, the population counts based on 2000 U.S. U.S. Census data for the Pine Ridge Indian Reservation totaled 15,521 individuals (U.S. Census Bureau, 2008), with approximately 93 percent Native American. However, recent studies suggest that the population may be larger (Housing Assistance Council, 2002).

Table 3.4-11. Summary of Affected Environment Within the Nebraska-South Dakota-Wyoming Uranium Milling Region

Counties Within Nebraska	Counties Within South Dakota	Counties Within Wyoming	Native American Communities Within South Dakota
Dawes	Butte	Campbell	Pine Ridge Indian Reservation
Sioux	Custer	Crook	
	Fall River	Niobrara	
	Shannon	Weston	

Table 3.4-12. 2000 U.S. Bureau of Census Population and Race Categories of Nebraska*

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
Nebraska	1,711,263	1,533,261	68,541	14,896	47,845	23,953	21,931	94,425	836
Percent of total		89.6%	4.0%	0.9%	2.8%	1.4%	1.3%	5.5%	0.0%
Dawes County	9,060	8,457	73	261	93	143	28	220	5
Percent of total		93.3%	0.8%	2.9%	1.0%	1.6%	0.3%	2.4%	0.1%
Sioux County	1,475	1,440	0	2	17	13	3	34	0
Percent of total		97.6%	0.0%	0.1%	1.2%	0.9%	0.2%	2.3%	0.0%

*U.S. Census Bureau. "American FactFinder." 2000. <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 26 February 2008).
†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100%.

Table 3.4-13. 2000 U.S. Bureau of Census Population and Race Categories of South Dakota*

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
South Dakota	754,854	669,404	4,685	62,283	3,677	10,156	4,378	10,903	261
Percent of total		88.7%	0.6%	8.3%	0.5%	1.3%	0.6%	1.4%	0.0%
Butte County	9,094	8,687	9	150	99	127	22	266	0
Percent of total		95.5%	0.1%	1.6%	1.1%	1.4%	0.2%	2.9%	0.0%
Custer County	7,275	6,851	20	227	26	137	13	110	1
Percent of total		94.2%	0.3%	3.1%	0.4%	1.9%	0.2%	1.5%	0.0%
Fall River County	7,453	6,746	24	451	22	189	17	130	4
Percent of total		90.5%	0.3%	6.1%	0.3%	2.5%	0.2%	1.7%	0.1%
Shannon County	12,466	562	10	11,743	28	114	3	177	6
Percent of total		4.5%	0.1%	94.2%	0.2%	0.9%	0.0%	1.4%	0.0%
Oglala (Pine Ridge Indian Reservation	1,229	9	0	1,214	1	4	1	4	0
Percent of total		0.7%	0.0%	98.8%	0.1%	0.3%	0.1%	0.3%	0.0%

Table 3.4-13. 2000 U.S. Bureau of Census Population and Race Categories of South Dakota* (continued)

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
Pine Ridge (Pine Ridge Indian Reservation	3,171	118	3	2,987	16	43	1	57	3
Percent of total		3.7%	0.1%	94.2%	0.5%	1.4%	0.0%	1.8%	0.1%

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 26 February 2008, and 15 April 2008).

†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100%).

Table 3.4-14. 2000 U.S. Bureau of Census Population and Race Categories of Northwestern Wyoming*

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
Wyoming	493,782	454,670	3,722	11,133	12,301	8,883	2,771	31,669	302
Percent of total		92.1%	0.8%	2.3%	2.5%	1.8%	0.6%	6.4%	0.1%
Campbell County	33,698	32,369	51	313	378	450	108	1,191	29
Percent of total		96.1%	0.2%	0.9%	1.1%	1.3%	0.3%	3.5%	0.1%
Crook County	5,887	5,761	3	60	15	44	4	54	0
Percent of total		97.9%	0.1%	1.0%	0.3%	0.7%	0.1%	0.9%	0.0%
Niobrara County	2,407	2,360	3	12	12	17	3	36	0
Percent of total		98.0%	0.1%	0.5%	0.5%	0.7%	0.1%	1.5%	0.0%
Weston County	6,644	6,374	8	84	62	102	13	137	1
Percent of total		95.9%	0.1%	1.3%	0.9%	1.5%	0.2%	2.1%	0.0%

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 25 February 2008, and 25 April 2008).

†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100%).

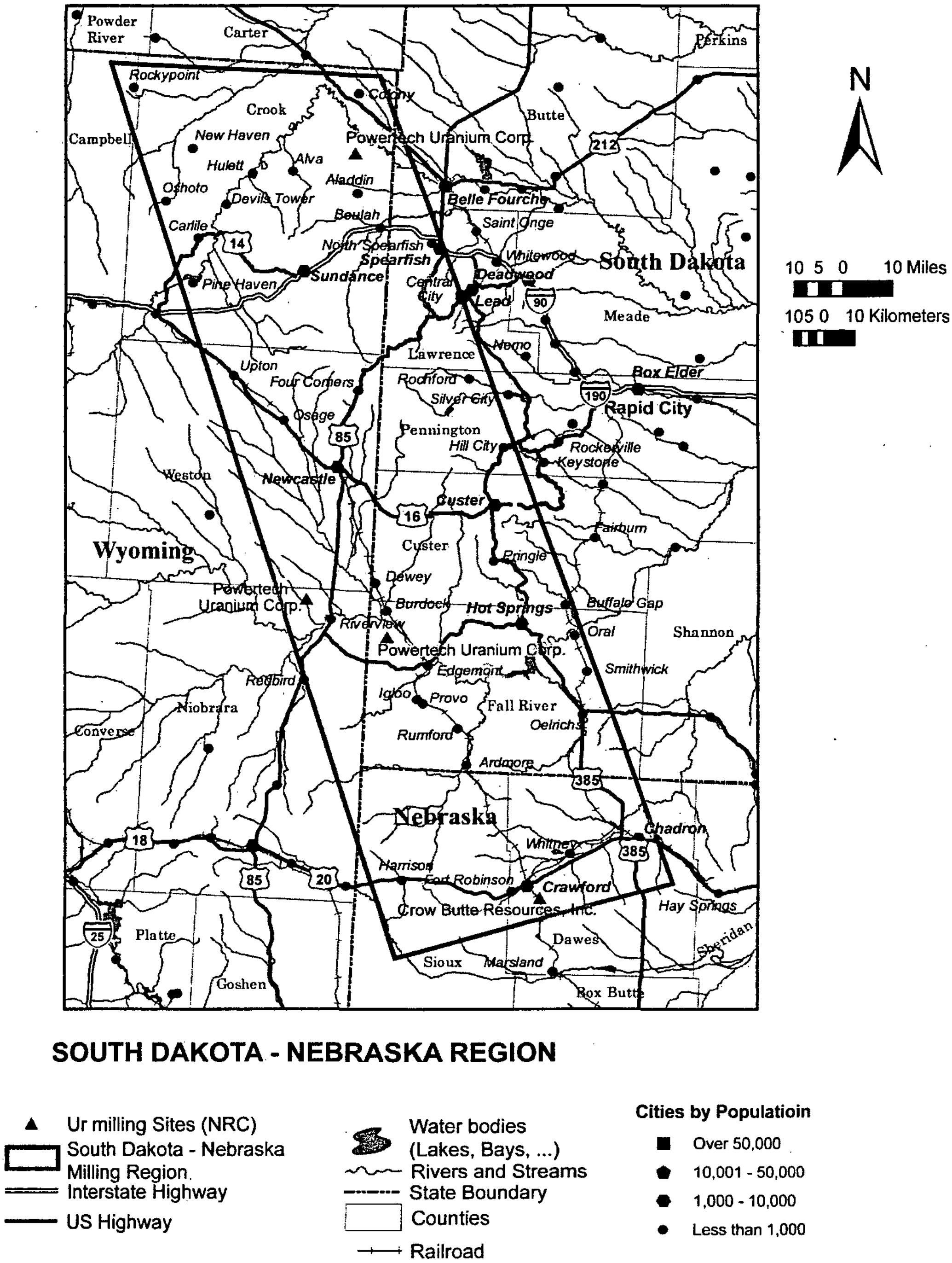


Figure 3.4-21. Nebraska-South Dakota-Wyoming Uranium Milling Region With Population

3.4.10.2 Income

Income information from the 2000 U.S. Census including labor force, income, and poverty levels for the affected environment in the Nebraska-South Dakota-Wyoming Uranium Milling Region is based on data collected at the state and county levels.

Data collected at the state level also includes information on towns, CBSAs, or Metropolitan Areas and considered an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than 48 km [30 mi]} for income opportunities or may be a workforce needed to fulfill specialized positions (if a local workforce is unavailable or unspecialized). Data collected from a county level is generally for the same affected environment previously discussed in Table 3.4-11 and also includes information on Native American communities near the Nebraska-South Dakota-Wyoming Uranium Milling Region. State-level information is provided in Table 3.4-15, and county data are listed in Table 3.4-16.

For the surrounding region, the state with the largest labor force population and families and individuals below poverty level is Nebraska (Table 3.4-15). The population with the largest labor force is Rapid City, South Dakota {48 km [30 mi] from the nearest potential ISL facility}, and the smallest labor force population is Sturgis, South Dakota {32 km [20 mi] from the nearest potential ISL facility}. The population with the largest per capita income is Rapid City, South Dakota, and the smallest per capita income population is Chadron, Nebraska {16 km [10 mi] from the nearest ISL facility}. The population with the highest percentage of individuals and families below poverty levels is Scottsbluff, Nebraska {32 km [20 mi] from the nearest ISL facility).

Within the Nebraska-South Dakota-Wyoming Uranium Milling Region, the county with the largest labor force population is Campbell County, Wyoming, and the county with the smallest labor force population is Sioux County, Nebraska (Table 3.4-16). The town with the largest labor force population is Pine Ridge, South Dakota (Pine Ridge Indian Reservation), and the town with the smallest labor force population is Oglala, South Dakota (Pine Ridge Indian Reservation). The county with the largest per capita income is Campbell County, Wyoming, and the lowest per capita income county is Shannon County, South Dakota. The county with the highest percentage of individuals and families below poverty levels is Shannon County, South Dakota, and the town with the highest percentage of individuals and families below poverty levels is Pine Ridge, South Dakota.

3.4.10.3 Housing

Housing information from the 2000 U.S. Census data for the affected environment is provided in Tables 3.4-17 through 3.4-19.

The availability of housing within the immediate vicinity of the proposed ISL facilities is limited (Housing Assistance Council, 2002). The majority of housing is available in larger populated areas such as the CBSA and towns of Rapid City, South Dakota {48 km [30 mi] from the nearest ISL facility}, Spearfish, South Dakota {16 km [10 mi] to nearest potential ISL facility}, Sturgis, South Dakota {32 km [20 mi] from the nearest ISL facility}, Chadron, Nebraska {16 km [10 mi] to nearest ISL facility}, Alliance, Nebraska {16 km [10 mi] from the nearest ISL facility}, and Gillette, Wyoming {64 km [40 mi] from the nearest ISL facility}. There are approximately 10 housing units including manufactured housing (trailer homes) and residential property (neighborhoods) currently available in the region (MapQuest, 2008c).

Table 3.4-15. U.S. Bureau of Census State Income Information for the Nebraska-South Dakota-Wyoming Uranium Milling Region*

Affected Environment	2000 Labor Force Population (16 Years and Over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Nebraska	917,470	$39,250	$48,032	$19,613	29,977	161,269
South Dakota	394,945	$35,282	$43,237	$17,562	18,172	95,900
Wyoming	257,808	$37,892	$45,685	$19,134	10,585	54,777
Alliance, Nebraska	4,531	$39,408	$47,766	$18,584	255	979
Percent of total†	66.7%	NA	NA	NA	10.6%	11.2%
Chadron, Nebraska	3,228	$27,400	$44,420	$16,312	127	1,025
Percent of total†	68.26%	NA‡	NA	NA	11.0%	21.4%
Gering, Nebraska	3,927	$35,185	$42,378	$18,775	130	590
Percent of total†	64.1%	NA	NA	NA	5.9%	7.8%
Rapid City, South Dakota	31,948	$35,978	$44,818	$19,445	1,441	7,328
Percent of total†	68.8%	NA	NA	NA	9.4%	12.7%
Scottsbluff, Nebraska	7,122	$29,938	$37,778	$17,065	562	2,654
Percent of total†	62.5%	NA	NA	NA	14.5%	18.3%

Table 3.4-15. U.S. Bureau of Census State Income Information for the Nebraska-South Dakota-Wyoming Uranium Milling Region* (continued)						
Affected Environment	**2000 Labor Force Population (16 Years and Over)**	**Median Household Income in 1999**	**Median Family Income in 1999**	**Per Capita Income in 1999**	**Families Below Poverty Level in 2000**	**Individuals Below Poverty Level in 2000**
Spearfish, South Dakota	4,635	$26,887	$40,257	$16,565	189	1,362
Percent of total†	65.1%	NA	NA	NA	9.8%	17.4%
Sturgis, South Dakota	3,199	$30,253	$38,698	$16,763	187	756
Percent of total†	63.0%	NA	NA	NA	11.0%	12.0%
Casper, Wyoming	26,343	$36,567	$46,267	$19,409	1,122	5,546
Percent of total†	68.4%	NA	NA	NA	8.5%	11.4%

U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 26 February 2008, 15 April 2008, and 25 April 2008).
†Percent of total based on a population of 16 years and over.
‡NA = not applicable.

Table 3.4-16. U.S. Bureau of Census County and Native American Income Information for the Nebraska-South Dakota-Wyoming Uranium Milling Region*

South Dakota*						
Affected Environment	**2000 Labor Force Population (16 Years and Over)**	**Median Household Income in 1999**	**Median Family Income in 1999**	**Per Capita Income in 1999**	**Families Below Poverty Level in 2000**	**Individuals Below Poverty Level in 2000**
Butte County	4,683	$29,040	$34,173	$13,997	234	1,147
Percent of total†	68.3%	NA‡	NA	NA	9.4%	12.8%
Custer County	3,535	$36,303	$43,628	$17,945	129	659
Percent of total†	59.6%	NA	NA	NA	6.2%	9.4%
Fall River County	3,408	$29,631	$37,827	$17,048	153	951
Percent of total†	59.6%	NA	NA	NA	7.8%	13.6%
Shannon County	3,884	$20,916	$20,897	$6,286	1,056	6,385
Percent of total†	52.4%	NA	NA	NA	45.1%	52.3%
Oglala (Pine Ridge Indian Reservation	339	$17,300	$19,688	$3,824	88	733
Percent of total†	49.9%	NA	NA	NA	45.1%	55.8%
Pine Ridge (Pine Ridge Indian Reservation	1,149	$21,089	$20,170	$6,067	320	2,057
Percent of total†	57.0%	NA	NA	NA	49.2%	61.0%

Table 3.4-16. U.S. Bureau of Census County and Native American Income Information for the Nebraska-South Dakota-Wyoming Uranium Milling Region (continued)*						
Affected Environment	**2000 Labor Force Population (16 Years and Over)**	**Median Household Income in 1999**	**Median Family Income in 1999**	**Per Capita Income in 1999**	**Families Below Poverty Level in 2000**	**Individuals Below Poverty Level in 2000**
Dawes County	4,989	$29,476	$41,092	$16,353	207	1,548
Percent of total†	66.8%	NA‡	NA	NA	9.8%	18.9%
Sioux County	749	$29,851	$31,406	$15,999	48	227
Percent of total†	64.7%	NA	NA	NA	11.1%	15.4%
Wyoming*						
Campbell County	18,805	$49,536	$53,927	$20,063	507	2,544
Percent of total†	76.6%	NA	NA	NA	5.6%	7.6%
Crook County	2,937	$35,601	$43,105	$17,379	129	529
Percent of total†	64.4%	NA	NA	NA	7.8%	9.1%
Niobrara County	1,193	$29,701	$33,714	$15,757	74	309
Percent of total†	61.5%	NA	NA	NA	10.7%	13.4%
Weston County	3,183	$32,348	$40,472	$17,366	119	628
Percent of total†	60.0%	NA	NA	NA	6.3%	9.9%

U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 26 February 2008, 15 April 2008, and 25 April 2008).
†Percent of total based on a population of 16 years and over.
‡NA = not applicable.

Table 3.4-17. U.S. Bureau of Census Housing Information for the Nebraska Uranium Milling Region*						
Affected Environment	Single Family Owner-Occupied Homes	Median Value in Dollars	Median Monthly Costs With a Mortgage	Median Monthly Costs Without a Mortgage	Occupied Housing Units	Renter-Occupied Units
Nebraska	370,495	$88,000	$895	$283	666,184	207,216
Dawes County	1,553	$55,200	$684	$262	3,512	1,211
Sioux County	140	$42,600	$600	$257	605	106

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 26 February 2008).

Table 3.4-18. U.S. Bureau of Census Housing Information for South Dakota*						
Affected Environment	Single Family Owner-Occupied Homes	Median Value in Dollars	Median Monthly Costs With a Mortgage	Median Monthly Costs Without a Mortgage	Occupied Housing Units	Renter-Occupied Units
South Dakota	137,531	$79,600	$828	$279	290,245	87,887
Butte County	1,360	$60,200	$706	$272	3,516	841
Custer County	1,073	$89,100	$884	$292	2,970	1,073
Fall River County	1,286	$54,300	$687	$271	3,127	901
Shannon County	631	$25,900	$515	$192	2,785	1,323
Oglala (Pine Ridge Indian Reservation)	29	$70,700	$450	$99	239	145
Pine Ridge (Pine Ridge Indian Reservation)	126	$15,000	$0	$185	709	473

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 26 February 2008, and 15 April 2008).

Table 3.4-19. U.S. Bureau of Census Housing Information for the Nebraska-South Dakota-Wyoming Uranium Milling Region*						
Affected Environment	**Single Family Owner-Occupied Homes**	**Median Value in Dollars**	**Median Monthly Costs With a Mortgage**	**Median Monthly Costs Without a Mortgage**	**Occupied Housing Units**	**Renter-Occupied Units**
Wyoming	95,591	$96,600	$825	$229	193,608	55,793
Campbell County	5,344	$102,900	$879	$247	12,207	3,174
Crook County	836	$85,4000	$682	$207	2,308	411
Niobrara County	480	$60,300	$562	$200	1,011	222
Weston County	1,174	$66,700	$664	$199	2,624	549
Source: U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 25 February 2008, and 25 April 2008).						

Temporary housing such as apartments, lodging, and trailer camps within the immediate vicinity of the proposed ISL facilities is not as limited. The majority of apartments is available in larger populated areas such as the CBSA and towns of Rapid City, Spearfish, and Sturgis in South Dakota; Chadron and Alliance in Nebraska; and Gillette in Wyoming, with about 25 apartment complexes currently available (MapQuest, 2008). There are also approximately 10 hotels/motels located along major highways or towns near the proposed ISL facilities. In addition to apartments and lodging, there are 20 trailer camps situated along major roads or near towns (MapQuest, 2008c).

3.4.10.4 Employment Structure

The regional employment structure from the 2000 U.S. Census data, including employment rate and type, is collected at the state and county levels. Data collected at the state level also include information on towns, CBSAs, or Metropolitan Areas and consider an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than 48 km [30 mi]} for employment opportunities or may be a workforce needed to fulfill specialized positions (if a local workforce is unavailable or un-specialized). Data collected from a county level is the same for the affected environment previously discussed in Table 3.4-11 and also includes information on Native American communities.

For the region surrounding the Nebraska-South Dakota-Wyoming Uranium Milling Region, the state with the highest percentage of employment is Nebraska. The population with the highest percentage of employment is the town of Chadron, Nebraska, and the population with the highest unemployment rate is Spearfish, South Dakota.

Within the Nebraska-South Dakota-Wyoming Uranium Milling Region, the county with the highest percentage of employment is Campbell County, Wyoming, and the county with the highest unemployment rate is Shannon County, Nebraska. The towns with the highest unemployment rate are located on the Pine Ridge Indian Reservation (Table 3.4-20).

3.4.10.4.1 State Data

3.4.10.4.1.1 Nebraska

The state of Nebraska has an employment rate of 66.7 percent and unemployment rate of 2.5 percent. The largest sector of employment is management, professional, and related occupations at 33.0 percent. The largest type of industry is educational, health, and social services at 20.7 percent. The largest class of worker is private wage and salary workers at 77.1 percent (U.S. Census Bureau, 2008).

<u>Gering</u>

Gering has an employment rate of 61.6 percent and unemployment rate the same as that of the state at 2.5 percent. The largest sector of employment is management, professional, and related occupations at 34.0 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Table 3.4-20. Employment Structure of the Pine Ridge Indian Reservation Within the Affected Area*

Affected Environment	2003 Labor Force Population	Unemployed as Percent of Labor Force	Employed Below Poverty Guidelines	
Oglala Sioux Tribe of Pine Ridge	27,778	87%	716	21%

* U.S. Department of the Interior. "Affairs American Indian Population and Labor Force Report 2003." <http://www.doi.gov/bia/labor.html>. Washington, DC: U.S. Department of the Interior, Bureau of Indian Affairs, Office of Tribal Affairs. 2003.

Scottsbluff

Scottsbluff has an employment rate of 57.6 percent and unemployment rate much higher than that of the state at 4.6 percent. The largest sector of employment is management, professional, and related occupations at 29.6 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Alliance

Alliance has an employment rate of 63.1 percent and unemployment rate higher than that of the state at 3.6 percent. The largest sector of employment is production, transportation, and material-moving occupations at 25.9 percent. The largest type of industry is transportation and warehousing, and utilities. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Chadron

Chadron has an employment rate of 65.2 percent and unemployment rate lower than that of the state at 2.8 percent. The largest sector of employment is management, professional, and related occupations at 29.2 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.4.10.4.1.2 South Dakota

The state of South Dakota has an employment rate of 64.9 percent and unemployment rate of 3.0 percent. The largest sector of employment is management, professional, and related occupations at 32.6 percent. The largest type of industry is educational, health, and social services at 22.0 percent. The largest class of worker is private wage and salary workers at 72.9 percent (U.S. Census Bureau, 2008).

Rapid City

Rapid City has an employment rate of 63.7 percent and unemployment rate higher than that of the state at 3.2 percent. The largest sector of employment is management, professional, and related occupations at 32.8 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

<u>Spearfish</u>

Spearfish has an employment rate of 53.5 percent and unemployment rate much higher than that of the state at 11.5 percent. The largest sector of employment is management, professional, and related occupations at 33.5 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

<u>Sturgis</u>

Sturgis has an employment rate of 59.5 percent and unemployment rate lower than that of the state at 2.8 percent. The largest sector of employment is sales and occupations at 27.6 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.4.10.4.1.3 Wyoming

The state of Wyoming has an employment rate of 63.1 percent and unemployment rate of 3.5 percent. The largest sector of employment is sales and office occupations. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

<u>Casper</u>

Casper has an employment rate of 64.9 percent and an unemployment rate lower than that of the state at 3.4 percent. The largest sector of employment is sales and office occupations at 30.6 percent followed by management, professional, and related occupations at 29.7 percent. The largest type of industry is educational, health, and social services at 22.1 percent. The largest class of worker is private wage and salary workers at 76.6 percent (U.S. Census Bureau, 2008).

3.4.10.4.2 County Data

3.4.10.4.2.1 Nebraska

<u>Dawes County</u>

Dawes County has an employment rate of 63.8 percent and unemployment rate slightly higher than that of the state at 2.7 percent. The largest sector of employment is management, professional, and related occupations at 32.4 percent. The largest type of industry is educational, health, and social services at 28.9 percent. The largest class of worker is private wage and salary workers at 58.8 percent (U.S. Census Bureau, 2008).

<u>Sioux County</u>

Sioux County has an employment rate of 62.1 percent and unemployment rate slightly higher than that of the state at 2.7 percent. The largest sector of employment is management, professional, and related occupations at 50.3 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 40.5 percent. The largest class of worker is private wage and salary workers at 52.8 percent (U.S. Census Bureau, 2008).

3.4.10.4.2.2 South Dakota

Butte County

Butte County has an employment rate of 64.3 percent and unemployment rate higher than that of the state at 3.9 percent. The largest sector of employment is management, professional, and related occupations at 27.0 percent. The largest type of industry is agriculture, forestry, fishing, and hunting, and mining at 19.4 percent. The largest class of worker is private wage and salary workers at 66.8 percent (U.S. Census Bureau, 2008).

Custer County

Custer County has an employment rate of 57.5 percent and unemployment rate lower than that of the state at 2.0 percent. The largest sector of employment is management, professional, and related occupations at 34.6 percent. The largest type of industry is educational, health, and social services at 20.6 percent. The largest class of worker is private wage and salary workers at 58.5 percent (U.S. Census Bureau, 2008).

Fall River County

Custer County has an employment rate of 52.9 percent and unemployment rate higher than that of the state at 3.9 percent. The largest sector of employment is management, professional, and related occupations at 34.7 percent. The largest type of industry is educational, health, and social services at 31.1 percent. The largest class of worker is private wage and salary workers at 58.2 percent (U.S. Census Bureau, 2008).

Shannon County

Shannon County has an employment rate of 35.1 percent and unemployment rate considerably higher than that of the state at 17.3 percent. The largest sector of employment is management, professional, and related occupations at 37.8 percent. The largest type of industry is educational, health and social services. The largest class of worker is government workers (U.S. Census Bureau, 2008).

3.4.10.4.2.3 Wyoming

Campbell County

Campbell County has an employment rate of 73.2 percent and an unemployment rate lower than that of the state at 3.4 percent. The largest sector of employment is management, professional, and related occupations at 23.9 percent followed by construction, extraction, and maintenance occupations at 23.7 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 23.3 percent followed by educational, health, and social services at 16.7 percent. The largest class of worker is private wage and salary workers at 78.4 percent (U.S. Census Bureau, 2008).

Crook County

Crook County has an employment rate of 62.2 percent and an unemployment rate lower than that of the state at 2.1 percent. The largest sector of employment is management, professional, and related occupations at 29.9 percent. The largest type of industry is agriculture, forestry,

fishing and hunting, and mining at 24.7 percent. The largest class of worker is private wage and salary workers at 59.5 percent (U.S. Census Bureau, 2008).

Niobrara County

Niobrara County has an employment rate of 59.4 percent and an unemployment rate lower than that of the state at 2.1 percent. The largest sector of employment is management, professional, and related occupations at 34.4 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 24.7 percent. The largest class of worker is private wage and salary workers at 62.6 percent (U.S. Census Bureau, 2008).

Weston County

Weston County has an employment rate of 56.6 percent and an unemployment rate lower than that of the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 24.3 percent. The largest type of industry is agriculture, forestry, fishing and hunting, and mining at 22.4 percent. The largest class of worker is private wage and salary workers at 68.9 percent (U.S. Census Bureau, 2008).

3.4.10.4.3 Native American Communities

Information on labor force and poverty levels for the Pine Ridge Indian Reservation is based on 2003 Bureau of Indian Affairs data and is provided in Table 3.4-20. The Oglala Sioux Tribe reports unemployment rates of more than 80 percent, much higher than the statewide levels that range from 2.5 percent for Nebraska to 3.5 percent for Wyoming (U.S. Census Bureau, 2008; U.S. Department of the Interior, 2003).

3.4.10.5 Local Finance

Local finance information such as revenue and tax information for the affected environment is provided in the following sections.

3.4.10.5.1 Nebraska

Sources of revenue for the State of Nebraska come from income, sales, cigarette, motor, and lodging taxes. Personal income tax rates for Nebraska range from 2.56 percent to 6.84 percent. The sales and use tax rate is 5.5 percent. Information on ad valorem taxes or mineral taxes such as that from uranium extraction is not available (Nebraska Department of Revenue, 2007). Information on local finance for the affected communities within the region of influence is presented next.

Dawes County

Sources of revenue for Dawes County come from real estate and property taxes. The net property taxes levied in 2003 were $1,634,113 with a state aid of $634,793 (Nebraska Department of Revenue, 2007).

Sioux County

Sources of revenue for Sioux County come from real estate and property taxes (Nebraska Department of Revenue, 2007).

3.4.10.5.2 South Dakota

Sources of revenue for the State of South Dakota come from 36 different state taxes. These taxes are grouped into four main categories: sales, use, and contractors' excise taxes; motor fuel taxes; motor vehicle fees and taxes; and special taxes. Once collected, these tax revenues are distributed into the state's general fund, local units of government, and the state highway fund. In 2006, 72 percent came from sales, use, and contractors' excise taxes; 11 percent from motor fuel taxes; 9 percent from special taxes; and 8 percent from vehicle taxes. South Dakota also imposes an energy minerals tax on owners of energy minerals (such as uranium). In 2006, the tax rate base was 4.5 percent of the taxable value and approximately 50 percent was disbursed to local government (South Dakota Department of Revenue and Regulation, 2007). Information on local finance for the affected communities within the region of influence is presented next.

Butte County

The majority of revenue for Butte County comes from sales, use, and property taxes. In 2004, a total revenue of $1,578,000 was collected from property taxes (City-Data.com, 2008).

Custer County

The majority of revenue for Custer County is from property taxes. In 2006, there were approximately 13,000 parcels of land in Custer County and $9.3 million was collected in real estate taxes. Other sources of revenue come from motor vehicle fees (Custer County South Dakota, 2007).

Fall River County

In 2004, the majority of revenue for Fall River County was from property taxes ($2,101,000) and motor vehicle fees ($482,000) (City-Data.com, 2007).

Shannon County

The majority of revenue for Shannon County comes from retail sales at $30,594 as of 2002 and federal grants at $197,565 as of 2004 (U.S. Census Bureau, 2008).

3.4.10.5.3 Wyoming

The State of Wyoming does not have an income tax nor does it assess tax on retirement income received from another state. Wyoming has a 4 percent state sales tax, 2 percent to 5 percent county lodging tax, and 5 percent use tax. Counties have the option of collecting an additional 1 percent tax for general revenue and 2 percent tax for specific purposes. Wyoming also imposes "ad valorem" taxes on mineral extraction properties. Taxes levied for uranium production were 10.0 percent in 2007 (6.0 percent "ad valorem" and 4 percent severance) totaling $1.7 million dollars (Wyoming Department of Revenue, 2007). None of this uranium tax revenue was generated in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Annual sales and use tax distribution information for affected counties (including cities and towns) is presented in Table 3.4-21.

Table 3.4-21. 2007 State and Local Annual Sales and Use Tax Distribution of Affected Counties Within Wyoming (Through September 28, 2007*)

Affected Counties	Use Tax		Sales Tax		Gross Revenue
	State	Local	State	Local	
Campbell County	9,104,434	8,130,984	72,443,855	64,724,530	155,316,435
Crook County	542,748	630,596	2,305,618	2,677,933	6,266,869
Niobrara County	156,916	182,363	1,091,293	1,268,288	2,745,320
Weston County	630,016	506,201	2,572,484	2,066,940	5,886,521

*Wyoming Department of Revenue. "State of Wyoming Department of Revenue 2007 Annual Report." 2007. <http://revenue.state.wy.us/PortalVBVS//uploads/2007%20DOR%20Annual%20Report.pdf> (7 April 2009).

3.4.10.5.4 Native American Communities

The Pine Ridge Indian Reservation is the poorest reservation in the United States. The majority of revenue for Pine Ridge comes from employment by the Oglala Sioux Tribe, Oglala Lakota College, Bureau of Indian Affairs, and the Indian Health Service. Some revenue also comes from agricultural production, gaming, hunting, and ranching (Housing Assistance Council, 2002)).

3.4.10.6 Education

Information on education for the affected communities is presented in the following paragraphs.

Based on review of the affected environment, the county with the largest number of schools is Campbell County, Wyoming, and the county with the smallest number of schools is Niobrara, Wyoming. The towns with the smallest number of schools or smaller schools are located on the Pine Ridge Indian Reservation.

3.4.10.6.1 Nebraska

Dawes County

Dawes County has a total of 17 schools including public schools, elementary schools, middle schools, high schools, and 1 academy. There are a total of approximately 5,500 students. The majority of schools provides bus services (Schoolbug.org, 2007a).

Sioux County

Sioux County has a total of 6 schools including 5 public schools and 1 high school, with a total of approximately 565 students. Information as to whether these schools provide bus services is not available (Publicschoolsreport.com, 2008).

3.4.10.6.2 South Dakota

Butte County

Butte County has three elementary schools, two middle schools, and two high schools. There are a total of approximately 1,789 students. Information as to whether these schools provide bus services is not available (Schoolbug.org, 2008).

Custer County

Custer County has five elementary schools, one middle school, one high school, and one alternative school for a total of nine schools. There are a total of approximately 1,207 students. Information as to whether these schools provide bus services is not available (Schoolbug.org, 2007b).

Fall River County

Fall River County has 4 elementary schools, 2 middle schools, 1 junior high school, and 3 high schools for a total of 10 schools. There are a total of approximately 1,200 students. Information as to whether these schools provide bus services is not available (Schoolbug.org, 2007c).

Shannon County

Shannon County has one school district, which consists of four elementary and junior high schools. There are approximately 991 students. Information as to whether these schools provide bus services is not available (Greatschools.net, 2008).

Native American Communities

The Pine Ridge Indian Reservation has the Pine Ridge School and the Oglala elementary school (Housing Assistance Council, 2002; Pine Ridge School, 2008). Specific information pertaining to school population or bus services is not available.

3.4.10.6.3 Wyoming

Campbell County

Campbell County has 1 school district with 24 schools consisting of 15 elementary schools, 2 junior high schools, 1 junior/senior high school, 1 high school, 1 alternative school, and 1 aquatic center. There are a total of approximately 7,441 students. The majority of schools provides bus services (Campbell County School District No. 1, 2007).

Crook County

Crook County has 1 school district with 2 elementary schools, 2 secondary schools, and 1 high school, with a total of approximately 1,142 students. Information as to whether these schools provide bus services is not available (Crook County School District, 2008).

Niobrara County

Niobrara County has one school district, Niobrara County School District No. 1, with a total of approximately 422 students. There is one elementary and middle school, one high school, and one private school. Information as to whether these schools provide bus services is not available (Niobrara County School District No. 1, 2008).

Weston County

Weston County has one school district, Weston County School District No. 1, with a total of approximately 1,134 students. There are two elementary schools, one middle school, and one high school. Information as to whether these schools provide bus services is not available (Weston County School District No. 1, 2008).

3.4.10.7 Health and Social Services

The majority of health care facilities is located within populated areas of the affected environment. The closest health care facilities within the vicinity of the potential ISL facilities are located in Spearfish, Edgemont, Rapid City, and Sturgis, South Dakota; Alliance, Gordon, and Chadron, Nebraska; and Gillette, Sundance, and Torrington, Wyoming, and have a total of at least 18 facilities (MapQuest, 2008b). These consist of hospitals, clinics, emergency centers, and medical services. The following hospitals are located proximate to the Nebraska-South Dakota-Wyoming Uranium Milling Region: Spearfish, South Dakota (one); Rapid City, South Dakota (two); Alliance, Nebraska (one); Gordon, Nebraska (one); Chadron, Nebraska (two); Gillette, Wyoming (two); and Torrington, Wyoming (one).

Local police within the Nebraska-South Dakota-Wyoming Uranium Milling Region are under the jurisdiction of each county. There are 20 police, sheriff, or marshals offices within the region: Butte County, South Dakota (2); Custer County, South Dakota (1); Fall River County, South Dakota (2); Shannon County, South Dakota (1); Dawes County, Nebraska (3); Sioux County, Nebraska (1); Campbell County, Wyoming (2); Crook County, Wyoming (3); Niobrara County, Wyoming (2); and Weston County, Wyoming (3) (Usacops, 2008).

Fire departments within the affected area are comprised at the county, town or CBSA level. There are 45 fire departments within the milling region: Rapid City, South Dakota (16); Sturgis, South Dakota (14); Spearfish, South Dakota (5); Alliance, Nebraska (1); Campbell County, Wyoming (2); Crook County, Wyoming (1); and Gillette, Wyoming (2) (50states, 2008).

3.4.11 Public and Occupational Health

3.4.11.1 Background Radiological Conditions

For a U.S. resident, the average total effective dose equivalent from natural background radiation sources is approximately 3 mSv/yr [300 mrem/yr] but varies by location and elevation (National Council on Radiation Protection and Measurements, 1987). In addition, the average American receives 0.6 mSv/yr [60 mrem/yr] from man-made sources including medical diagnostic tests and consumer products (National Council of Radiation Protection and Measurements, 1987). Therefore, the total from natural background and man-made sources for the average U.S. resident is 3.6 mSv/yr [360 mrem/yr]. For a breakdown of the sources of this radiation, see Figure 3.2-22.

The total effective dose equivalent is the total dose from external sources and internal material released from licensed operations. Doses from sources in the general environment (such as terrestrial radiation, cosmic radiation, and naturally occurring radon) are not included in the dose calculation for compliance with 10 CFR Part 20, even if these sources are from technologically enhanced naturally occurring radioactive material, such as preexisting radioactive residues from prior mining (Atomic Safety and Licensing Board, 2006).

Background dose varies by location primarily because of elevation changes and variations in the dose from radon. As elevation increases so does the dose from cosmic radiation and hence the total dose. Radon is a radioactive gas produced from the decay of U-238, which is naturally found in soil. The amount of radon in the soil/bedrock depends on the type, porosity, and moisture content. Areas that have types of soils/bedrock like granite and limestone have higher radon levels that those with other types of soils/bedrock (EPA, 2006). Radiological background for Wyoming is provided in Section 3.2.11.1. For the states of South Dakota and Nebraska, the average background rate including natural and man-made sources is 6.0 and 3.5 mSv/yr [600 and 350 mrem/yr], respectively (EPA, 2006). The average background rate for South Dakota is significantly higher than the U.S. average background rate of 3.6 mSv/yr [360 mSv/yr], and for Nebraska it is very similar.

For South Dakota, the radon dose is 4.4 mSv/yr [440 mrem/yr] compared to the U.S. average radon dose of 2.0 mSv/yr [200 mrem/yr]. For South Dakota, the indoor average radon rate is significantly higher than the U.S. average due to geological reasons and poor ventilation within homes (EPA, 2006). For the western region of South Dakota of interest here, the radon levels are half as much when compared to the state average (South Dakota Department of Environmental and Natural Resources, 2008), and therefore, background dose is expected to be closer to the national average for this region.

3.4.11.2 Public Health and Safety

Public health and safety standards are the same regardless of a facility's location. Therefore, see Section 3.2.11.2 for further discussion of these standards.

3.4.11.3 Occupational Health and Safety

Occupational health and safety standards are the same regardless of facility's location. Therefore, see Section 3.2.11.3 for further discussion of these standards.

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3.5 Northwestern New Mexico Uranium Milling Region

3.5.1 Land Use

The Northwestern New Mexico Uranium Milling Region defined in this GEIS lies within the Navajo section of the Colorado Plateau (U.S. Geological Survey, 2004). This region includes McKinley County and the northern part of Cibola County (Figure 3.5-1). Past, current and potential uranium milling operations are found in two areas: (1) the central western part of McKinley County, east of Gallup, New Mexico and (2) the southeastern part of McKinley County and the northern part of Cibola County, east and northeast of Grants, New Mexico. These two areas are parts of the Grants Uranium District (Figure 3.5-2). Details on the geology and soils of this district and its subdivisions are provided in Section 3.5.3.

Land distribution statistics in Table 3.5-1 were calculated using the Geographic Information System used to construct the map shown in Figure 3.5-1. The data show that 91 percent of the Northwestern New Mexico Uranium Milling Region is composed of private (surface ownership) land (50 percent), Indian Reservation land (27 percent), and U.S. national forest land (14 percent).

Indian Reservation land, administered by the Bureau of Indian Affairs, comprises Acoma Pueblo, Laguna, Navajo, Ramah Navajo, and Zuni Indian land. Navajo land forms the northwest corner of McKinley County and abuts the northwestern part of the Grants Uranium District. Portions of any potential new ISL facility in this area of this district could fall within Navajo allottees, who own the surface and mineral rights. Bureau of Indian Affairs administers the leases needed for both the surface use and mineral rights on such land. In this area of McKinley County, the Crownpoint and Church Rock Chapters of the Navajo Nation are part of an area known as the checkerboard due to its mixed private tribal and government property rights. Certain properties are under the Navajo Tribal Trust while individual Navajo allotments are privately held, with some Bureau of Indian Affairs oversight. In this area, the Crownpoint Unit 1 site is located on allotted land and the Church Rock site is located on Navajo Tribal Trust land (NRC, 1997).

Land use issues in the area of the Navajo Nation are a sensitive issue and consideration should be paid to ongoing jurisdictional disputes over the checkerboard lands. In addition, contamination of water supplies within the Rio San Jose Basin as a result of uranium milling has further heightened the Navajo Nation's sensitivity to land uses that may affect their ability to use tribal lands for raising livestock.

BLM lands occupy only approximately 8 percent of the region and are mostly concentrated in the northeastern corner of McKinley County (Figure 3.5-1). Other federal lands managed by the U.S. Department of Defense (Fort Wingate Military Reservation) and the National Park Service represent less than 1 percent of the region.

Although sparsely populated, this region has three fairly large population centers: Gallup, with more than 20,000 people; Grants, with approximately 9,000 people; and Zuni Pueblo, with about 6,400 people. Smaller communities are scattered along the Interstate 40 corridor (Figure 3.5-2). Generally, private, federal, and Indian Reservation lands in this region are rural, mainly undeveloped, sparsely populated, and mostly used for livestock grazing and to a lesser extent for timber and agricultural production. In McKinley County, for example, more than 85 percent of the land is used for agricultural purposes and 83 percent of that land is used for livestock grazing. Only 9 percent and 0.6 percent of the land is used for timber production and for dry

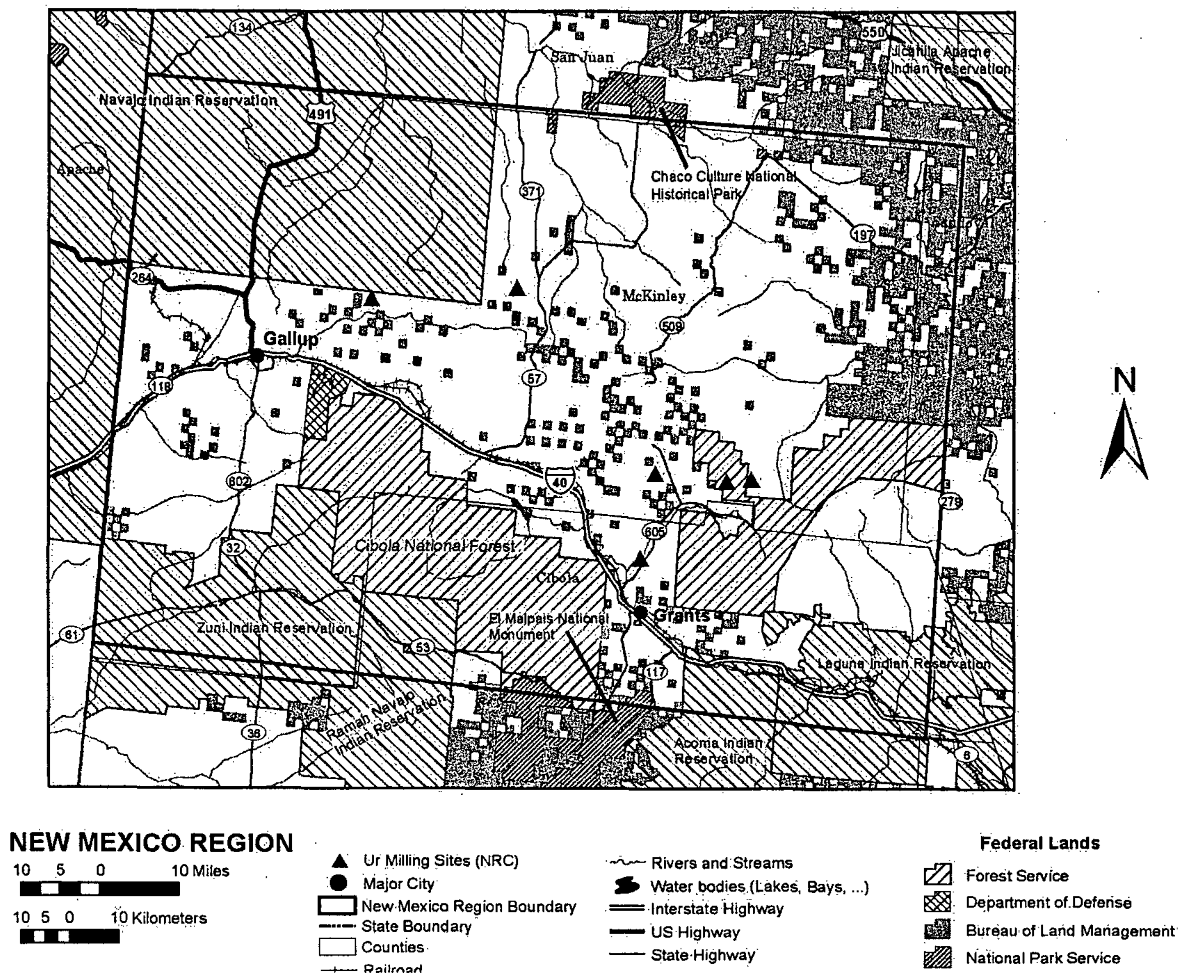


Figure 3.5-1. Northwestern New Mexico Uranium Milling Region General Map With Current and Future Uranium Milling Site Locations

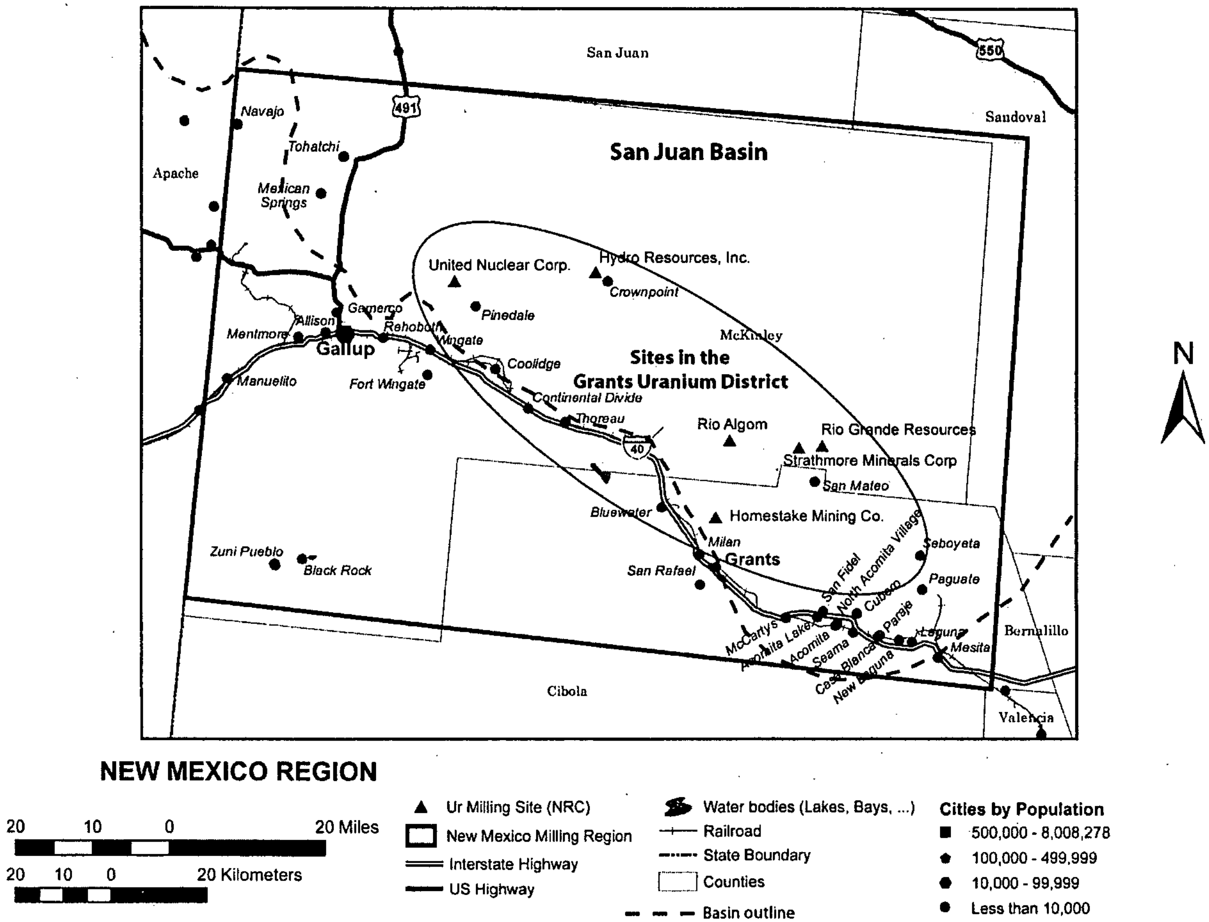


Figure 3.5-2. Map Showing Outline of the Northwestern New Mexico Region and the Location of the Grants Uranium District Along the Southern Margin of the San Juan Basin

Table 3.5-1. Land Surface Ownership and General Use in the Northwestern New Mexico Uranium Milling Region

Land Surface Ownership and General Use	Area (mi²)	Area (km²)	Percent
State and Private Lands	3,682	9,537	50.1
Bureau of Indian Affairs, Indian Reservations	1,999	5,176	27.2
U.S. Forest Service, National Forest	1,028	2,662	14
U.S. Bureau of Land Management (BLM), Public Domain Land	579	1,501	7.9
U.S. Department of Defense (Army)	29	75	0.4
National Park Service, National Monument	25	64	0.3
National Park Service, National Historic Park	6	16	0.08
BLM, National Conservation Area	1	2	0.01
BLM, Wilderness	0.5	1	0.01
Totals	7,350	19,035	100

and irrigated crop production, respectively. Coal and uranium milling activities use less than 1 percent of the land in McKinley County (NRC, 1997).

Recreational and cultural activities for the public are available in the Mount Taylor Ranger District, part of the Cibola National Forest. This forest includes the Zuni Mountains to the west of Grants and the San Mateo Mountains and Mount Taylor, about 24 km [15 mi] to the east-northeast of Grants. Mount Taylor is designated by the Navajo Nation as one of six sacred mountains. In Navajo tradition, Mount Taylor has a special significance as it represents the southern boundary of the Navajo traditional homeland (USFS, 2006). On June 14, 2008, the New Mexico Cultural Properties Review Committee approved a 1-year emergency listing of more than 171,000 ha [422,000 acres] of land surrounding Mount Taylor on the New Mexico Register of Cultural Properties (Los Angeles Times, 2008) (see Section 3.5.8.3).

El Malpais National Monument in Cibola County and the Chaco Culture National Historical Park, which has several sites in McKinley County and San Juan County farther north, are the two main recreational and cultural areas managed by the National Park Service in the Northwestern New Mexico Uranium Milling Region.

3.5.2 Transportation

Past experience at NRC-licensed ISL facilities indicates these facilities rely on roads for transportation of most goods and personnel (Section 2.8). As shown in Figure 3.5-3, the Northwestern New Mexico Uranium Milling Region is accessed from the east and west by Interstate 40, from the north by U.S. Highway 491 (formerly U.S. Highway 666) and State Routes 371 and 509, and from the south by State Routes 36 and 602. A rail line traverses the region east and west along the path of Interstate 40.

Areas of past, present, or future interest in uranium milling in the region are shown in Figure 3.5-3. These areas are located in three subregions when considering site access by local roads. Areas of milling interest from west to east include areas near Pinedale northeast of Gallup, the area near Crownpoint north of Thoreau, and the area northeast of Milan and Grants near Ambrosia Lake and San Mateo. All these areas have access to Interstate 40 to the south using local access roads to State Routes 566 near Pinedale, 371 near Crownpoint, and 509 and 605 near Ambrosia Lake and San Mateo.

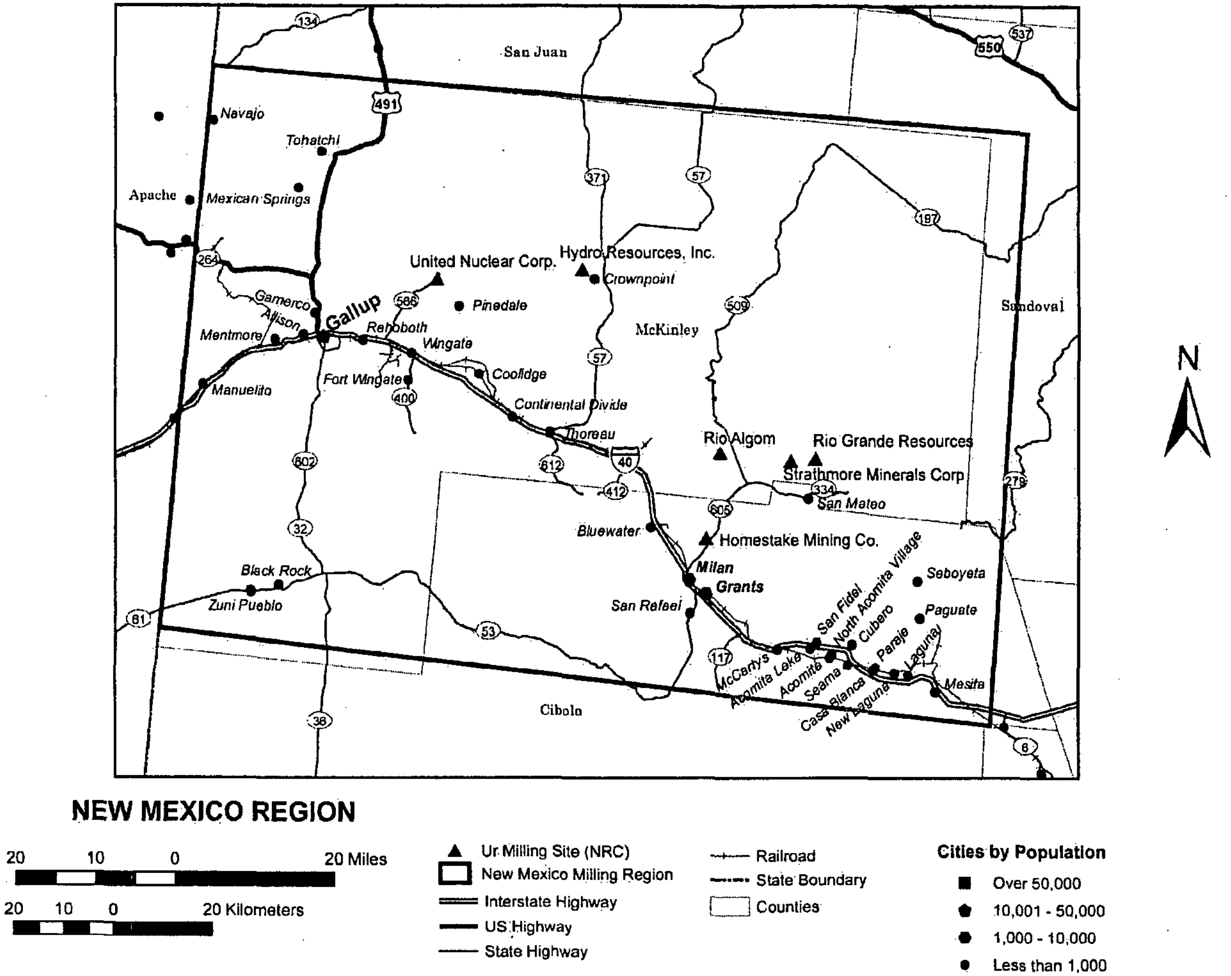


Figure 3.5-3. Northwestern New Mexico Uranium Milling Region Transportation Corridor Locations

Table 3.5-2 provides available traffic count data for roads that support areas of past, present, or future milling interest in the Northwestern New Mexico Uranium Milling Region. Counts are variable, with the minimum all-vehicle count at 330 vehicles per day on State Route 509 North at State Route 605 and the maximum on Interstate 40, Thoreau Interchange North at 11,709 vehicles per day. Most all vehicle counts in the Northwestern New Mexico Uranium Milling Region are above 1,500 vehicles per day.

Yellowcake product shipments are expected to travel from the milling facility to a uranium hexafluoride production (conversion) facility in Metropolis, Illinois (the only facility currently licensed by NRC in the United States for this purpose). Major interstate transportation routes are expected to be used for these shipments, which are required to follow NRC packaging and transportation regulations in 10 CFR Part 71 and U.S. Department of Transportation hazardous material transportation regulations at 49 CFR Parts 171–189. Table 3.5-3 describes representative routes and distances for shipments of yellowcake from locations of uranium milling interest in the Northwestern New Mexico Uranium Milling Region. Representative routes are considered owing to the number of routing options available that could be used by a future ISL facility. Because transportation risks are dependent on shipment distance, identification of representative routes is used to generate estimates of shipment distances for evaluation of transportation impacts in Chapter 4 (Section 4.2.2). An ISL facility could use a variety of routes for actual yellowcake shipments, but the shipment distances for alternate routes are not expected to differ significantly from those estimated for the representative routes.

3.5.3 Geology and Soils

New Mexico ranks second in uranium reserves in the United States. In the Northwestern New Mexico Uranium Milling Region, uranium resources are located primarily within the Morrison

Table 3.5-2. Average Annual Daily Traffic Counts for Roads in the Northwestern New Mexico Uranium Milling Region*

Road Segment	County	All Vehicles	
		2005	2006
State Route 566 North at State Route 118	McKinley	4,605	4.637
State Route 371 at Interstate 40 (Thoreau)	McKinley	5,514	5,552
State Route 371 North at Navajo 9 to Mariano Lake	McKinley	3,842	3,868
State Route 605 North at County Line North of Milan	McKinley	2,522	2,488
State Route 605 North at State Route 509 to Ambrosia Lake	McKinley	1,595	1,562
State Route 509 North at State Route 605	McKinley	338	330
Interstate 40, Thoreau Interchange North	McKinley	11,676	11,709
State Route 605 North at State Route 122 in Milan	Cibola	1,232	1,196
Interstate 40, Grants-Milan Interchange	Cibola	10,186	9,993

*NMDOT. "Road Segments by Traffic (AADT) Info." Data for Cibola and McKinley Counties from the New Mexico State Highway and Transportation Department's Consolidated Highway Data Base, provided by request. Santa Fe, New Mexico: New Mexico Department of Transportation. April 2008.

Table 3.5-3. Representative Transportation Routes for Yellowcake Shipments From the Northwestern New Mexico Uranium Milling Region*

Origin	Destination	Major Links	Distance* (mi)
North of Pinedale, New Mexico	Metropolis, Illinois	Local access road to State Route 566 State Route 566 south to Interstate 40 Interstate 40 east to Memphis, Tennessee Interstate 55 north to Interstate 155 Interstate 155 north to Interstate 24 Interstate 24 north to Metropolis, Illinois	1,360
Crownpoint, New Mexico	Metropolis, Illinois	Local access road to State Route 371 State Route 371 south to Interstate 40 Interstate 40 east to Metropolis, Illinois (as above)	1,360
North of San Mateo, New Mexico	Metropolis, Illinois	Local access road to State Route 334 at San Mateo State Route 334 west to State Route 605 State Route 605 to Interstate 40 at Milan near Grants	1,300

*American Map Corporation. "Road Atlas of the United States, Canada, and Mexico." Long Island City, New York: American Map Corporation. p. 144. 2006.

Formation in the Grants Uranium District (see Figure 3.5-2). The Grants Uranium District includes a belt of sandstone-type uranium deposits stretching 135 km [85 mi] along the south side of the San Juan Basin. The Grants Uranium District consists of eight subdistricts, which extend from east of Laguna to west of Gallup (Figure 3.5-4) (McLemore and Chenoweth, 1989). The sandstone-type uranium deposits in the Grants Uranium District are generally in a geologic setting favorable for exploitation by ISL milling. More than 150,000 metric tons [170,000 tons] of U_3O_8 have been produced from these deposits from 1948 to 2002, accounting for 97 percent of the total production in New Mexico and more than 30 percent of the total production in the United States (McLemore and Chenoweth, 1989). Estimates of uranium reserves indicate that there are an additional 150,000 metric tons [170,000 tons] of U_3O_8 in the Morrison Formation (McLemore, 2007).

The San Juan Basin is a structural depression occupying a major portion of the southeastern Colorado Plateau physiographic province (Hunt, 1974). The plateau encompasses much of western Colorado, eastern Utah, northeastern Arizona, and northwestern New Mexico. The San Juan Basin is underlain by up to 3,000 m [10,000 ft] of sedimentary strata, which generally dip gently from the margins toward the center of the basin. The margins of the basin are characterized by relatively small elongate domes, uplifts, and synclinal depressions.

Uranium mineralization in the Grants Uranium District occurs within Upper Jurassic (144- to 159-million-year-old) and Cretaceous (65 to 144 million year old) sandstones. Stratigraphic descriptions presented here are limited to formations that would be involved in potential milling operations or formations that may have environmental significance, such as important aquifers and confining units above and below potential milling zones. A generalized stratigraphic column of formations in the Grants Uranium District is shown in Figure 3.5-5.

The Morrison Formation is composed of the Recapture, Westwater Canyon, and Brushy Basin Members and is the host formation for major uranium deposits in the Grants Uranium District. Most of the deposits are within the main sandstone bodies of the Westwater Canyon Member. In addition, the Westwater Canyon is an important regional aquifer. Large uranium deposits are

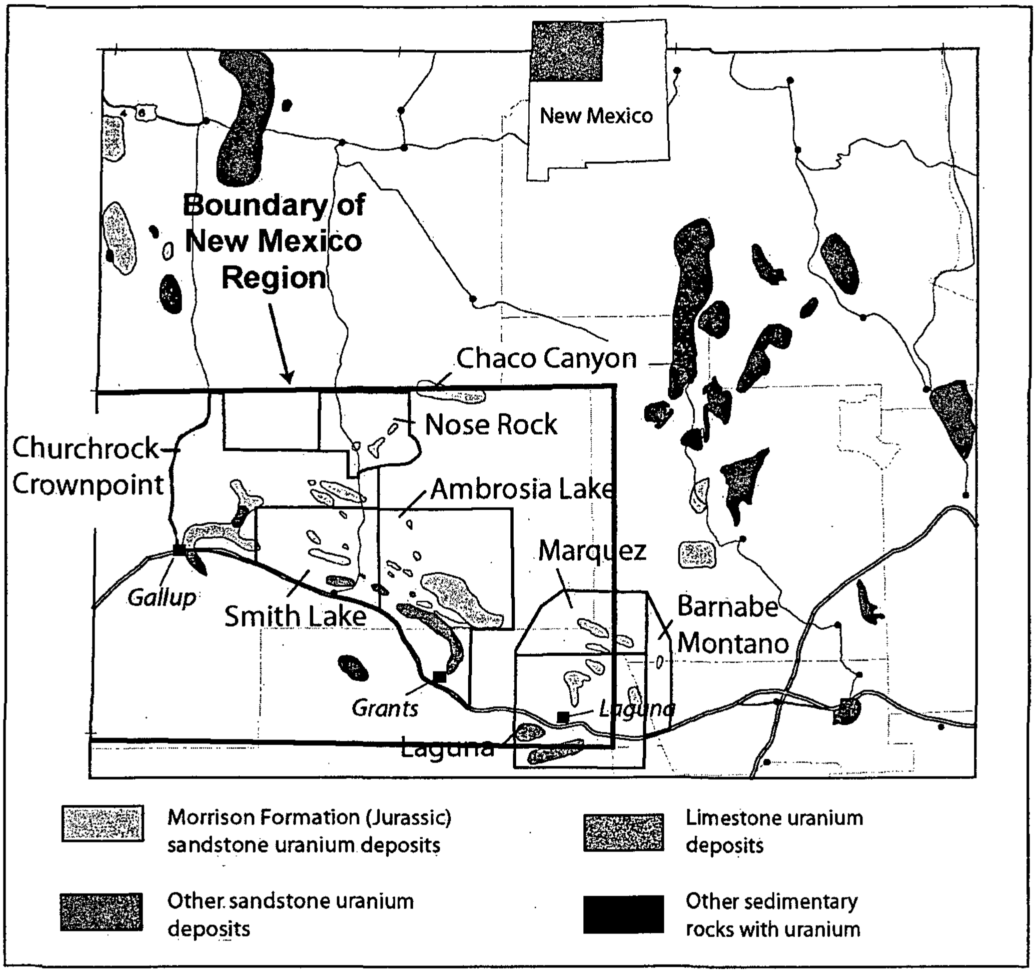


Figure 3.5-4. Index Map of the Grants Uranium District, San Juan Basin, New Mexico, Showing Eight Subdistricts (Modified From McLemore, 2007)

also found in a series of sandstone beds, known collectively as the Poison Canyon sandstones of economic usage, which occur near the base of the Brushy Basin Member in the Blackjack (Smith Lake), Poison Canyon, and Ambrosia Lake mining areas (Holen and Hatchell, 1986). Deposits also occur in sandstone lenses higher in the Brushy Basin in the Blackjack (Smith Lake) mining area. In the Laguna district, a bed of sandstone overlying the Brushy Basin, the Jackpile Sandstone Member of the Morrison (Owen, 1984), contains the large Jackpile-Paguate, L-Bar, and Saint Anthony deposits. Relationships of the deposits in the various Morrison units are shown in Figure 3.5-6.

Elsewhere in the San Juan Basin, significant but relatively small sandstone-type deposits also occur in the Dakota Sandstone in the Church Rock area and in the Burro Canyon Formation in the Carjilon area (Holen and Hatchell, 1986). The Todilto Limestone in the Grants Uranium District, which has accounted for about 2 percent of total production, is quite impermeable and is unlikely to be amenable to production by ISL. Beyond the San Juan Basin, significant but

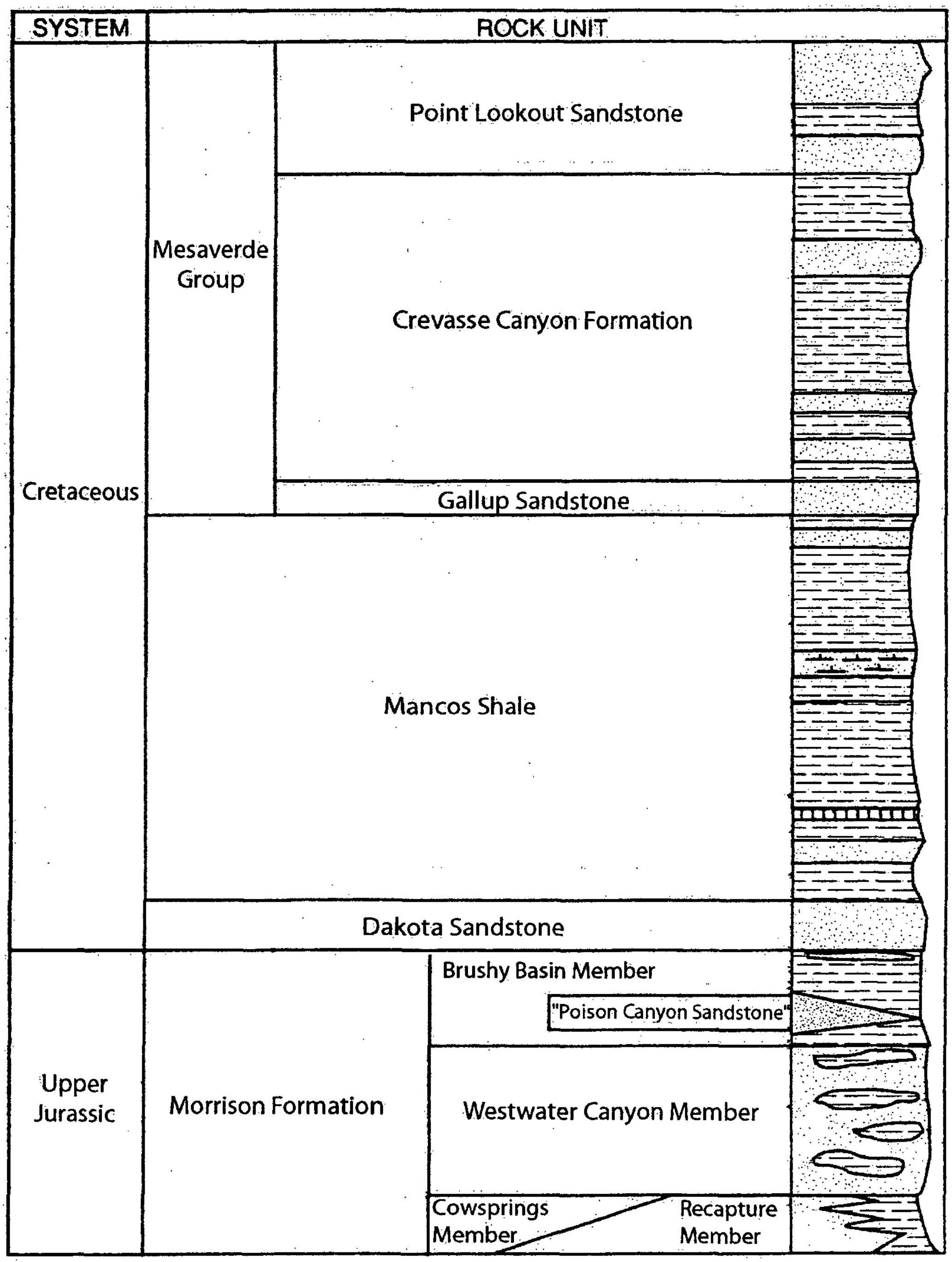


Figure 3.5-5. Generalized Stratigraphic Section of Upper Jurassic and Cretaceous Formations in the Grants Uranium District (NRC, 1997)

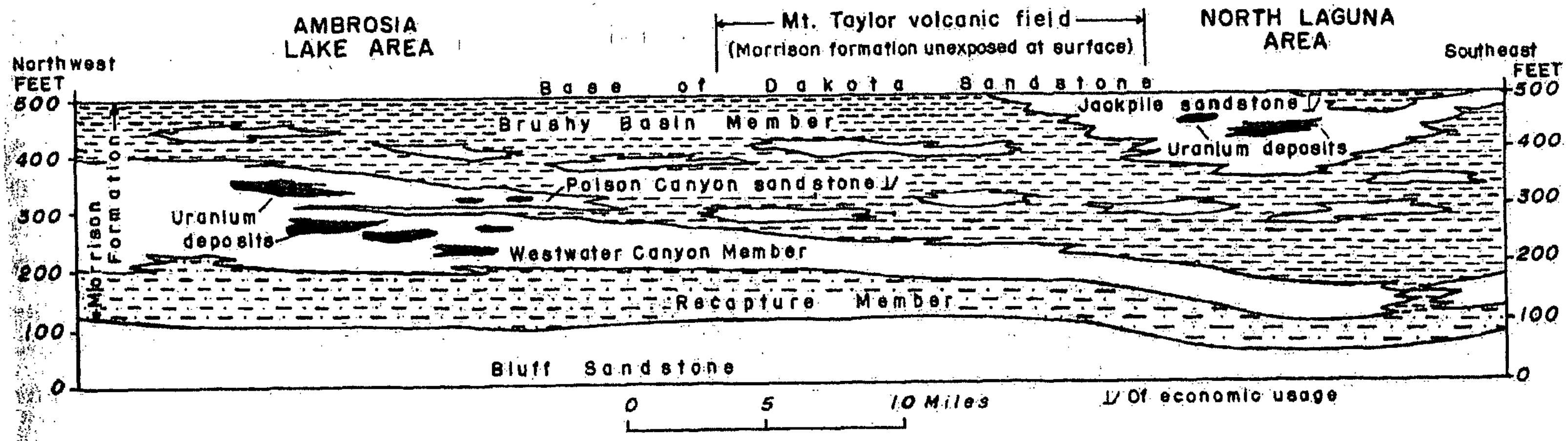


Figure 3.5-6. Generalized Geologic Section Showing the Stratigraphic Relations of the Morrison Formation Between the Ambrosia Lake and Laguna Areas (From Hilpert, 1969)

relatively small sandstone-type deposits occur in the Galisteo Formation in the Hagan Basin, and in the Crevasse Canyon and Baca Formations in the Riley-Pie Town areas.

The following regional descriptions of the stratigraphic units within the San Juan Basin are derived from reports by Green and Pierson (1977), Hilpert (1963, 1969), Chenoweth and Learned (1980), and Holen and Hatchell (1986).

The Recapture Member is the bottommost member of the Morrison Formation. It is as thick as 150 m [500 ft] northwest of Gallup but thins to 45 to 90 m [150 to 300 ft] in outcrops near Gallup and eastward. The Recapture is one of the most variable stratigraphic units in the area. It occurs in the Gallup Mining District as a sequence of interbedded siltstone, mudstone, and sandstone strata. Individual strata range from centimeters to meters [inches to feet] in thickness. Sandstone beds are generally less than 5 m [15 ft] thick (Hilpert, 1969). The Recapture is believed to interfinger with the underlying Cow Springs Sandstone, and several authors have combined the two units as one. No significant uranium deposits occur in the Recapture Member.

The Westwater Canyon Member of the Morrison Formation consists of interbedded fluvial red, tan, and light-gray arkosic sandstone (i.e., sandstone containing a significant fraction of feldspar), claystone, and mudstone. It is a major water-bearing member of the Morrison. The unit ranges from 53 to 85 m [175 to 275 ft] thick in outcrops from Gallup to the Continental Divide (Hilpert, 1969) and is known to be considerably thicker locally. In most places, the Westwater Canyon displays one or more mudstone units that range from thin partings to units up to 6 m [20 ft] thick. The mudstone units have limited lateral continuity, and only the thicker ones are extensive. The Westwater Canyon is host for the major uranium deposits in the region. The uranium occurs in coarse-grained, poorly sorted sandstone units and is closely associated with the carbonaceous material that coats the sand grains.

Three types of stratabound uranium deposits are present in the Westwater Canyon Member: primary (trend or tabular), roll front (redistributed), and remnant-primary sandstone uranium deposits (Figure 3.5-7) (Holen and Hatchell, 1986; McLemore, 2007). Primary sandstone-hosted uranium deposits, also known as prefault, trend, blanket, and black-band ores, are found as blanketlike, roughly parallel ore bodies along sandstone trends. These deposits are characteristically less than 2.5 m [8 ft] thick, average more than 0.20 percent U_3O_8, and have sharp ore-to-waste boundaries. The largest deposits in the Grants Uranium District contain more than 13,600 metric tons [15,000 tons] of U_3O_8.

During the Tertiary (1.8 to 65 million years ago) period, oxidizing groundwaters migrated through the Morrison Formation and remobilized some of the primary sandstone uranium deposits (Saucier, 1981). Uranium was reprecipitated ahead of the oxidizing waters forming roll-front sandstone uranium deposits (see Section 3.1.1). Roll-front uranium deposits are also known as postfault, stack, secondary, and redistributed ores. A schematic diagram of the formation of a redistributed or roll-front uranium deposit is shown in Figure 3.1-5. They are discordant, asymmetrical, irregularly shaped, and characteristically more than 2.5 m [8 ft] thick; have diffuse ore-to-waste contacts; and cut across sedimentary structures. The average deposit contains approximately 8,500 metric tons [9,400 tons] U_3O_8 with an average grade of 0.16 percent. Some redistributed uranium deposits are vertically stacked along faults (see Figure 3.5-7).

Remnant sandstone-hosted uranium deposits were preserved in sandstone after oxidizing waters that formed roll-front uranium deposits had passed. Some remnant sandstone-hosted

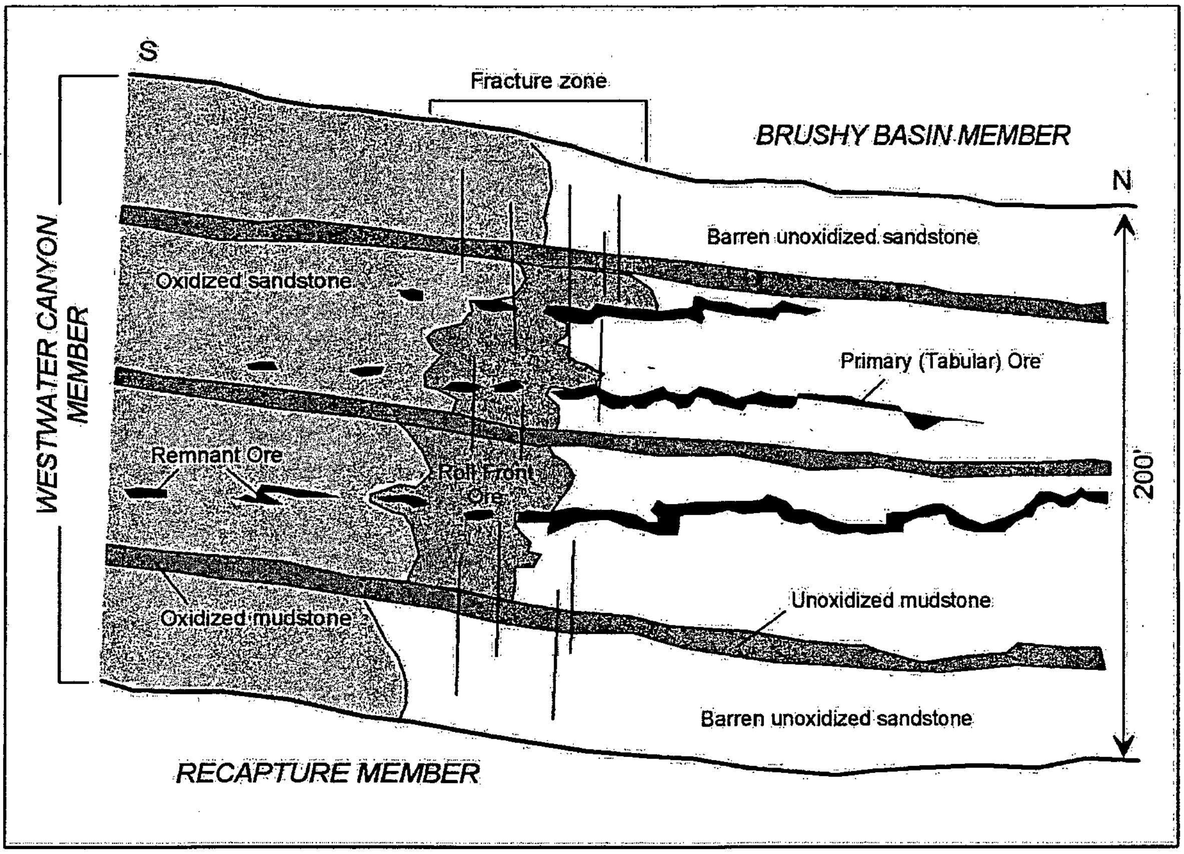


Figure 3.5-7. Schematic Diagram of the Different Types of Uranium Deposits in the Morrison Formation, Grants Uranium District, New Mexico (Modified From Holen and Hatchell, 1986). See Text for Description.

uranium deposits were preserved because they were surrounded by or found in less permeable sandstone and could not be reached by oxidizing groundwaters. These deposits are similar to primary sandstone-hosted uranium deposits, but are difficult to locate because they occur sporadically within the oxidized sandstone. The average size is approximately 1,200 metric tons [1,400 tons] U_3O_8 at a grade of 0.20 percent.

There is no consensus on the origin of the Morrison Formation sandstone uranium deposits and the source of uranium is not well constrained (Sanford, 1992). Uranium could be derived from alteration of volcanic detritus and shales within the Morrison Formation (Thamm, et al., 1981; Adams and Saucier, 1981) or from groundwater derived from a volcanic highland to the southwest. The majority of the proposed models for their formation suggests that deposition occurred at a groundwater interface between two fluids of different chemical compositions and/or oxidation/reduction states. Bleaching of the Morrison sandstones and the geometry of tabular uranium bodies floating in sandstone beds supports the reaction of two chemically different waters, most likely a dilute meteoric water and saline brine from deeper in the basin (McLemore, 2007).

The Brushy Basin Member overlies the Westwater Canyon and ranges from 12 to 40 m [40 to 125 ft] thick in the Gallup region. It is mainly composed of light greenish gray and varicolored

claystone, interbedded with sandstone lenses having similar lithology and appearance to sandstones found in the Westwater Canyon Member (Ristorcelli, 1980). The mudstones are largely derived from volcanic ash falls (Peterson, 1980) and contain considerable amounts of bentonite. The contact between the Brushy Basin and the Westwater Canyon is gradational and interfingering.

The Dakota Sandstone is the basal formation of the Cretaceous System and unconformably overlies the Morrison Formation. The Dakota is a gray-brown quartz sandstone with some interbedded conglomerate, shale, carbonaceous shale, and coal. The Dakota Sandstone is marine in origin and is considered to represent the earliest transgression of late Cretaceous seas. The Dakota crops out around the margins of the San Juan Basin and thickens toward the center of the basin to about 60 m [200 ft]. The Mancos Shale overlies the Dakota Sandstone and is a thick, mostly uniform gray marine shale containing thin lenses of fine-grained sandstone.

Approximately 227 metric tons [250 tons] of U_3O_8 have been produced from roll-front uranium deposits in the Dakota Sandstone in the southern part of the San Juan Basin (Chenoweth, 1989). Uranium deposits in the Dakota Sandstone are typically tabular masses that range in size from thin pods a few meters [feet] long and wide to masses as much as 760 m [2,500 ft] long and 300 m [1,000 ft] wide. The larger deposits are only a few meters [feet] thick, but a few are as much as 8 m [25 ft] thick (Hilpert, 1969). Ore grades range from 0.12 to 0.30 percent and average 0.21 percent U_3O_8. Uranium is found with carbonaceous plant material near or at the base of channel sandstones or in carbonaceous shale and lignite and is associated with fractures, joints, or faults and with underlying permeable sandstone of the Brushy Basin or Westwater Canyon Members. The largest deposits in the Dakota Sandstone are found in the Old Church Rock mine in the Church Rock subdistrict, where uranium is associated with a major northeast-trending fault. More than 81 metric tons [90 tons] of U_3O_8 have been produced from the Dakota Sandstone in the Old Church Rock mine (Chenoweth, 1989).

The San Juan Basin is part of the Colorado Plateau physiographic province, which is generally characterized by rough, broken terrain, including small steep mountainous areas, plateaus, cuestas, and mesas intermingled with steep canyon walls, escarpments, and valleys. Thick colluvium deposits are commonly found forming a mantle on steep slopes surrounding sandstone mesas and cuestas in the San Juan Basin. In contrast, Quaternary alluvium is found on the valley floors of the region. These deposits consist of fine sand, silt, and clay derived from the weathering of sandstone, siltstone, and mudstone exposed at the surface. Alluvial deposits generally are thin but are known to exceed a thickness of 10 m [30 ft] in larger valleys.

General soils information associated with landforms in the southern part of the San Juan Basin was obtained from the Soil Survey of McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties (NRCS, 2001). For site-specific evaluations at proposed ISL milling facilities, more detailed soils information would be expected to be obtained from published county soil surveys or the U.S. Department of Agriculture NRCS.

In the southern part of the San Juan Basin, soils on hills and mountains vary greatly in horizon development, from soils with no development to soils that have well-developed clay horizons. Gravelly clay loams having little or no horizon development are usually found on steeper slopes where erosional activity is greatest. Clay loam soils that have well-developed horizons are generally found on gently sloping to moderately steep slopes, where erosion is slight to moderate. Gravelly to fine-sand loam soils characterized by well-developed clay horizons are found on mesa summits and cuesta dip slopes, which are nearly level to gently sloping. Sandy

to fine sandy loam soils with little or no horizon development are found on the escarpment of mesas and cuestas and on hogbacks, where erosional activity is great. Fine sandy loam soils are found on the summits of ridges and are mostly shallow, whereas sandy loam soils are found on the side slopes of ridges and are generally shallow but sometimes deeper. Soils on alluvial fans are generally very deep, and their soil textures are highly variable, depending on the local geology. Soils found on alluvial fans include clay loam and fine sandy loam. Soils on stream terraces are underlain by stratified sand, gravel, loamy, silty, or clayey sediments and, in some cases, buried paleosols. Typical soils that represent stream terraces are sandy clay loam and silt loam. Soils on floodplains and drainageways are generally very deep, with soil textures that are highly variable, depending on the local geology. Clay loam and fine-sand loam soils are found in drainageways, and fine sand and clay loam soils are found on floodplains.

3.5.4 Water Resources

3.5.4.1 Surface Waters

The Northwestern New Mexico Uranium Milling Region includes McKinley and the northern portion of Cibola County and a small portion western Bernalillo County. Average annual surface runoff, in terms of average annual flow per unit area of a watershed in the Northwestern New Mexico Uranium Milling Region, is generally less than 2.5 cm/yr [1 in\yr]. Watersheds in the Northwestern New Mexico Uranium Milling Region are Rio San Jose, Zuni, Chaco Canyon, Upper Puerco River,[1] Arroyo Chico, and a small portion of Rio Puerco (EPA, 2008) (Figure 3.5-8). The named uranium deposits shown in Figure 3.5-4 are listed with their corresponding watershed in Table 3.5-4. The unnamed uranium deposits northeast of Chaco Canyon are located in the Arroyo Chico and Rio Puerco watersheds. Historical and potential uranium milling sites are located in the Upper Puerco, Chaco, Arroyo Chico, and Rio San Jose watersheds. The Zuni River watershed does not contain any identified uranium deposits that are being considered for ISL uranium recovery. The Rio San Jose is the only watershed with perennial stream reaches within the area of potential uranium milling.

The Rio San Jose and associated tributaries drain the south-central portion of McKinley County and northeastern portion of Cibola County. The Rio San Jose flows into Rio Puerco east of the Northwestern New Mexico Uranium Milling Region. The state-designated uses of Rio San Jose and its tributaries are listed in Table 3.5-5 along with known impairments to these uses. Impairments to water quality within the Rio San Jose watershed include elevated nutrients, metals (aluminum), turbidity, temperature and sediment. Flow of the Rio San Jose is not gauged within the region.

The Rio Puerco drains a small portion of the east-central part of the Northwestern New Mexico Uranium Milling Region (Figure 3.5-8). The Rio Puerco flows southeast to the Rio Grande southeast of the Northwestern New Mexico Uranium Milling Region. The mainstem of the Rio Puerco is east of the Northwestern New Mexico Uranium Milling Region, and none of the tributaries of Rio Puerco are perennial within the Northwestern New Mexico Uranium Milling Region.

[1]The Rio Puerco watershed is located in north-central New Mexico and drains into the Rio Grande. The Puerco River watershed is located in west-central New Mexico and drains into the Little Colorado River in Arizona.

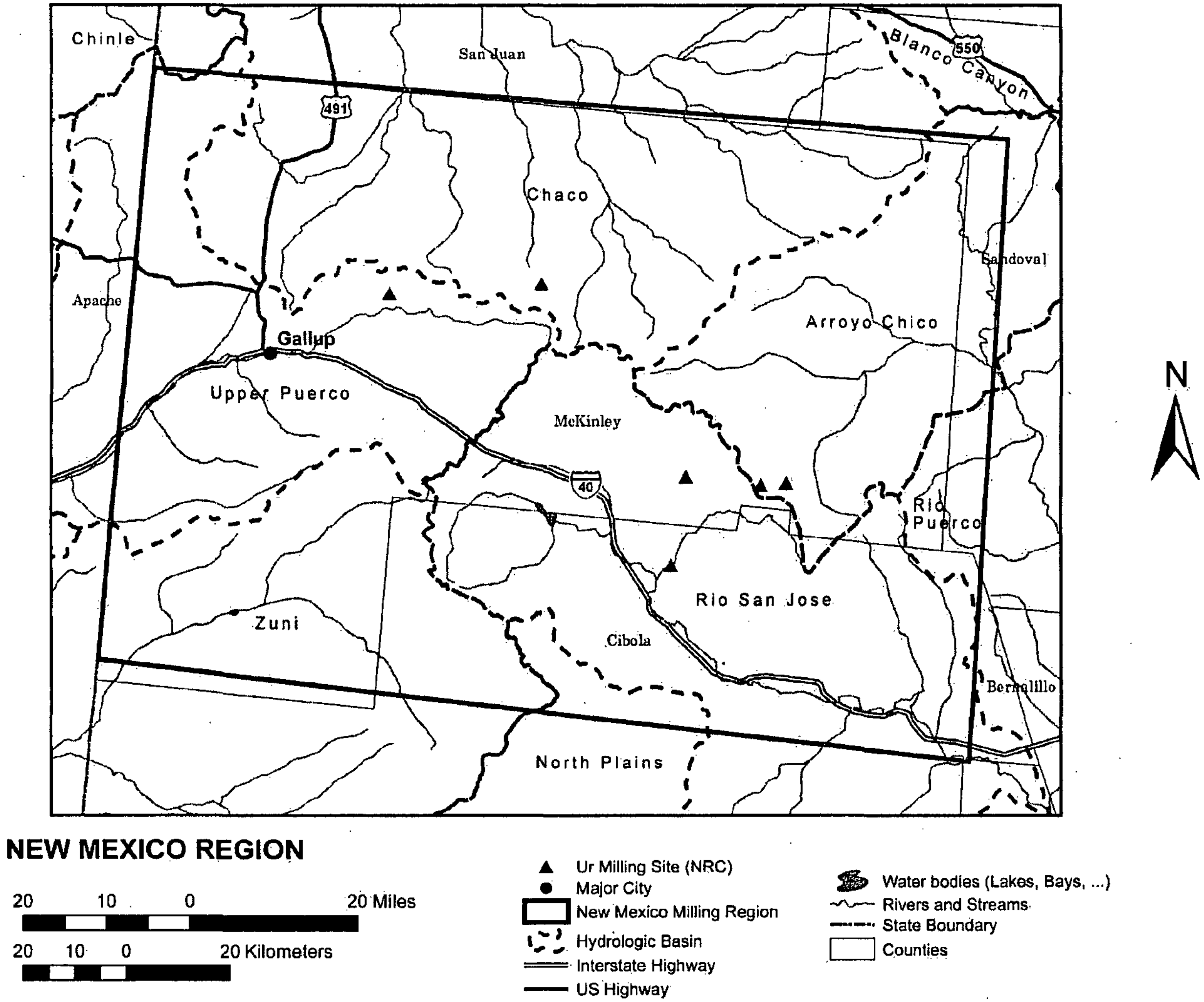


Figure 3.5-8. Watersheds in the Northwestern New Mexico Uranium Milling Region

Table 3.5-4. Named Uranium Deposits in New Mexico and Corresponding Watersheds	
Uranium Deposit	**Watershed**
Barnabe Montano	Rio San Jose
Marquez	Rio San Jose
Laguna	Rio San Jose
Grants	Rio San Jose
Smith Lake	Rio San Jose
Nose Rock	Chaco Canyon
Chaco Canyon	Chaco Canyon
Church Rock	Puerco River
Crownpoint	Chaco Canyon

Table 3.5-5. Primary Watersheds in New Mexico, Designated Uses, and Known Impairments

Watershed	Tributary or Reach	State-Designated Uses	Known Impairments
Rio San Jose	Bluewater Creek	Wildlife Habitat Irrigation Fish Culture Domestic Water Supply Cold Water Fishery Primary Contact Livestock Watering	Nutrients Aluminum Turbidity Temperature Sedimentation
	Bluewater Lake	Wildlife Habitat Irrigation Fish Culture Domestic Water Supply Cold Water Fishery Primary Contact Livestock Watering	None
	Rio Moquino	Wildlife Habitat Irrigation Fish Culture Domestic Water Supply Cold Water Fishery Primary Contact Livestock Watering	Temperature Sedimentation

Table 3.5-5. Primary Watersheds in New Mexico, Designated Uses, and Known Impairments (continued)			
Watershed	Tributary or Reach	State-Designated Uses	Known Impairments
	Rio Paquate	Wildlife Habitat Irrigation Fish Culture Domestic Water Supply Cold Water Fishery Primary Contact Livestock Watering	Selenium Temperature Sedimentation
	Rio San Jose	Wildlife Habitat Livestock Watering	None
	Seboyeta Creek	Wildlife Habitat Irrigation Fish Culture Domestic Water Supply Cold Water Fishery Primary Contact Livestock Watering	None
Rio Puerco	No Perennial Reaches in New Mexico Region		
Upper Puerco River	No Perennial Reaches in New Mexico Region		
Arroyo Chico	No Perennial Reaches in New Mexico Region		
Chaco	No Perennial Reaches in New Mexico Region		
Zuni River	No Known Uranium Recovery Activities in Zuni Watershed		

The other watersheds within the area of potential uranium recovery of the Northwestern New Mexico Uranium Milling Region contain ephemeral streams that flow only after precipitation events. The only surface water features in these watersheds are springs and stock ponds. Many springs are present within the Northwestern New Mexico Uranium Milling Region in McKinley and Cibola Counties. These springs occur on the flanks of mountainous areas, such as the Chuska Mountains in the western portion of the region and the Mount Taylor area in the southeastern portion of the region as well as in the intermontane areas. These springs are fed by both local and regional aquifer systems (see Section 3.5.4.3).

3.5.4.2 Wetlands and Waters of the United States

Wetlands and other shallow aquatic habitats occupy only about 1–5 percent of the land surface in this region (USACE, 2006).

Within this region no digital data are available. However, hardcopy National Wetland Inventory Maps can be obtained from the U.S. Fish and Wildlife Service. In general, Waters of the United States in this region consist of ephemeral stream/arroyos with few perennial rivers. Bands of wetlands are concentrated along rivers and streams within this region. Seasonally emergent wetland areas may be found within woody habitat at high elevations. Within this region, springs and seeps often support small marshes (cienegas), oases, and other wetland types (USACE, 2006). Desert playas are intermittent shallow lakes that develop in the flat, lower portions of

arid basins during the wet season. Most are unvegetated and may not contain water every year.

Waters of the United States and special aquatic sites that include wetlands would be expected to be identified and the impact delineated upon individual site selection. Based on impacts and consultation with each area, appropriate permits would be expected to be obtained from the local USACE district. Within this region, the state does not regulate wetlands; however, Section 401 state water quality certification is required for work in Waters of the United States.

3.5.4.3 Groundwater

Groundwater resources in the Northwestern New Mexico Uranium Milling Region are part of regional aquifer systems that extend well beyond the areas of uranium milling interest in this part of New Mexico. Uranium-bearing aquifers exist within these regional aquifer systems in the Northwestern New Mexico Uranium Milling Region. This section provides a general overview of the regional aquifer systems to provide context for a more focused discussion of the uranium-bearing aquifers in northwester New Mexico, including hydrologic characteristics, level of confinement, groundwater quality, water uses, and important surrounding aquifers.

3.5.4.3.1 Regional Aquifer Systems

The Colorado Plateau aquifers underlie northwestern New Mexico and most parts of the Northwestern New Mexico Uranium Milling Region (Robson and Banta, 1995). The principal aquifers are present only in the San Juan Basin in northwest New Mexico. The geographical region in New Mexico underlain by the Colorado Plateaus aquifers is sparsely populated, and the quality and quantity of the groundwater pumped from these aquifers are suitable for most agricultural or domestic uses. The aquifers are typically composed of permeable sedimentary rocks of Permian to Tertiary ages.

Robson and Banta (1995) grouped the Colorado Plateau aquifers into four principal aquifers from shallowest to deepest: the Uinta-Animas aquifer, the Mesaverde aquifer, the Dakota-Glen Canyon aquifer system, and the Coconino-De Chelly aquifer. These four principal aquifers are hydraulically separated by relatively impermeable confining layers. The Mancos shale confining unit that underlies the Mesaverde aquifer and the Chinle-Moenkopi confining unit that underlies the Dakota-Glen Canyon aquifer system are the thickest confining layers. Among these four aquifer systems, the Mesaverde aquifer system (for water supplies) and the Dakota-Glen Canyon aquifer system (for water supplies and uranium milling) are the most important aquifer systems in the Northwestern New Mexico Uranium Milling Region.

The Mesaverde Aquifer: The Mesaverde aquifer is a regionally important aquifer for water supplies. It consists of sandstone, coal, siltstone, and shale of the Mesaverde Group in the San Juan Basin. The formations of the Mesaverde Group extensively interbedded with the Mancos Shale and, to a lesser extent, with the Lewis Shale. The thickness of the Mancos Shale typically ranges from 305 to 1,830 m [1,000 to 6,000 ft], and in general it forms a thick barrier to vertical and lateral groundwater flow. The maximum thickness of the Mesaverde aquifer is about 1,370 m [4,500 ft] in the southern part of San Juan Basin. The recharge to aquifer is by precipitation and discharge from aquifer is to streams, springs, and seeps; by upward movement across confining layers and into overlying aquifers; and by withdrawals. In general, water pumpage from the Mesaverde aquifer is small; therefore, water-level declines are usually localized. The altitude of the potentiometric surface ranges from 1,525 to 2,440 m [5,000 to 8,000 ft] in the San Juan Basin. In most parts of the basin, transmissivity of the Mesaverde

aquifer is typically less than 4.65 m^2/day [50 ft^2/day]. However, where the aquifer is fractured, the local transmissivities could be 100 times higher.

The water quality in the Mesaverde aquifer is variable. The dissolved solids concentration ranges from about 1,000 to 4,000 mg/L [1,000 to 4,000 ppm] in parts of the San Juan Basin, which exceed EPA's Secondary Drinking Water Standard of 500 mg/L [500 ppm].

Dakota-Glen Canyon Aquifer System: Large depths to the water table or poor water quality make the aquifers of the Dakota-Glen Canyon aquifer system unsuitable for production in most parts of the Northwestern New Mexico Uranium Million Region. Where an aquifer is close to the land surface, however, it can be important source of water. The Dakota-Glen Canyon aquifer system is confined by the Mancos confining unit above and by the Chinle-Moenkopi confining unit below. The thickness of the Chinle-Moenkopi confining unit is typically 305 to 610 m [1,000 to 2,000 ft]. These confining units substantially limit the Dakota-Glen Canyon aquifer system's hydraulic connection with the overlying and underlying aquifers.

The Dakota-Glen Canyon aquifer system consists of four major aquifers: the Dakota aquifer (including the Dakota Sandstone and adjacent water-yielding rocks), the Morrison aquifer (including water-yielding rocks generally of the lower part of the Morrison Formation), the Entrada aquifer (including the Entrada Sandstone and the Preuss Sandstone), and the Glen Canyon aquifer (including the Glen Canyon Sandstone or Group and the Nugget Sandstone). The aquifer systems typically include confining units that separate these aquifers. At the regional scale, recharge areas, discharge areas, groundwater flow directions, and water quality are similar among these four aquifers.

The top of the Dakota aquifer is less than 610 m [2,000 ft] below the surface in the San Juan Basin. The transmissivity of the Dakota aquifer is poorly defined in the region. The Dakota aquifer is underlain by the Morrison Formation. In most parts of the basin, the relatively impermeable Morrison confining unit is present in the upper parts of the Morrison Formation. The middle and lower parts of the Morrison Formation forms the Morrison aquifer, but only the coarser-grained strata generally yields water. In the San Juan Basin, the Morrison aquifer includes two underlying water-yielding sandstone units: the Cow Springs and Junction Creek Sandstones. In most places, the Morrison aquifer is underlain by the relatively impermeable Curtis-Stump confining unit.

The Entrada aquifer underlies either the Curtis-Stump confining unit or the Morrison aquifer. The Entrada aquifer consists mainly of the Entrada Sandstone. In the western part of the Uinta Basin, the aquifer is composed of the Preuss Sandstone, which is an equivalent of the Entrada aquifer. In part of the basins, the Entrada aquifer directly overlies the Glen Canyon aquifer that consists of Wingate Sandstone, Kayente Formation, and the Navajo Sandstone. The Glen Canyon is the thickest and where fractured has relatively high transmissivities. The transmissivity of the Glen Canyon aquifer typically ranges from about 9.23 to 92.9 m^2/day [100 to 1,000 ft^2/day]. Groundwater flow in the Glen Canyon aquifer is toward major discharge areas along the San Juan Rivers. The depth to the top of the Glen Canyon aquifer is typically less than 610 m [2,000 ft]. The dissolved-solids concentration in the Glen Canyon aquifer is less than 1,000 mg/L [1,000 ppm].

3.5.4.3.2 Aquifer Systems In the Vicinity of Uranium Milling Sites

The underlying hydrogeological system in past and current areas of uranium milling interest in the Northwestern New Mexico Uranium Milling Region consists of a thick sequence of primarily sandstone aquifers and shale aquitards.

Areas of uranium milling interest at the Crownpoint, Unit 1, and Church Rock areas are underlain, from shallowest to deepest, by water-bearing layers in the Mesaverde Formation, the Dakota sandstone, the Morrison Formation (including the uranium-bearing Westwater Canyon aquifer), the Cow Springs Sandstone, and Entrada Sandstone. The Mesaverde Formation is regionally important for water supplies. The uranium-bearing Westwater Canyon aquifer at the active uranium milling sites is also important for water supplies in the milling region. Little information is available for the Cow Springs sandstone aquifer, but the existing data suggests that the Cow Springs aquifer underlying the Westwater Canyon aquifer contains good quality water (Hydro Resources, Inc., 1996). Although the Dakota sandstone at the town of Crownpoint is qualified as a drinking water supply according to EPA's National Primary Drinking Water Regulations, it is locally (e.g., in McKinley County) unused as a water supply because of its poor water quality (NRC, 1997).

3.5.4.3.3 Uranium-Bearing Aquifers

The most important uranium deposits in the Northwestern New Mexico Uranium Milling Region are hosted by the Westwater Canyon sandstone aquifer in the Morrison Formation (NRC, 1997; McLemore, 2007). The uranium-bearing sandstone aquifers in the Westwater Canyon aquifer and the Dakota sandstone near the town of Crownpoint must be exempted (Section 1.7.2) by EPA's UIC program (40 CFR § 144.3) before ISL operations begin.

Hydrogeological characteristics: The groundwater flow velocities in the Westwater Canyon aquifer at the Crownpoint site ranged from 3.9 m/yr [12.9 ft/yr] in the east to 2.4 m/yr [8 ft/yr] in the west side of the site. Transmissivity estimates for the Westwater Canyon aquifer range from 235 to 250 m^2/day [2,550 to 2,700 gal/day/ft]. The storage coefficient values ranged from 4.50×10^{-5} to 1.39×10^{-4} (NRC, 1997).

At Unit 1, the aquifers are the same as those at the Crownpoint site. The calculated average groundwater velocity is 1.5 m/yr [5 ft/yr] in the Westwater Canyon aquifer. In the Westwater Canyon aquifer, transmissivity ranges from 84 to 133 m^2/day [905 to 1,432 gal/day/ft], and the storage coefficient values range from 9.40×10^{-5} to 1.60×10^{-4} (NRC, 1997).

The aquifers located beneath the Church Rock site are similar to those beneath the Crownpoint and Unit 1 sites. The average groundwater flow velocity in the Westwater Canyon at Church Rock is 2.7 m/yr [8.7 ft/yr]. Transmissivity of the Westwater Canyon aquifer ranges from 86 to 123 m^2/day [926 to 1,326 gal/day/ft], and the storage coefficient ranges from 8.90×10^{-5} to 4.13×10^{-4} (NRC, 1997).

The average storage coefficient of the Westwater Canyon aquifer is on the order of 10^{-5}–0^{-4} at the Crownpoint, Unit 1, and Church Rock sites, indicating the confined nature of the production aquifer [typical storage coefficients for confined aquifers range from 10^{-5}–10^{-3} (Driscoll, 1986)].

Level of confinement: At the Crownpoint site, the Westwater Canyon aquifer is confined below by the Recapture Shale and confined above by the Brushy Basin Shale. The upper aquitard is about 80 m [260 ft] thick and is continuous at the site. The lower confinement unit

consists entirely of shale and is continuous at the site. Aquifer tests revealed no significant vertical flow across the Recapture Shale and Brushy Basin Shale aquitards. At Unit 1, both the upper (Brushy Basin Shale) and lower (Recapture Shale) aquitards that confine the Westwater Canyon aquifer are continuous beneath Unit 1. No significant vertical flow across the aquitards was detected. At the Church Rock site, the upper aquitard above the Westwater Canyon aquifer (Brushy Basin Shale) is 4–9 m [13–28 ft] thick. The thickness of the lower aquitard (Recapture Shale) was reported to be 55 m [180 ft] thick (NRC, 1997).

Groundwater quality: At the Crownpoint site, the artesian uranium-ore bearing Westwater Canyon sandstone aquifer is a valuable resource for high-quality groundwater, which fits the definition of underground sources of drinking water in the EPA National Primary Drinking Water Regulations (NRC, 1997). The TDS concentrations in groundwater range from 281 to 3,180 mg/L [281 to 3,180 ppm] and average 773 mg/L [773 ppm]. The TDS levels in four town water wells ranged from 325 to 406 mg/L [325 to 406 ppm], which are lower than the EPA's Secondary Drinking Water Standard of 500 mg/L [500 mg/L]. Even though the town's water supply wells are completed in sandstones that contain uranium deposits, radionuclide concentrations in the Crownpoint public water supply are low. The uranium and radium-226 concentrations at the Crownpoint ISL site's monitoring wells were in the range of less than 0.001 to 0.007 mg/L [0.001 to 0.007 ppm] and 0.3 to 0.6 pCi/L, respectively {EPA's drinking water standard for uranium is 0.03 mg/L [0.03 ppm] and for radium-226 is 5.0 pCi/L} (NRC, 1997).

At the Unit 1 site, groundwater in the Westwater Canyon aquifer in general meets New Mexico drinking water quality standards, except for radium-226 and uranium concentrations. The average radium-226 concentration at the Unit 1 ISL site's monitoring wells is 10.3 pCi/L, which exceeds the EPA drinking water standard for radium-226 (5.0 pCi/L). The average uranium concentration at the Unit 1 site is about 2.0 mg/L [2 ppm], which is higher than at the Crownpoint site. The average TDS of 285.0 mg/L [285 ppm] was lower than the EPA drinking water standard of 500 mg/L [500 ppm] (NRC, 1997).

At the Church Rock site, the groundwater quality is generally good in Westwater Canyon aquifer and meets the New Mexico drinking water quality standards, except for radium-226 concentration. However, the average radium-226 concentration at the monitoring wells was 10.2 pCi/L, exceeding the EPA drinking water standard of 5.0 pCi/L for radium. The average uranium concentration was 0.01 mg/L [0.01 ppm]. The average TDS of 369.75 mg/L [369.75 ppm] was lower than the EPA drinking water standard of 500 mg/L [500 ppm] (NRC, 1997).

Current groundwater uses: Groundwater in the Northwestern New Mexico Uranium Milling Region area is in general suitable for drinking. Groundwater has been used for domestic supplies, especially in the Crownpoint and Unit 1 areas. Most of the wells in and near the Church Rock site either owned by Hydro Resources, Inc. or are private wells (NRC, 1997).

3.5.4.3.4 Other Important Surrounding Aquifers for Water Supply

The Dakota Sandstone at the town of Crownpoint is qualified as a drinking water supply according to EPA's National Primary Drinking Water Regulations. Little information is available for the Cow Springs aquifer, but the existing data suggest that Cow Springs aquifer underlying the Westwater Canyon aquifer contains good quality water (Hydrology Resources Inc., 1996).

3.5.5 Ecology

3.5.5.1 Terrestrial

Northwestern New Mexico Flora

According to EPA, the Northwestern New Mexico Uranium Milling Region contains two ecoregions: the Arizona/New Mexico Plateau and the Arizona/New Mexico Mountains (Figure 3.5-9). This regions and subregions are as follows. The Grants Uranium District in the region is located in the Semi Arid Tablelands, Conifer Woodlands, and Savannas ecoregions and near the San Juan/Chaco Tablelands and Mesas ecoregions.

The Arizona/New Mexico Plateau is a transitional region between shrublands and wooded higher relief tablelands of the Colorado Plateaus in the north, the lower less vegetated Mojave Basin and Range in the west, and forested mountain ecoregions that border the region on the northeast and south. The topography in the region changes from a few meters [feet] on plains and mesa tops to well over 305 m [1,000 ft] along tableland side slopes. This region extends across northern Arizona, northwestern New Mexico, and into Colorado in the San Luis Valley (Griffith, et al., 2006).

The San Juan/Chaco Tablelands and Mesas ecoregion of plateaus, valleys, and canyons contains a mix of desert scrub, semidesert shrub-steppe, and semi-desert grasslands. Native vegetation found within the region include shadscale, fourwing saltbush (*Atriplex canescens*), mat saltbush, greasewood, mormon tea (*Ephedra* spp.), Indian ricegrass, alkali sacaton, galleta (*Pleuraphis jamesii)*, and blue and black gramas. Rocky Mountain juniper (*Juniperus scopulorum*), one-seed (*Juniperus monosperma*), and Utah junipers (*Juniperus osteosperma*) can be found on higher mesas (Griffith, et al., 2006).

The Semiarid Tablelands consists of mesas, plateaus, valleys, and canyons. This region contains areas of high and low relief plains. Grass, shrubs, and woodland cover the tablelands. The vegetation is not as sparse as that found in the San Juan/Chaco Tablelands to the north or the Albuquerque Basin to the east. Scattered junipers occur on shallow, stony soils and are dense in some areas. Pinyon-juniper woodland is also common in some areas. Fourwing saltbush, alkali sacaton, sand dropseed (*Sporobolus cryptandrus*), and mixed grama grasses are common species found in this region (Griffith, et al., 2006).

The Lava Malpais can be found in the south central portion of the region. The lava substrate has the ability to trap and retain moisture, allowing for a more mesophytic vegetation, such as stunted Douglas fir and ponderosa pine, to occur in some areas. Other species that are found in this region include grasses like blue grama and side oats grama (*Bouteloua curtipendula*) with shrubs of Apache plume (*Fallugia paradoxa*) and New Mexico olive (*Forestiera pubescens*) (Griffith, et al., 2006).

The Near-Rockies Valleys and Mesas ecoregion is a region comoised of mostly pinyon-juniper woodland, juniper savanna, and mesa and valley topography, with influences of higher elevation vegetation in drainages from the adjacent Southern Rockies. Other natural species that can be found in this region include one seed and Rocky Mountain junipers, Indian ricegrass, big sagebrush, sand dropseed, gallets, threeawns (*Aristida* spp.), blue grama, and rabbitbrush (Griffith, et al., 2006).

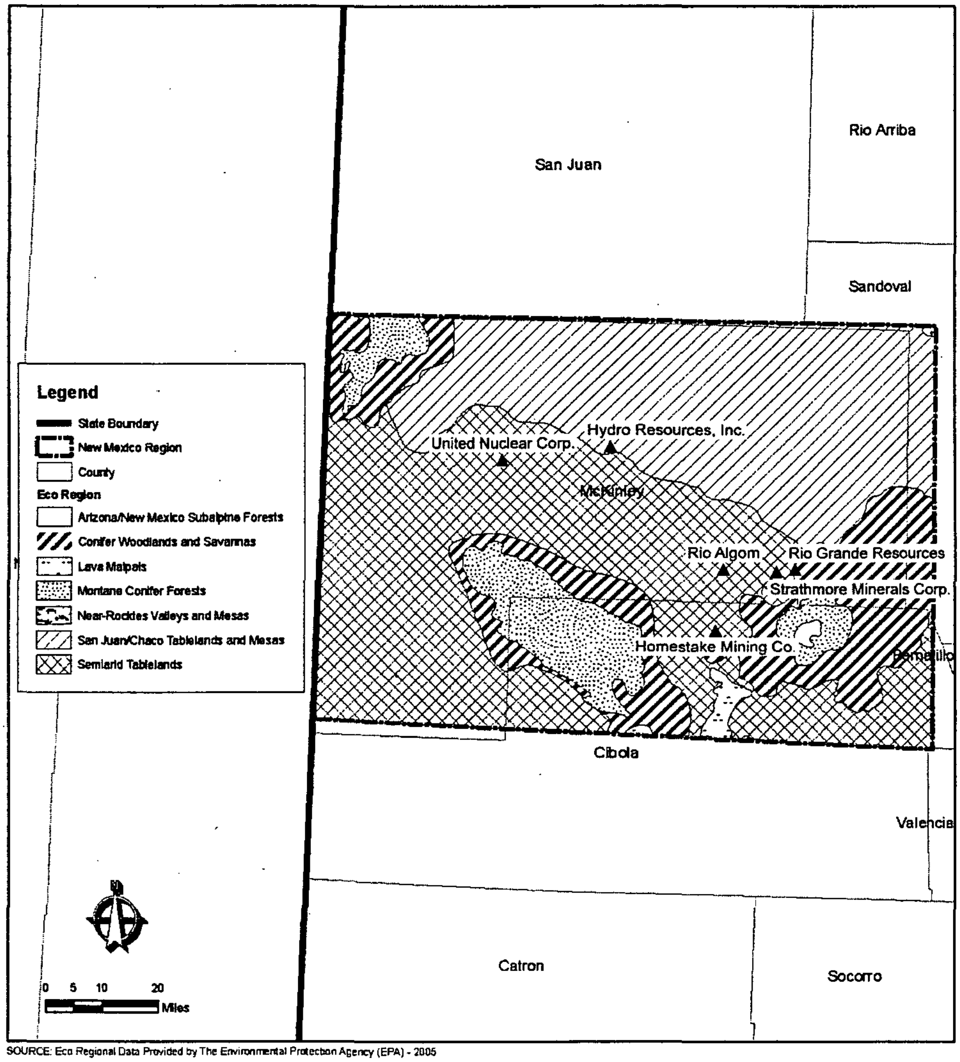


Figure 3.5-9. Ecoregions for the Northwestern New Mexico Uranium Milling Region

The Arizona/New Mexico Mountains region is distinguished from neighboring mountainous ecoregions by lower elevations and associated vegetation indicative of drier, warmer environments. Forests of spruce, fir, and Douglas fir, which are common in mountainous regions, are limited to the highest elevations in this region. Chaparral is common at lower elevations in some areas; pinyon-juniper and oak woodlands are found at lower and middle elevations. Higher elevations in the region are mostly covered with open to dense ponderosa pine forests. These mountains are the northern extent of some Mexican plant and animal species. Surrounded by deserts or grasslands, these mountains in New Mexico can be considered biogeographical islands (Griffith, et al., 2006).

The Montane Conifer Forests are found west of the Rio Grande at elevations from about 2,130 to 2,900 m [7,000 to 9,500 ft]. Ponderosa pine and Gambel oak are common, along with mountain mahogany and serviceberry (*Amelanchier alnifolia*). Some Douglas fir, southwestern white pine (*Pinus strobiformis*), and white fir (*Abies concolor*) occur in a few areas (Griffith, 2006). This region also includes mixed conifer/aspen stands. Seven different conifers can be found growing in the same region, and there are a number of common cold-deciduous shrub and grass species, including a few maple (*Acer* spp.), blueberry (*Vaccinium* ssp), gray alder (*Alnus incana*), kinnikinnick (*Arctostaphylos uva-ursi*), water birch (*Betula occidentalis*), redosier dogwood (*Cornussericea*), Arizona fescue (*Festuca arizonica*), fivepetal cliffbush (*Jamesia Americana*), creeping barberry (*Mahonia repens*), Oregon boxleaf (*Paxistima myrsinites*), Kuntze mallow ninebark (*Physocarpus malvaceus*), New Mexico locust (*Robinia neomexicana*), mountain snowberry, and Gambel oak (*Quercus gambelii*). Herbaceous species include fringed brome (*Bromus ciliatus*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*Carex rossii*), dryspike sedge (*Carex siccata*), screwleaf muhly, bluebunch wheatgrass, sprucefir fleabane (*Erigeron eximius*), Virginia strawberry (*Fragaria virginiana*), smallflowered woodrush (*Luzula parviflora*), sweetcicely (*Osmorhiza berteroi*), bittercress ragwort (*Packera cardamine*), western meadow-rue (*Thalictrum occidentale*), and Fendler's meadow-rue (*Thalictrum fendleri*) (New Mexico Department of Game and Fish, 2006).

The Conifer Woodlands and Savannas ecoregion is an area of mostly pinyon-juniper woodlands consisting of one-seed, alligator, and Rocky Mountain junipers with some ponderosa pine at higher elevations. It often intermingles with grasslands and shrublands consisting of blue grama, junegrass, gallet, and bottlebrush squirreltail (*Elymus elymoides*). In addition, some areas may have Gambel oak. Utah juniper and big sagebrush can be found in the Chuska Mountains. At lower elevations, yuccas and cactus can be found (Griffith, et al., 2006)

The Arizona/New Mexico Subalpine Forests occur west of the Rio Grande at the higher elevations, generally above about 2,900 m [9,500 ft]. The region includes parts of the Mogollon Mountains, Black Range, San Mateo Mountains, Magdalena Mountains, and Mount Taylor. Although there are some vegetational differences from mountain range to mountain range within the region, the major forest trees include Engelmann spruce, corkbark fir (*Abies lasiocarpa var. arizonica*), blue spruce (*Picea pungens*), white fir, and aspen. Some Douglas fir occurs at lower elevations (Griffith, et al., 2006).

Northwestern New Mexico Fauna

According to the Biota Information System of New Mexico (2007), more than 1,100 species of amphibians, reptiles, mammals, birds, invertebrates, and fish are found throughout the state. Bird fauna is diverse with more than 500 species. Mammal diversity is high compared to other southwestern states, with approximately 184 species. New Mexico has approximately 26 species of amphibians and over 100 species of reptiles.

Common mammals found within the Northwester New Mexico Uranium Milling Region include numerous myotis bat species, black bear, bobcat, numerous rodents, coyotes, bighorn sheep, Gunnison's prairie dogs, skunks, and squirrels. In addition, critical elk winter habitat and calving areas are located in the area (Figure 3.5-10). Currently, most of the proposed or existing ISL facilities are located within designated critical elk winter habitat. Most of the habitat in this region is found within the southern half of McKinley County and most of Cibola County. Common bird species found in the region include bluebirds, buntings, doves, ducks, cormorants (*Phalacrocorax* spp.), hummingbirds, jays, flycatchers, kingbirds, mockingbird, sparrows, and ravens. Raptor species include hawks such as the ferruginous hawk, red-tailed hawk, sharp shinned hawk, and Swainson's hawk; noted owl species found in the counties are the barn owl (*Tyto alba*), burrowing owl (*Athene cunicularia*), elf owl (*Micrathene whitneyi*), flammulated owl (*Otus flammeolus*), great horned owl (*Bubo virginianus*), pygmy owl (*Glaucidium* spp.), and Mexican spotted owl (*Strix occidentalis lucida*). The climax raptor found in the region is the golden eagle (Biota Information System of New Mexico, 2007).

Individual county listings can be obtained through the Biota Information System of New Mexico. A comprehensive listing of habitat types and species (with their scientific names) found within New Mexico are compiled as part of the Southwest Regional Gap Analysis Project (New Mexico State University, 2007).

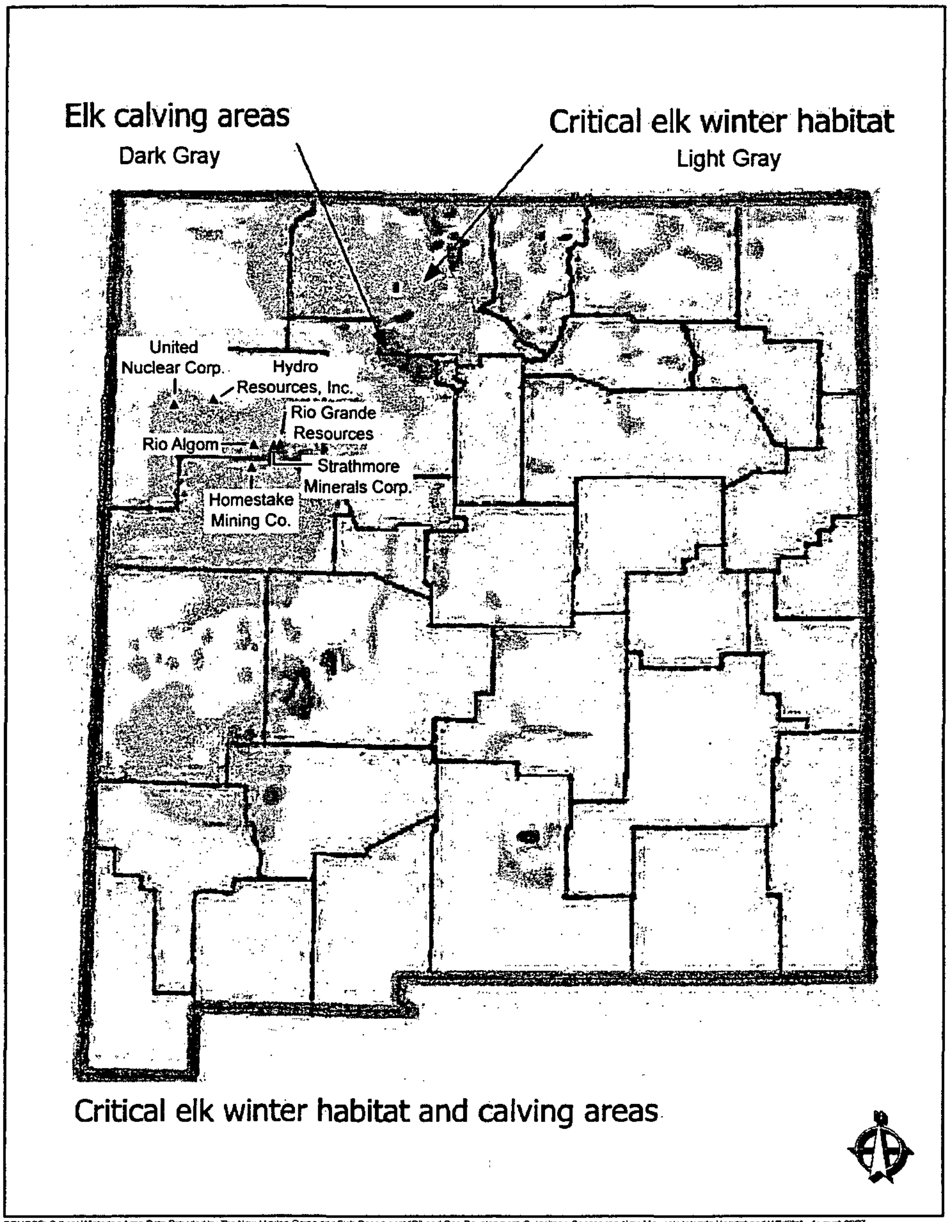
3.5.5.2 Aquatic

There are approximately 161 different species of fish located within the state, with approximately 48 species found in the watersheds of the region (Table 3.5-6) (Biota Information System of New Mexico, 2007). The New Mexico Comprehensive Wildlife Conservation Strategy Plan indicates that the majority of the areas in which milling would occur lie within the Zuni, Rio Grande, and the lower portion of the San Juan watersheds (New Mexico Department of Game and Fish, 2006).

The Zuni watershed also encompasses the upper Puerco watershed. The Zuni watershed has an impacted water system due to settlement changes, overgrazing, and logging. The loss of vegetative cover led to increased erosion, gullying, head cutting, wide discharge fluctuations, and loss of water in the system (New Mexico Department of Game and Fish, 2006). Eight nonnative fish have been found in the watershed, with the green sunfish (*Lepomis cyanellus*), fathead minnow, and the plains killifish comparatively common and widespread. Several sport fish have been introduced to the system such as northern pike (*Esox lucius*), rainbow trout, and channel catfish. Crayfish (*Orconectes virilis*) have also been introduced into the system (New Mexico Department of Game and Fish, 2006).

Two fish, the roundtail chub (*Gila robusta*) and Zuni bluehead sucker (*Catostomus discobolus yarrowi*) and one crustacean (*Hyalella* spp.) have been identified as species of greatest conservation need (New Mexico Department of Game and Fish, 2006).

The Rio Grande watershed originates in the San Juan Mountains of Southern Colorado and flows south through the entire length of New Mexico. This waters shed also encompasses the Arroyo Chico, Rio San Jose and Rio Puerco watersheds as previously discussed. The aquatic habitats in the Rio Grande consist of reservoirs, marshes, and perennial streams (New Mexico Department of Game and Fish, 2006). Numerous species have been introduced into the Rio Grande Watershed. Common carp (*Cyprinus carpio*) are widespread and nonnative



SOURCE: Critical Wintering Area Data Provided by The New Mexico Game and Fish Department "Oil and Gas Development Guidelines Conserving New Mexico's Wildlife Habitat and Wildlife" - August 2007

Figure 3.5-10. Elk Winter Habitat and Calving Areas for the Northwestern New Mexico Uranium Milling Region (Modified From New Mexico Department of Game and Fish, 2007)

Table 3.5-6. Native Fish Species Found in New Mexico	
Common Name	**Scientific Name**
Largemouth Bass	*Micropterus salmoides salmoides (NM)*
Smallmouth Bass	*Micropterus dolomieui*
Striped Bass	*Morone saxatilis*
White Bass	*Morone chrysops*
Bluegill	*Lepomis macrochirus*
Smallmouth Buffalo	*Ictiobus bubalus*
Black Bullhead	*Ameiurus melas*
Yellow Bullhead	*Ameiurus natalis*
Common Carp	*Cyprinus carpio*
Grass Carp	*Ctenopharyngodon idella*
River Carpsucker	*Carpiodes carpio carpio*
Blue Catfish	*Ictalurus furcatus*
Channel Catfish	*Ictalurus punctatus*
Chihuahua Catfish	*Ictalurus sp (NM)*
Flathead Catfish	*Pylodictis olivaris*
Chub Flathead	*Platygobio gracilis*
Gila Chub	*Gila intermedia*
Rio Grande Chub	*Gila pandora*
Roundtail Chub	*Gila robusta*
Black Crappie	*Pomoxis nigromaculatus*
White Crappie	*Pomoxis annularis*
Longfin Dace	*Agosia chrysogaster*
Longnose Dace	*Rhinichthys cataractae*
Speckled Dace	*Rhinichthys osculus (Gila pop.)*
Speckled Dace	*Rhinichthys osculus (Non-Gila pop.)*
Rainwater Killifish	*Lucania parva*
Fathead Minnow	*Pimephales promelas*
Loach Minnow	*Tiaroga cobitis*
Roundnose Minnow	*Dionda episcopa*
Rio Grand Silvery Minnow	*Hybognathus amarus*
Yellow Perch	*Perca flavescens*
Gizzard Shad	*Dorosoma cepedianum*
Threadfin Shad	*Dorosoma petenense*
Golden Shiner	*Notemigonus crysoleucas*
Red Shiner	*Cyprinella lutrensis*
Rio Grande Shiner	*Notropis jemezanus*
Spikedance	*Meda fulgida*
Central Stoneroller	*Campostoma anomalum*
Zuni Bluehead,Sucker	*Catostomus discobolus yarrowi (NM)*
Desert Sucker	*Catostomus clarki*
Rio Grande Sucker	*Catostomus plebeius*
Sonora Sucker	*Catostomus insignis*
White Sucker	*Catostomus commersoni*
Green Sunfish	*Lepomis cyanellus*
Brown Trout	*Salmo trutta*
Gila Trout	*Oncorhynchus gilae*

Table 3.5-6. Native Fish Species Found in New Mexico (continued)	
Common Name	**Scientific Name**
Rainbow Trout	*Oncorhynchus mykiss*
Western Mosquito Fish	*Gambusia affinis*

salmonids, including rainbow trout, cutthroat subspecies (*O. clarki*) brook trout, and brown trout live in mountain streams. Kokanee salmon (*Oncorhynchus nerka*), rainbow trout, and brown trout are present in reservoirs. Warm/cool water fish include largemouth bass, smallmouth bass, walleye, northern pike, white bass (*Morone chryops*), crappie (*Pomoxis* spp.), and sunfishes (*Lepomis* spp.) (New Mexico Department of Game and Fish, 2006).

Eleven fish species have been designated as a species of greatest conservation need. The Mexican tetra (*Astyanax mexicanus*), speckled chub (*Macrhybopsis aestivalis*), Rio Grande shiner (*Notropis jemezanus*), blue sucker (*Cycleptus elongates*), and gray redhorse (*Moxostoma congestum*) have disappeared from key habitats in the Rio Grande watershed. The following fish are in conservation need: Rio Grande cutthroat trout, Rio Grande chub, Rio Grande sucker, smallmouth sucker, and blue catfish (New Mexico Department of Game and Fish, 2006).

Noted native fish species historically found within the watersheds associated with sites in the Grants Uranium District include blue catfish (*Ictalurus furcatus*), desert sucker (*catostomus clarki*), Gila chub (*Gila intermedia*), Gila topminnow (*Poeciliopis occidentalis*), Gila trout (*Oncorhynchus gilae*), loach minnow (*Rhinichthys cobitis*), Rio Grande sucker (*Catostomus plebeius*), Rio Grande silver minnow (*Hybognathus amarus*), Rio Grande shiner, Rio Grande cutthroat trout (O*hcorhynchus clarki virgininalis*), Rio Grande chub (*Gila pandora*), roundtail chub, spikedace (*Meda fulgida*), smallmouth buffalo (*Ictiiobus bubalus*), Sonora sucker (*Catostomus insignis*), and the Zuni bluehead sucker (Biota Information System of New Mexico, 2007).

The San Juan watershed that contains many first and second order streams found in the Chaco watershed within the milling region. The San Juan River Basin is the second largest of the three subbasins that comprise the Upper Colorado River Basin. The San Juan River Basin drains about 97,300 km^2 [38,000 mi^2] of southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southeastern Utah (U.S. Fish and Wildlife Service, 2006). At least eight native fish species—cutthroat trout, roundtail chub, Colorado pikeminnow, speckled dace, flannelmouth sucker, bluehead sucker, razorback sucker, and mottled sculpin—are located within the basin. Colorado pikeminnow, razorback sucker, and the bonytail chub are federally listed as endangered species, with New Mexico listing the roundtail chub as endangered. Noted non native fish found within the higher order streams in the watershed include red shiner, common carp, fathead minnow, plains killifish, whiter sucker, brown trout, rainbow trout, and channel catfish (New Mexico Department of Game and Fish, 2006).

3.5.5.3 Threatened and Endangered Species

Federally listed threatened and endangered and species which are known to exist within habitats found within the region include the following:

- Bald Eagle, Delisted Monitored.
- Black-Footed Ferret, Extirpated.

- Mexican Spotted Owl (*Strix occidentalis lucida*), Critical Habitat Designated—Mexican spotted owls nest, roost, forage, and disperse in a diverse assemblage of biotic communities. Mixed-conifer forests are commonly used throughout most of the range which may include Douglas fir and/or white fir, with codominant species including southwestern white pine, limber pine, and ponderosa pine. The understory often contains the above coniferous species as well as broadleaved species, such as Gambel oak, maples, box elder, and/or New Mexico locust. In southern Arizona and Mexico, Madrean pine-oak forests are also commonly used. Spotted owls nest and roost primarily in closed-canopy forests or rocky canyons. They nest in these areas on cliff ledges, in stick nests built by other birds, on debris platforms in trees, and in tree cavities. In southern Utah, Colorado, and some portions of northern New Mexico, most nests are in caves or on cliff ledges in rocky canyons. Forests used for roosting and nesting often contain mature or old-growth stands with complex structure, are typically uneven-aged and multistoried, and have high canopy closure. A wider variety of trees are used for roosting, but again Douglas fir is the most commonly used species (U.S. Fish and Wildlife Service, 2008)

- Pecos Puzzle Sunflower (*Helianthus paradoxus*)—This species is found in areas that have permanently saturated soils, including desert wetlands (cienegas) that are associated with springs, but may include stream and lake margins. When found around lakes, these lakes are usually natural cienega habitats that have been impounded (Center for Plant Conservation, 2008).

- South Western Willow Fly Catcher (*Empidonax traillii extimus*)—The southwestern willow flycatcher breeds in patchy to dense riparian habitats along streams, reservoirs, or other wetlands. Common tree or shrub species include willow, seep willow, boxelder, stinging nettle, blackberry, cottonwood, arrowweed, tamarisk (salt cedar), and Russian olive. Habitat characteristics vary across the subspecies' range. However, occupied sites usually consist of dense vegetation in the patch interior, or dense patches interspersed with openings, creating a mosaic that is not uniformly dense. In almost all cases, slow-moving or still water, or saturated soil is present at or near breeding sites during non-drought years (U.S. Fish and Wildlife Service, 2008).

- Yellow Billed Cuckoo (*Coccyzus americanus*)—Discussed in Section 3.2.5.3.

- Zuni Bluehead Sucker (*Catostomus dicobolus yarrowi*), Candidate—More recent surveys (early to mid 1990s) determined the distribution of Zuni bluehead sucker in New Mexico to be limited mainly to the Río Nutria drainage upstream of the mouth of the Nutria Box Canyon. This included the mouth of Río Nutria box canyon, upper Río Nutria, confluence of Tampico Draw and Río Nutria, Tampico Spring, and Agua Remora. Definitive habitat associations for Zuni bluehead sucker have not been determined. Zuni bluehead sucker are primarily found in shaded pools and pool runs, about 0.3 to 0.5 m [1 to 1.5 ft] deep with water velocity less than 10 cm/s [4 in/s]. Zuni bluehead suckers were found over clean, hard substrate, from gravel and cobble to boulders and bedrock (New Mexico Department Game and Fish, 2004).

- Zuni Fleabane (*Erigeron rhizomatus)*—Zuni fleabane grows in selenium-rich red or gray detrital clay soils derived from the Chinle and Baca formations. Plants are found at elevations from 2,230-2,440 m [7,300–8,000 ft] in pinyon-juniper woodland. Zuni fleabane prefers slopes of up to 40°, usually with a north-facing aspect. Although the overall vegetative cover is usually high, there are few other competing plants on the

steep easily erodible slopes that are Zuni fleabane's primary habitat. Zuni fleabane is found only in areas of suitable soils. These soils occur most extensively in the Sawtooth Mountains and in the northwestern part of the Datil Mountains in Catron County, New Mexico. There are 29 known sites in this area, which range in size from a fraction of an acre to about 105 ha [260 acres]. There are two sites on the northwest side of the Zuni Mountains in McKinley County, New Mexico, and one site in Apache County, Arizona (U.S. Fish and Wildlife Service, 2008).

- Rio Grande Silvery Minnow (*Hybognathus amarus*)—Currently, the Rio Grande silvery minnow is believed to occur only in one reach of the Rio Grande in New Mexico, a 280-km (174-mi) stretch of river that runs from Cochiti Dam to the headwaters of Elephant Butte Reservoir. Its current habitat is limited to about 7 percent of its former range. The Rio Grande silvery minnow uses only a small portion of the available aquatic habitat. In general, the species most often uses silt substrates in areas of low or moderate water velocity (e.g., eddies formed by debris piles, pools, and backwaters). The Rio Grande silvery minnow is rarely found in habitats with high water velocities, such as main channel runs, which are often deep and swift. The species is most commonly found in depths of less than 20 cm [7.9 in] in the summer and 31–40 cm [12.2–15.75 in] in the winter (U.S. Fish and Wildlife Service, 2007).

State-listed threatened and endangered species for the region include the following:

- American Marten (*Martes americana*)—The American marten is broadly distributed. It extends from the spruce-fir forests of northern New Mexico to the northern limit of trees in arctic Alaska and Canada. American martens live in mature, dense conifer forests or mixed conifer-hardwood forests. They prefer woods with a mixture of conifers and deciduous trees including hemlock, white pine, yellow birch, maple, fir and spruce. Especially critical is presence of many large limbs and fallen trees in the understory, known as coarse woody debris. These forests provide prey, protection and den sites (New Mexico Department of Game and Fish, 2008).

- Arctic Peregrine Falcon (*Falco peregrinus tundrius*)—Peregrine falcons live mostly along mountain ranges, river valleys, and coastlines. Historically, they were most common in parts of the Appalachian Mountains and nearby valleys from New England south to Georgia, the upper Mississippi River Valley, and the Rocky Mountains. Peregrines also inhabited mountain ranges and islands along the Pacific Coast from Mexico north to Alaska and in the Arctic tundra (U.S. Fish and Wildlife Service, 2008).

- Bald Eagle (*Haliaeetus leucocephalus*)—In New Mexico, migrating bald eagles can be found near rivers and lakes, where occasional tall trees provide lookout perches and night roosts. Reservoirs with sizable populations of migrating bald eagles include Ute, Conchas, Ft. Sumner, Santa Rosa, Elephant Butte, Caballo, Cochiti, El Vado, Heron, and Navajo (New Mexico Department of Game and Fish, 2008).

- Baird's Sparrow (*Ammodramus bairdii*)—Breeds in native mixed-grass and fescue prairie. Winters in grasslands; specific winter habitat requirements not well described. Baird's sparrow does not inhabit prairie lands where fire suppression and changes in natural grazing patterns have allowed woody vegetation to grow excessively. Some hayfields or pastures may support Baird's sparrow where native grasses occur in sufficient quantity, but generally cultivated land is a far inferior habitat relative to true

prairie. Winters from southeast Arizona, southern New Mexico, and south Texas to north-central Mexico (Cornell Laboratory of Ornithology, 2008)

- Broadbilled Hummingbird (*Cynanthus latirostris)*—In the United States this hummingbird is found in riparian woodlands at low to moderate elevations. In Guadalupe Canyon, these woodlands are characterized by cottonwoods, sycamores, white oaks, and hackberries. Nests found in Guadalupe Canyon have been in a variety of trees, shrubs, and even forests (New Mexico Department of Game and Fish, 2004).

- Brown Pelican (*Pelecanus occidentalis)*—Brown pelicans nest on small, isolated coastal islands where they are safe from predators such as raccoons and coyotes. This is a potential migrant though the region (Texas Parks and Wildlife Department, 2007)

- Common black hawk (*Buteogallus anthracinus*)—Obligate riparian nester, dependent on mature, relatively undisturbed habitat supported by a permanent flowing stream. Streams less than 30 cm [12 in] deep of low to moderate gradient with many riffles, runs, pools, and scattered boulders or lapped with branches provide ideal hunting conditions (Public Employees for Environmental Responsibility, 2008).

- Costa's Hummingbird (*Calypte costae)*—Occurs mainly in Southern California, Arizona, Baja California, and western Mexico, but also extends into Nevada, extreme southeastern Utah, and southeastern New Mexico. Habitats occupied by Costa's hummingbirds include Sonoran desert scrub, the Mojave Desert, California chaparral, California coastal scrub, and the Cape deciduous forest of Baja California (Audubon Society, 2007).

- Gray Vireo (*Vireo vicinior*)—Gray vireo breeds in some of the hottest, driest areas of the American Southwest, favoring dry thorn scrub, chaparral, and pinyon-juniper and oak-juniper scrub, in arid mountains and high plains scrubland. This species forages in thickets, taking most of its prey from leaves, twigs, and branches of small trees and bushes. Its diet on the breeding grounds consists of a variety of arthropods, including large grasshoppers, cicadas, and caterpillars. Winter diet differs based on locality—birds found in western Texas are primarily insectivorous, while those wintering in southern Arizona and adjacent northern Mexico feed mainly on fruit (Audubon Society, 2007).

- Interior Least Tern (*Sterna antillarum athalassos*)—Discussed in Section 3.3.5.3.

- Jemez Mountains Salamander (*Plethodon neomexicanus*)—Native to north-central New Mexico, this species has been found in various localities in the Jemez Mountains in Sandoval, Los Alamos, and Rio Arriba counties. This salamander typically lives on shady, wooded sites at elevations of about 2,300 to 2,900 m [7,500 to 9,500 ft]. In these habitats, characterized by coniferous trees, salamanders spend much of their time under and in fallen logs. Old, stabilized talus slopes, especially those with a good covering of damp soil and plant debris, are important types of cover for this species (New Mexico Department of Game and Fish, 2008).

- Meadow Jumping Mouse (*Zapus hudsonius)*—Jumping mice are nocturnal, and in New Mexico this species occurs in moist habitats dominated by damp and rich vegetation. The meadow jumping mouse inhabits areas with streams, moist soil, and lush streamside vegetation consisting of grasses, sedges, and forbs. Such habitats are

in the Jemez Mountains and in the edges of permanent ditches and cattail stands in the Rio Grande Valley (New Mexico Department of Game and Fish, 2008).

- Neotropic cormorant (*Phalacrocorax brasilianus)*—This cormorant is found from southern New Mexico to southern Louisiana and southward through Central America and the Caribbean to South America. Neotropic cormorants also may wander northward to the Bernalillo area and westward to the Gila Valley. This bird is rare in southern Hidalgo County, the area near Alamogordo, and in the lower Pecos Valley from Bitter Lake National Wildlife Refuge southward (New Mexico Department of Game and Fish, 2008).

- Peregrine Falcon (*Falco peregrines*)—In New Mexico the breeding sites of peregrine falcons are on cliffs in wooded and forested habitats, with large "gulfs" of air nearby in which these predators can forage (New Mexico Department of Game and Fish, 2008).

- Rio Grande Shiner (*Notropis jemezanus*)—The Rio Grande shiner is found in the Rio Grande drainage, from just above the mouth to the Pecos River (north in Pecos River to Sumner Lake, New Mexico) and (formerly) Rio Grande, New Mexico (where now extirpated). It is absent from large sections of the Rio Grande and Pecos Rivers in western Texas; occurs in Rio San Juan, Rio Salado, and Rio Conchos, Mexico; common in the lower Rio Grande, and is less common elsewhere. It can be found in runs and flowing pools of large open weedless rivers and large creeks with bottom of rubble, gravel, and sand, often overlain with silt (NatureServe, 2008).

- Spotted Bat (*Euderma maculatum)*—The rarity of this bat and the diverse habitats in which it has been seen have caused confusion about its preferences. Some have been captured in pine forests at high elevations 2,400–2,700 m [8,000–9,000 ft]; others came from a pinyon pinejuniper association; and still others from desert scrub areas. Spotted Bats are known only from about 20 locations in western and southern New Mexico (New Mexico Department of Game and Fish, 2008).

- Southwestern Willow Flycatcher—previously described in this section as a federally listed species.

- Wrinkled Marsh Snail (*Stagnicola caperata*)—The wrinkled marsh snail occurs in such habitats as vegetated ditches, marshes, streams, and ponds, that are typically seasonally dry. Such a site is occupied by the New Mexico population in the Jemez Mountains, where the habitat is a shallow pond at 2,600 m [8,500 ft] elevation. The species also occurs in areas of perennial water, including the former population at Bitter Lake National Wildlife Refuge (USACE, 2007).

- Zuni Bluehead Sucker—previously described in this section as a federally listed species.

3.5.6 Meteorology, Climatology, and Air Quality

3.5.6.1 Meteorology and Climatology

Temperature in New Mexico is influenced more by elevation than latitude. Mean annual temperatures range from 17 °C [64 °F] in the southeast to less than 4 °C [40 °F] in the high mountains and northern valleys (National Climatic Data Center, 2005). New Mexico typically

experiences variations between daytime and nighttime temperatures. Table 3.5-7 identifies two climate stations located in the Northwestern New Mexico Uranium Milling Region. Climate data for these stations are found in the National Climatic Data Center's Climatography of the United States No. 20 Monthly Station Climate Summaries for 1971–2000 (National Climatic Data Center, 2004). This summary contains climate data for 4,273 stations throughout the United States and some territories. Table 3.5-8 contains temperature data for two stations in the Northwestern New Mexico Uranium Milling Region.

The precipitation and snow that New Mexico receives comes from both the Pacific Ocean to the west and the Gulf of Mexico to the southeast. Average annual precipitation ranges from 25 cm [10 in] to more than 50 cm [20 in] at higher elevations (National Climatic Data Center, 2005). In summer, the source of precipitation is usually brief, but often intense thunderstorms. For most of the state, 30 to 40 percent of the year's annual moisture falls in July and August. Typically, New Mexico does not experience widespread floods. Heavy thunderstorms can cause local flash floods. Heavy rains or rain in conjunction with snowmelt can cause large rivers to flood.

Table 3.5-8 contains precipitation data for two stations in the Northestern New Mexico Uranium Milling Region. The wettest month for both stations identified in Table 3.5-8 is August and, based on the snow depth data, snowpack melting usually occurs earlier in the summer (National Climatic Data Center, 2004). One of the stations is in Cibola County and the other is in McKinley County. Data from the National Climatic Data Center's Storm Events Database from 1950 to 2007 indicate that the majority of thunderstorms in Cibola and McKinley Counties occurs somewhat evenly between May and September (National Climatic Data Center, 2007).

Table 3.5-7. *Information on Two Climate Stations in the Northwestern New Mexico* Uranium Milling Region*

Station (Map Number)	County	State	Longitude	Latitude
Grants Milan AP	Cibola	New Mexico	107°54W	35°10N
McGaffey 5 SE	McKinley	New Mexico	108°27W	35°20N

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.

Table 3.5-8. Climate Data for Stations in the Northwestern New Mexico Uranium Milling Region*

		Grants Milan AP	McGaffey 5 SE
Temperature (°C) †	Mean—Annual	10.4	5.9
	Low—Monthly Mean	−0.6	−4.5
	High—Monthly Mean	22.1	17.2
Precipitation (cm) ‡	Mean—Annual	27.6	51.6
	Low—Monthly Mean	1.1	1.7
	High—Monthly Mean	5.3	7.0
Snowfall (cm)	Mean—Annual	23.9	136
	Low—Monthly Mean	0	0
	High—Monthly Mean	7.4	26.9

*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.
†To convert Celsius (°C) to Fahrenheit (°F), multiply by 1.8 and add 32.
‡To convert centimeters (cm) to inches (in), multiply by 0.3937.

In winter, the precipitation usually falls as snow in the mountains; however, the precipitation in the valleys can be either rain or snow. Table 3.5-9 contains snowfall data for two stations in the Northwestern New Mexico Uranium Milling Region.

As an example, Figure 3.5-11 shows a wind rose for Gallup, New Mexico, for 1991. Winds are predominantly from the west southwest and southwest. Wind speeds are depicted in knots where 1 knot is approximately equal to 0.51 m/s [1.7 ft/s]. Wind roses such as these should be obtained for the actual location of the facility for preferably a period of time of 1 year or longer. This data can be used for dispersion estimates.

The pan evaporation rates for the Northwestern New Mexico Uranium Milling Region range from about 114 to 152 cm [45 to 60 in] (National Weather Service, 1982). Pan evaporation is a technique that measures the evaporation from a metal pan typically 121 cm [48 in] in diameter and 25 cm [10 in] tall. Pan evaporation rates can be used to estimate the evaporation rates of other bodies of water such as lakes or ponds. Pan evaporation rate data are typically available only from May to October. Freezing conditions often prevent collection of quality data during the other part of the year.

3.5.6.2 Air Quality

The general air quality general description for the Northwestern New Mexico Uranium Milling Region would be similar to the description in Section 3.2.6 for the Wyoming West Uranium Milling Region.

Table 3.5-9. U.S. Environmental Protection Agency Class I Prevention of Significant Deterioration Areas in New Mexico and Arizona*

New Mexico	Arizona
Bandelier Wilderness	Chiricahua National Monument Wilderness
Bosque del Apache Wilderness	Chiricahua Wilderness
Carlsbad Caverns National Park	Galiuro Wilderness
Gila Wilderness	Grand Canyon National Park
Pecos Wilderness	Mazatzal Wilderness
Salt Creek Wilderness	Mount Baldy Wilderness
San Pedro Parks Wilderness	Petrified Forest National Park
Wheeler Peak Wilderness	Pine Mountain Wilderness
White Mountain Wilderness	Saguaro Wilderness
	Sierra Ancha Wilderness
	Superstition Wilderness
	Sycamore Canyon Wilderness

*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40—Protection of the Environment, Part 81. Washington, DC: U.S. Government Printing Office. 2005.

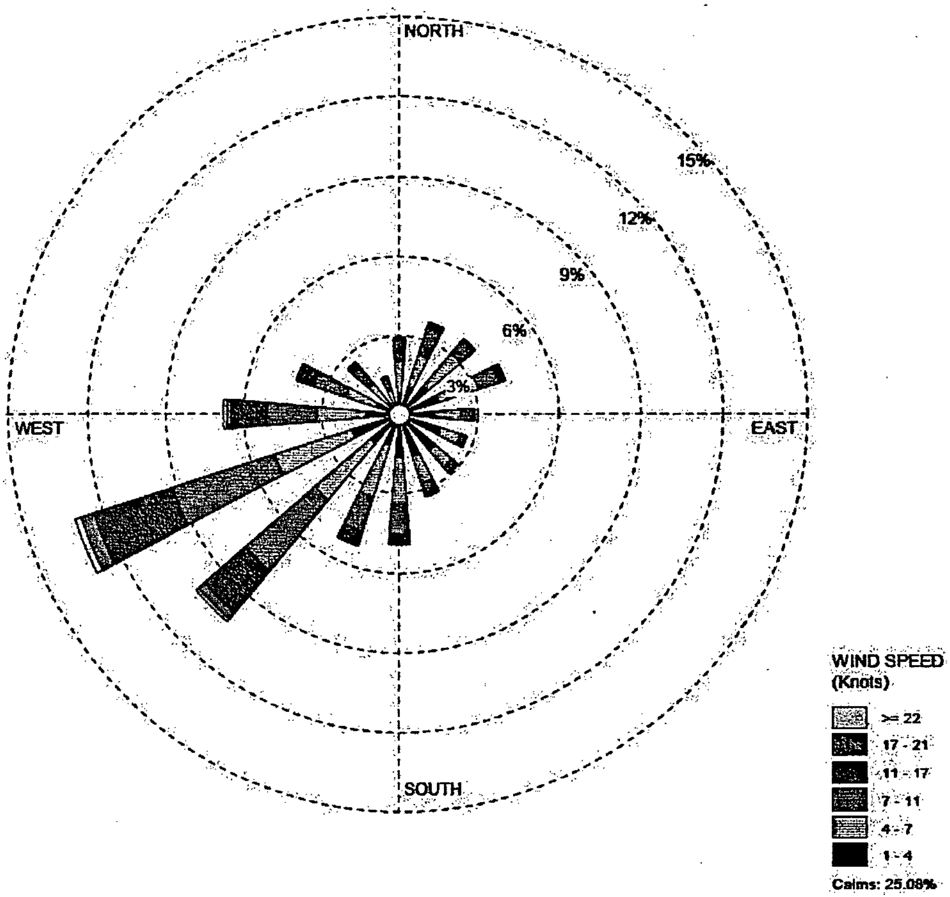


Figure 3.5-11. Wind Rose for Gallup, New Mexico, Airport for 1991 (New Mexico Environmental Department, 2007)

As described in Section 1.7.2.2, the permitting process is the mechanism used to address air quality. If warranted, permits may set facility air pollutant emission levels, require mitigation measures, or require additional air quality analyses. Except for Indian Country, New Source Review permits in New Mexico are regulated under the EPA-approved State Implementation Plan. For Indian Country in New Mexico, the New Source Review permits are regulated under 40 CFR 52.21 (EPA, 2007a).

State implementation plans and permit conditions are based in part on federal regulations developed by the EPA. The NAAQS are federal standards that define acceptable ambient air

concentrations for six common nonradiological air pollutants: nitrogen oxides, ozone, sulfur oxides, carbon monoxide, lead, and particulates. In June 2005, EPA revoked the 1-hour ozone standard nationwide in all locations except certain Early Action Compact Areas. None of the 1-hour ozone Early Action Compact Areas are in New Mexico. States may develop standards that are stricter or supplement the NAAQS. New Mexico has a more restrictive standard for carbon monoxide throughout the state and for sulfur dioxide in a small area around the city of Hurley. This area around Hurley is not within the Northwestern New Mexico Uranium Milling Region. New Mexico also has a nitrogen dioxide standard with a 24-hour averaging time (New Mexico Environment Department, 2002).

Prevention of Significant Deterioration requirements identify maximum allowable increases in concentrations for particulate matter, sulfur dioxide, and nitrogen dioxide for areas designated as attainment. Different increment levels are identified for different classes of areas and Class I areas have the most stringent requirements.

The Northwestern New Mexico Uranium Milling Region air quality description focuses on two topics: NAAQS attainment status and Prevention of Significant Deterioration classifications in the region.

Figure 3.5-12 identifies the counties in and around the Northwestern New Mexico Uranium Milling Region that are partially or entirely designated as nonattainment or maintenance for NAAQS at the time this GEIS was prepared (EPA, 2007b). The Northwestern New Mexico Uranium Milling Region covers portions of New Mexico and borders Arizona. All of the area within this milling region is classified as attainment. Portions of two counties in New Mexico are not in attainment: Bernalillo County (central New Mexico) and Doña Ana County (south central New Mexico). The city of Albuquerque in Bernalillo County is designated as maintenance for carbon monoxide. The northwest part of Bernalillo County is only several kilometers [miles] from the Northwestern New Mexico Uranium Milling Region border; however, Albuquerque is about 50 km [31 mi] from this border. The city of Anthony in Doña Ana County is designated as nonattainment for PM_{10}. The Sunland Park area of Doña Ana County was designated as nonattainment for the 1-hour ozone standard until the EPA revoked the standard in 2005. Several counties in southern Arizona, including one that borders New Mexico, are not in attainment. However, the one Arizona county (Apache County) that borders the Northwestern New Mexico Uranium Milling Region is in attainment.

Table 3.5-9 identifies the Prevention of Significant Deterioration Class I areas in New Mexico and Arizona. The Class I areas in and around the Northwestern New Mexico Uranium Milling Region are shown in Figure 3.5-13. There are no Class I areas in the Northwestern New Mexico Uranium Milling Region.

3.5.7 Noise

The existing ambient noise levels for undeveloped rural areas in the Northwestern New Mexico Uranium Milling Region would be similar to those described in Section 3.2.7 for the Wyoming West Uranium Milling Region (up to 38 dB). The largest communities in the region include Gallup with a population of more than 20,000; Grants with a population of about 9,000; and Zuni Pueblo (about 6,400) (see Section 3.5.10). Urban noise levels in these communities and the smaller surrounding population centers would be similar to those (up to about 78 dB) for other urban areas (Washington State Department of Transportation, 2006).

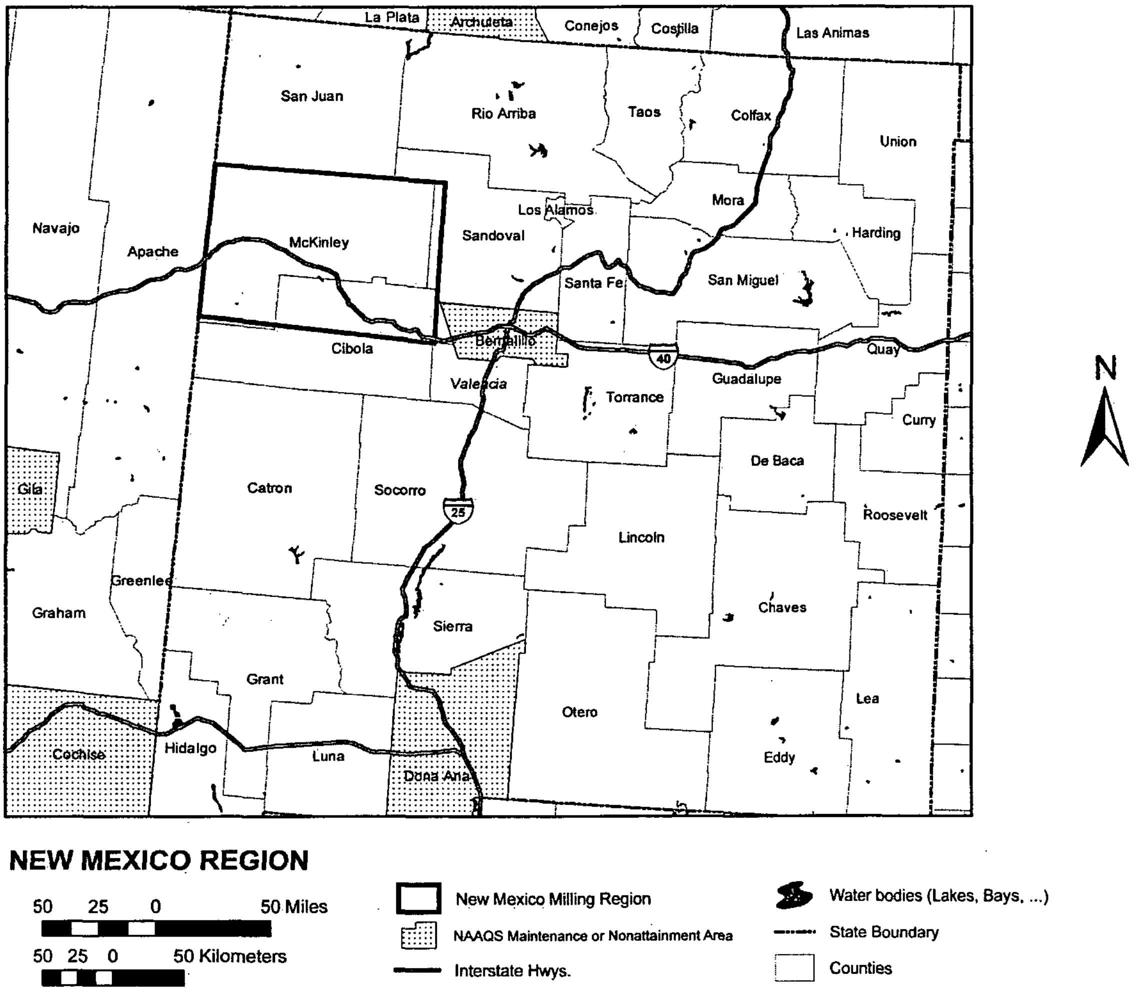


Figure 3.5-12. Air Quality Attainment Status for the Northwestern New Mexico Uranium Milling Region and Surrounding Areas (EPA, 2007a)

As described in Section 3.5.2, two major highways cross the Northwestern New Mexico Uranium Milling Region: Interstate 40 runs east west and U.S. Highway 491 runs north from Gallup. There are also several state undivided highways, but the area is only sparsely served by paved roads. Traffic counts for Interstate 40 are higher than those reported for Interstate-80 in Wyoming, with annual average daily traffic reported at about 16,500 just east of the New Mexico/Arizona line (New Mexico Department of Transportation, 2007). Traffic counts for U.S. Highway 491 are less, with annual average daily traffic of about 9,700 north of Gallup (New Mexico Department of Transportation, 2007). This suggests that ambient noise levels near these highways might be higher than the levels measured for Interstate-80 (Wyoming Department of Transportation, 2005; Federal Highway Administration, 2004; see also Section 3.2.7).

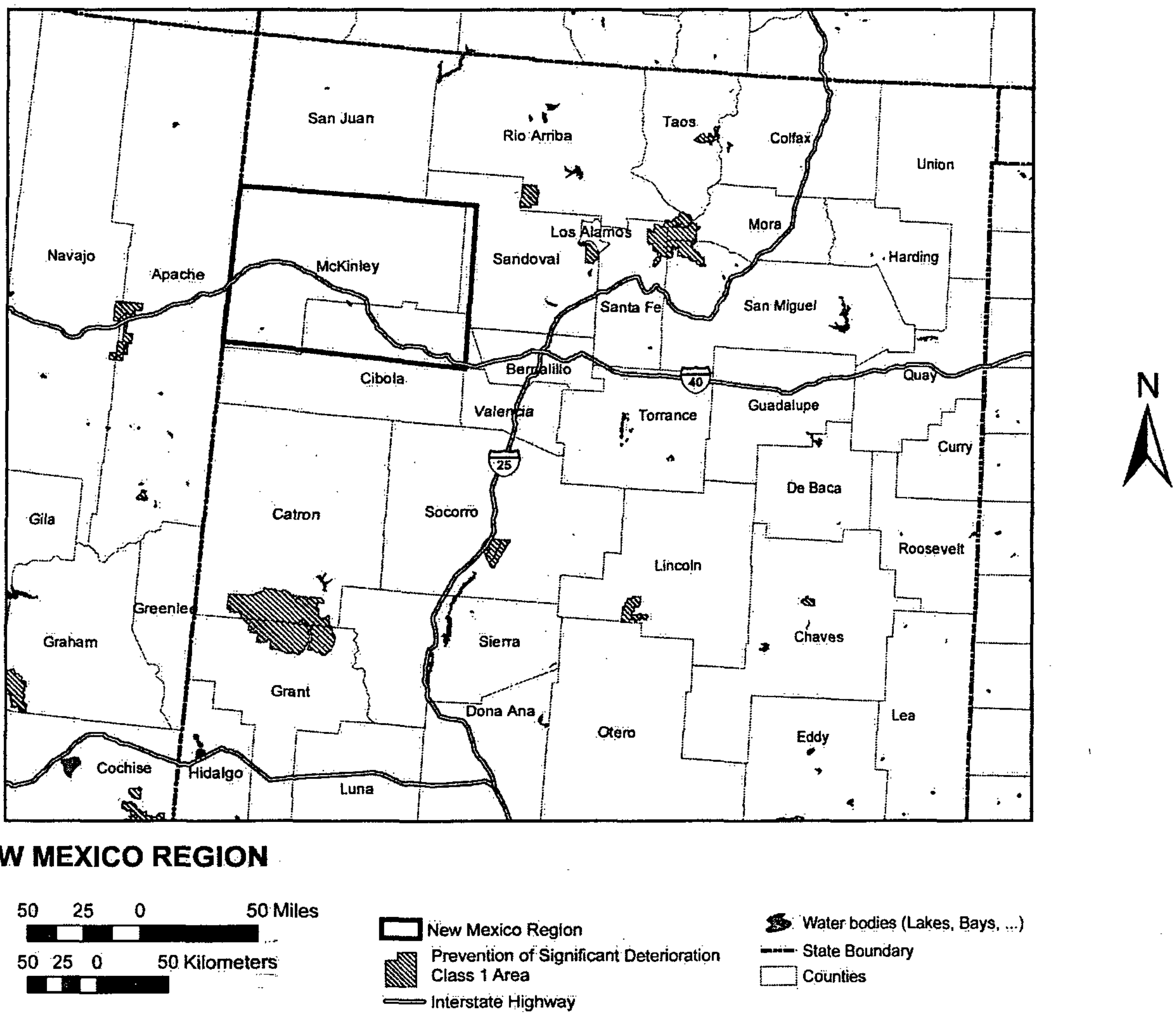


Figure 3.5-13. Prevention of Significant Deterioration Class I Areas in the Northwestern New Mexico Uranium Milling Region and Surrounding Areas (40 CFR Part 81)

The potential uranium projects in the region are more than 8 km [5 mi] from Interstate 40, and ambient noise levels would not be affected by highway noise. In some cases, such as at Crownpoint, the proposed facility would be located close to a small community, and the ambient noise levels would be expected to be slightly higher. Areas of special sensitivity to potential noise impacts could include areas of special significance to the Native American culture in the region (see Section 3.5.8).

3.5.8 Historical and Cultural Resources

The New Mexico SHPO is responsible for the oversight of federal and state historic preservation compliance laws, regulations, and statutes. The Cultural Properties Act (Sections 16-6

through 18-6-23, New Mexico Statutes Annotated 1978) was enacted in 1969 and amended several times in the ensuing years. It established the State Historic Preservation Division and Cultural Properties Review Committee, which issues permits for survey and excavation on state lands, and for the excavation of burials. Burial excavation permits are specifically required by the Unmarked Burial Statute (18-6-11.2, 1989) and the Marked Burial Statute (30-12-12, 1989) for human remains found on state or private land; whereas the NAGPRA applies to federal lands. The Reburial Grounds Act (18-6-14, 2006) provides for the designation of reburial areas for unclaimed human remains. The Cultural Properties Act also requires that state agencies provide the New Mexico SHPO with the opportunity to participate in planning activities that would affect properties on the State Register of Cultural Properties or the National Register of Historic Places. The Prehistoric and Historic Sites Preservation Act of 1969 (Sections 18-8-1 through 18-8-8, NMSA 1978) prohibits the use of state funds that would adversely affect sites on the state or national registers, unless the state agency demonstrates that there is no feasible or prudent alternative. The Cultural Properties Protection Act (Sections 18-6A-1 through 18-6A-6, New Mexico Statutes Annotated 1978) enacted in 1993 encourages state agencies to consult with the New Mexico SHPO in order to develop programs that will identify cultural properties and ensure that they will not be inadvertently damaged or destroyed. Lastly, Executive Order No. 2005-003 recognizes the sovereignty of Native American tribes in the state of New Mexico and provides that state agencies should conduct tribal consultation on the protection of culturally significant places and the repatriation of human remains and cultural items. Information on the New Mexico SHPO can be found at the following link: <http://www.nmhistoricpreservation.org>.

The U.S. government and the State of New Mexico recognize the sovereignty of certain Native American tribes. These tribal governments have legal authority for their respective reservations. Executive Order 13175 requires executive branch federal agencies to undertake consultation and coordination with Native American tribal governments on a government-to-government basis. NRC, as an independent federal agency, has agreed to voluntarily comply with Executive Order 13175.

In addition, the NHPA provides these tribal groups with the opportunity to manage cultural resources within their own lands under the legal authority of a THPO. The THPO therefore replaces the New Mexico SHPO as the agency responsible for the oversight of all federal and state historic preservation compliance laws. Both the Navajo Nation and Zuni Pueblo have a recognized THPO program. Other tribes have historic and cultural preservation offices that are not recognized as THPOs, but they should be consulted where they exist (see appended New Mexico tribal consultation list for Cibola and McKinley Counties).

The Navajo Nation has passed the Natural Resources Protection Act of 2005, which is designed to "ensure that no further damage to the culture, society, and economy of the Navajo Nation occurs because of uranium mining within the Navajo Nation ..." An insight into the effects of uranium exploration on traditional Navajo life is provided in the recent publication (Udall, et al., 2007). The Navajo Nation Code also states that "the six culturally significant mountains...Tsoodzil...must be respected, honored and protected for they, as leaders, are the foundation of the Navajo Nation (Navajo Nation, 2005, pp. 22–23)." *Tsoodzil* (Turquoise Mountain) is the Navajo word for Mount Taylor, some 24 km [15 mi] north of Grants, New Mexico, and in Navajo tradition, marks the southern boundary of the Navajo Dinetah or traditional homeland.

3.5.8.1 New Mexico Historic and Cultural Resources

McKinley and Cibola Counties are rich in cultural resources. In fact, the first highway salvage archaeological excavations in the nation were conducted along old Route 66 in this vicinity during the 1950s. Archaeological compliance work continues through the 21st century in respect to a variety of economic activities, including highway construction, energy development, tourism at the national monuments, and the realignment of military installations. Cultural resource overviews and Class II surveys of the region have therefore been provided by several federal agencies; however, they date to the 1980s when most of the energy-related development was initiated. The San Juan Basin Regional Uranium Study was certainly one of the most important of these studies (Broster and Harrill, 1982; Dulaney and Dosh, 1981; Plog and Wait, 1979; Powers, et al., 1983; Tainter and Gillio, 1980).

Interstate 40 passes through Albuquerque, Grants, and Gallup, acting as a primary east-west link across the region. New Mexico State Road 491 heads north from Gallup to Shiprock and the Four-Corners area. Lastly, Grants is connected to Chaco Canyon National Monument by way of State Road 371. A variety of archaeological projects have therefore been conducted in respect to highway-related compliance work (e.g., Damp, et al., 2002; Gilpin, 2007).

McKinley and Cibola Counties have been a major focus of energy development activities, including coal, uranium, and natural gas pipeline projects. The McKinley Coal Mine and the Laguna uranium mine represent two examples of extensive surface mining operations (Allen and Nelson, 1982; Kelley, 1982). In addition, the ENRON and El Paso pipeline projects have crosscut the region to supply the west with natural gas from sources in northwest New Mexico (Winter, 1994).

Three national monuments are located within the Northwestern New Mexico Uranium Milling Region: Chaco Canyon, El Morro, and El Malpais. Although Chaco Canyon is situated to the north of Grants, New Mexico, in San Juan County, several outlying components of Chaco National Monument are present in Cibola and McKinley Counties including the Red Mesa Valley group east of Gallup, the Cebolleta Mesa Group, Puerco of the West Group, and portions of the South Chaco Slope Group (Marshall, et al., 1979; Powers, et al., 1983). El Morro and El Malpais National Monuments are also located near Grants (Powers and Orcutt, 2005a; Murphy, et al., 2003).

Fort Wingate is a closed military installation that has been extensively surveyed for cultural resources. The former Army munitions depot is located south of Interstate 40 between Gallup and Grants. These lands contain numerous archaeological sites and have ancestral ties to both Zuni Pueblo and the Navajo Nation (Schutt and Chapman, 1997; Perlman, 1997).

A total of 21,625 archaeological sites have been recorded in McKinley and Cibola Counties as of this writing. A single Class II sample survey identified an average density of 6 sites/km^2 [15 sites/mi^2] for the southern San Juan Basin (Dulaney and Dosh, 1981); however, site densities as high as 12 sites/km^2 [30 sites/mi^2] were identified on Cebolleta Mesa (Broster and Harrill, 1982). Table 3.5-10 provides a summary of sites recorded by time period for McKinley and Cibola Counties, and Figure 3.5-14 illustrates the distribution of these sites across the counties. However, this distribution only includes those areas that have been systematically surveyed for cultural resources. Together these resources represent over 10,000 years of human land-use in the region. The following is a brief review of the Native American occupation of the area.

Table 3.5-10. Number of Recorded Sites by Time Period and County		
	County	
Period	McKinley	Cibola
Paleoindian	18	34
Archaic	426	359
Ancestral Pueblo	8,211	2,742
Historic Pueblo	575	290
Navajo	4,476	378
Other Historic	518	1,057
Undetermined	2,822	2,331
Total*	15,040	6,585
*Note: Because many sites include multiple temporal components, the total number of sites presented above does not reflect the total number of components (occupations) that might exist at each site.		

Paleoindian (ca. 10,000 to 6000 B.C.)

The Paleoindian occupation of the region is primarily represented by the presence of isolated projectile points with a few campsites (Figure 3.5-15). Clovis (10,000–9,000 B.C.), Folsom (9,000–8,000 B.C.) and Late Paleoindian (8,000–6,000 B.C.) points have been identified at various locations across the landscape. The Clovis inhabitants presumably hunted a range of large animal species including mammoth, whereas Folsom hunters focused on migratory bison herds and Late Paleoindian hunters on bison, with other animal and plant species (Amick, 1994; Broster and Harrill, 1982; Judge, 2004; Stanford, 2005).

Archaic (ca. 6,000 B.C to A.D. 400)

The Archaic occupation of the region is characterized by the presence of numerous temporary campsites (Figure 3.5-16). Early Archaic (6,000–4,000 B.C.) and Middle Archaic (4,000–2000 B.C.) sites appear to be less common than those occupied during the Late Archaic (2000 B.C.–A.D. 400); however, this may be a product of differential preservation and the exposure of subsurface deposits, rather than differences in the degree to which these groups occupied the area. Early and Middle Archaic groups gathered a variety of plant species while hunting medium- to small-sized game. In contrast, domesticated maize first appeared in New Mexico by 2100 B.C., probably as a supplement to gathered plant foods, with the first evidence of simple irrigation perhaps as early as 1000 B.C. (Damp, et al., 2002; Huber and Van West, 2005; Simmons, 1986; Vierra, 2008).

Ancestral Puebloan (ca. A.D. 400 to 1540)

For many years, archaeologists referred to the prehistoric culture that arose in the San Juan Basin after the Archaic period as the "Anasazi," a word borrowed from the Navajo that means "old people" or "enemy ancestors" (Kantner, 2004). Although this term continues to be widely used among archaeologists and the public alike, many contemporary Pueblo people find the use of Anasazi to be offensive. Although controversy about this issue continues (Kantner, 2004; Riggs, 2005), archaeologists and government agencies increasingly use the term "Ancestral Puebloan" in place of Anasazi, a practice that is followed here.

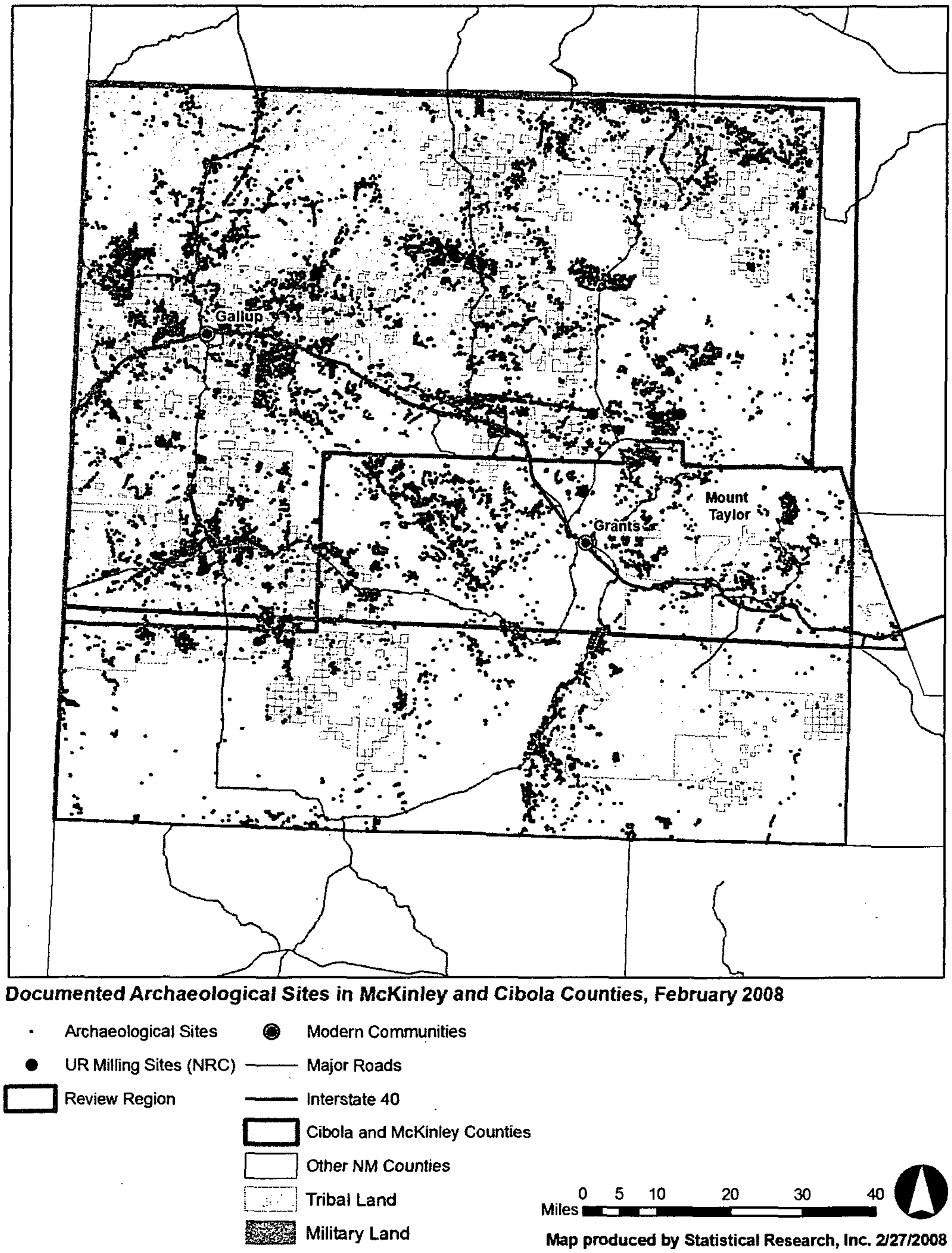


Figure 3.5-14. Distribution of Recorded Archaeological Sites in McKinley and Cibola Counties, New Mexico

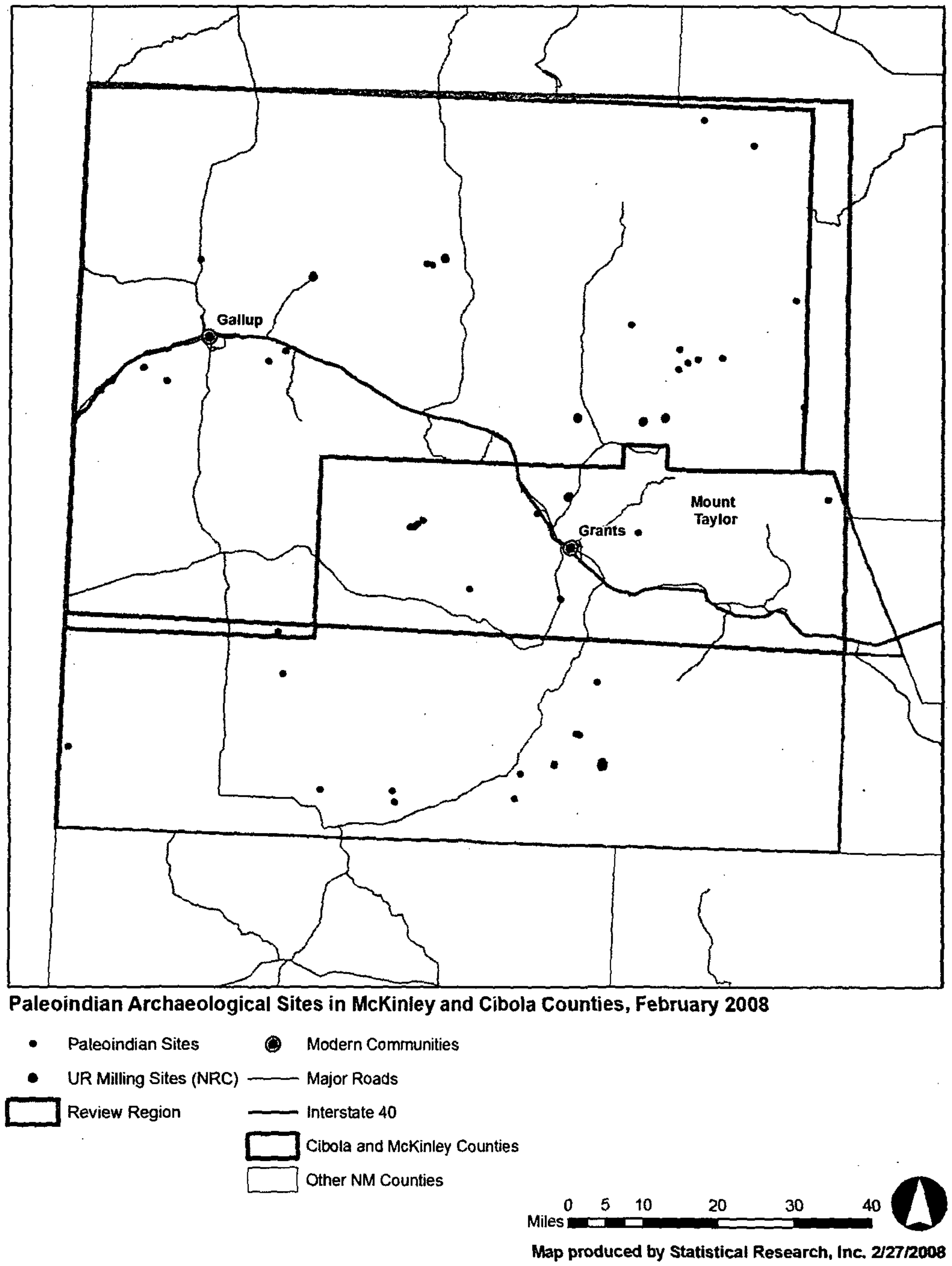


Figure 3.5-15. Paleoindian Sites

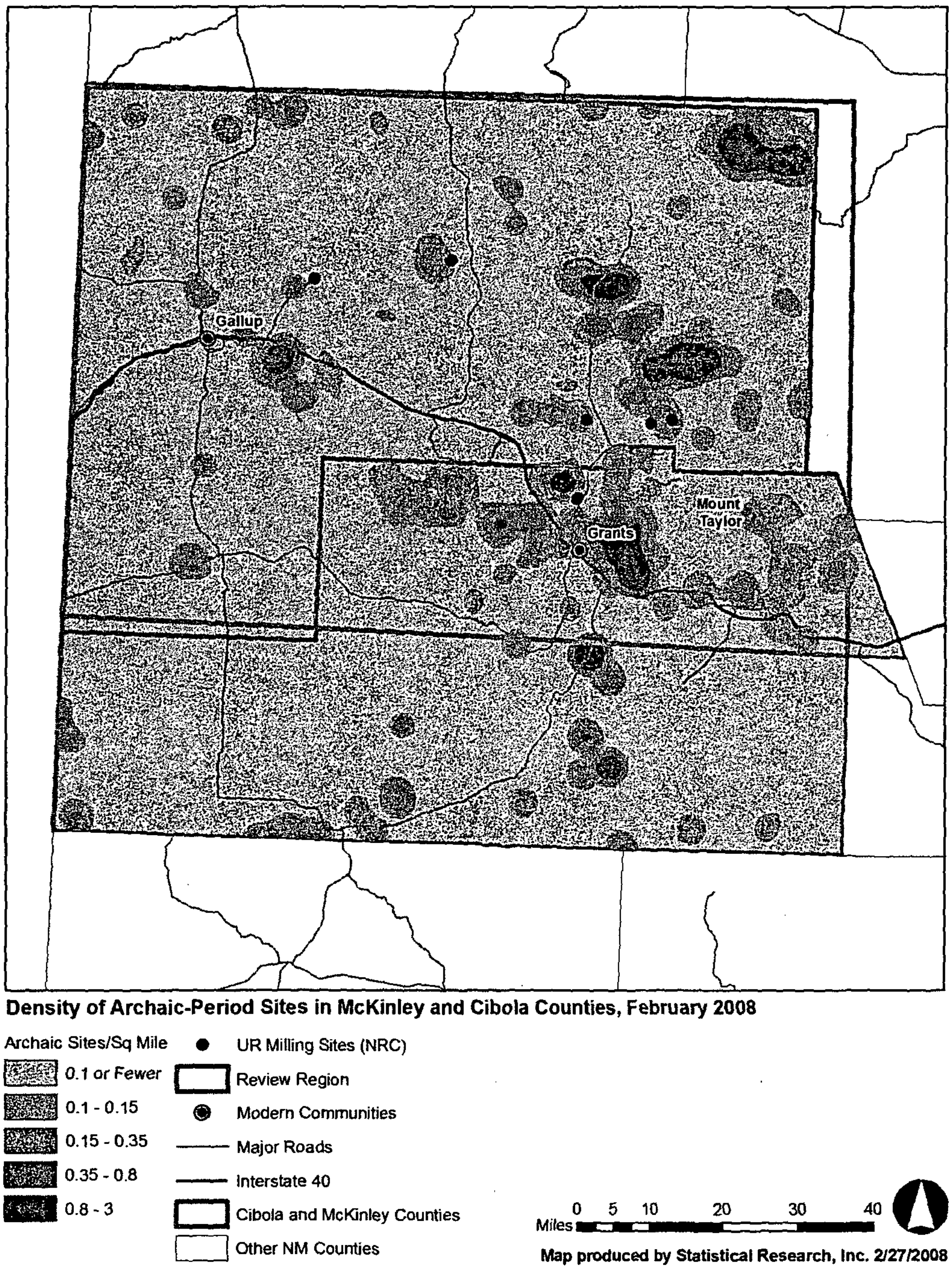


Figure 3.5-16. Distribution of Archaic-Period Sites

The Ancestral Puebloan period appears to have emerged directly from the preceding Archaic period and begins with the initial appearance of pottery and the bow and arrow, more elaborate pit structure architecture, and the more intensive use of maize agriculture. Although a number of chronological sequences for this period have been proposed for the region, the two major sequences currently in use are the Cebolleta Mesa and Pecos Chronologies (Kidder, 1927) (Table 3.5-11, Figure 3.5-17).

Basketmaker II (ca. 500 B.C. to A.D. 400)

Basketmaker II (or Late Archaic) represents a continuation of the previous hunting and gathering lifestyle. However, important changes in subsistence and social organization were occurring with a growing dependence on the cultivation of maize. Recent excavations in the region have documented habitation sites with houses, storage pits, and refuse areas. High water table farming adjacent to playa settings appears to have been an important niche for early maize cultivation, with numerous storage features having been discovered in these contexts. In addition, the earliest evidence of water diversion through irrigation channels is also represented. Lastly, important changes in technology were also occurring, including the use of ceramic containers and the bow and arrow (Damp, et al., 2002; Kearns, et al., 1998; Vierra, 1994, 2008).

Basketmaker III (ca. A.D. 400 to 700)

In comparison to the preceding Late Archaic period, Basketmaker III material culture is characterized by the introduction of the bow and arrow and fired ceramic vessels. Basketmaker III sites in the San Juan region also featured larger and more elaborate pit habitation structures, larger villages, and evidence for increased trade and greater reliance on agriculture, including both corn and beans (Reed, 2000b). Although Basketmaker III sites have been identified throughout McKinley and Cibola Counties, these sites typically date to the later portion of this time period and transition gradually into Pueblo I occupations, with few major cultural differences between them (Tainter and Gillio, 1980). In general, Basketmaker III sites are fairly rare in most of the McKinley/Cibola region compared to other areas to the north and west (Cordell, 1979; Orcutt, et al., 2005, Powers and Orcutt, 2005b; Schutt and Chapman, 1997; Tainter and Gillio, 1980). In McKinley County, however, many sites that became important during the later Pueblo II period were initially occupied at this time (Powers, et al., 1983).

Table 3.5-11. Cebolleta Mesa and Pecos Chronologies

Cebolleta Mesa Sequence	Dates B.C./A.D.	Pecos Classification
—	Ca. 500 B.C.–A.D. 500	Basketmaker II
Lobo Period	?–700 A.D.	Basketmaker III
White Mound Phase	700–800	Basketmaker III/Pueblo I
Kiatuthlana Phase	800–870	Pueblo I
Red Mesa Phase	850–950	Early Pueblo II
Cebolleta Phase	950–1100	Pueblo II
Pilares Phase	1100–1200	Pueblo III
Kowina Phase	1200–1400	Pueblo III to IV
Cubero Phase	1400–1540	Late Pueblo IV
Acoma Phase	1540–present	Pueblo V/Historic Pueblo

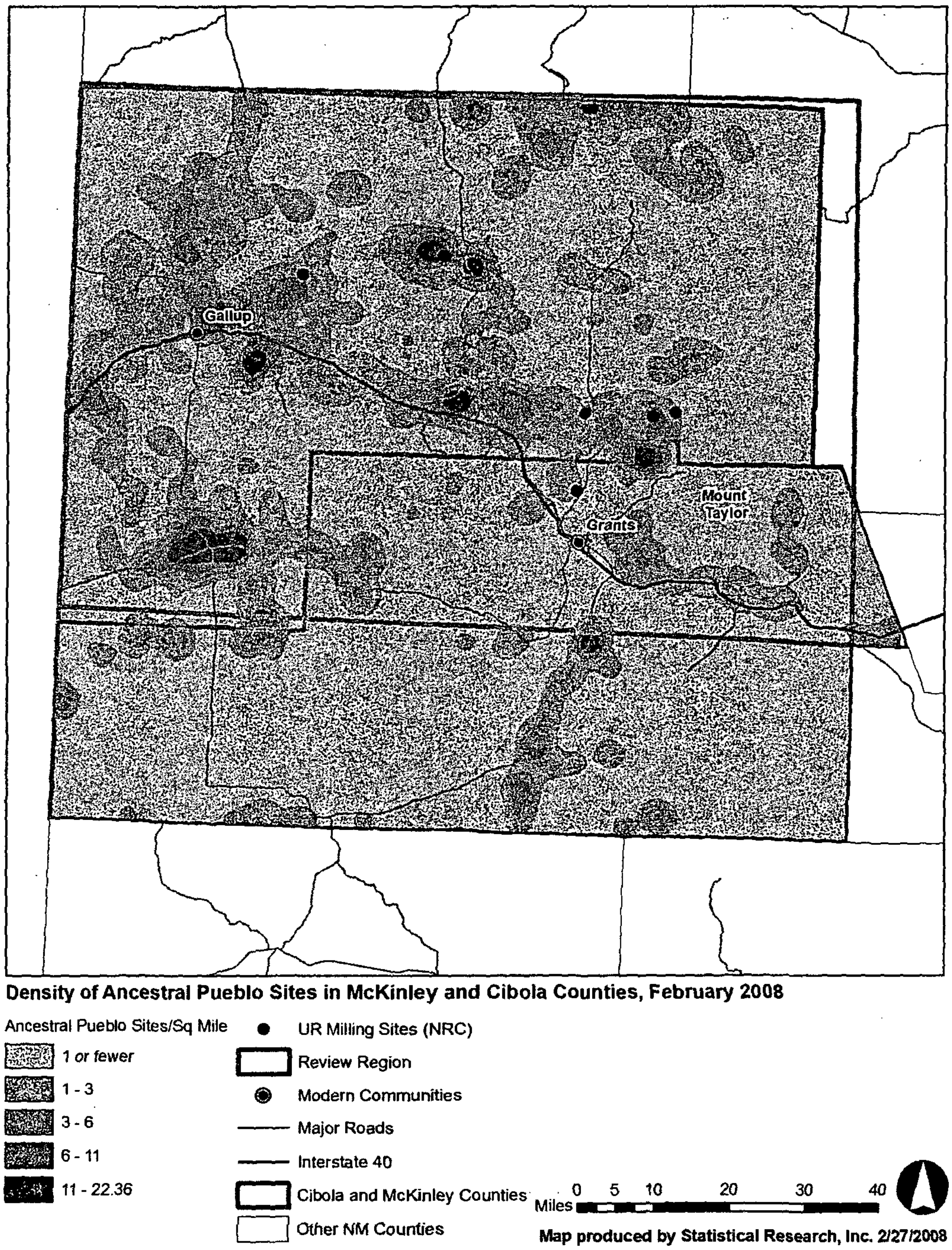


Figure 3.5-17. Distribution of Ancestral Puebloan Sites

Pueblo I (ca. A.D. 700 to 900)

The Pueblo I period is distinguished from the Basketmaker III period by the first appearance of painted black-on-white pottery. Although a shift away from living in subterranean pit structures and into aboveground rooms is also typically part of the Basketmaker III/Pueblo I transition (Reed, 2000a), pithouses remained the dominant structure type in much of McKinley and Cibola Counties until fairly late in the Pueblo I period, with small surface rooms primarily used for storage (Schutt and Chapman, 1997; Tainter and Gillio, 1980). Small aboveground pueblos constructed from masonry or jacal (wattle-and-daub) began to be used for habitation in some areas by the end of the Pueblo I period (Schutt and Chapman, 1997). Kivas—subterranean structures with a specialized ceremonial function—also made their first appearances during this period (Schutt and Chapman, 1997). Although Pueblo I-period sites are not particularly common in McKinley and Cibola Counties, they are more numerous than Basketmaker III sites and represent the first substantial Ancestral Puebloan occupations in many areas (Schachner and Kilby, 2005; Schutt and Chapman, 1997; Tainter and Gillio, 1980).

Pueblo II (ca. A.D. 900 to 1100)

The Pueblo II period represents a considerable change in Ancestral Puebloan culture throughout the Four Corners region, including the present study area (Powers, et al., 1983; Schutt and Chapman, 1997; Tainter and Gillio, 1980). Blocks of contiguous, aboveground masonry rooms become the primary focus of occupation, with belowground structures increasingly shifting to a predominantly ceremonial function (Powers and Orcutt, 2005b; Schutt and Chapman, 1997). Sites are often much larger than in the preceding Pueblo I period, and populations increase steeply throughout McKinley and Cibola Counties: in many areas, populations during Pueblo II reach a peak that is not exceeded during the prehistoric period (Tainter and Gillio, 1980).

This period also marks the development of the Chacoan regional system, an event with major repercussions for the entire Four Corners region (Kantner and Mahoney, 2000; Noble, 2004; Powers, et al., 1983). Beginning around A.D. 850, Ancestral Puebloan peoples living in Chaco Canyon, located just north of McKinley County (Judge, 2004; Powers, et al., 1983; Windes, 2004), began constructing a series of elaborate, carefully planned, multistory masonry structures today known as "great houses" (Windes, 2004). Although rooted in the Puebloan architecture of previous periods, the great houses were larger than contemporary structures anywhere else in the Puebloan world (Mills, 2002b). By the mid-13th century, when major construction ceased, at least 18 great houses had been constructed in and around the canyon, the largest reaching 4 or more stories and incorporating hundreds of rooms and an elaborate, decorative core-and-veneer masonry style (Judge, 2004; Mahoney and Kantner, 2000; Mills, 2002b).

Nor was great house construction limited to Chaco Canyon. Starting at about A.D 950, great houses began to be built beyond the canyon at numerous locations throughout the San Juan Basin. More than 200 great houses with Chacoan-style architecture and features have been identified to date across an area stretching from eastern Arizona and southern Colorado to the edges of the Jemez Mountains and the foothills of Mount Taylor. Outlier sites in McKinley and Cibola Counties include Casamero, Kin Nizhoni, and Village of the Great Kivas (Mahoney and Kantner, 2000; Marshall, et al., 1979). Southern and eastern areas near Acoma and Laguna are less clearly part of the Chaco system, exhibiting clear differences from sites in the San Juan Basin (Tainter and Gillio, 1980), but outliers may exist in these areas as well (Powers and Orcutt, 2005b). Outlying great houses are typically located among much smaller and less

elaborate masonry pueblos and are often accompanied by distinctive structures including extremely large "great kivas" and Chacoan roads. These roads are intentionally constructed trails that typically measure 8 to 12 m [26 to 39 ft] in width and incorporate raised beds, borders, gates, stairways, and other features (Mahoney and Kantner, 2000; Mills, 2002b; Powers and Orcutt, 2005b). Their function is not well understood, but recent studies suggest they may link ceremonially and ritually important features of the Chacoan landscape (Kantner, 1997; Van Dyke, 2004).

The function and meaning of Chacoan great houses are not well understood, but most evidence suggests they were not simply residential structures. Excavated great houses in Chaco Canyon typically contain few rooms with cooking hearths and very little household trash, leading some archaeologists to suggest that even the largest structures never housed more than 100 permanent residents (Mills, 2002b). Most archaeologists now believe these structures served some sort of public function, perhaps as part of a ceremonial system centered around Chaco itself. However it functioned, Chaco's far-reaching influence served to funnel trade goods into the canyon. Recent studies of ceramic and lithic artifacts, wooden roof beams, and even foodstuffs like corn from great houses in the canyon suggest that many of these goods were brought in from far-flung areas such as the Chuska Mountains in eastern Arizona, the Mesa Verde area in southern Colorado, and the Mount Taylor region (Cordell, 2004; Mills, 2002b; Toll, 2004).

Pueblo III (ca. A.D. 1100 to 1300)

Great house construction within Chaco Canyon itself ceased by about A.D. 1130, and most of the canyon's occupants appear to have moved elsewhere by the late 12th century (Judge, 2004; Mills, 2002b). Many factors probably contributed to the demise of Chaco, but a series of major droughts that afflicted the region throughout much of the 12th century may have had a particularly influential role (Mills, 2002b). Beyond Chaco Canyon, however, many great house communities remained occupied throughout the 1100s, retaining many aspects of their Chacoan origins but incorporating new and distinctly different features as well (Mills, 2002b). Perhaps spurred by drought, populations declined throughout much of McKinley and Cibola Counties (Kintigh, 1996; Roney, 1996; Tainter and Gillio, 1980). New settlements founded during this period were frequently larger and more compact than the great house communities of the preceding period as populations aggregated in areas more conducive to conserving and managing water (Kintigh, 1996). Populations in some areas appear to have recovered and stabilized somewhat by the early 13th century (Powers and Orcutt, 2005a; Roney, 1996). The process of abandonment and aggregation began to accelerate again by the late 1200s, however, as renewed drought increasingly pushed Pueblo populations into relatively well-watered areas along the Zuni River to the west and the Rio San Jose to the east (Kintigh, 1996; Roney, 1996; Tainter and Gillio, 1980).

Pueblo IV (ca. A.D. 1300 to 1540)

The settlement reorganization that began during the Pueblo III period continued during Pueblo IV. By A.D. 1400, most of the Four Corners region was abandoned, with remnant populations concentrated in the Zuni and Rio San Jose areas and at the Hopi mesas in Arizona (Huntley and Kintigh, 2004; Kintigh, 1996; Roney, 1996). The number of sites present in these areas continued to drop as populations aggregated in large villages, but the compactly laid-out pueblos that remained were often extremely large, with several including more than 1,000 rooms (Huntley and Kintigh, 2004). By the late Pueblo IV period, the vast majority of Puebloan people in west-central New Mexico were at least part-time residents of one of these

large pueblos; the smaller habitation sites that characterized earlier periods were virtually absent in many areas (Huntley and Kintigh, 2004; Roney, 1996). These newly aggregated large villages shared many similarities across the region: settlements typically consisted of blocks of contiguous rooms arranged around plaza areas used for domestic activities and public rituals. At larger sites, these roomblocks were often two or more stories tall. Sites were also frequently located in highly defensive locations, especially early in the period (Huntley and Kintigh, 2004; Roney, 1996; Tainter and Gillio, 1980).

Historic Pueblo (post A.D. 1540)

By the mid-16th century, Puebloan groups occupied no more than 10 villages in west-central New Mexico: 6 to 9 Zuni-speaking pueblos arrayed along the lower Zuni River and its tributaries south of modern Gallup (Huntley and Kintigh, 2004) and the single Keres-speaking village of Acoma, located on a mesa top in eastern Cibola county along the Rio San Jose (Adams and Duff, 2004) (Figure 3.5-18). The first contact between these villages and the Spanish came in 1539, when a small expedition led by Franciscan friar Marcos de Niza and the former slave Esteban entered the Zuni region; de Niza returned abruptly to Mexico when Esteban was killed (Ferguson and Hart, 1985; Spicer, 1962). The much larger expedition of Francisco Vasquez de Coronado fought a battle with the Zuni in July 1540 outside the village of Hawikuh and stopped briefly at Acoma on its way to the Rio Grande valley (Ferguson and Hart, 1985; Flint and Flint, 2005). More sustained contact with the Spanish empire came in 1598, when both the Zuni and Acoma areas were formally subjugated by the expedition of Juan de Oñate (Spicer, 1962).

Franciscan missions were established at both Zuni and Acoma in 1629, but the distance between Zuni and the center of Spanish power along the Rio Grande allowed the Zuni to retain a degree of cultural and religious independence (Ferguson and Hart, 1985; Spicer, 1962). Franciscan missions at Acoma and the Zuni villages of Hawikuh and Halona operated until the Pueblo Revolt of 1680, when the Spanish were driven from New Mexico for a dozen years, but missionization in the Zuni region continued only sporadically after the Spanish reconquest in the late 1600s. At both Acoma and Zuni, however, European infectious diseases and the economic demands of the colonizers decimated Puebloan populations: at Zuni, the six or more villages inhabited at contact dwindled to three by 1680, and only one village, the present pueblo of Zuni, was reoccupied after the reconquest (Mills, 2002a). To the east, Acoma remained the only village along the Rio San Jose until 1697, when the pueblo of Laguna was established by a group of Acoma dissidents and refugees from other villages after the Spanish reconquest (Ellis, 1979).

More benign aspects of colonialism included new economic opportunities afforded by the food crops and domesticated animals brought by the Spanish. Sheepherding, in particular, began at both Zuni and Acoma as early as the mid-17th century, and by the mid-18th century, the Zunis grazed more than 15,000 sheep across an area extending as far as 112 km [70 mi] from the central pueblo itself (Ferguson and Hart, 1985; Schutt and Chapman, 1997). Small, temporary campsites associated with sheepherding and agriculture are among the most common historic period Puebloan archaeological sites from the 1600s into the 20th century (Ferguson, 1996; Schutt and Chapman, 1997).

Navajo (ca. 1700 to present)

With the exception of the areas just discussed, much of the northern Southwest, including northwestern New Mexico, was abandoned by Ancestral Puebloan groups during the

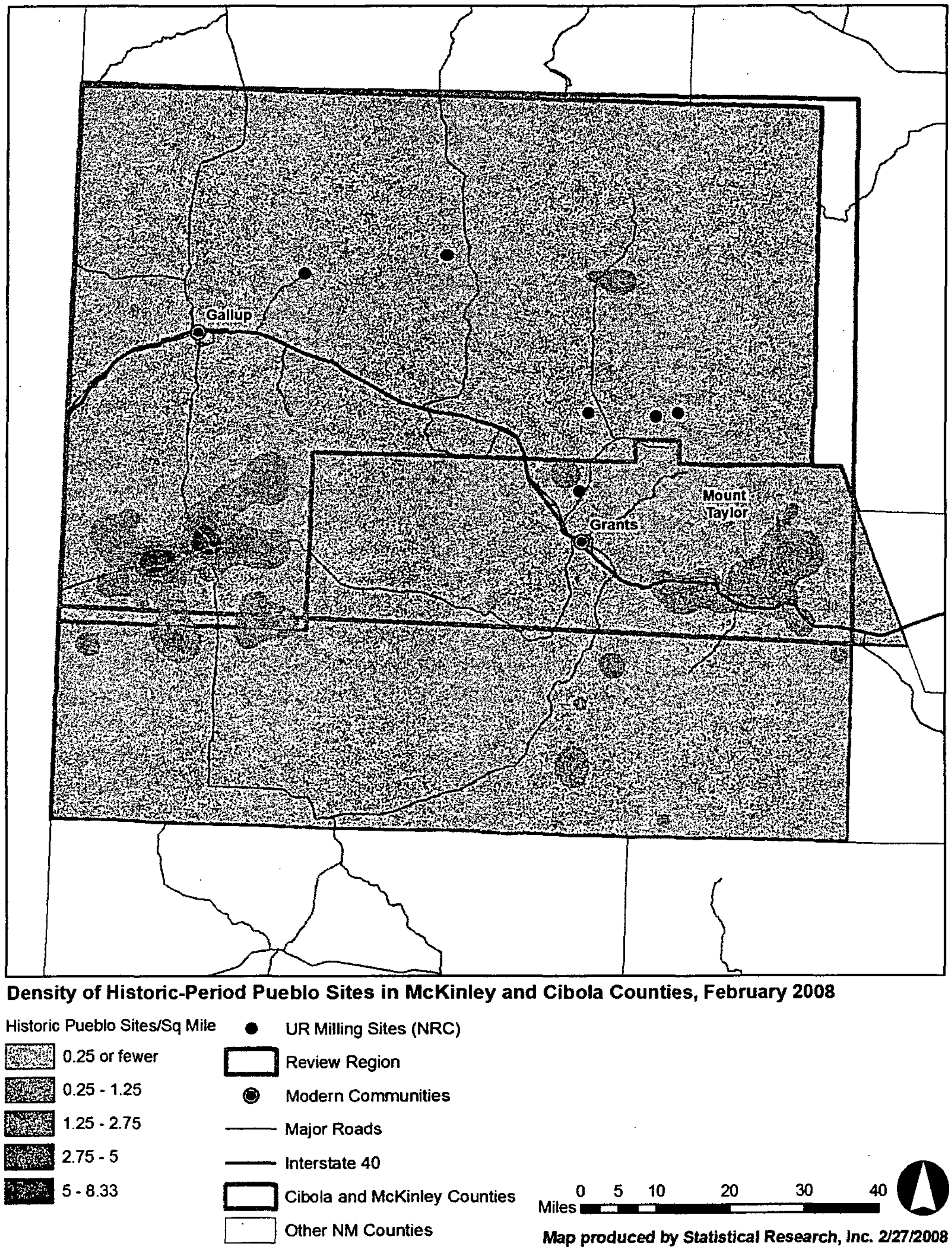


Figure 3.5-18. Distribution of Historic Pueblo Sites

14th century, followed by the expansion of Athabaskan hunter-gatherers into these vacated areas, perhaps as early as the late 15th century (Dean, et al., 1994; Towner, 1996). The Athabaskan-speaking groups are believed to have been the ancestors of today's Navajo and Apachean groups in the Southwest. The ancestral Navajo groups subsequently adopted maize cultivation and later moved south into the southern San Juan Basin by the 1700s (Figure 3.5-19). The 18th century Navajo migration southward was due to several factors including conflict with the Comanches and Utes, drought, and disease outbreaks. Records of Navajo baptisms at the Cebolleta Mission occur after 1749, with Navajo raids on local settlers and Laguna Pueblo Indians being reported in the late 1700s (Brugge, 1968; Correll, 1976; Reeve, 1959). This conflict continued through the 1800s, although the Navajos in the Mount Taylor (Tsoodzil) area were also involved in trade relations with both local Spanish and Pueblo Indians. Nonetheless, in 1864 all the Navajos residing in the region were forcibly moved to Fort Sumner in eastern New Mexico. By 1868 the Navajos were allowed to return to their lands within a newly designated reservation. The arrival of the railroad during the 1880s provided them with a market for wool blankets and jewelry. However, this was a mixed blessing, with pressures on the Navajo households to produce market items, versus subsistence self-sufficiency. Ultimately, Navajos expanded into more marginal areas that could not sustain the growing economic markets, with the long-term result being the partitioning of landholdings into smaller family-owned tracts, the overgrazing of these tracts, and a shift toward wage-earning jobs (Kelley, 1986).

3.5.8.2 National Register of Historic Properties and State Registers

Table 3.5-12 includes a summary of sites in the Northwestern New Mexico Uranium Milling Region that are listed on the New Mexico State and/or NRHP. Most of the sites are located in McKinley County, and the locations of many of the archaeological sites are not identified to reduce the likelihood of vandalism. Historic sites are located in the communities of Grants, Gallup, and Crownpoint, all of which are close to potential uranium ISL milling locations.

3.5.8.3 New Mexico Tribal Consultation

There are 22 Native American Pueblos and tribes located within the state of New Mexico. Most of these groups are situated along the Rio Grande valley corridor from Albuquerque to Taos, with several additional groups being represented in the northwest and southern parts of the state. Five tribes have reservation lands within McKinley and Cibola Counties, consisting of Acoma Pueblo, Laguna Pueblo, Zuni Pueblo, the Navajo Nation and the Ramah Navajo Tribe. These counties lie in the northwestern section of the state, along the southern periphery of the San Juan Basin. The region is characterized by mesas and open grasslands, which are bounded by the Chuska Mountains, Zuni Mountains, and Mount Taylor rising to heights of over 2,950 m [9,700 ft]. The Continental Divide bisects the area with drainages flowing toward the north, west, and east. Silko provides an insight into the Pueblo perspective of this environment when she states that "there is no high mesa edge or mountain peak where one can stand and not immediately be part of all that surrounds. Human identity is linked with all the elements of Creation" (Silko, 1990, pp. 884–885).

Traditional cultural properties are places of special heritage value to contemporary communities because of their association with cultural practices and beliefs that are rooted in the histories of those communities and are important in maintaining the cultural identity of the communities (Parker and King, 1998; King, 2003). Religious places are often associated with prominent topographic features like mountains, peaks, mesas, springs and lakes (Silko, 1990). In addition,

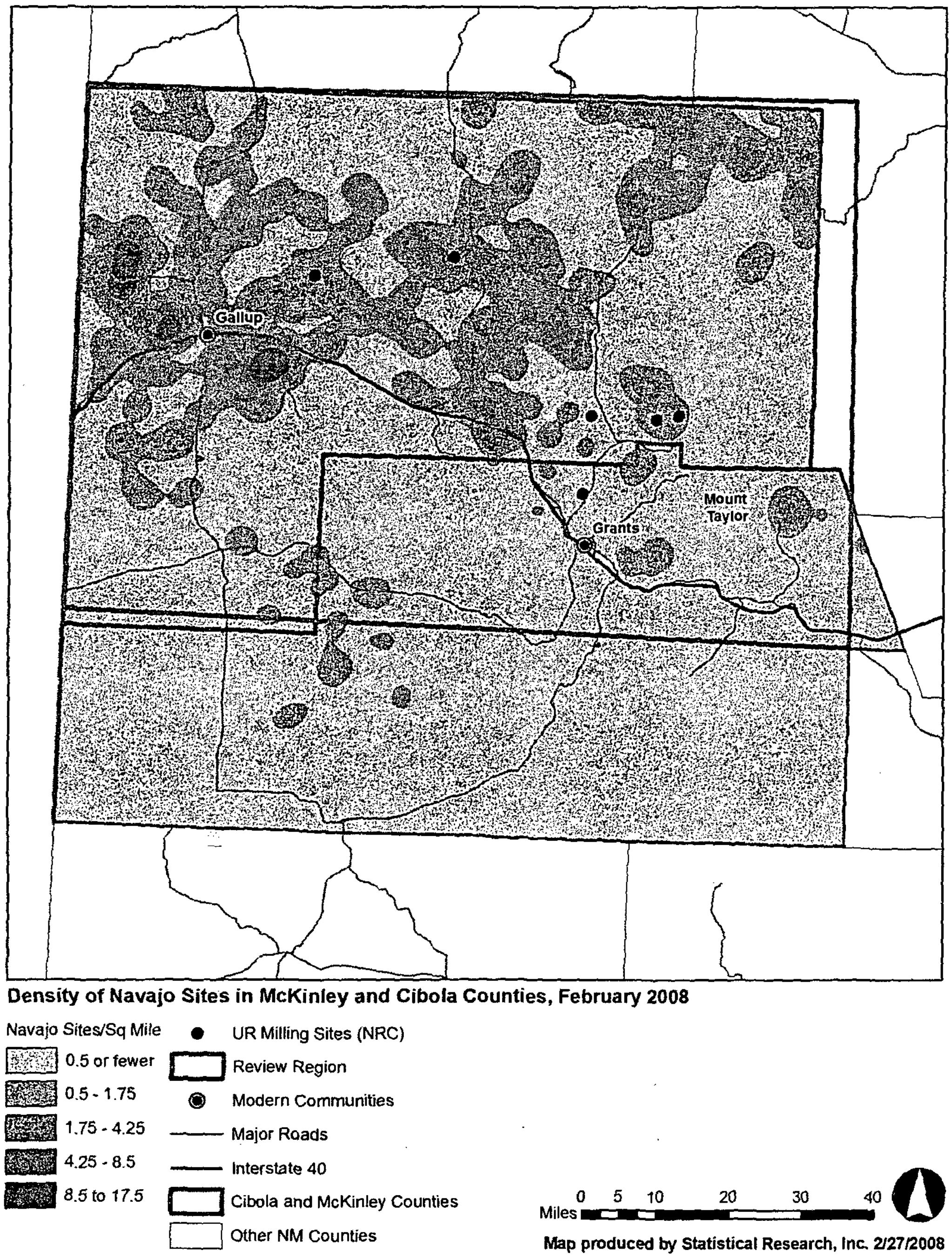


Figure 3.5-19. Distribution of Navajo Archaeological Sites

Table 3.5-12. National Register Listed Properties in Counties Included in the Northwestern New Mexico Uranium Milling Region			
County	**Resource Name**	**City**	**Date Listed YYYY-MM-DD**
Cibola	Bowlin's Old Crater Trading Post	Bluewater	2006-03-21
Cibola	Candelaria Pueblo	Grants	1983-03-10
Cibola	Route 66 Rural Historic District: Laguna to McCarty's	Cubero	1994-01-13
Cibola	Route 66, State Maintained from McCarty's to Grants	Grants	1997-11-19
Cibola	Route 66, State Maintained from Milan to Continental Divide	Continental Divide	1997-11-19
McKinley	Andrews Archeological District	Prewitt	1979-05-17
McKinley	Archaeological Site # LA 15278 (Reservoir Site; CM 100)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,780	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,781	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,782	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,784	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,785	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,786	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 45,789	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,000	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,001	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,013 (CM101)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,014 (CM 102)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,015 (CM 102A)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,016 (CM 103)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,017 (CM 104)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,018	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,019 (CM 105)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,020 (CM 106)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,021	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,022 (CM 107)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,023 (CM 118)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,024 (CM 108)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,025 (CM 109)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,026 (CM 108)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,027 (CM 111)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,028 (CM 112)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,030 (CM 114)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,031 (CM 115)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,033 (CM 117)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,034	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,036	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,037	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,038	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,044	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,071 (CM 148)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,072 (CM 94)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,074 (CM 181)	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,077	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,080	Pueblo Pintado	1985-08-02
McKinley	Archaeological Site # LA 50,035	Pueblo Pintado	1985-10-09

Table 3.5-12. National Register Listed Properties in Counties Included in the Northwestern New Mexico Uranium Milling Region (continued)			
County	Resource Name	City	Date Listed YYYY-MM-DD
McKinley	Ashcroft—Merrill Historic District	Ramah	1990-07-27
McKinley	Bee Burrow Archeological District	Seven Lakes	1984-12-10
McKinley	Casa de Estrella Archeological Site	Crownpoint	1980-10-10
McKinley	Chaco Culture National Historical Park	Thoreau	1966-10-15
McKinley	Chief Theater	Gallup	1988-05-16
McKinley	Cotton, C.N., Warehouse	Gallup	1988-01-14
McKinley	Cousins Bros. Trading Post	Chi Chil Tah	2006-03-22
McKinley	Dalton Pass Archeological Site	Crownpoint	1980-10-10
McKinley	Drake Hotel	Gallup	1988-01-14
McKinley	El Morro Theater	Gallup	1988-05-16
McKinley	El Rancho Hotel	Gallup	1988-01-14
McKinley	Fort Wingate Archeological Site	Fort Wingate	1980-10-10
McKinley	Fort Wingate Historic District	Fort Wingate	1978-05-26
McKinley	Grand Hotel	Gallup	1988-05-25
McKinley	Greenlee Archeological Site	Crownpoint	1980-10-10
McKinley	Halona Pueblo	Gallup	1975-02-10
McKinley	Harvey Hotel	Gallup	1988-05-25
McKinley	Haystack Archeological District	Crownpoint	1980-10-10
McKinley	Herman's, Roy T., Garage and Service Station	Thoreau	1993-11-22
McKinley	Lebanon Lodge No. 22	Gallup	1989-02-14
McKinley	Log Cabin Motel	Gallup	1993-11-22
McKinley	Manuelito Complex	Manuelito	1966-10-15
McKinley	McKinley County Courthouse	Gallup	1989-02-15
McKinley	Palace Hotel	Gallup	1988-05-16
McKinley	Peggy's Pueblo	Zuni	1994-08-16
McKinley	Redwood Lodge	Gallup	1998-02-13
McKinley	Rex Hotel	Gallup	1988-01-14
McKinley	Route 66, State Maintained from Iyanbito to Rehobeth	Rehobeth	1997-11-19
McKinley	Southwestern Range and Sheep Breeding Laboratory Historic District	Fort Wingate	2003-05-30
McKinley	State Maintained Route 66—Manuelito to the Arizona Border	Mentmore	1993-11-22
McKinley	Upper Kin Klizhin Archeological Site	Crownpoint	1980-10-10
McKinley	U.S. Post Office	Gallup	1988-05-25
McKinley	Vogt, Evon Zartman, Ranch House	Ramah	1993-02-04
McKinley	White Cafe	Gallup	1988-01-14

shrines are present across the landscape to denote specific culturally significant locations where an individual can place offerings (Ellis, 1974a,b; Perlman, 1997; Rands, 1974a,b). Ancestral villages also represent culturally significant places where the ancestors of these contemporary communities once resided in the distant past, and these villages are sometimes linked to Pueblo migration stories (Ellis, 1974a,b). In addition, specific resource collecting areas may have significance for maintaining traditional lifeways (Ferguson and Hart, 1985; Perlman, 1997; Rands 1974a,b). Lastly, pilgrimage trails with trail markers provide a link to all these areas across the broad ethnic landscape (Ferguson and Hart, 1985; Fox, 1994; Parsons, 1918; Sedgwick, 1926).

The area of McKinley and Cibola Counties only composes a small portion of the lands considered to be affiliated with traditional land-use activities. For example, the Navajo Nation

bounds their traditional lands by the four culturally significant mountains: Hesperus Peak, Blanca Peak, Mount Taylor, and the San Francisco Peaks, which are located in Colorado, New Mexico, and Arizona, respectively (Linford, 2000). Zuni Pueblo recognizes a shrine that is situated more than 240 km [150 mi] away at Bandelier National Monument near Los Alamos, New Mexico (Ferguson and Hart, 1985). On the other hand, Mount Taylor is significant to nearby Acoma and Laguna Pueblos for its role in their traditional origin myth where the Gambler held captive the Rainclouds until released by Sun Youth and Old Grandmother Spider (Sterling, 1942; Silko, 1990).

Information on traditional land use and the location of culturally significant places is often protected information within the community (e.g., King, 2003). Therefore, the information presented on religious places is limited to those that are identified in the published literature and is therefore restricted to a few highly recognized places on the landscape within McKinley and Cibola counties. Various documents pertaining to the Indian land claims also provide background information on local history and traditional land use (Ellis, 1974a,b; Minge, 1974; Rands, 1974a,b; Jenkins, 1974).

Linford's (2000) statement on the relation between mythology and place names is relevant to all traditional communities when he states that "a location's religious significance is more obscure, usually ascribed through it's [sic] association with, or mention in, one or more of the stories that are the foundation of Navajo ceremonies" (Kelley and Francis, 1994; Holt, 1981; Ortiz, 1992; Silko, 1990). The list of religious places provided in Table 3.5-13 is most often associated with traditional stories that recount the community's heritage through oral traditions. Ellis (1974a,b) and Rand (1974a,b) do, however, provide a list of shrines that are associated with Laguna and Acoma Pueblos, and Ferguson and Hart (1985) list religious sites associated with Zuni Pueblo.

On June 14, 2008, the New Mexico Cultural Properties Review Committee accepted an emergency listing of the Mount Taylor traditional cultural property to the State Register of Cultural Properties (Los Angeles Times, 2008). The nomination was submitted by Acoma Pueblo, Hopi Tribe, Laguna Pueblo, the Navajo Nation, and Zuni Pueblo. The boundaries of the traditional cultural property have been tentatively set to include the summit and surrounding mesas above 2,440 m [8,000 ft], with the boundary dropping down to 2,224 m [7,300 ft] in the area of Horace Mesa. This application was specifically initiated to protect culturally sensitive sites that may be impacted by proposed uranium mining activities. The nominating group has 1 year to complete the final nomination to the state register; however, during this time, the traditional property is given the full status of being listed. Also in 2008, the USFS has determined that Mount Taylor is eligible for listing in the NRHP as a traditional cultural property.

If the listing of Mount Taylor is approved and NRC receives a license application for the Mount Taylor area, NRC regulations require that the application be reviewed. Under applicable NRC regulations, if an ISL license application is received, consultation and site-specific review of the application will be undertaken according to NEPA, NHPA, and NRC regulations. Appendix D summarizes the NHPA process that would occur should a license application be received.

The New Mexico Historic Preservation website suggests that the following Pueblo and tribal groups should be contacted for consultation associated with activities in McKinley and Cibola Counties: Acoma Pueblo, Hopi Tribe, Isleta Pueblo, Laguna Pueblo, Mescalero Apache Tribe, Navajo Nation, Sandia Pueblo, White Mountain Apache Tribe and Zuni Pueblo. This list was generated from the Pueblo and American land claims, Historic Preservation Division ethnographic study, the National Park Service's Native American Consultation database and groups that directly contacted Historic Preservation Division requesting to be notified of potential

Table 3.5-13. Known Culturally Significant Places in McKinley and Cibola Counties		
Place	**Affiliated Tribe**	**Reference**
Bandera Crater	Zuni	Ferguson and Hart (p. 127)*
Cerro del Oro	Laguna	Parsons†, Rands (p. 68)‡
Chuska Mountains (various locations)	Navajo	Linford (p. 194)§
Correo Snake Pit	Acoma and Laguna	Ellis (p. 92) ‖, Parsons†, Rands (p. 8)¶
Dowa Yalanne	Zuni	Ferguson and Hart (p. 124)*
El Malpais	Navajo	Linford (p. 204)§
El Morro	Zuni	Ferguson and Hart (p. 127)*
Hosta Butte	Navajo	Linford (p. 218)§
Ice Caves	Zuni	Ferguson and Hart (p. 125)*
Mount Taylor Shrines	Acoma Laguna Zuni	Parsons (p. 185) #, Rands (p. 97)¶, Ellis (p. 92)‖, Ferguson and Hart (p. 126)*
Mount Taylor: Kaweshtima Tsiipiya T'se pina Tsoodzil Dewankwi Kyabachu Yalanne	Acoma Hopi Laguna Navajo Zuni	Application for Register. New Mexico State Register of Cultural Properties, June 14, 2008 (Los Angeles Times**). New Mexico State Historic Preservation Office.
Pueblo Pintado	Navajo	Linford (p. 247)§
Red Lake	Navajo	Linford (p. 250)§
Springs	Acoma Laguna Zuni	Rands (p. 97)¶, White (pp. 45–47)††, Ellis (p. 92)‖, Ferguson and Hart (pp. 125–132)*
Zuni Salt Lake	Laguna Zuni Navajo	Rands (p. 68)‡, Ferguson and Hart (p. 126)*, Linford (p. 284)§
Zuni Mountains (various locations)	Zuni	Ferguson and Hart (pp. 125, 132)*

*Ferguson, T.J. and E. Hart. *A Zuni Atlas.* Norman, Oklahoma: University of Oklahoma Press. 1985.
†Parsons, E.C. "War God Shrines of Laguna and Zuni." *American Anthropologist.* Vol. 20. pp. 381–405. 1918.
‡Rands, R. *Laguna Land Utilization: Pueblo Indians IV.* New York City, New York: Garland Publishing. 1974.
§Linford, L. *Navajo Places: History, Legend and Landscape.* Salt Lake City, Utah: University of Utah Press. 2000.
‖Ellis, F.H. *Archaeologic and Ethnologic Data: Acoma-Laguna Land Claims.* New York City, New York: Garland Publishing, Inc. 1974.
¶Rands, R. *Acoma Land Utilization: Pueblo Indians III.* New York City, New York: Garland Publishing. 1974.
#Parsons, E.C. "Notes on Acoma and Laguna." *American Anthropologist.* pp. 162–186. 1918.
**Los Angeles Times. "Tribes Get Mt. Taylor Listed as Protected." Los Angeles Times, June 15, 2008. <http://articles.latimes.com/2008/jun/15/nation/na-mountain 15>
††White, L.A. *The Acoma Indians.* Forty-Seventh Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution. Washington, DC: Smithsonian Institution. 1932.

activities in these areas. The Pueblo and tribal contact information provided in Table 3.5-14 was obtained from the State of New Mexico, Indian Affairs Department website at <http://www.iad.state.nm.us/ pueblogovandtribaloff.html>.

Table 3.5-14. 2008 Pueblo and Tribal Government Contacts for McKinley and Cibola Counties, New Mexico		
Affiliated Tribe	**Contact**	**Address**
Acoma Pueblo	Governor Chandler Sanchez	Pueblo of Acoma P.O. Box 309 Acoma, NM 87034 (505) 552-6604/6605
Acoma Pueblo	Director Teresa Pasqual,	Pueblo of Acoma Historic Preservation Office PO Box 309 Acoma, NM 87034 (505) 552-5170
Hopi Tribe	Chairman Benjamin Nuvamsa	Hopi Tribe P.O. Box 123 Kykotsmovi, AZ 86039 (928) 734-3000
Hopi Tribe	Leigh Kuwanwisiwma	Hopi Cultural Preservation Office The Hopi Tribe P.O. Box 123 Kykotsmovi, AZ 86039 (928) 734-6636 P (928) 734-3613 EX611 Leigh (928) 734-3629 Fax
Jemez Pueblo	Governor Paul Chinana	Jemez Pueblo P.O. Box 100 Jemez Pueblo, NM 87024 (505) 834-7359
Jicarilla Apache Nation	President Levi Pesata	Jicarilla Apache Nation P.O. Box 507 Dulce, NM 507 (505) 759-3242
Isleta Pueblo	Governor Robert Benavides	Pueblo of Isleta P.O. Box 1270 Isleta Pueblo, NM 87022 (505) 869-3111/6333
Laguna Pueblo	Governor John Antonio, Sr.	Pueblo of Laguna P.O. Box 194 Laguna Pueblo, NM 87026 (505) 552-6654/6655/6598
Mescalero Apache Tribe	President Carleton Naiche-Palmer	Mescalero Apache Tribe P.O. Box 227 Mescalero, NM 88340 (505) 464-4494
Navajo Nation	President Joe Shirley, Jr.	Navajo Nation P.O. Box 9000 Window Rock, AZ 86515 (928) 871-6352/6357

Table 3.5-14. 2008 Pueblo and Tribal Government Contacts for McKinley and Cibola Counties, New Mexico (continued)		
Affiliated Tribe	**Affiliated Tribe**	**Affiliated Tribe**
Navajo Nation	Alan Downer	Tribal Preservation Officer Navajo Nation Historic Preservation Department P.O. Box 4950 Window Rock, AZ 86515 (928) 871-6437
Sandia Pueblo	Governor Robert Montoya	Pueblo of Sandia 481 Sandia Loop Bernalillo, NM 87004 (505) 867-3317
White Mountain Apache	Mr. Ramon Riley	White Mountain Apache Tribe P.O. Box 507 Fort Apache, AZ 85926
Zuni Pueblo	Governor Norman Cooeyate	Pueblo of Zuni P.O. Box 339 Zuni, NM 87327 (505) 782-7022
Zuni Pueblo	Kurt Dongoske	Office of Heritage and Historic Preservation Pueblo of Zuni P.O. Box 339 Zuni, New Mexico 87327-0339 (928) 782-4814 P (928) 782-2393 F

3.5.8.4 Traditional Cultural Landscapes

Although archaeology and cultural resources management have historically focused on archaeological sites and artifact finds, past and present human interactions with their natural surroundings extend beyond the material traces of past human behavior. As a result, archaeologists and resource managers alike are increasingly focusing on the concept of traditional *cultural landscapes* as a broader, more accurate perspective on the way humans conceive of and use their environments. A cultural landscape is not the same as a natural "environmen"; rather, it is produced by a cultural group's interaction with their environment. In simple terms, a cultural landscape is what results as members of a particular human group "project culture onto nature" (Crumley and Marquardt, 1990) by interacting with, modifying, and conceptualizing their natural surroundings over time (Anschuetz, et al., 2001).

The notion of a cultural landscape includes the physical evidence of a group's interactions with the natural world, but is not limited to quantifiable material resources or patterns. A landscape perspective also incorporates the significance of particular places or landmarks for a group's histories, traditional stories, or religious beliefs (Anschuetz, 2007; Anschuetz, et al., 2001; Basso, 1996). Particular locations may serve as reminders of traditional beliefs or ways of life, or be venerated as supernatural beings in their own right. To quote a recent summary, a landscape perspective encompasses a "community's intimate relationships with the land and its resources in every aspect of its material life, including economy, society, polity, and recreation" (Anschuetz, 2007).

Understanding the importance of traditional cultural landscapes, then, means being aware of many overlapping dynamics of a culture's relationships with its environment. A landscape perspective must also take into account the overlapping, diverse cultural landscapes of many different cultures. In west-central New Mexico, for instance, a survey of cultural landscapes would include the distinct, extensive territories formerly used by the Zunis for economic activities ranging from farming and herding to gathering medicinal plants or collecting raw materials for stone tools (Ferguson and Hart, 1985). It would also recognize the culturally significant springs, caves, and shrines dotting the world as conceived by the Keres people of Laguna and Acoma, or the culturally significant peaks at the four cardinal directions delineating this world's boundaries (Snead and Preucel, 1999; White, 1932). Similar culturally significant landmarks recognized by the Navajo form part of yet another traditional landscape perspective, as described previously. Finally, the roads and ruins of the ancient inhabitants of Chaco Canyon figure in the traditional histories of Zuni, Acoma, and Navajo alike, but also serve as clues to illuminate the traditional landscapes of the Chacoans themselves. Like their modern descendents, the ancient Chacoans seem to have placed importance on astronomical alignments, the cardinal directions, and prominent peaks, mesas, and other landmarks (Van Dyke, 2004).

In summary, then, the distribution of archaeological sites, artifacts, and other physical markers of human activity are only one dimension of the processes in which past human groups used and conceptualized their surroundings. The traditional cultural landscapes of west-central New Mexico's indigenous groups include a wide variety of landmarks, traditional use areas, and other important features, many of which retain importance for contemporary groups. These traditional landscapes are increasingly recognized by agencies and archaeologists alike and play an expanding role in historic preservation and cultural resource management decision making.

3.5.9 Visual/Scenic Resources

Based on the BLM Visual Resource Handbook (BLM, 2007a–c), the Grants Uranium District in the Northwestern New Mexico Uranium Milling Region is located in the Colorado Plateau physiographic province (BLM, 2007a). The Farmington and Albuquerque field offices of the BLM have classified most of the region as VRM Class III and IV (BLM, 2003, 2000). There are no VRM Class I VRM areas, and most of the Class II areas are located just north of Interstate 40. As described in NRC (1997), the primary viewers in the San Juan Basin and Grants Uranium District are likely to be Native American residents living on and near a proposed ISL facility (see Section 3.5.8). For this reason, their aesthetic sense at the landscape scale is important. In general, Native American thought is "integrative and comprehensive. It does not separate intellectual, moral, emotional, aesthetic, economic, and other activities, motivations, and functions" (Norwood and Monk, 1987). For both the Navajo and Zuni, moral good tends to be equated with aesthetic good: that which promotes or represents human survival and human happiness tends to be experienced as "beautiful." The landscape is beautiful by definition because the Holy People designed it to be a beautiful, harmonious, happy, and healthy place (Norwood and Monk, 1987). Native Americans have not created an abstract category for unspecified vistas; the emphasis is on specific mountains, specific trees, and specific colors of the soil (Norwood and Monk, 1987). References to the visual quality of a given area may be more meaningful when linked to an identifiable place and not to more generalized landscapes.

Natural and scenic attractions within the Grants Uranium District in the Northwestern New Mexico Uranium Milling Region are minimal. Regionally, the Chaco Culture National Historic Park, El Malpais National Monument (BLM, 2000), El Morro National Monument, and the Red

Rock State Park, among other features, attract tourists for scenic, historic, and cultural features (see Section 3.5.1). Near Gallup and south of Interstate 40, the USFS categorizes the visual quality objectives within the Cibola National Forest as predominantly (about 75 percent) in the Modification and Maximum Modification class (USFS, 1985), with some areas such as the Mount Taylor district in the San Mateo Mountains having high scenic integrity (USFS, 2007). In addition, in June 2008 (Los Angeles Times, 2008), the New Mexico Cultural Properties Review Committee approved listing the Mount Taylor traditional cultural property in the State Register of Cultural Properties (see Section 3.5.8.3). With the exception of major highways such as Interstate 40 and U.S. Highway 491, area roads are used mostly for local travel. The urban areas such as Gallup, Crownpoint, and Grants tend to dominate visual resources near these cities and towns (NRC, 1997).

The resource management plan for the Farmington field office of the BLM provides a VRM classification for the public lands in the Northwestern New Mexico Uranium Milling Region (BLM, 2003) (Figure 3.5-20). The visual context is also an important component of the cultural resource values of the Chacoan Outliers, Native American Use and Sacred Areas of Critical Environmental Concern, and additional traditional cultural properties (BLM, 2003). The approximately 2 million ha [5 million acres] of regional public lands and subsurface mineral resources BLM administers in the Farmington field office have a relatively small amount (about 13 percent) of VRM Classes I and II viewsheds associated with wilderness areas, wilderness study areas, specially designated areas, and special management areas. As categorized by BLM, the visual landscape in northwestern New Mexico is dominated by VRM Class IV (55 percent) and Class III (32 percent). The natural state has been considerably modified by human activities and structures associated with oil and gas development, including gas wells, pipelines, and the accompanying access roads. There are no Class I areas within the Northwestern New Mexico Uranium Milling Region. Areas categorized as Class II include locations where scenic vistas (from major highways), riverfronts, and high places are important because of associated sightseeing and recreational value (BLM, 2003).

Specific VRM Class II locations identified by BLM within and near the region include the Cabezon Peak, Cañon Jarido, Elk Springs, Ignacio Chavez, Jones Canyon, and La Lena special management areas and the Empedrado wilderness study areas (BLM 2003) at the eastern edge of the Northwestern New Mexico Uranium Milling Region. The USFS also identifies Corral Canyon and the western edge of the San Pedro Mountains in the La Jara area of the Santa Fe National Forest just to the east of the Northwestern New Mexico Uranium Milling Region as areas where recreation and timber are to be managed to preserve visual resource value (USFS, 2007). These Class II resource areas are adjacent to the Grants Uranium District, but the closest potential uranium ISL facility to these resource areas is about 16 km [10 mi]. A Class II area associated with the Chaco Culture National Historic Park is north of the Northwestern New Mexico Uranium Milling Region and extends into the region about 50 km [30 mi] north of the nearest potential uranium recovery facility (Figure 3.5-20). BLM National Conservation Areas, adjacent to the El Malpais National Monument and about 3 km [2 mi] south of Grants, are also identified as Class II. Two potential facilities are located near San Mateo Mesa about 16 km [10 mi] northwest of Mount Taylor. In addition, two of the proposed facilities are located within about 3–8 km [2–5 mi] of the borders of the Navajo Nation (Figure 3.5-20). Current indications from industry are that these would be developed as conventional milling operations (NRC, 2008).

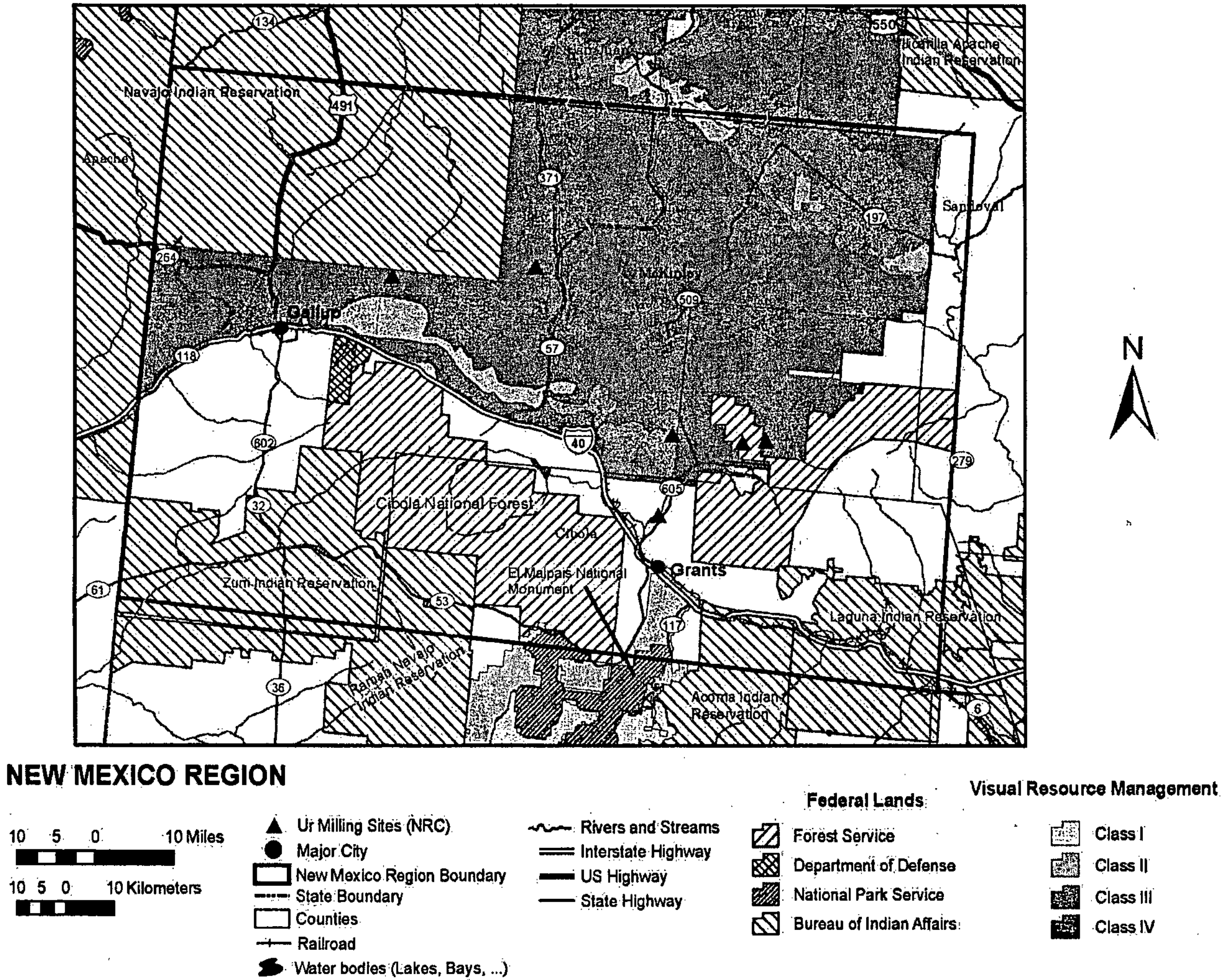


Figure 3.5-20. BLM Visual Resource Classifications for the Northwestern New Mexico Uranium Milling Region (BLM, 2003, 2000)

3.5.10 *Socioeconomics*

For the purpose of this GEIS, the socioeconomic description for the Northwestern New Mexico Uranium Milling Region includes communities within the region of influence for potential ISL facilities in the Grants Uranium District. These include communities that have the highest potential for socioeconomic impacts and are considered the affected environment. Communities that have the highest potential for socioeconomic impacts are defined by (1) proximity to an ISL facility {generally within about 48 km [30 mi]}; (2) economic profile, such as potential for income growth or destabilization; (3) employment structure, such as potential for job placement or displacement; and (4) community profile, such as potential for growth or destabilization to local emergency services, schools, or public housing. The affected environment consists of counties, towns, CBSAs, and Native American communities (reservation land) (Table 3.5-15). A CBSA, according to the U.S. Census Bureau, is a collective term for both metro and micro areas ranging from a population of 10,000 to 50,000 (U.S. Census Bureau, 2008). The following subsections describe areas most likely to have implications with regard to socioeconomics. In some subsections, Metropolitan Areas are also discussed. A Metropolitan Area is greater than 50,000 and a town has less than 10,000 in population (U.S. Census Bureau, 2008).

3.5.10.1 Demographics

Demographics are based on 2000 U.S. Census data on population and racial characteristics of the affected environment (Table 3.5-16). Figure 3.5-21 illustrates the populations of communities within the Northwestern New Mexico Uranium Milling Region. Most 2006 data compiled by the U.S. Census Bureau is not yet available for the geographic area of interest.

Based on review of Table 3.5-16, the most populated county is Sandoval County and the most sparsely populated county is Cibola County. The largest populated town/CBSAs in the Northwestern New Mexico Uranuim Milling Region is Gallup. The county with the largest percentage of non-minorities is Sandoval County with a white population of 65.1 percent. The town/CBSAs with the largest percentage of non-minorities is Grants with a white population of 56.2 percent. The largest minority-based county is McKinley County with a white population of

Table 3.5-15. Summary of Affected Environment Within the Northwestern New Mexico Uranium Milling Region

Counties Within New Mexico	Towns Within New Mexico	CBSAs Within New Mexico	Native American Communities Within New Mexico
Cibola	Grants	Gallup	Acoma Indian Reservation
McKinley			Tohajiilee Indian Reservation
Sandoval			Laguna Indian Reservation
			Navajo Nation Indian Reservation
			Ramah Navajo Indian Reservation
			Zuni Indian Reservation

Table 3.5-16. 2000 U.S. Bureau of Census Population and Race Categories of the Northwestern New Mexico Uranium Milling Region*

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
New Mexico	1,819,046	1,214,253	34,343	173,483	309,882	66,327	19,255	765,386	1,503
Percent of total		66.8%	1.9%	9.5%	3.6%	3.6%	1.1%	42.1%	0.1%
Cibola County	25,595	10,138	246	10,319	3,952	828	98	8,555	14
Percent of total		39.6%	1.0%	40.3%	15.4%	3.2%	0.4%	33.4%	0.1%
McKinley County	74,798	12,257	296	55,892	4,095	1,882	344	9,276	32
Percent of total		16.4%	0.4%	74.7%	5.5%	2.5%	0.5%	12.4%	0.0%
Sandoval County	89,908	58,512	1,535	14,634	11,118	3,117	894	26,437	98
Percent of total		65.1%	1.7%	16.3%	12.4%	3.5%	1.0%	29.4%	0.1%
Gallup	20,274	8,106	219	7,404	2,985	1,187	289	6,699	19
Percent of total		40.1%	1.1%	36.6%	14.8%	5.9%	1.4%	33.1%	0.1%
Grants	8,806	4,947	143	1,054	2,184	386	81	4,611	11
Percent of total		56.2%	1.6%	12.0%	24.8%	4.4%	0.9%	52.4%	0.1%

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100 percent).

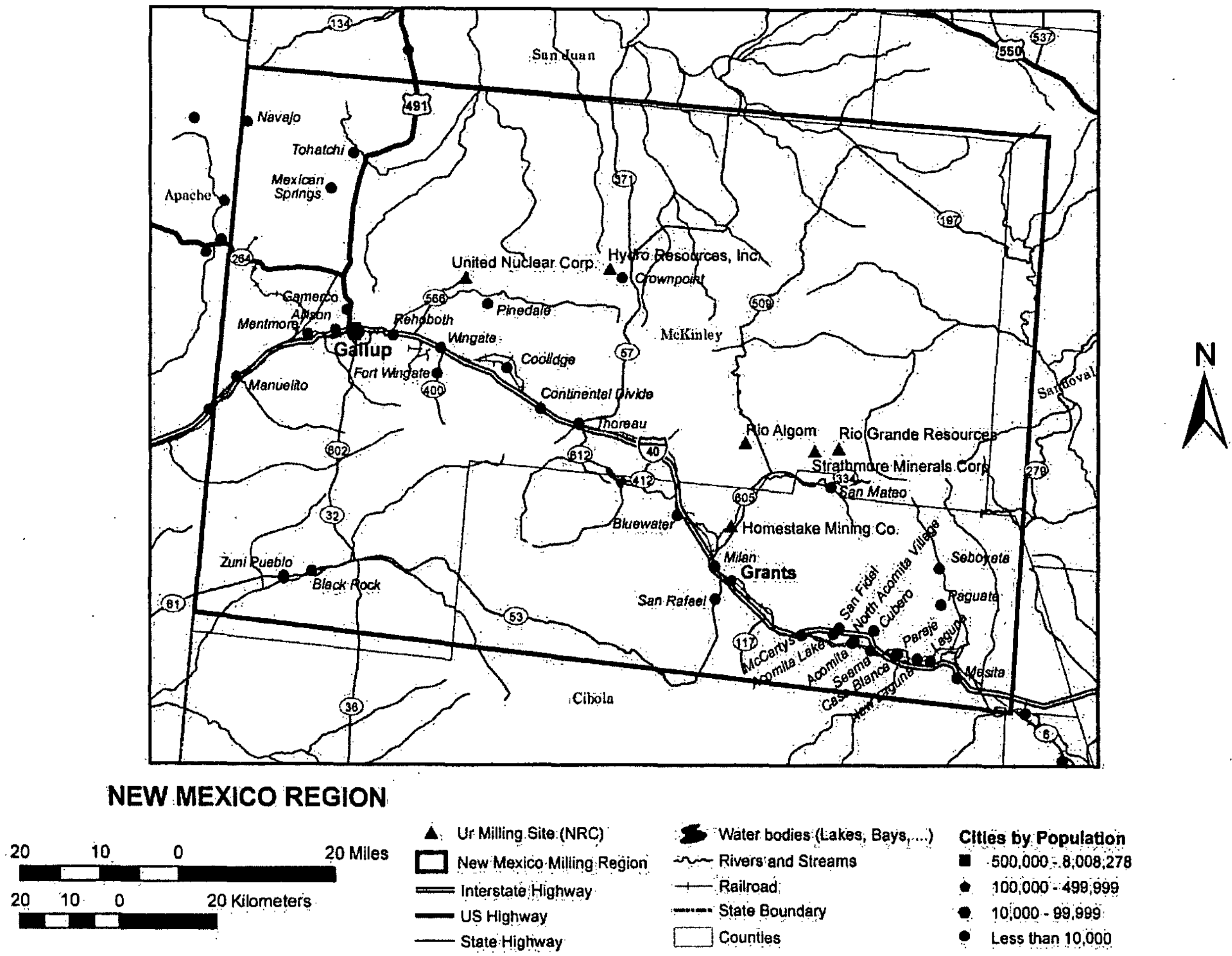


Figure 3.5-21. Northwestern New Mexico Uranium Milling Region With Population

only 16.4 percent. The largest minority-based town is Gallup with a white population of 40.1 percent.

Although not listed in Table 3.5-16, total population counts based on 2000 U.S. Census Bureau data (U.S. Census Bureau, 2008) for the Native American communities (reservation land) that would be affected are

- Acoma Indian Reservation: 2,802
- Tohajiilee Indian Reservation: 1,649
- Laguna Indian Reservation: not available
- Navajo Nation Indian Reservation: 173,987 [Includes Arizona, Utah, and New Mexico (131,166 were reported as living in Arizona]
- Ramah Navajo Indian Reservation: 2,167
- Zuni Indian Reservation: 7,758

3.5.10.2 Income

Income information from 2000 U.S. Census data including labor force, income, and poverty levels for the affected environment is collected at the state and county levels. Data collected from a state level also include information on towns, CBSAs, or Metropolitan Areas and consider an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than 48 km [30 mi]} for income opportunities or may be a workforce needed to fulfill specialized positions (if a local workforce is unavailable or unspecialized). Data collected from a county level is generally the same affected environment discussed previously in Table 3.5-15 and also includes information on Native American communities in the Northwestern New Mexico Uranium Milling Region. State-level information is provided in Table 3.5-17, and county data is listed in Table 3.5-18.

For the region surrounding the Northwestern New Mexico Uranium Milling Region, the state with the largest labor force population is Arizona. The community with the largest labor force is Albuquerque, New Mexico {144 km [90 mi] from the nearest potential ISL facility}, and the smallest community labor force is Grants, New Mexico {8 km [5 mi] from the nearest potential ISL facility}. The community with the highest per capita income is Santa Fe, New Mexico {96 km [60 mi] from the nearest potential ISL facility} and the lowest per capita income population is Silver City, New Mexico {161 km [100 mi] from the nearest potential ISL facility}. Outside of tribal lands, the community with the highest percentage of individuals and families below poverty levels is Grants, New Mexico.

The county with the largest labor force population in the Northwestern New Mexico Uranium Milling Region is Sandoval County, and the county with the smallest labor force population is Cibola County. The county with the highest per capita income is Sandoval County, and the lowest per capita income county is McKinley County. The county with the highest percentage of individuals and families below the poverty level is McKinley County (Table 3.5-18).

3.5.10.3 Housing

Housing information from the 2000 U.S. Census data is provided in Table 3.5-19.

The availability of housing within the immediate vicinity of the proposed ISL facilities is somewhat limited. The majority of housing is available in larger populated areas such as Gallup

Table 3.5-17. U.S. Bureau of Census State Income Information for the Northwestern New Mexico Uranium Milling Region*						
Affected Environment	**2000 Labor Force Population (16 years and over)**	**Median Household Income In 1999**	**Median Family Income In 1999**	**Per Capita Income In 1999**	**Families Below Poverty Level In 2000**	**Individuals Below Poverty Level In 2000**
Arizona	2,387,139	$40,558	$46,723	$20,275	128,318	698,669
New Mexico	834,632	$34,133	$39,425	$17,261	68,178	328,933
Albuquerque, New Mexico	232,320	$38,272	$46,979	$20,884	11,285	59,641
Percent of total†	66.2%	NA‡	NA	NA	10.0%	13.5%
Farmington, New Mexico	18,204	$37,663	$42,605	$18,167	1,328	5,910
Percent of total	65.0%	NA	NA	NA	12.9%	16.0%
Flagstaff, Arizona	30,822	$37,146	$48,427	$18,637	1,255	8,751
Percent of total	73.7%	NA	NA	NA	10.6%	17.4%
Gallup, New Mexico	8,941	$34,868	$39,197	$15,789	804	4,079
Percent of total	61.9%	NA	NA	NA	16.6%	20.8%
Grants, New Mexico	3,801	$30,652	$33,464	$14,053	446	1,810
Percent of total	58.3%	NA	NA	NA	19.4%	21.9%
Rio Rancho, New Mexico	25,964	$47,169	$52,233	$20,322	521	2,619
Percent of total	67.9%	NA	NA	NA	3.7%	5.1%

Table 3.5-17. U.S. Bureau of Census State Income Information for the Northwestern New Mexico Uranium Milling Region* (continued)

Affected Environment	2000 Labor Force Population (16 years and over)	Median Household Income in 1999	Median Family Income in 1999	Per Capita Income in 1999	Families Below Poverty Level in 2000	Individuals Below Poverty Level in 2000
Santa Fe, New Mexico	34,033	$40,392	$49,705	$25,454	1,425	7,439
Percent of total	66.8%	NA	NA	NA	9.5%	12.3%
Silver City, New Mexico	4,249	$25,881	$31,374	$13,813	483	2,237
Percent of total	52.5%	NA	NA	NA	17.7%	21.9%

*Source: U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 25 February 2008, and 15 April 2008).
†Percent of total based on a population of 16 years and over.
‡NA—not applicable.

Table 3.5-18. U.S. Bureau of Census County Income Information for the Northwestern New Mexico Uranium Milling Region*						
Affected Environment	**2000 Labor Force Population (16 years and over)**	**Median Household Income In 1999**	**Median Family Income In 1999**	**Per Capita Income In 1999**	**Families Below Poverty Level In 2000**	**Individuals Below Poverty Level In 2000**
Cibola County, New Mexico	9,848	$27,774	$30,714	$11,731	1,365	6,054
Percent of total	53.0%	NA	NA	NA	21.5%	24.8%
McKinley County, New Mexico	26,498	$25,005	$26,806	$9,872	5,303	26,664
Percent of total	53.4%	NA	NA	NA	31.9%	36.1%
Sandoval County, New Mexico	41,599	$44,949	$48,984	$19,174	2,130	10,847
Percent of total	63.0%	NA	NA	NA	9.0%	12.1%

*Source: U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Percent of total based on a population of 16 years and over.
‡NA—not applicable.

Table 3.5-19. U.S. Bureau of Census Housing Information for the Northwestern New Mexico Uranium Milling Region*						
Affected Environment	**Single Family Owner-Occupied Homes**	**Median Value in Dollars**	**Median Monthly Costs With a Mortgage**	**Median Monthly Costs Without a Mortgage**	**Occupied Housing Units**	**Renter-Occupied Units**
New Mexico	339,888	$108,100	$929	$228	677,971	200,908
Cibola County	3,742	$62,600	$654	$179	8,327	1,873
McKinley County	10,235	$57,000	$841	$140	21,476	5,840
Sandoval County	21,873	$115,400	$979	$233	31,411	5,097
Gallup	2,922	$97,000	$933	$4,245	6,807	2,682
Grants	1,634	$64,700	$697	$210	3,160	1,024

* U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).

{24 km [15 mi] to the nearest potential ISL facility}, Grants {8 km [5 mi] to nearest potential ISL facility}, Albuquerque {144 km [90 mi] to the nearest potential ISL facility}, and Rio Rancho {161 km [100 mi] to the nearest potential ISL facility}. There are approximately 20 housing units, including manufactured housing parks or residential neighborhoods in this region (MapQuest, 2008).

Temporary housing such as apartments, lodging, and trailer camps within the immediate vicinity of the Grants Uranium District ISL facilities is not as limited. The majority of apartments is available in larger populated areas such as Gallup, Grants, Belen, Los Lunas, and Albuquerque with approximately 75 apartment complexes (MapQuest, 2008). There are 19 hotels/motels along major highways or towns near the ISL facilities. In addition to apartments and lodging, there are three trailer camps also located near potential ISL facilities (along major roads or near towns) (MapQuest, 2008).

3.5.10.4 Employment Structure

Employment structure from the 2000 U.S. Census data including employment rate and type is based on data collected at the state and county levels. Data collected at the state level also include information on towns, CBSAs, or Metropolitan Areas and consider an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than [48 km [30 mi]} for employment opportunities or may be a workforce needed to fulfill specialized positions (if local workforce is unavailable or unspecialized). Data collected from a county level are generally the same affected environment previously discussed in Table 3.5-15 and also include information on Native American communities.

Based on review of state information, the state in the vicinity of the Northwestern New Mexico Uranium Milling Region with the highest percentage of employment is Arizona.

The county with the highest percentage of employment is Sandoval County, and the county with the highest unemployment rate is McKinley County. Native American communities (Navajo Nation, Zuni, and Laguna Reservations) report unemployment rates of 60 percent or more, much greater than the state unemployment levels of 3.4 percent (Arizona) to 4.4 percent (New Mexico) Table 3.5-20.

3.5.10.4.1 State Data

3.5.10.4.1.1 Arizona

The state of Arizona has an employment rate of 57.2 percent and unemployment rate of 3.4 percent. The largest sector of employment is management, professional, and related occupations. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

<u>Flagstaff</u>

Flagstaff has an employment rate of 69.8 percent and an unemployment rate slightly higher than that of the state at 3.9 percent. The largest sector of employment is management, professional, and related occupations at 30.2 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.5.10.4.1.2 New Mexico

The State of New Mexico has an employment rate of 55.7 percent and unemployment rate of 4.4 percent. The largest sector of employment is management, professional, and related occupations. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Albuquerque

Albuquerque has an employment rate of 61.8 percent and an unemployment rate lower than that of the state at 3.8 percent. The largest sector of employment is management, professional, and related occupations at 38.5 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Gallup

Gallup has an employment rate of 57.1 percent and an unemployment rate slightly higher than that of the state at 4.8 percent. The largest sector of employment is management, professional, and related occupations at 38.9 percent. The largest type of industry is educational, health, and social services at 31.5 percent. The largest class of worker is private wage and salary workers at 65.2 percent (U.S. Census Bureau, 2008).

Grants

Grants has an employment rate of 51.9 percent and an unemployment rate higher than that of the state at 6.2 percent. The largest sector of employment is management, professional, and related occupations at 30.0 percent. The largest type of industry is educational, health, and social services at 23.6 percent. The largest class of worker is private wage and salary workers at 61.3 percent (U.S. Census Bureau, 2008).

Farmington

Farmington has an employment rate of 60.4 percent and an unemployment rate slightly higher than that of the state at 4.5 percent. The largest sector of employment is management, professional, and related occupations at 30.2 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Rio Rancho

Rio Rancho has an employment rate of 64.3 percent and an unemployment rate slightly higher than that of the state at 3.2 percent. The largest sector of employment is management, professional, and related occupations at 34.5 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Santa Fe

Santa Fe has an employment rate of 63.7 percent and an unemployment rate much lower than that of the state at 3.0 percent. The largest sector of employment is management, professional,

and related occupations at 43.0 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.5.10.4.2 County Data

Cibola County, New Mexico

Cibola County has an employment rate of 46.8 percent and an unemployment rate relatively higher than that of the state at 6.1 percent. The largest sector of employment is management, professional, and related occupations at 29.6 percent. The largest type of industry is educational, health, and social services at 27.4 percent. The largest class of worker is private wage and salary workers at 58.4 percent (U.S. Census Bureau, 2008).

McKinley County, New Mexico

McKinley County has an employment rate of 44.2 percent and an unemployment rate relatively higher than that of the state at 9.2 percent. The largest sector of employment is management, professional, and related occupations at 32.4 percent. The largest type of industry is educational, health, and social services at 32.4 percent. The largest class of worker is private wage and salary workers at 55.9 percent (U.S. Census Bureau, 2008).

Sandoval County, New Mexico

Sandoval County has an employment rate of 58.8 percent and an unemployment rate lower than that of the state at 3.9 percent. The largest sector of employment is management, professional, and related occupations at 36.0 percent. The largest type of industry is educational, health, and social services at 17.4 percent. The largest class of worker is private wage and salary workers at 73.6 percent (U.S. Census Bureau, 2008).

Native American Communities

Information on labor force and poverty levels for the affected Native American communities within the Northwestern New Mexico Uranium Milling Region is based on 2003 Bureau of Indian Affairs data and is provided in Table 3.5-20 (U.S. Department of the Interior, 2003).

3.5.10.5 Local Finance

Local finance such as revenue and tax information for the affected environment is provided next and in Tables 3.5-21 to 3.5-23.

New Mexico

Sources of revenue for the State of New Mexico come from income, mineral extraction, and property taxes. Personal income tax rates for New Mexico range from 1.7 percent to 5.3 percent. New Mexico does not have a sales tax and instead has a 5 percent gross receipts tax. Combined gross receipts tax rates throughout the state range from 5.125 to 7.8125 percent. Net taxable values for affected counties in New Mexico are presented in Table 3.5-21 (New Mexico Taxation and Revenue Department, 2008).

Table 3.5-20. Employment Structure of Native American Communities Within the Affected Environment of the Northwestern New Mexico Uranium Milling Region*

Affected Areas	2003 Labor Force Population	Unemployed as Percent of Labor Force	Employed Below Poverty Guidelines	
Acoma Indian Reservation	NR†	NR	NR	NR
Canoncito Indian Reservation	NA‡	NA	NA	NA
Laguna Indian Reservation	828	81%	NR	NR
Navajo Nation Indian Reservation (Eastern Navajo Agency)	2,664	74%	62	2%
Ramah Navajo Indian Reservation	NR	NR	NR	NR
Zuni Indian Reservation	1,591	64%	110	7%

* U.S. Department of the Interior. "Affairs American Indian Population and Labor Force Report 2003." <http://www.doi.gov/bia/labor.html>. Washington, DC: U.S. Department of the Interior, Bureau of Indian Affairs, Office of Tribal Affairs. 2003.
†NR—Not reported by tribes.
‡NA—not available.

Table 3.5-21. Net Taxable Values for Affected Counties Within New Mexico for 2006*

Affected Counties	Residential	Nonresidential	Total
Cibola County	$88,563,082	$145,457,203	$234,020,285
McKinley County	$219,073,850	$410,061,159	$629,311,981
Sandoval County	$1,631,727,293	$449,148,142	$6,755,265

*New Mexico Taxation and Revenue Department. "2006 Property Tax Facts." <http://www.tax.state.nm.us/pubs/taxresstat.htm>. Santa Fe, New Mexico: New Mexico Taxation and Revenue Department. (18 October 2007 and 25 February 2008).

Table 3.5-22. Percent Change in Tax Values From 2005 to 2006 for the Affected Counties Within New Mexico*

Affected Counties	Residential	Nonresidential	Total
Cibola County	3.0 percent	3.6 percent	3.4 percent
McKinley County	4.1 percent	4.0 percent	4.0 percent
Sandoval County	18.8 percent	8.7 percent	16.5 percent

*New Mexico Taxation and Revenue Department. "2006 Property Tax Facts." <http://www.tax.state.nm.us/pubs/taxresstat.htm>. Santa Fe, New Mexico: New Mexico Taxation and Revenue Department. (18 October 2007 and 25 February 2008).

Table 3.5-23. Percent Distribution of New Mexico Property Tax Obligations Within Affected Counties for 2006*					
Affected Counties	**State**	**County**	**Municipal**	**School District**	**Other**
Cibola County	4.4 percent	34.4 percent	9.8 percent	34.4 percent	17 percent
McKinley County	3.9 percent	32.3 percent	10.9 percent	31.6 percent	21.1 percent
Sandoval County	4.8 percent	26.6 percent	19.7 percent	39.7 percent	9.1 percent
*New Mexico Taxation and Revenue Department. "2006 Property Tax Facts." <http://www.tax.state.nm.us/pubs/taxresstat.htm>. Santa Fe, New Mexico: New Mexico Taxation and Revenue Department (18 October 2007 and 25 February 2008).					

Percentages and sources of revenue for 2006 were counties at 32.3 percent, municipalities at 14.3 percent, school districts at 30.0 percent, conservancy districts at 0.1 percent, state debt service at 4.8 percent, health facilities at 8.8 percent, and higher education at 9.7 percent. Total tax values for the affected counties within New Mexico follow. Percentage change in net taxable values from 2005 to 2006 for the affected counties is provided in Table 3.5-22 (New Mexico Taxation and Revenue Department, 2008).

New Mexico imposes ad valorem production and ad valorem production equipment taxes in lieu of property taxes on mineral extraction properties. Taxes are levied monthly on all owners and are imposed on products below the wellhead, such as oil and gas (New Mexico Taxation and Revenue Department, 2000.) Equipment is also levied against the operator of the property. In 2000, ad valorem production and production equipment taxes totaled approximately $43.4 million. Of this total, 83 percent came from the oil and gas production tax. How revenues are distributed in a particular county is determined by property tax rates imposed at the county level.

Percentage distribution of New Mexico property tax obligations for 2006 within the affected counties is listed in Table 3.5-23. Information on local finance for the CBSAs of Gallup and town of Grants is presented next.

Gallup

Sources of revenue for Gallup consist of gross receipts taxes, compensating taxes, corporate income taxes, franchise taxes, property taxes, severance taxes, and workers' compensation taxes. The largest tax revenues are gross receipts at a rate of 7.6 percent and property tax ranging from 4.7 percent to 7.4 percent. Revenue from gross receipts totaled $115,031,909 as of 2004 (City of Gallup Economic Development Center, 2007).

Grants

Sources of revenue for Grants consist of gross receipts taxes and property taxes (New Mexico Economic Development, 2008).

Native American Communities

The Acoma Indian Reservation's largest sources of revenue come from the Sky City Casino and big game hunting. Specific financial information including tax revenue is not available (Acoma New Mexico, 2007).

The Tohajiilee Indian Reservation receives revenue from local retail and gaming. Specific financial information including tax revenue is not available (Division of Economic Development of the Navajo Nation, 2006).

The Laguna Indian Reservation receives revenue from local retail and gaming. Specific financial information including tax revenue is not available (New Mexico Tourism Department, 2008).

The largest source of revenue for the Navajo Nation Indian Reservation comes from internal and external revenue. Internal revenue is referred to as General Fund revenues and consists of mining and taxes. Mining is the largest source of internal revenue. Taxes are the second largest sources of internal revenue and in 2005 accounted for $75.0 million (Division of Economic Development of the Navajo Nation, 2006). Taxes include business gross receipts. This tax could be levied on uranium production within the Navajo Reservation if production is determined to occur on the reservation (NRC, 1997). External sources of revenue consist of Federal, State, Private and other funds, and are mostly in the form of grants (Division of Economic Development of the Navajo Nation, 2006).

The Ramah Navajo Indian Reservation is one of 110 chapters that make up the larger Navajo Nation. The Ramah Navajo take no assistance from the Navajo Nation. The majority of revenue comes from federal funding because this group does not have a single, sustainable economic development program that generates significant income (Ramah Navajo Chapter, 2003).

The majority of revenue for the Zuni Indian Reservation comes from federal grants, such as the Community Services Block Grant. Other sources of income include local taxes such as sales tax from gross receipts (Pueblo of Zuni, 2008).

3.5.10.6 Education

Based on review of the affected environment, the county with the largest number of schools is McKinley County and the county with the smallest number of schools is Cibola County. The town/CBSA with the largest number of schools is Gallup, and the town/ CBSA with the smallest number of schools is Grants. The Native American community with the largest number of schools is the Navajo Nation, and the Native American community with the smallest number of schools is the Tohajiilee Indian Reservation.

Grants

Grants has 2 elementary schools, 1 middle school, 1 high school, 3 private academies, and 1 public school, with a total of approximately 2,414 students (Localschooldirectory.com, 2008).

Gallup

Gallup has 33 public schools and 2 parochial schools, with a total of approximately 8,013 students. (City of Gallup Economic Development Center, 2007).

Cibola County

Public education in Cibola County is operated by Grants/Cibola County Schools, which is based in Grants, New Mexico. There are 7 elementary schools, 1 middle school, 1 middle-high school, and 1 high school, with a total of approximately 3,698 students. The majority of schools provide bus services (Grants-Cibola County Schools, 2007).

McKinley County

Public education in the McKinley County education system is operated by the Gallup-McKinley County School District, which serves students from Gallup and surrounding areas of McKinley County. There are 36 public and private elementary, middle, and high schools within the county, with a total of approximately 13,840 students. The majority of schools provides bus services (Greatschools, 2007).

Sandoval County

Sandoval County has a total of 11 elementary schools, 6 middle schools, and 5 high schools, with a total of approximately 8,580 students. The majority of schools provides bus services (Publicschoolreview.com, 2008).

Native American Communities

The Acoma Indian Reservation has the Sky City Community School located at Acoma Pueblo. The total number of students is approximately 275. Information as to whether this school provides bus services is not available (Public Schools Report, 2007).

The Tohajiilee Indian Reservation has one school that is located within the Tohajiilee Indian Reservation. Specific information pertaining to school population or bus services is not available (Tohajiilee Chapter, 2008).

The Laguna Indian Reservation has one elementary school, one middle school, one high school, and one academy. Specific information pertaining to school population or bus services is not available (Lat-Long.com, 2008).

The Navajo Nation Indian Reservation has over 150 public, private, and Bureau of Indian Affairs schools serving students from kindergarten through high school. There are over 10,000 students. Information as to whether these schools provide bus services is not available (Division of Economic Development of the Navajo Nation, 2008).

The Ramah Navajo Indian Reservation school system is operated by the Ramah Navajo School Board and the Ramah Navajo Chapter. It has an Indian-controlled contract school located in Pine Hill, New Mexico. It accommodates almost 600 students from elementary through 12th grade. Information as to whether this school provides bus services is not available (Ramah Navajo Chapter, 2003).

The Zuni Indian Reservation has 2 elementary schools, 1 middle school, and 2 high schools, with a total of approximately 2,000 students. Information as to whether these schools provide bus services is not available (Zuni Pueblo Public School District, 2008).

3.5.10.7 Health and Social Services

Health Care Facilities

The majority of health care facilities is located within populated areas of the affected environment. The closest health care facilities within the vicinity of the ISL facilities are located in Gallup, Zuni, Rio Rancho, and Albuquerque and total approximately 50 facilities (MapQuest, 2008). These consist of hospitals, clinics, emergency centers, and medical services. There are 13 hospitals located within or proximate of this region: Gallup (1), Zuni (1), Rio Rancho (1), and Albuquerque (greater than10).

Local Emergency

Local police within the affected environment are within the jurisdiction of each county. There are 12 police, sheriff, or marshal's offices within the region: Cibola County (3), McKinley County (3), and Sandoval County (6) (Usacops, 2008).

Fire departments within the affected area are comprised at the town, CBSA, or city level. There are 24 fire departments within the milling region: Grants (4), Gallup (13), and Albuquerque (7) (50states, 2008).

3.5.11 Public and Occupational Health

3.5.11.1 Background Radiological Conditions

For a U.S. resident, the average total effective dose equivalent from natural background radiation sources is approximately 3 mSv/yr [300 mrem/yr] but varies by location and elevation (National Council of Radiation Protection and Measurements, 1987). In addition, the average American receives 0.6 mSv/yr [60 mrem/yr] from man-made sources including medical diagnostic tests and consumer products (National Council of Radiation Protection and Measurements, 1987). Therefore, the total from natural background and man-made sources for the average U.S. resident is 3.6 mSv/yr [360 mrem/yr]. For a breakdown of the sources of this radiation, see Figure 3.2-22.

Background dose varies by location primarily because of elevation changes and variations in the dose from radon. As elevation increases so does the dose from cosmic radiation and hence the total dose. Radon is a radioactive gas produced from the decay of U-238, which is naturally found in soil. The amount of radon in the soil/bedrock depends on the type, porosity, and moisture content. Areas that have types of soils/bedrock like granite and limestone have higher radon levels that those with other types of soils/bedrock (EPA, 2006).

The total effective dose equivalent is the total dose from external sources and internal material released from licensed operations. Doses from sources in the general environment (such as terrestrial radiation, cosmic radiation, and naturally occurring radon) are not included in the dose calculation for compliance with 10 CFR Part 20, even if these sources are from technologically enhanced naturally occurring radioactive material, such as preexisting radioactive residues from prior mining (Atomic Safety and Licensing Board, 2006).

For the Northwestern New Mexico Uranium Milling Region, the average background rate including natural and man-made sources for the state of New Mexico is used, which is 3.15 mSv/yr [315 mrem/yr] (EPA, 2006). This average background rate in New Mexico is lower than the U.S. average rate of 3.6 mSv/yr [360 mrem/yr] primarily because average annual radon dose is less for New Mexico {1.32 mSv/yr [132 mrem/yr] versus the national average of 2 mSv/yr [200 mrem/yr]}. The background contribution from cosmic radiation is slightly higher for New Mexico versus the U.S. average {0.47 mSv/yr [47 mrem/yr] versus the national average of 0.27 mSv/yr [27 mrem/yr]}. The remaining contributors to background dose (terrestrial radiation, internal radiation, and man-made) are similar for New Mexico {1.36 mSv [136 mrem/yr]} and the U.S. average {1.33 mSv/yr [133 mrem/yr]}. The combination of these differences results in a decrease from the national average of about 0.45 mSv [45 mrem/yr].

3.5.11.2 Public Health and Safety

Public health and safety standards are the same regardless of a facility's location. Therefore, see Section 3.2.11.2 for further discussion of these public health and safety standards.

3.5.11.3 Occupational Health and Safety

Occupational health and safety standards are the same regardless of facility's location. Therefore, see Section 3.2.11.3 for further discussion of these occupational health and safety standards.

3.5.12 References

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4 ENVIRONMENTAL IMPACTS OF CONSTRUCTION, OPERATION, AQUIFER RESTORATION, AND DECOMMISSIONING ACTIVITIES

4.1 Introduction

The potential impacts to environmental resources during the construction, operation, aquifer restoration, and decommissioning phases at *in-situ* leach (ISL) uranium recovery facilities are analyzed in this chapter. As discussed in Section 1.4.3, the potential environmental impacts are evaluated for each of the four geographic regions that form the basis for this generic environmental impact statement (GEIS). In essence, the analysis involves placing an ISL uranium recovery facility with the characteristics described in Chapter 2 of the GEIS within each of the four regional areas described in Chapter 3. The potential impacts for each resource are described and evaluated separately for each region at each stage in an ISL facility's lifetime: construction, operation, aquifer restoration, and decommissioning/reclamation. Impact significance is evaluated and reported based on the SMALL, MODERATE, LARGE classification described in U.S. Nuclear Regulatory Commission (NRC) guidance in NUREG–1748 (NRC, 2003) and summarized in Section 1.4.3.

Classifying Impact Significance (After NRC, 2003)

- *Small Impact*: The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource considered.
- *Moderate Impact*: The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource considered.
- *Large Impact*: The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource considered.

Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated With NMSS Programs. Final Report." Washington, DC: NRC. August 2003.

4.2 Wyoming West Uranium Milling Region

The general introductory impact information presented here will be applicable to NRC's review of license applications for new ISL facilities in the Wyoming West Uranium Milling Region. As appropriate, information that is also generally applicable to NRC's reviews for potential new ISL facilities to be located in the three other regions will be identified and discussed in the GEIS.

4.2.1 Land Use Impacts

In the Wyoming West Uranium Milling Region, current information indicates that potential ISL facilities would primarily be developed in two uranium districts (Gas Hills and Crooks Gap) that are located on rangeland used for livestock grazing and to a lesser extent for farming. Areas of past and present uranium milling interest in the Wyoming West Uranium Milling Region are shown in Figures 3.2-1 and 3.2-2. These areas of milling interest are generally located on unpopulated rangeland managed by the U.S. Bureau of Land Management (BLM) and can be in proximity to cultivated areas, private or public lands used for recreation and wildlife management, timber management, oil and gas exploration and production, coal and metals mining, and cultural and historical resources areas.

The permitted areas of existing ISL facilities can be large, ranging from about 1,134 ha [2,800 acres] for the Crow Butte ISL facility site in Dawes County, Nebraska, to over 6,480 ha [16,000 acres] for the Smith Ranch Uranium Project site in Converse County, Wyoming (Section 2.11.1). However, the central processing facility at a commercial-scale facility may occupy only 1 to 6 ha [2.5 to 15 acres], and satellite plants may be even smaller (NRC, 2006). For the purposes of this discussion, the site areas of current and new ISL facilities to be licensed can be bounded as follows:

- Total permit area of a new ISL site: 1,000 to 7,000 ha [2,471 to 17,297 acres]

- Total (disturbed land) surface area of a new ISL site including multiple well fields, a central processing facility, and satellite plants within the overall permit area: 50 to 750 ha [120 to 1,860 acres] (Section 2.11.1)

Much of the total permitted area of ISL facilities would be expected to remain undisturbed since surface operations (well fields and processing facilities) would affect only a small portion of the permitted area. Operations and activities that cause the greatest disturbance of the land and the subsurface would be expected to take place in the well fields.

ISL surface facilities are considered controlled areas that are fenced to limit access. Entire well fields or areas around pump houses and well heads may also be fenced for safety, security, and to prevent livestock grazing or other types of access.

4.2.1.1 Construction Impacts to Land Use

The construction of an ISL facility can potentially impact land uses by: (1) changing and disturbing existing land uses, (2) restricting access or establishing right-of-way for access, (3) affecting mineral rights, (4) restricting livestock grazing areas, (5) restricting recreational activities, and (6) altering ecological, cultural and historical resources.

Changes and Disturbances in Land Uses: Construction of an ISL facility would temporarily prevent land from being used for other purposes. Because the predominant land use in areas of milling interest is rangeland managed by BLM (Section 3.2.1), grazing and cultivated areas would be temporarily lost. If an ISL facility was located in forest land, access to timber could be impeded by construction and some forest resources could be potentially lost. If an ISL facility abutted public or private land used for recreational activities and for protecting ecological resources (e.g., National or State Parks, National Forests or Grasslands), these activities and resources could also be affected.

Land use changes and disturbances would be expected to be most intense during the construction, period but these disturbances are typically temporary, spanning one to three construction seasons (Freeman and Stover, 1999). Drilling, trenching, excavating, grading, and surface facilities construction would be expected to disturb the land most during the construction phase. Compared to the overall total permit area of a new ISL facility, only a relatively small fraction (on average, approximately 15 percent) of the permitted site area would be expected to be changed and disturbed (Section 2.11.1). In addition, the amount of disturbed land would be small compared to the total ranchland area managed by BLM in the Wyoming West Uranium Milling Region (see Table 3.2-1). Therefore, impacts to land use changes would be SMALL. Additionally, licensees implement postconstruction actions, such as recontouring and restoring surface cover, well sites, staging areas, trenches and parts of dirt access roads to minimize the temporary loss of pasture land, grazing rights, or timber resources. The licensees would coordinate these postconstruction mitigation measures with responsible federal or state agencies such as BLM, U.S. Fish and Wildlife Service (USFS) or private entities.

Access Restrictions: Access restrictions would be expected to be limited but continue beyond the construction phase over the operational lifecycle of an ISL facility. As previously noted (Section 2.11.1), the area of fenced surface facilities would be relatively SMALL (typically around restricted areas only). The well fields could remain open, but also could be fenced to limit access. The land around the wells and pump houses would be restored and reseeded. Right-of-way for access to dirt roads and well fields would be established for the duration of the project but such rights would not be permanent. Overall, the relatively small areas involved and the temporary nature of construction indicate the access restriction impacts for potential ISL facilities in the Wyoming West Uranium Milling Region would be SMALL.

Mineral Rights: It is anticipated that future mineral rights for resources in the permit area other than uranium, could be either delayed for the duration of an ISL project or intermixed within the overall permit area of an ISL facility. It is expected that any potential oil and gas, or coal and metals mining exploration and production activities would be addressed by obtaining mineral rights and surface owner consent before an ISL facility is built. For example, the Wyoming Department of Environmental Quality (WDEQ) requires a surface owner consent form for all surface owners (WDEQ, 2007). Existing oil and gas exploration and production or coal bed methane well sites could coexist within an ISL total permit area given that the actual footprint of an ISL facility is small relative to the total permit area. There has been relatively little coal bed methane development in the Wyoming West Uranium Milling Region, with a few wells located near the Carbon-Sweetwater County line (Ruckelshaus Institute and

Mineral Rights, Mining Rights, Oil Rights, or Drilling Rights

Rights may be conferred to remove minerals, oil, or sometimes water that may be present on and under some land. In jurisdictions supporting such rights, they may be separate from other rights to the land. The rights to develop minerals, and the purchase and sale of those rights, are contractual matters that must be agreed between the parties involved.

Environment and Natural Resources, 2005). It is expected that the coexistence and potential conflicts among different mineral rights on an ISL permit area on public or private lands, would be negotiated and agreed upon between the different mineral rights owners involved. Thus the potential impacts to current or future mineral rights for resources other than uranium on an ISL facility permit area are expected to be SMALL.

Livestock Grazing and Agricultural Restrictions: One of the main commercial uses of publicly or privately owned open rangelands in the west is livestock grazing, but rangelands also provide scenic vistas, open spaces, wildlife, and recreational opportunities. Livestock grazing is an integral and historical part of the western rangeland and contributes to maintaining its ecological, historical, and social values for owners, residents, and visitors. The potential impairment to these rangeland values associated with the loss of livestock grazing should also be considered by ISL operators. Where used, fencing would potentially restrict livestock access to forage on private or federal lands along dirt roads, on well fields, and on satellite and central processing facilities. Use of the land as rangeland or cultivated fields and pasture land would likely be excluded from these fenced areas during the life of the project. For example, for the Reynolds Ranch satellite plant area, an addition to the Smith Ranch-Highlands property in Converse County, Wyoming, it was estimated that livestock would be prevented from grazing on about 131 ha [325 acres] of land that would be used for uranium recovery and related activities (e.g., access road construction, pipelines, satellite facility construction) (NRC, 2006). This is in comparison to the 3,500 ha [8,700 acres] within the Reynolds Ranch permitted area. If part of the land is cultivated or if grazing permits are in effect, mitigation or compensation measures would need to be defined and implemented through agreements between surface owners or grazing permit holders and ISL operators to mitigate the loss of agricultural production or grazing rights in areas with restricted access and fenced areas. Examples of mitigation or compensation measures could include relocation of livestock and water, pasture and rangeland improvement on alternate public or private land, purchase of hay to replace the loss of cultivated pasture or open rangeland, purchase of additional grazing rights, or reimbursement to livestock ranchers for loss of grazing or pasture land.

Impacts to grazing from other ISL facilities would be expected to be similar to the example cited. Overall, about 150 ha [370 acres] of grazing area could be restricted, compared to the thousands of hectares [acres] for the whole permitted area of a new ISL facility that would remain available for grazing. Because a relatively small portion of the grazing permit area available in the Wyoming West Uranium Milling Region would be restricted on fenced portions of the land, overall impacts to grazing and farming would be SMALL. In terms of duration, these impacts would not necessarily last for the entire duration of an ISL operation and decommissioning phases, because uranium extraction operations often move from one well field to the next and the land of a particular well field where operations ceased could partly or totally be reclaimed and returned to previous grazing, farming, or recreational uses.

Restriction on Recreational Activities: Fencing and right-of-way conditions would minimally restrict hunting and off-road vehicle access to previously open areas. These recreational activities are most common on the grass- or shrub-covered rolling hills of the Wyoming West Uranium Milling Region where new ISL facilities would be developed on BLM and private lands. Because the fenced area of an ISL facility, as previously described, would be relatively SMALL and temporary, and because there would be abundant open space available around the ISL facility, the impacts to these recreational activities would be SMALL.

Altering Ecological, Historical, and Cultural Resources: Depending on the specific locations of a proposed ISL facility and characteristics of the land and environment, the construction of a new ISL facility could potentially impact portions of managed lands that contain localized ecological, historical, and cultural resources (see details in Sections 4.2.5 and 4.2.8, respectively). These resources could be altered, destroyed, restricted, or made inaccessible. If these types of impacts were to occur, they would be expected during the construction phase when most of the land surface disturbances would occur. Impacts would be expected to be mitigated by consultations with appropriate federal, tribal, and state agencies to identify appropriate planning and surveying prior to the construction phase that would clearly identify and delineate those site-specific resources. Such planning could help to avoid or mitigate the degree and intensity of impacts from construction activities. However, surveying and due diligence activities might not be sufficient to identify historical and cultural resources. These buried resources could be altered or destroyed during excavation, drilling, and grading activities; thus impacts to portions of the land containing localized ecological, historical; and cultural resources would range from SMALL to LARGE, depending on local conditions.

4.2.1.2 Operation Impacts to Land Use

The types of land use impacts for operational activities would be expected to be similar to construction impacts regarding access restrictions because the infrastructure would be in place. Additional land disturbances would not be expected from conducting the operational activities described in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the expansion of well fields, which is addressed as a construction impact in Section 4.2.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be partly restored and reopened for grazing or recreation while a new well field is being developed, which would have impacts similar to those described in the preceding section for the construction phase.

The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to ensure release limits would be met and soil sampling to establish background and monitor for uranium, radium, and other metals. Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted areas would be appropriately characterized and remediated, as necessary, in accordance with NRC and applicable state regulations. Because access restriction and land disturbance impacts would be expected to be similar to or less than those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.2.1.3 Aquifer Restoration Impacts to Land Use

During aquifer restoration, the land use impacts described previously for the construction phase and the operations phase would remain. In terms of specific activities, the aquifer restoration uses the same infrastructure as the operations phase and maintenance would be at a similar level. Land use impacts from aquifer restoration could also decrease as fewer wells and pump houses would be used and overall equipment traffic and use diminish. Thus, the overall potential impacts to land use during the aquifer restoration phase are comparable to those of the operation phase and would be SMALL.

4.2.1.4 Decommissioning Impacts to Land Use

The types of land use impacts described for construction, operations, and aquifer restoration would be similar during the decommissioning of an ISL facility. The specific site activities and their effects would temporarily increase during decommissioning compared to the operation and aquifer restoration phases, because there would be greater use of earth- and material-moving equipment and other heavy equipment associated with land reclamation, dismantling, removal, and disposal of well field materials, pipelines, and central and satellite processing facilities. Additionally, surface reclamation activities would involve use of earth-moving equipment in regrading certain areas or in removing evaporation pond embankments. Reclaimed areas would be replanted in accordance with appropriate state or federal regulations and standards. Because most of the decommissioning phase would occur on previously disturbed and potentially restricted land, the additional potential impacts to land use during the decommissioning phase would range from SMALL to MODERATE. Impacts would decrease to SMALL as decommissioning and reclamation are completed and land is restored to previous uses.

The principal outcomes of aquifer restoration and decommissioning activities would be to end uranium recovery activities, restore the land to its original condition, and to reestablish the prior land uses or to redevelop the land for other potential uses.

4.2.2 Transportation Impacts

Truck and automobile use is associated with all phases of the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8), when compared with local traffic volumes in the Wyoming West Uranium Milling Region (Section 3.2.2), is not expected to significantly change the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak employment (during construction), would have greater impacts when roads with the lowest levels of current traffic are traveled. These low traffic roads may also be more susceptible to wear and tear from increased traffic. Localized intermittent and temporary SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions including the proximity of local residential housing, other regularly occupied structures, wildlife habitat, farming, or grazing areas to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC-site-specific environmental review. Potential local impacts include loss of forage palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle is provided in the following sections.

4.2.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Sections 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation (Section 2.8) is expected to vary depending on the size of the facility; however, when considered with the regional traffic counts provided in Section 3.2.2, most roads that would be

used for construction transportation in the Wyoming West Uranium Milling Region would not gain significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. Roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak employment. The limited duration of construction activities (12–18 months) suggests impacts would be temporary in many areas where an ISL facility would be sited. Temporary SMALL to MODERATE dust and noise impacts are possible for residents living in the vicinity of unpaved access roads used for construction transportation activities in the vicinity of ISL facilities.

4.2.2.2 Operation Impacts to Transportation

Operational transportation activities include employee commuting, supply shipments, waste transportation, ion exchange resin transport (where applicable), and yellowcake transportation. Overall, the estimated magnitude of operational truck transportation (Section 2.8) is generally low (a few trucks per day or less) and unlikely to generate any significant environmental impacts above those mentioned in Section 4.2.2.1. Commuting impacts will depend on the size of the workforce; however, most of the roads assessed for average annual daily traffic counts in the Wyoming West Uranium Milling Region (Section 3.2.2) have sufficiently high counts that the increase in traffic due to ISL facility commuting (Section 2.8) is not expected to significantly change traffic conditions or accident rates. For these roads, traffic impacts would be SMALL. For the roads with the lowest traffic counts, ISL facility commuting could significantly increase traffic and impacts would be MODERATE, particularly during times of peak employment.

Calculating Potential Radiation Exposure

Radiation Dose. Radiation dose estimates are quantified in units of either **sievert** or **rem** and are often referred to in either milliSievert (mSv) or millirem (mrem) where 1,000 mSv=1 Sv and 1,000 mrem=1 rem (Sv=100 rem). These units are used in radiation protection to quantify the amount of damage to human tissue expected from a dose of ionizing radiation.

Person-Sv. Person-Sv [Person-rem] is a metric used to quantify population radiation dose (also referred to as collective dose). It represents the sum of all estimated doses received by each individual in a population and is commonly used in calculations to estimate latent cancer fatalities in a population exposed to radiation.

Latent Cancer Fatality (LCF). Latent cancer fatality is a measure of the calculated number of excess cancer deaths expected in a population as a result of exposure to radiation. Latent cancers can occur from one to many years after the exposure takes place.

International Commission on Radiological Protection (1990) suggests a conversion factor that for every person-Sv [100 person-rem] of collective dose, about 0.06 individuals would develop a cancer induced by radiation exposure. If the conversion factor is multiplied by the collective dose to a population, the result is the number of latent cancer fatalities in excess of what would be expected without the radiation exposure.

Because these results are statistical estimates, values for expected latent cancer fatalities can be, and often are, less than one for cases involving low doses or small populations.

Yellowcake Transportation. NRC and others have previously analyzed the hazards associated with yellowcake transportation for both the generic case (Mackin, et al., 2001; NRC, 1980, NRC, 1977) and in site-specific environmental assessments (e.g., in NRC, 1997). These analyses are conservative and tend to overestimate impacts (e.g., release model, accident rates, dosimetry selections, exposed population density); however, they are appropriate for screening-level calculations. The risk analyses combined with past experience show that accidents resulting in potential yellowcake release must be considered when uranium milling activities are evaluated for safety. Estimated and actual consequences of such accidents are small, however, in part, due to the appropriate use of safety controls and emergency response protocols.

After yellowcake is produced at an ISL facility, it is transported to a conversion facility in Metropolis, Illinois (the only conversion facility in the United States), to produce uranium hexafluoride (UF_6) for use in the production of nuclear reactor fuel.

Potential routes and distances from the Wyoming West Uranium Milling Region are discussed in Section 3.2.2.

A prior transportation analysis (NRC, 1980) estimated risks of transporting yellowcake 2,414 km [1,500 mi] to a conversion plant in Illinois—a distance that is bounding for routes originating from the Wyoming West Uranium Milling Region to the conversion facility (Section 3.2.2). In the prior analysis, annual production estimates (the basis for the estimated number of shipments) were assumed to be 589,670 kg [1,300,000 lb]. This amount of yellowcake results in a facility making approximately 34 shipments per year {based on 40 drums per shipment carrying 430 kg [950 lb] of yellowcake per drum}. This number of shipments is within the range of shipments reported by ISL facilities discussed in Section 2.8. Yellowcake release was calculated considering the degree of loss of package containment for a range of accident severities and information on the likelihood that an accident of a particular severity class would occur when an accident happens. Two models for package response to accident conditions were considered. Model 1 assumed complete loss of package contents for any accident severe enough to breach packages, whereas Model 2 used results from package tests indicating only partial release of contents for accidents sufficient to breach packages. The resulting population dose estimates for these estimated releases from a single accident in an area containing 61 people per km^2 [158 people per mi^2] (i.e., rural residential population living on a given area of land) were 200 person-rem [2 person-Sv] for Model 1 and 14 person-rem [0.14 person-Sv] for Model 2 (NRC, 1980).

When the accident dose results are weighted by accident probabilities (computed as the product of the vehicle accident rate per unit distance traveled, the number of shipments, and the shipment distance) and converted to estimated latent cancer fatalities (Mackin, et al., 2001), the results are 0.01 and 0.0008 cancer deaths per year from yellowcake accidents for a single ISL facility. These risk results can be recalculated for facilities with higher production estimates, longer shipment distances, or increased accident rates by adjusting the computed accident probability term. For comparison, the Smith Ranch-Highlands property in Converse County, Wyoming, is licensed at 2,500,000 kg [5,500,000 lb] yellowcake per year (NRC, 2006; Energy Metals Corporation, U.S., 2007; Energy Information Administration, 2004), which would translate to 145 yellowcake shipments if they were to produce at their maximum permitted level, thereby increasing the aforementioned risk results of 0.01 and 0.0008 latent cancer fatalities by a factor of 4.3 to 0.04 and 0.003 latent cancer fatalities.

Previously reported accidents involving yellowcake release indicate up to 30 percent of shipment contents were released (Mackin, et al., 2001; Grella, 1983), which is less than the fraction used in the previously mentioned calculations. In all cases reviewed, spills from accidents have been contained and cleaned up quickly (by the shipper with state involvement) without significant health or safety impacts to workers or the public.

Safety controls and compliance with existing transportation regulations in 10 CFR Part 71 add confidence that yellowcake can be shipped safely with a low potential of affecting the environment. For example, transport drums must meet specifications of 49 CFR Part 173, which is incorporated in NRC regulations at 10 CFR Part 71. To further minimize transportation

risk, NRC recommends that delivery trucks meet safety certifications and that drivers hold appropriate licenses (NRC, 1997).

As described in Mackin, et al. (2001, Section 4.5), the potential radiological impacts associated with yellowcake transportation are SMALL.

Ion Exchange Resin Transport: Sites that include remote ion exchange processing will transport loaded ion exchange resins (usually by sole-use trucks) from the remote ion exchange processing sites to a central processing facility (one truck per day, 7 days per week). The radiological impacts of these shipments are expected to be lower than estimated risks from the finished yellowcake product because (1) ion exchange resins are less concentrated {about 50 g/L [0.009 oz/gal]} than yellowcake and therefore will contain less uranium per shipment than a yellowcake (about 85 percent uranium by weight) shipment, (2) the uranium in ion exchange resins is chemically bound to the resins; therefore, it is less likely to spread and easier to remediate in the event of a spill or release of shipped material, and (3) while the shipment distance for remote ion exchange varies for each ISL site, the total annual distance traveled by ion-exchange shipments is normally less than the same for yellowcake shipments. The NRC regulations at 10 CFR Part 71 and the incorporated U.S. Department of Transportation regulations for shipping ion exchange resins, which are enforced by NRC onsite inspections, also provide confidence that safety will be maintained and the potential for environmental impacts would be SMALL.

Radioactive Waste Transportation: Operational 11e.(2) byproduct wastes (as defined in the Atomic Energy Act of 1954, as amended) can be shipped offsite by truck for disposal at a licensed disposal site (Section 2.8). All radioactive waste shipments are shipped in accordance with the applicable NRC requirements in 10 CFR Part 71 and U.S. Department of Transportation requirements in 49 CFR Parts 171–189. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments, owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Therefore, impacts from transporting ISL facility byproduct wastes would be SMALL.

Hazardous Chemical Transportation: The number of operational chemical supply shipments is discussed in Section 2.8 (one facility reported 272 bulk chemical shipments per year). These shipments must follow U.S. Department of Transportation hazardous materials shipping regulations and requirements. Spill responses would be similar to the aforementioned for yellowcake transportation, although a spill of nonradiological materials is reportable to the appropriate state agency, the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Transportation. The Occupational Safety and Health Administration sets worker exposure limits for these chemicals. Mackin, et al. (2001) concluded that the risks associated with handling and transporting hazardous chemicals can be minimized by using accepted codes and standards and compliance with Occupational Safety and Health Administration Standards. The consequences of a chemical transportation incident, however, if it were to occur in a populated area, could have significant impacts. A chemical transportation incident at the ISL facility could also affect the impacts associated with radiological processes carried out at an ISL facility. However, given the precautions taken with such materials, the likelihood of an incident in a populated area is considered low and therefore the overall risk of a high consequence accident is considered small. As a result of the low frequency of shipments (<1 per day) and the low risk of high consequence accidents, the potential environmental

impacts of chemical transportation to potential ISL facilities within the Wyoming West Uranium Milling Region would be SMALL.

4.2.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than previously discussed impacts for construction and operations because transportation activities will be primarily limited to supplies (including chemicals for reverse osmosis), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE considering the potential impacts of commuting during peak employment periods (Section 2.8) on low traffic roads in the Wyoming West Uranium Milling Region (Section 3.2.2).

4.2.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment (Section 2.8) due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected for potential ISL facilities in the Wyoming West Uranium Milling Region during decommissioning, impacts would be SMALL.

4.2.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities at ISL facilities may impact geology and soils. The potential impacts to geology and soils from these activities in the Wyoming West Uranium Milling Region are discussed in the following sections.

4.2.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts to geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures

- Excavating and backfilling trenches for pipelines and cables

- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Wyoming West Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities will result in only SMALL (on average, approximately 15 percent of permitted site area) impacts and temporary disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons will be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance will be limited to drill pad grading, mud pit excavation, well completion, and access road construction.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). For example, soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles are typically located, shaped, and seeded with a cover crop by the operator to control erosion. Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas; using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is typically constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only SMALL and temporary disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated rock and soil and graded to surrounding ground topography.

Based on the previous discussion, the impacts of construction activities on geology and soils at ISL facilities in the Wyoming West Uranium Milling Region would be SMALL because of the limited time the activity takes place (months), the limited area of site disturbance (on average, approximately 15 percent of permitted site area), and the shallow depth of excavation 1.2–1.8 m [4–6 ft].

4.2.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting

"pregnant" lixiviant, which now contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure. In addition, the source formations for uranium in the Wyoming West Uranium Milling Region occur at depths of hundreds of meters [hundreds to thousands of feet] (Section 3.2.3), and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick (Section 3.1.2). At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts to geology from ground subsidence would be expected to be SMALL.

The pressure of the producing aquifer is decreased during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the potential for spread of contamination. This change in pressure theoretically could impact the transmissivity of faults in permitted areas. However, because uranium producing sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations, reactivation of faults has not been observed in the Wyoming West Uranium Milling Region.

A potential impact to soils arises from the necessity to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can (1) be released and pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater.

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). If the spill is allowed to dry, it can pose an ingestion or inhalation hazard to both humans and wildlife. Upon detection, licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soil for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning

activities. Licensees of ISL facilities in the Wyoming West Uranium Milling Region must also comply with applicable WDEQ requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these yellowcake or resin spills to both the NRC and WDEQ. License conditions may also require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA.

In the short term, impacts to soils from spills could range from small to large depending on the volume of soil affected by the spill. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils would be expected to be SMALL.

Uranium mobilization and processing during ISL operations produce excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts of and requirements for discharging treated waste streams to surface water bodies during ISL activities in the Wyoming West Uranium Milling Region are discussed in Section 4.2.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Although waste streams are treated before discharge to evaporation ponds, they may still contain radionuclides and other metals that may become concentrated during evaporation. Therefore, evaporation pond liner failures and pond embankment failures could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are monitored and inspected by licensees in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the federal Dam Safety program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be evapotranspired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium or other metals) to accumulate in the soils, thereby degrading the site potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to

identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits.

Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be expected to be SMALL.

4.2.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by recirculation of treated groundwater, and therefore it is very unlikely that ISL operations will reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts on geology in the Wyoming West Uranium Milling Region from aquifer restoration would be expected to be SMALL, if any.

The main potential impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the dose limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Wyoming West Uranium Milling Region are also required to comply with WDEQ requirements for spill response and reporting. The short-term impact on soils from spills of contaminated groundwater could range from small to large depending on the volume of the affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

During aquifer restoration, the groundwater is passed through semipermeable membranes that yield a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal, while the treated wastewater may be reinjected into the aquifer or applied to the land.

If reject water is sent to an evaporation pond, failure of the pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated water during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the potential impacts to soil from land application of treated wastewater would be expected to be SMALL.

4.2.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes dismantling process facilities and associated structures, removing buried piping, and plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Wyoming West Uranium Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee's spill documentation—an NRC requirement—would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions, to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.2.4 Water Resources Impacts

4.2.4.1 Surface Water Impacts

4.2.4.1.1 Construction Impacts to Surface Water

There would be potential impacts to surface water bodies and wetlands as a result of constructing ISL uranium recovery facilities (Section 2.3): (1) water quality degradation from temporary increases in suspended solids concentrations above background levels during in-stream construction or runoff from disturbed lands; (2) increased sedimentation in waterbodies resulting from either in-stream construction or construction activities on adjacent upland areas; (3) channel and bank modifications that affect channel morphology and stability; (4) reduced flows in waterbodies where fills have occurred; (5) water quality degradation in water bodies, lakes, impoundments, or surface water-based public water supplies from spills or leaks of fuel, lubricants, or hazardous materials during construction; and (6) fills and destruction of wetland areas (e.g., USACE, 2007a–c).

Depending on the construction methods used, installing pipelines and roads across waterbodies may affect surface water quality in any of these ways. Clearing land for roads, well pads, pipelines, and other structures exposes bare soil to water and wind erosion thereby increasing the erosion potential. Erosion potential can be increased further from the decreased permeability of roads and well pads (i.e., compaction of soil from vehicles increases water runoff). Increasing the number of low permeability areas increases the energy of runoff, which in turn can carry more sediment to streams, change flow characteristics, and increase stream erosion. Best management practices that would be expected to be implemented, as needed, to limit impacts to surface water are discussed in Chapter 7.

Linear transportation crossings over waterbodies can be built using bridges, pipe culverts, and box culverts. Impacts from road development would be a direct result of design and the extent of the waterway and would be handled on a site-specific basis through the U.S. Army Corps of Engineers (USACE) Section 404 permitting process. Under Section 404 of the Clean Water Act (see Appendix B), the USACE—and specifically, the Secretary of the Army—is responsible for administering a regulatory program that requires permits to discharge dredged or fill material into U.S. waters, including wetlands. If these activities satisfy general conditions, they may be authorized under various nationwide permits (USACE, 2007a–c). Specific construction practices that may reduce construction impacts to surface waterbodies are defined as part of the USACE permitting process (USACE, 2007a–c). The use of these permits also requires that the actions satisfy the individual state Section 401 certification with regard to water quality. If the project does not meet the requirements for a nationwide permit, then an individual Section 404 permit from USACE would be required. Permanent fills from placing bridge columns within the waterway or impacts from construction equipment may be long-term effects of constructing a bridge crossing. The placement of pipe and box culverts could have impacts to the waterway, along with any temporary impacts from construction.

Clearing existing vegetation when the collection pipelines and linear crossings are built would be as minimal as necessary to prepare for grading. Grading is typically directed away from the waterbody to reduce the potential for sediment to enter. Temporary erosion control measures (e.g., silt fences, straw bales) are installed as necessary to minimize the potential for disturbed soils to enter the waterbody from the right-of-way. Staging areas near waterbody crossings

would typically be set back from the water's edge as permitted by topographic and other site conditions.

Other measures related to minimizing temporary impacts to waterbody crossings such as managing spoil, timing crossing, providing temporary access, and limiting equipment working in waterbodies would be considered, as appropriate, during the planning process. For example, spoil containment devices such as silt fences or straw bales would be installed and set back from the waterbody bank, minimizing potential for sediment leaving the construction right-of-way and reentering the waterbody. Operation- or transportation-related spills, collected product storage, or equipment failure in or near a waterbody could affect aquatic resources and contaminate the waterbody downstream of the release point. Spill responses at ISL facilities are described in Section 2.11.2.

Any construction activity in waters protected for fisheries uses is likely to exceed Wyoming's water quality criteria for turbidity; however, temporary increases in turbidity above the numeric criteria in Wyoming's Surface Water Quality Standards for a specific activity may be authorized in response to an application for a variance provided the application is submitted to the state for review and approval prior to exceeding the standards.

In summary, potential impacts to surface waters from the construction of an ISL facility would be expected to be SMALL based on the application of federal and state clean water regulations in conjunction with the use of best management practices. Should the facility require an individual permit from the USACE, the facility could have MODERATE impacts. However, as a result of the permitting process, those impacts would be expected to be mitigated though various mitigation options such as mitigation banking, riparian/wetland enhancement, or creation of new Waters of the United States. Storm water runoff during construction would be controlled through a Storm Water Pollution Prevention Plan that is part of a Wyoming Pollutant Discharge Elimination System permit issued by WDEQ (Section 1.7.5.1). Temporary wastewater discharges from hydrostatic testing of pipes, tanks, or other vessels; construction dewatering; and well pump tests would be regulated by a temporary discharge permit from WDEQ. Well pump tests in uranium-bearing zones would also need to comply with WDEQ monitoring and effluent limits for total radium and uranium. Isolated wetlands and associated mitigation measures are also regulated by the WDEQ. Overall, compliance with the applicable federal and state regulations and permit conditions and the implementation of best management practices and other mitigation measures would result in potential impacts during construction that would be SMALL.

4.2.4.1.2 Operation Impacts to Surface Water

During operations (Section 2.4), surface waters could be impacted by accidental spills from the ISL facility or by permitted discharges. Spills from the central processing plant or well fields, as well as spills during transportation, could impact surface waters by contaminating storm water runoff or by contaminating surficial aquifers that are hydraulically connected to surface waters.

As described in Section 4.2.4.2.2.1, flow monitoring and spill response procedures are expected to limit the impact of potential spills to surficial aquifers. Impacts of spills to surface waters that are hydraulically connected to surficial aquifers may be SMALL to MODERATE, depending on the size of the spill, success of remediation, use of the surface water (e.g., for domestic or agricultural water supply), proximity of the spill to the surface water, and relative contribution of the aquifer discharge to the surface water.

Storm water discharges are controlled through a Storm Water Pollution Prevention Plan that is part of a Wyoming Pollutant Discharge Elimination System permit issued by the WDEQ. The Storm Water Pollution Prevention Plan describes the potential sources of storm water contamination at the facility, routes by which storm water may leave the facility, and the best management practices that would be used to prevent storm water contamination. For example, concrete curbing and berms are typically used to contain spills and facilitate cleanup in accordance with approved operating procedures. Although the Wyoming Pollutant Discharge Elimination System permit for storm water discharges does not provide specific numerical water quality standards, it does include monitoring requirements and specifies that storm water discharge shall not cause pollution, contamination or degradation of waters of the state. Waters of the state include wetlands; surface water channels, whether perennial or not; and lakes and reservoirs. Thus storm water discharges compliant with the Wyoming Pollutant Discharge Elimination System would be expected to result in SMALL impacts to surface waters.

If the licensee wishes to discharge treated wastewater to a surface water body (Section 2.7.2), the licensee must obtain a Wyoming Pollutant Discharge Elimination System permit from the WDEQ. The Wyoming Pollutant Discharge Elimination System permit would contain numerical discharge limits for various pollutants intended to protect surface water quality. Any discharges must be treated as necessary to meet these limits. The State of Wyoming issues Wyoming Pollutant Discharge Elimination System permits under authority delegated by the National Pollutant Discharge Elimination System (NPDES). Compliance with permit requirements would result in SMALL impacts to surface waters from ISL facility operation activities.

Should the facility require expansion or new pipelines or linear crossings, then the same impacts from construction are anticipated (SMALL to MODERATE).

Most ISL operations extract slightly more groundwater than they reinject into the uranium-bearing formation (Section 2.4.1). The groundwater extracted from the formation could result in a depletion of flow in nearby streams and springs if the ore-bearing aquifer is hydraulically connected to such features. Most, if not all, ISL operations would take place in ore bodies within confined aquifers. For the operations to impact local surface water features, the ore-bearing aquifer would need to have Artesian head and the upper confining beds would need to have sufficient permeability to allow groundwater to flow to the surface features. Such conditions near the ISL facility would not be favorable to permitting an ISL in the first place and would have allowed groundwater contaminated by the ore body to discharge to the surface water features even in the absence of any ISL operation. Thus, NRC finds it unlikely that ISL activities would take place at sites with ore-bearing aquifers with any significant connection to surface water features. Assuming the ore-bearing aquifer at an ISL facility had a weak hydraulic connection to a local surface water feature, the effect of the net groundwater extractions during operation would also be weak and the potential impact to the surface water feature would be SMALL. Discharge of produced water to local drainage channels could also result in channel erosion and headcutting. The impact of any such erosion processes would be SMALL if mitigated by using properly designed discharge structures.

4.2.4.1.3 Aquifer Restoration Impacts to Surface Water

Activities occurring during aquifer restoration that could impact surface waters include management of produced water, storm water runoff and accidental spills, and management of brine reject from the reverse osmosis system (Sections 2.5 and 2.7.2). Storm water quality

would be controlled under a Storm Water Pollution Prevention Plan in the same manner as during operations.

Alternatives for disposal of produced water that could affect surface water quality include land application of the treated water, discharge to solar evaporation ponds, and discharge of treated wastewater to surface waters, depending on site-specific facility planning (Section 2.7.2).

Prior to disposal by land application, water would be treated to remove contaminants and naturally occurring dissolved solids to levels established by the state. In addition, NRC requires that public and occupational dose limits of 10 CFR Part 20 be met during and after disposal by land application. Despite water treatment to meet these requirements, residual contaminants and dissolved solids could accumulate on the surface and in the root zone of the irrigated land. The extent to which these materials would accumulate in the soil at a specific site depends on the degree to which actual evapotranspiration exceeds the applied irrigation rate plus precipitation at the site, and the sorptive properties of the soil with respect to specific constituents.

Contaminants and accumulated natural salts could leave the facility and enter surface water due to runoff from excess irrigation or storm events. During land application, these impacts could be mitigated in accordance with permit requirements by adjusting water application rates to be consistent with site-specific climate, soil, and vegetation conditions. Residual contaminants, if any, that remain in soil when operations are shut down would be included in land surveys and cleaned up, as needed, during decommissioning (Section 2.6) to meet NRC safety regulations. Because of permit requirements and subsequent decommissioning, potential impacts from permitted land application would be SMALL.

Produced water permitted to be discharged to local waterways (Section 2.7.2), including ephemeral stream channels, under a Wyoming Pollutant Discharge Elimination System permit would need to be treated to remove contaminants to meet state and federal water quality standards. Potential impacts associated with surface water discharge could include leaching of natural salts from unsaturated soils and accidental releases of water not meeting discharge standards, but compliance with permit requirements for discharge would be expected to result in SMALL potential impacts.

Groundwater extracted from the formation during aquifer restoration could result in a depletion of flow in nearby streams and springs if the ore-bearing aquifer is hydraulically connected to such features. Because most, if not all ISL aquifer restoration would be expected to occur where the ore-bearing aquifers are confined and would have a weak connection to surface water bodies, local depletion of streams and springs would be unlikely, and potential impacts would be expected to be SMALL.

4.2.4.1.4 *Decommissioning Impacts to Surface Water*

During decommissioning of the facility (Section 2.6), temporary impacts to surface waters are anticipated from sediment loading associated with removal of piping, linear crossings, and other facility infrastructure. Decommissioning and reclamation would be expected to return the Waters of the United States to preconstruction/operation status. Storm water runoff would also be controlled by implementing a Storm Water Pollution Prevention Plan during decommissioning activities. Impacts to surface water from decommissioning and reclamation activities would be SMALL.

4.2.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Wyoming West Uranium Milling Region can occur during each phase of the ISL facility's lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer's chemistry, and waste management practices involving land application, evaporation ponds, or deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.2.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, introduction of drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment (see Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small relative to pumpable water and would have a SMALL and temporary impact to groundwater supplies within the Wyoming West Uranium Milling Region. Groundwater quality of near-surface aquifers during construction would be protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts to groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.2.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (see Section 2.4). Disposal of processing wastes by deep well injection (see Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.2.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers.

The potential environmental impacts of pipeline, valve, or well integrity failures to shallow aquifers could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)
- The shallow aquifers are important sources for local domestic or agricultural water supplies
- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydraulically separated from other locally and regionally important aquifers.

In some parts of the Wyoming West Uranium Milling Region, local shallow aquifers exist and they are important sources of groundwater locally [e.g., in the vicinity of the Lost Creek area (Lost Creek ISR, LLC, 2007)]. Hence, for some sites in the Wyoming West Uranium Milling Region, potential environmental impacts due to spills and leaks from pipeline networks or failures of well mechanical integrity in shallow aquifers could be MODERATE to LARGE, depending on site-specific conditions. Potential impacts would be reduced by flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well mechanical integrity testing (MIT) (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.2.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term "consumptive use" refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Wyoming West Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L per ha [4.36 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 18 ha [44 acres] in Wyoming for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by lowering water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would significantly overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). In this extreme case, drawdowns at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from the hypothetical well would be 71, 55, and 39 m [233, 55, and 128 ft] after 10 years of operation. These hypothetical values were calculated using the Theis Equation (McWhorter and Sunada, 1977) with transmissivity and storage coefficient values of 10 m^2/day [108 ft^2/day] and 1×10^{-4}, respectively (chosen from the range of respective parameter values discussed in Section 3.2.4.3).

To quantify the sensitivity of the drawdowns to aquifer properties, additional drawdowns were computed by decreasing the aquifer transmissivity or storage coefficient by an order of magnitude. An order of magnitude (factor of 10) decrease in aquifer transmissivity {i.e., from 10 m^2/day [108 ft^2/day] to 1 m^2/day [11 ft^2/day]} may not be consistent with the transmissivity of a production aquifer; for an ISL facility to be practical, the hydraulic conductivity of the production aquifer must be large enough to allow reasonable water flow from injection to production wells. Therefore, the analysis presented here is only intended to demonstrate the sensitivity of drawdown to transmissivity. The effect of reducing the transmissivity was to increase the hypothetical drawdowns in the production aquifer to 190, 142, and 94 m [623, 142, and 308 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from a single hypothetical pumping well used to represent an entire ISL facility. If the aquifer storage coefficients were 10 times smaller, drawdowns would be 24, 19, and 14 m [79, 62, and 46 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from the hypothetical well. These calculations indicate that drawdowns are more sensitive to aquifer transmissivity than storage coefficient. Drawdowns near the producing wells would be slightly smaller for larger storage coefficients. However, drawdowns would be much smaller for larger transmissivity values.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield significant overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use could be MODERATE if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well isolated from other aquifers that are used locally. However, because localized drawdown near well fields would dissipate after pumping stops, these localized effects are expected to be temporary. The long-term impacts would be expected to be SMALL in most cases, depending on site-specific conditions. Important site-specific conditions would include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. In order for ISL operations to occur, the uranium-bearing production aquifer must be exempted as an underground source of drinking water through the Wyoming Underground Injection Control (UIC) program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to preoperational conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. The remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or in the producing aquifer outside of the well field to be affected by excursions during ISL operations.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal excursions can occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone and the well field. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL production zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be affected during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1977; Driscoll, 1986). For example, for the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction between two aquifers and a vertical hydraulic conductivity of 1.0×10^{-3} m/day [3.3×10^{-3} ft/day] for an aquitard (upper confinement of the Battle Springs Formation) separating those two aquifers (Section 3.2.4.3), a leaching solution would move vertically upward from the production aquifer to an overlying aquifer at a rate of nearly 3.6 cm/yr [1.4 in/yr]. If the vertical migration rate of a leaching solution {i.e., 3.6 cm/yr [1.4 in/yr]} was assumed be constant in the next 10 years, then the leaching solution would move vertically 36 cm [1.2 ft] away from the production zone. If the thickness of the aquitard is 1 m [3.3 ft] or more, then the leaching solution would not enter the overlying aquifer in the next 10 years. The thickness of confining layers is typically greater than 1 m [3.3 ft] in the Wyoming West Uranium Milling Region (Section 3.2.4.3), and it would take many decades for the vertical excursion to reach the upper aquifer. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying or underlying aquifers for water supply purposes in the vicinity of an ISL facility (e.g., from the overlying Green River Formation or the underlying Fort Union Formation near the Great Divide Basin), which may enhance potential vertical excursions from the production aquifer (e.g., the Battle Springs Formation near the Great Divide Basin). Discontinuities in the thickness and

spatial heterogeneities in the vertical hydraulic conductivity of confining units could lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology, proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters, and the upper control limits (UCLs) for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

WDEQ noted that monitoring wells should be completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As discussed in Section 3.2.4.3.2, in the Lost Creek area, Quaternary-aged sedimentary deposits and sandstone layers are above the ore-bearing aquifer and the Fort Union Formation is below the ore-bearing aquifer. Near the Gas Hills area, the Split Rock Formation is above the ore-bearing aquifer and the Fort Union Formation is below the ore-bearing aquifer.

As discussed in Section 3.2.4.3., in the Wyoming West Uranium Milling Region, the Lewis Shale, with a vertical hydraulic conductivity on the order of 10^{-3} m/day [3.3×10^{-3} ft/day], is continuous and thick {e.g., it is 820 m [2,700 ft] thick in the Lost Creek area (Lost Creek ISR, LLC, 2007)}. The Lewis Shale underlies the aquifer system that includes, from shallowest to deepest, the Wasatch/Battle Spring (equivalent to the ore-bearing Wind River Formation), Fort Union, and Lance Formation and the Fox Hill sandstone. Uranium-bearing sandstone layers in the Wind River Formation near the Gas Hills area are confined by low permeability layers. At the potential Lost Creek ISL facility, the ore-bearing Battle Springs Formation is confined below by the thick Lewis Shale (Section 3.2.4.3.3.), which could preclude downward vertical excursions from the production aquifer. However, although the upper confinement is reported to be continuous and effective at the local scale at the proposed ISL sites discussed in

Section 3.2.4.3, the discontinuous nature of the upper confinement of the Battle Springs Formation at the regional scale (AATA International Inc., 2005) could allow vertical excursions of leaching solutions from the production aquifer to the aquifers above at some sites.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts would be expected to be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine how to remediate it.

At the previously discussed ISL facilities in the Wyoming West Uranium Milling Region, the ore-bearing aquifers (the Battle Springs and the Green River Formations) are confined below and above by continuous and thick confining layers. Preliminary calculations discussed previously suggest that the confinements would effectively restrict potential vertical excursions. Additionally, if the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be expected to be SMALL. However, the potential discontinuous nature of the upper confinement at the regional scale (AATA International Inc., 2005) should be taken into account in assessing potential environmental impacts of other potential ISL facilities in the Wyoming West Uranium Milling Region.

4.2.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act, the Safe Drinking Water Act, and the Clean Air Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from EPA (Section 1.7.2) or from an authorized state UIC program. As discussed in Section 1.7.5.1, Wyoming requires UIC Class III permits for injection wells in areas not previously mined using conventional mining and milling. UIC Class V permits are required for injection wells leaching from older conventional uranium recovery sites.

In the Wyoming West Uranium Milling Region, the Paleozoic aquifers included in the Upper Colorado River Basin aquifer system are typically deeply buried, contain saline water, and are not commonly tapped for water supply (Whitehead, 1996). The Paleozoic aquifers are separated from the overlying aquifers (including the ore-bearing aquifer) by the regionally extensive Lewis Shale. Hence, the Paleozoic aquifers (e.g., Tensleep Sandstone) could be suitable for disposal of leaching solutions.

The potential environmental impacts of injection of leaching solutions into deep aquifers below ore-bearing aquifers would be expected to be SMALL, if water production from deep aquifers is not economically feasible or the groundwater quality from these aquifers is not suitable for

domestic or agricultural uses (e.g., high salinity), and they are confined above by sufficiently thick and continuous low permeability layers.

4.2.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following steps: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These steps are discussed in more detail in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from the well field prior to commencing milling. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from a well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because up to 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired flow of water from outside of the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than groundwater consumption during ISL operation (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

As discussed in Section 2.5, restoration typically is performed as well fields end production, so all of the well fields do not undergo groundwater sweep at the same time. For example, at the Irigaray Mine (Cogema Mining, Inc., 2004), average pumping rates for groundwater sweep ranged from approximately 100 L/min [27 gal/min] to pump 120 million L [31 million gal] from two well fields between June 1991 and August 1993 to 380 L/min [100 gal/min] to pump 190 million L [49 million gal] from three well fields between May 1990 and April 1991. At the Smith Ranch/Highland Uranium Project in Converse County, Wyoming, an average pumping

rate of approximately 38 L/min [10 gal/min] was used to pump 3.2 pore volumes {49 million L [13 million gal]} from the A-Wellfield during almost 3 years of groundwater sweep (Power Resources, Inc., 2004).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].

At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in 1 year. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L/ha [4.36 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in 1 year of restoration would be roughly equivalent to the water used to irrigate 21 ha [53 acres] in Wyoming for 1 year.

Potential environmental impacts are affected by the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility. The potential environmental impacts of groundwater consumption during restoration could be SMALL to MODERATE depending on site-specific conditions. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the facility wastewater treatment system (e.g., deep well injection, solar evaporation ponds, land application after treatment). The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.2.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from the EPA or the authorized state and approval from NRC. Additionally, the briny slurry produced during the reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injection must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be expected to be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A,

Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.2.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills and facilitate cleanup. Based on consideration of best management practices to minimize water use and spills, impacts to the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitoring, injection, and production wells will be plugged and abandoned in accordance with the Wyoming UIC program requirements. The wells would be filled with cement and clay and then cut off below plow depth to ensure that groundwater does not flow through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be expected to be SMALL.

4.2.5 Ecological Resources Impacts

4.2.5.1 Construction Impacts to Ecological Resources

Vegetation

ISL uranium recovery facility construction primarily affects terrestrial vegetation through (1) the removal of vegetation from the milling site during construction (and associated reduction in wildlife habitat and forage productivity and an increased risk of soil erosion and weed invasion); (2) the modification of existing vegetative communities as a result of milling maintenance; (3) the loss of sensitive plants and habitats as a result of construction clearing and grading; and (4) the potential spread of invasive species and noxious weed populations as a result of construction.

ISL facilities are typically located in large remote areas of the region. Permit areas of past facilities have ranges from 1,034 ha to 6,480 ha [2,552 to 16,000 acres] of land (Section 2.10.1). Typically the impact within these permit areas have been from 49 ha to 490 ha [120 acres to 1,200 acres]. The percent of vegetation removed or land disturbance has been from below 1 to 20 percent, which would be a SMALL impact in relation to the total permit area and surrounding plant communities.

Clearing herbaceous vegetation during construction in a open grassland or shrub steppe community is anticipated to have a short-term impact. If active revegetation measures were used with seed mixtures approved by the WDEQ, Land Quality Division, rapid colonization by annual and perennial herbaceous species in the disturbed staging areas and rights-of-way would restore most vegetative cover within the first growing season. Impacts from clearing in this community would be SMALL.

Clearing woody shrubs and trees would have a primary long-term impact on vegetation associated with the project if the project is located in a wooded area. Woody shrubs and trees would recolonize after construction of the right-of-way and staging areas, although recolonization of disturbed areas would be slower than for herbaceous species. As natural succession is allowed to proceed in these areas, the early successional or forested communities that existed before construction would eventually be reestablished. Clearing trees in the milling site could affect forest vegetation growing along the edges of the cleared areas. Exposing some edge trees to elevated levels of sunlight and wind could increase evaporation rates and the probability of tree knockdown. Due to the increased light levels penetrating the previously shaded interior, shade-intolerant species would be able to grow, and the species composition of the newly created forest edge may change. Clearing could also temporarily reduce local competition for available soil moisture and light and may allow some early successional species to become established and persist on the edge of the uncleared areas adjacent to the milling site. Impacts from clearing this community would be SMALL to MODERATE depending on the amount of surrounding wooded area.

Noxious weeds that may invade areas disturbed by construction would be expected to be controlled on a regular basis. The applicant would be expected to employ minimal use of herbicides to control noxious weeds, so as not to affect native species on the site. Application would be by hand sprayers or broadcasting using truck-mounted spraying equipment, as necessary. Using applicable control techniques, impacts from noxious weeds would be SMALL.

Wildlife

There are three primary impacts of ISL uranium recovery facility construction on terrestrial wildlife: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and/or indirect mortalities from project construction and operation.

Construction activities in wellfields would result in some loss of wildlife habitat; however, this loss can be minimized if disturbed areas are reseeded when construction is completed in that area. The impacts would expected to be greatest in vegetative communities where clearing would be required to construct wells, access roads, header houses, and pipelines from the well fields to the header houses. In general, most wildlife, including the larger and more mobile animals, would disperse from the project area as construction activities approach. Displaced species may recolonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and suitable habitats are reestablished. Some smaller, less mobile wildlife such as amphibians, reptiles, and small mammals may die during clearing and grading activities. Small mammals and songbirds dependent on shrubs and trees for food, nesting, and cover would be impacted in areas where clearing is needed for construction. Wildlife habitat fragmentation, temporary displacement of animal species, and direct or indirect mortalities is possible, therefore construction impacts would be SMALL to MODERATE.

Even if available habitat within the site and in adjacent areas supported displaced individuals, some impact from competition for resources between preexisting species may occur. Some localized foraging areas may be avoided by big game during construction periods when workers are present. Noise, dust, and increased presence of workers in or adjacent to foraging areas may temporarily preclude use by wildlife (NRC, 2004). Habitat loss and fragmentation could be reduced if the percentage of land affected compared to the total undisturbed vegetative community acreage within the permitted area and or surrounding area was small. Standard management practices issued by the Wyoming Game and Fish Department can help to minimize habitat fragmentation, wildlife stress, and incidental death. Impacts to wildlife species could range from SMALL to MODERATE, depending on site-specific conditions.

Crucial wintering and year-long ranges vital for survival of local populations of big game and sage-grouse leks or breeding ranges are located within the region (Figures 3.2-8 through 3.2-14). If the proposed facility exists within these ranges, guidelines have been issued by the Wyoming Game and Fish Department for the development of oil and gas resources that would apply to ISL facility operations (Wyoming Game and Fish Department, 2004) and limit the impacts to a SMALL magnitude. In addition, BLM has issued guidelines for sage-grouse management, which can be used to help mitigate impacts from ISL facilities. Consultation with the Wyoming Game and Fish Department and a site-specific analysis would help determine impacts from the facility to these species.

Disturbed areas revegetated with a seed mixture of grasses, forbs, and shrubs approved by the WDEQ, Land Quality Division, would further mitigate impact to wildlife after construction of the well fields and facility infrastructure. Mitigation measures would reduce the overall impacts to be SMALL.

Wellfield operations would require the construction of power distribution lines. Lines may be supported by single-pole wood structures with a wooden cross arm. The conductors would be configured to assure adequate spacing between the shield wire (i.e., ground wire) and conductors to avoid potential electrocution of raptors that land on the cross arms. Other alternatives may include the construction of underground power lines to minimize impacts. Construction of the distribution lines would be expected to follow guidance in Avian Power Line Interaction Committee (2006). Raptors breeding in the site may be affected by construction activities, or mining operations may be temporarily impacted depending on the time of year construction activities occur. Potential impacts to this species would be SMALL.

Impacts to raptors would be reduced at facilities that avoided disturbing areas within 800 m [0.5 mi] of active raptor nests and prior to fledging of young. Impacts can also be reduced by employing mitigation in areas that cannot be avoided based on approval by the fish and wildlife service and the Wyoming Game and Fish Department. Proposed mitigation could include construction of alternate nest sites on natural features (e.g., trees, rock outcrops, and cliffs) and erection of appropriate nesting platforms on wooden poles (NRC, 2004). Construction activities will be required to comply with the Migratory Bird Treaty Act. Consultation with the U.S. Department of Interior should occur prior to construction activities.

Aquatic

ISL uranium recovery facility construction primarily affects aquatic resources through (1) short-term physical disturbances to stream channels; (2) short-term increases in suspended sediments from in-stream activities and erosion from adjacent disturbed lands; (3) increases in

downstream sedimentation, during construction, from in-stream activities and erosion from adjacent disturbed lands; (4) potential fuel spills from equipment and refueling operations during construction; and (5) short-term reductions in habitat and potential loss of individual specimens from water appropriations if needed.

Due to disturbances associated with construction, movement of fish upstream and downstream of waterbody crossings could be temporarily affected when pipelines or roads are installed. The physical disturbance of the streambed could temporarily displace adult fish and could dislodge other aquatic organisms, including invertebrates. Some limited mortality of less mobile organisms such as small fish and invertebrates could occur within the immediate area of the crossing. Aquatic plants, woody debris, and boulders that provide an in-stream fish habitat would also be expected to be removed if trenching occurred. Noise upstream and downstream of the site could deter fish that might otherwise inhabit the area. These disturbances would be expected to be temporary and are not expected to significantly affect fisheries resources. Studies have shown that natural recolonization of the disturbed areas would begin soon after the streambed is restored; areas would be completely recolonized within 1 year after construction (Schubert, et al., 1985; Anderson, et al., 1997). Therefore impacts, would be SMALL.

Sediment loads could be temporarily increased downstream during construction. These increased loads could temporarily affect sensitive fish eggs, fish fry, and invertebrates inhabiting the downstream area. However, sediment levels would quickly taper off both over time and distance and would not be expected to adversely affect resident fish populations or permanently alter existing habitats (McKinnon and Hnytka, 1988), and long-term impacts would be SMALL.

Removal of riparian vegetation could increase the amount of light able to penetrate the water, thus increasing the water temperature. Changes in the light and temperature characteristics of some waterbodies could affect the behavioral patterns of fish, including spawning and feeding activities, at the crossing location.

Standard management practices issued by the Wyoming Game and Fish Department would help to limit impacts to aquatic life and surface waters to a SMALL magnitude.

Threatened and Endangered Species

There are three primary impacts of ISL uranium recovery facility construction on threatened and endangered species: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and indirect mortalities from project construction and operation.

Numerous threatened and endangered species and state species of concern are located within the region. These species with habitat descriptions are provided in Section 3.2.5.3. After a site has been selected, the habitats and impacts would be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff consult with the U.S. Fish and Wildlife Service and Wyoming Game and Fish Department for potential survey requirements and explore ways to protect these resources. If any of the species are identified in the project site during surveys, impacts could range from SMALL to

LARGE, depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be developed.

- The black-footed ferret behavior revolves around prairie dog towns. Should prairie dog towns be present within close proximity to the construction area, impacts from construction activities would be MODERATE or LARGE. Destruction of prairie dog towns and/or conflict with machinery could impact black-footed ferret populations.

- The blowout penstemon are located in the sand dune habitat in the northeastern Great Divide Basin in Wyoming on sandy aprons or the lower half of steep sandy slopes deposited at the base of granitic or sedimentary mountains or ridges in northwestern Carbon County. The clearing of vegetation as a result of milling activities would have a LARGE impact to this species population if located in the impact area.

- The bonytail chub is found in slower water habitats in the mainstream such as eddies, pools, side channels, and coves. Proper best management practices with regard to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- Canada lynx generally require cool and moist coniferous forests with cold, snowy winters and abundant snowshoe hares. Lynx are extremely mobile and will occasionally move across and be recorded in unsuitable habitats, even shrublands and true grasslands. In general, ISL facilities are not located with the main habitat of the lynx. Potential exists that these species may cross the project area. Impacts from construction to this species would be temporary and SMALL if encountered.

- The downstream populations of the Colorado pikeminnow could be affected from construction activities from increased stream sedimentation and degrading of waterways in the region that connect to the upper Colorado River Basin. Proper best management practices with regard to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- The downstream populations of the humpback chub could be impacted from construction activities from increased stream sedimentation and degrading of waterways in the region that connect to the upper Colorado River Basin. Proper best management practices with regards to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- Impacts to the interior least tern would be SMALL if nesting habitat of bare or sparsely vegetated sand, shell, and gravel beaches and sandbars, islands, and salt flats associated with rivers and reservoirs is avoided.

- The downstream pallid sturgeon could be impacted from construction activities from increased stream sedimentation and degrading of waterways in the region that connect to the Missouri River. Proper best management practices with regards to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- The impacts to the piping plover will be SMALL or mitigated if construction activities avoid open, sparsely vegetated sand or gravel beaches adjacent to alkali wetlands and on beaches, sand bars, and dredged material islands of major river systems.

- The Preble's meadow jumping mouse is found in heavily vegetated, shrub-dominated riparian habitats and immediately adjacent upland habitats along the foothills of Albany, Laramie, Platte Goshen, and Converse Counties in Wyoming. Impact to this species would be SMALL or mitigated if the construction activities avoid vegetation removal and buffers along riparian habitats are established. Critical habitat has been established for this species.

- The razorback sucker is a large river species not found in smaller tributaries and headwater streams. Found in water from .06–3 m [4–10 ft] in depth, adults are associated with areas of strong current and backwaters. This species has been extirpated from Wyoming; however, it can have occasional occurrences in Sweetwater County. Impacts to this species would be SMALL if waterways do not meet habitat requirements.

- Impacts to the Ute ladies' tresses orchid would be MODERATE to LARGE if construction activities remove vegetation along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams or in wetland and seepy areas near freshwater lakes or springs.

- Impacts to the Western prairie fringed orchid would be MODERATE to LARGE if construction activities occur in the tall grass prairies in moist habitats or sedge meadows in which this species has been identified within the region.

- The whooping crane is a predictable spring and fall migrant in the Missouri River drainage. Impacts to this species from construction activities would be SMALL due to the transient nature of this species.

- Potential impact to the yellow-billed cuckoo would be SMALL to MODERATE if vegetation removal from construction occurs in cottonwood and willow riparian woodlands.

4.2.5.2 Operation Impacts to Ecological Resources

The primary impacts of ISL facility operation on terrestrial wildlife are (1) habitat alteration and incremental habitat fragmentation; (2) displacement/stress to wildlife from human activity; and (3) direct and/or indirect mortalities from project construction and operation.

Big game distribution in this region of Wyoming is limited by availability of winter range and water. Movement of pronghorn and mule deer through the area is not expected to be impacted by most mining operations. The limited the use of fencing that impedes ingress to and egress from the permit region would further mitigate impact to wildlife's use of the area. Within this region, the recommended fencing is that preferred by the Wyoming Game and Fish Department, which consists of three wires with a smooth bottom wire 41 cm [16 in] off the ground, a 30-cm [12-in] gap between the top two wires, and a total height of 97 cm [38 in]. This type of fencing will provide for relatively unimpeded movement of big game through the site (NRC, 2004).

Some SMALL impacts to wildlife would be expected to occur from direct conflict with vehicular traffic and the presence of onsite personnel. Generally these would be SMALL impacts that would not affect the total population of a species. However, proximity to crucial wintering ranges and active sage-grouse leks or raptor nests have the potential to have a MODERATE to LARGE impact. Seasonal guidelines with respect to noise, vehicular traffic, human proximity, and operational timing have been established by the Wyoming Game and Fish Department (Wyoming Game and Fish, 2004).

Potential impacts to migratory birds and other wildlife from exposure to selenium concentrations and radioactive materials in the evaporation ponds may occur. Past experience at NRC-licensed ISL facilities has not identified impacts to wildlife from evaporation ponds. Typically, evaporation ponds are lined with a synthetic liner that inhibits the growth of aquatic vegetation which might otherwise serve as a potential source of exposure to radioactive materials via a food pathway. Such vegetation could also potentially provide habitat for wildlife (NRC, 2004). Mitigative measures including perimeter fencing and surface netting would limit potential impacts to wildlife from evaporation ponds to SMALL.

Impacts to the aquatic resources and vegetation from facility operations resulting from spills around well heads and leaks from pipelines would be SMALL and would be handled using best management practices (NRC, 2007). Leak detection systems and spill response plans to remove affected soils and capture release fluids would be expected to reduce the impact to aquatic systems.

Impacts to federal threatened and endangered species beyond those that occurred during construction would be SMALL. The potential exists for mobile species to experience conflicts with vehicles during facility operations.

Potential impacts to vegetation may occur as a result of land application of wastewater generated from the operation. These impacts could range from increased vegetation growth due to the increase of available water and/or the destruction of vegetation from the build-up of salts in the soils. Additional details related to waste disposal operation are described in Section 4.2.12.2. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive and other constituents (e.g., arsenic, selenium, molybdenum) within allowable release standards. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to ensure release limits would be met and soil sampling to establish background and to monitor for uranium, radium, and other metals. The impacts from land application of treated wastewater would be SMALL.

4.2.5.3 Aquifer Restoration Impacts to Ecological Resources

Because the existing infrastructure is already in place, aquifer restoration activities would produce potential ecological impacts similar to facility operations, and therefore potential impacts would be SMALL.

4.2.5.4 Decommissioning Impacts to Ecological Resources

Impacts from decommissioning would, in part, be similar to those discussed for construction of the facility. However, these impacts would be temporary (12–18 months) and reduce with time

as decommissioning and reclamation proceed. The removal of piping would impact vegetation that has reestablished itself. Wildlife could come in conflict with heavy equipment. During decommissioning, reclamation activities would revegetate previously disturbed areas and restore streams and drainages to their preconstruction contours. It is expected that temporarily displaced wildlife would return to the area once decommissioning and reclamation are completed. As a result, the potential impacts to ecological resources during decommissioning would be expected to be SMALL.

Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted (contaminated) areas would be appropriately characterized and remediated, as necessary, in accordance with NRC regulations. Because of the NRC review of site-specific conditions prior to approval, the routine monitoring program, and the inclusion of irrigated areas in decommissioning surveys, the impacts from land application of treated wastewater would be SMALL.

4.2.6 Air Quality Impacts

In general, ISL milling facilities are not major nonradiological air emission sources, and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

These conditions apply to activities conducted as part of all four phases of the ISL facility lifecycle: construction, operation, aquifer restoration, and decommissioning. Therefore, a general discussion is presented here with appropriate details provided in the impact analyses for these activities. These conditions reflect the fact that determining the significance of ISL milling facilities' impacts on air quality depends on the emission levels of the proposed action and the existing air quality in the defined region of influence. The GEIS significance assessment is a general one. Site-specific environmental reviews would be conducted that account for the local affected environment and the specific action proposed. Complying with requirements imposed for the protection of the environment is one of the factors identified in the National Environmental Policy Act regulations for determining impact significance (see 40 CFR 1508.27). Actions where the region of influence includes NAAQS nonattainment or maintenance areas typically would generate more scrutiny in the permitting process. Because of the existing air quality condition in these areas, any activity generating gaseous emissions could potentially create impacts to air quality that could be classified as MODERATE or LARGE. Classification as a major source under any permit program indicates facility emission levels warrant analyses to determine whether impacts would be at the MODERATE or LARGE level.

The area within the Wyoming West Uranium Milling Region is classified as attainment for NAAQS (see Figure 3.2-15). This also includes the counties immediately surrounding this region. The Wyoming West Uranium Milling region does not include any Prevention of Significant Deterioration Class I areas (see Figure 3.2-16). Therefore, the less stringent Class II area allowable increments apply.

Regulatory thresholds, compliance status, and Prevention of Significant Deterioration classifications can change over time. Any site-specific environmental review should determine whether any regulatory thresholds or classification designations presented in this GEIS have changed. The air quality impacts analyzed in Section 4.2.6 only cover nonradiological emissions. Radiological emissions and dose information are addressed in the public and occupational health and safety impacts analyses in Section 4.2.11.

4.2.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration during the construction phase and result in SMALL, short-term effects.

For the purposes of evaluating potential impacts to air quality for a large, commercial-scale ISL facility, Table 2.7-2 contains the annual total releases and average air concentrations of particulate (fugitive dust) and gaseous (diesel combustion products) emissions estimated for the construction phase of the ISL facility proposed for Crownpoint, New Mexico, as documented in NRC (1997). These emission levels are below the major source threshold for NAAQS attainment areas. The annual average particulate (fugitive dust) concentration was estimated to be 0.28 $\mu g/m^3$ [8×10^{-9} oz/yd^3] (NRC, 1997). However, this estimate did not categorize the particulates as PM_{10} or $PM_{2.5}$. This estimate is under 2 percent of the federal $PM_{2.5}$ ambient air standard, under 1 percent of the previous federal and current Wyoming PM_{10} ambient air standard, and under 2 percent of the Class II Prevention of Significant Deterioration allowable increment. The annual average sulfur dioxide concentration was estimated to be 0.18 $\mu g/m^3$ [5×10^{-9} oz/yd^3] (NRC, 1997). This estimate is less than 1 percent of both the federal and more restrictive Wyoming ambient air standard and less than 1 percent of the Class II Prevention of Significant Deterioration allowable increment. Finally, the annual average nitrogen oxide concentration was estimated to be 2.1 $\mu g/m^3$ [5.8×10^{-8} oz/yd^3] (NRC, 1997). This estimate is slightly over 2 percent of the federal and Wyoming ambient air standard and less than 9 percent of the Class II Prevention of Significant Deterioration allowable increment.

In general, ISL facilities use best management practices to reduce fugitive dust and emissions (e.g., wetting of dirt roads and cleared land areas to suppress fugitive dust emissions). Table 7.4-1 provides a list of potential best management practices and management actions for various resources including air quality.

The Wyoming West Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility would be expected to comply with applicable regulatory limits and restrictions (Section 3.2.6.2). Therefore, construction impacts to air quality from ISL facilities would be SMALL.

4.2.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous

effluents during resin transfer or elution. These gases come from two sources: (1) the liquefied gases such as oxygen and carbon dioxide used in the lixiviant that come out of solution and (2) gases in the underground environment that are mobilized. The greatest concern from venting the well pipeline system is the release of naturally occurring radon gas. Radon release impacts are addressed in the public and occupational health and safety impacts analyses in Section 4.2.11. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution would be rapidly dispersed in the atmosphere and would be SMALL, primarily due to the low volume of effluent produced.

Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. Multihearth dryers operate at relatively high temperatures and produce combustion products that are typically scrubbed before they are released into the atmosphere. Vacuum driers basically release no gaseous effluents other than water vapor (Section 2.4.2.3). The greatest air quality concern for yellowcake drying is the release of uranium particles. This concern is addressed in the public and occupational health and safety impacts analyses in Section 4.2.11. In general, nonradiological emissions from yellowcake drying would be SMALL and reduced further by required filtration systems [e.g., high-efficiency particulate air (HEPA) filters].

Other potential operation phase nonradiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified earlier for activities related to construction. ISL operations phase fugitive dust emissions sources include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions associated with well field construction. Therefore, operations phase impacts would be expected to be less than the construction phase impacts.

The Wyoming West Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts to air quality from ISL facilities would be SMALL. If impacts were assessed at a higher level, permit conditions would be expected to impose conditions or mitigation to reduce impacts.

4.2.6.3 Aquifer Restoration Impacts to Air Quality

Potential aquifer restoration phase nonradiological air impacts include fugitive dust and vehicle emissions from many of the same sources identified earlier in the operations phase. The plugging and abandonment of production and injection wells use equipment that generates gaseous emissions. These emissions would be expected to be limited in duration and result in small, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not be expected to exceed those of the construction phase. Therefore, aquifer restoration phase impacts to air quality would be SMALL.

4.2.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase air quality impacts would include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified earlier in the

construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Potential impacts from decommissioning activities would be expected to be similar to construction phase impacts and would decrease as decommissioning proceeds. Therefore, decommissioning phase impacts to air quality would be expected to be SMALL.

4.2.7 Noise Impacts

4.2.7.1 Construction Impacts to Noise

It is anticipated that because of the use of heavy equipment (e.g., bulldozers, graders, drill rigs, compressors), potential noise impacts would be greatest when an ISL facility is being built, especially for new ISL facilities developed in rural, previously undeveloped areas, because the baseline noise levels are likely to be lower for these areas than for more developed settings such as existing uranium recovery facilities, urban environments, or near highways (Section 3.3.7). For this reason, the analysis presented here considers impacts compared to typical background noise in rural, undeveloped areas.

Standard construction techniques using appropriate heavy equipment would be used to build well fields and buildings and to grade access roads for a new ISL facility (Section 2.3). Drill rigs, construction vehicles, heavy trucks, bulldozers, and other equipment used to construct and operate the well fields, drill the wells, develop the necessary access roads, and build the production facilities would generate noise that would be audible above the undisturbed background levels (NRC, 1997; Reinke, 2005; Washington State Department of Transportation, 2006; Spencer and Kovalchik, 2007). Representative noise ranges at 15 m [50 ft] are presented in Table 4.2-1.

Table 4.2-1. Average Noise Levels at 15 m [50 ft] From Representative Construction Heavy Equipment

Equipment*	Noise Level (dBA)
Heavy Truck	82–96
Bulldozer†	92–109
Grader	79–93
Excavator	81–97
Crane	74–89
Concrete Mixer	75–88
Compressor	73–88
Backhoe	72–90
Front Loader	72–90
Generator	71–82
Jackhammer/Rock Drill	75–99
Pump	68–80

*Washington State Department of Transportation. "WSDOT's Guidance for Addressing Noise Impacts in Biological Assessments—Noise Impacts." Seattle, Washington: Washington State Department of Transportation. November 2006. <http://www.wsdot.wa.gov/TA/Operations/Environmental/NoiseChapter011906.pdf> (9 October 2007).
†Spencer, E. and P. Kovalchik. "Heavy Construction Equipment Noise Study Using Dosimetry and Time-Motion Studies." *Noise Control Engineering Journal.* Vol. 55. pp. 408–416. 2007.

Initial construction of larger surface facilities such as a central processing facility would be completed early in the project, but because of the staged nature of uranium ISL facilities, construction activities would be expected to continue throughout the life of the project as well as when fields are developed and brought into production.

The Occupational Safety and Health Administration current permissible exposure limit for workplace noise is 90 dBA for a duration of 8 hours per day (29 CFR 1910.95). Employers are required to have hearing conservation programs in all workplaces where noise levels equal or exceed 85 dBA as an 8-hour time-weighted average—the recommended exposure limit for noise established by the National Institute for Occupational Safety and Health (1998). A similar level is used by the Mine Safety and Health Administration (Bauer and Kohler, 2000). In all cases, higher exposure levels are permissible, but only if the exposure time is shortened. Depending on the type of construction and the equipment being used, noise levels (other than occasional instantaneous levels) resulting from construction activities might reach or occasionally exceed 85 dBA at 15 m [50 ft] from the source (Table 4.2-1). Personal hearing protection would be required for workers in these areas.

Noise levels lessen with distance from the source (Golden, et al., 1979). Noise from a line source like a highway is reduced by about 3 dB per doubling of distance. For example, road noise at 15 m [49 ft] from a highway is reduced by 3 dB at 30 m [98 ft] and further reduced by an additional 3 dB at 60 m [197 ft]. For point sources like compressors and pumps, the reduction factor with distance is greater at about 6 dB per doubling of distance. During construction, noise levels associated with a typical water well drill rig may exceed 100 dBA within 2 m [7 ft] of the compressor, but quickly drop to less than 90 dBA within 6 m [20 ft] (Figure 4.2-1). The U.S. Department of Energy (DOE) calculated that in an arid environment similar to that in the Wyoming West Uranium Milling Region, sound levels as high as 132 dBA will taper off to the lower limit of human hearing (20 dBA) at a distance of 6 km [3.7 mi] (DOE, 2007, Section 4.1.9.1). The presence of vegetation and topography between the noise-generating activity and the receptor reduces noise levels even more (Washington State Department of Transportation, 2006; Federal Highway Administration, 1995).

Noise resulting from construction activities could occasionally be annoying to residents within 300 m [1,000 ft] of the noise sources, particularly during the night (Figure 4.2-2). Traffic associated with construction activities for an ISL facility would include workers commuting to and from the jobsite, as well as relocation of construction equipment to different parts of the project. This might affect small communities located along existing roads. Because well field and facility construction activities would generally occur during daytime hours (see Section 2.7), related noise would not be expected to exceed the 24-hour average sound-energy guideline of 70 dBA EPA (1978) determined to protect hearing with a margin of safety.

Residents or users of multiuse facilities such as churches or community centers located less than 300 m [1,000 ft] from construction activities might experience outdoor noise levels greater than 70 dBA. This exceeds 55 dBA, the level EPA (1978) gives as protective against activity interference and annoyance with a margin of safety. Indoor noise levels typically range from 15 to 25 dBA lower than outdoor levels, depending on whether windows are open or closed. With windows open during construction hours, indoor noise levels could be substantially greater than the 45 dBA level EPA (1978) gives as protective against indoor interference and annoyance with a margin of safety. In both cases, however, at distances greater than 300 m [1,000 ft] from ongoing construction activities, potential noise impacts will be small. Elevated

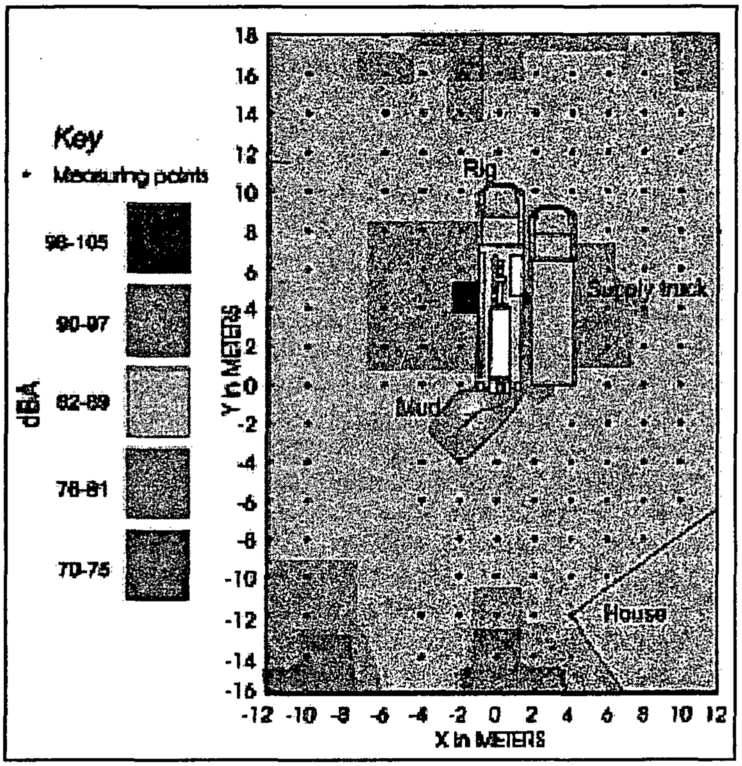

Figure 4.2-1. Sound Levels Around a Typical Water Well Work Site (From Reinke, 2005) [1 m = 3.28 ft]

noise levels associated with construction activities could affect wildlife behavior (Federal Highway Administration, 2004; Brattstrom and Bondello, 1983; BLM, 2008). For example, continuous elevated noise levels may reduce the breeding success of sage grouse near equipment by making it more difficult for the female sage hens to locate and respond to the vocalizations of the male leks (BLM, 2008; Holloran, 2005) (see Section 4.2.5.1).

The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, construction activities and associated traffic would have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities.

Construction worker hearing would be protected by compliance with Occupational Safety and Health Administration noise regulations. During construction, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

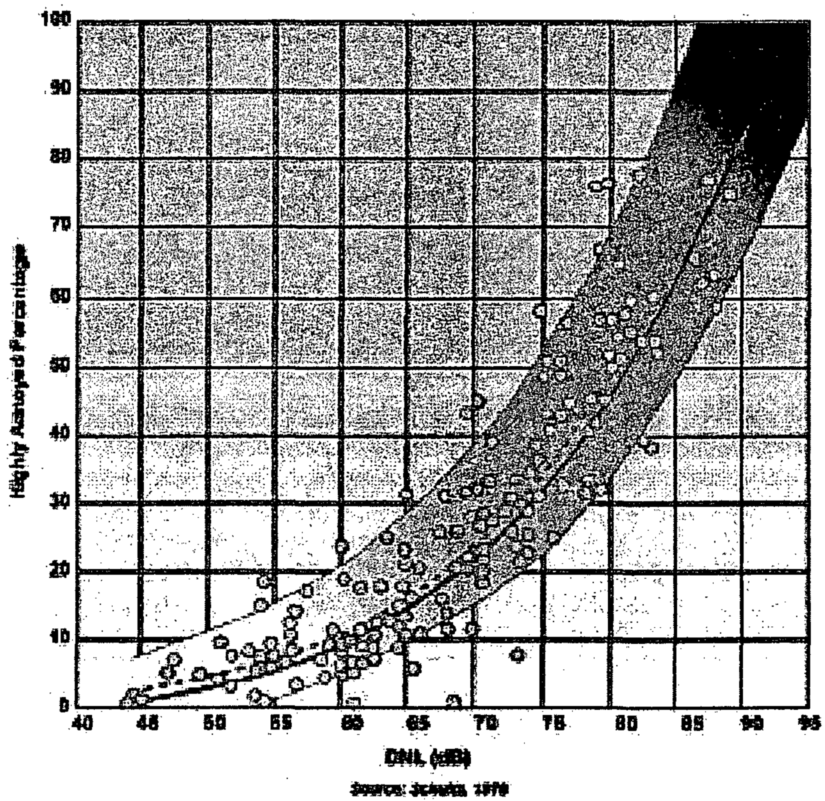

Figure 4.2-2. Community Surveys of Noise Annoyance (From U.S. Air Force, 2007, After Schultz, 1978). DNL is the Day-Night Average Sound Level—a Way To Account for the Fact That Noise Tends To Be More Intrusive at Night Than During the Day. Calculating the DNL Involves Adding a 10-dB Penalty to the 24-Hour Average Sound Level for Those Noise Events That Occur at a Given Location After 10:00 p.m. and Before 7:00 a.m.

4.2.7.2 Operation Impacts to Noise

Except for heavy truck traffic associated with the operation, operations at ISL uranium recovery facilities generally do not create important sources of noise for offsite receptors. In the well fields, the only noise sources would be the groundwater pumps and occasional truck traffic required to perform maintenance and inspections. For operations, heavy truck traffic associated with transporting uranium-loaded resins to the central processing facility and shipments of yellowcake would also result in short-term noise (see Section 4.2.2.2). Depending on traffic, the sound levels near heavily traveled highways might reach as high as 85 dBA or more, depending on the speed limits and amount of heavy truck traffic (Washington State Department of Transportation, 2006). Compared to daily traffic counts of 12,400 vehicles per day on Interstate-80 (Wyoming Department of Transportation, 2005; see also Section 3.2.2), additional traffic associated with ISL operations would have only a SMALL impact on noise levels near the

highway. As noted in Section 4.2.7.1, noise levels at 78 dBA at 30 m [98 ft] would decrease with distance from the highway, reaching levels of 60 dBA or less within about 360 m [1,180 ft] (Washington State Department of Transportation, 2006). Some country roads with the lowest average annual daily traffic counts would be expected to have higher relative increases in traffic and noise impacts, especially when facilities are experiencing peak employment. These impacts would be MODERATE.

Operational noises at an ISL facility would be typical of an industrial facility. Noise would be generated by trucks, pumps, generators, and other heavy equipment used around the mill site. This noise would likely be less than that generated during construction, but the production facilities would still generate noise that would be audible above the undisturbed background levels of 50–60 dBA (see Table 4.2-1). Administrative and engineering controls would be used to ensure that noise levels meet Occupational Safety and Health Administration exposure limits (29 CFR 1910.95). Personal hearing protection would be used for those working in areas that exceed these noise levels.

Noise from operations within the milling facility would be reduced outside of the buildings, but noise resulting from operations could occasionally be annoying to nearby residents, particularly during the night (see Section 4.2.7.1).

Overall, because most activities will be conducted inside buildings, potential noise impacts during ISL operations are anticipated to be less than those during construction. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, operations activities and associated traffic would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During operations, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Compared to existing traffic counts, truck traffic associated with yellowcake and chemical shipments and traffic noise related to commuting would have a SMALL, temporary impact on communities located along the existing roads. Therefore, overall noise impacts during operations would be SMALL.

4.2.7.3 Aquifer Restoration Impacts to Noise

General noise levels during aquifer restoration would be expected to be similar to or less than those during the operational period, and workplace noise exposure would be managed using the same administrative and engineering controls. In the well fields, the greatest source of temporary noise would be from equipment used during plugging and abandonment of production and injection wells. Cement mixers, compressors, and pumps would potentially be the largest contributors to noise (see Table 4.2-1) but would be operated only for a relatively short daytime duration. Potential noise impacts during aquifer restoration would be expected to be less than those during construction (see Section 4.2.7.1) and of short duration. Aquifer restoration activities may, however, continue over much of the life of the project as uranium recovery operations are completed in different well fields. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, aquifer restoration activities and associated traffic would have only SMALL and temporary noise

impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during aquifer restoration would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during the aquifer restoration period would be SMALL to MODERATE.

4.2.7.4 Decommissioning Impacts to Noise

General noise levels during decommissioning and reclamation would be expected to be similar to or less than those during the construction period, and workplace noise exposure would be managed using the same administrative and engineering controls (see Section 4.2.7.1). As with construction impacts, the anticipated noise impacts from decommissioning activities would be expected to be greatest for an ISL facility in a rural, previously undeveloped area. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, decommissioning activities and associated traffic would be expected to have only SMALL and short-term noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities. Noise impacts to workers during decommissioning would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. Equipment used to dismantle buildings and milling equipment, remove any contaminated soils, or grade the surface as part of reclamation activities would generate noise levels that would exceed the background (see Table 4.2-1). These noise levels would be temporary, and once decommissioning and reclamation activities were complete, noise levels would return to baseline, with occasional vehicle traffic for any longer term monitoring activities. Therefore, overall noise impacts from the decommissioning and reclamation activities would be SMALL.

4.2.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Wyoming West Uranium Milling Region is provided in Section 3.2.8 of this GEIS. Construction involving land disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, are the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, licensees and applicants review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area and all its related facilities and components are subjected to a comprehensive cultural resources inventory (performed by the licensee) that meets the requirements of responsible federal, state, and local agencies [e.g., the Wyoming State Historic Preservation Office (SHPO)]. The literature and records searches will help identify known or potential cultural resources and Native American sites and features. The cultural resources inventory will identify the previously documented sites and any newly identified cultural resources sites. The eligibility evaluation of cultural resources for listing in the National Register of Historic Places (NRHP)

under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties is conducted as part of the site-specific review and NRC licensing procedures undertaken during the National Environmental Policy Act (NEPA) review process. Long linear features such as the Bozeman National Historic Trail in the Wyoming East Uranium Milling Regions require detailed assessment of potential construction and operation impacts. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties also occur during the site-specific licensing application and review process. Consultation to determine whether significant cultural resources would be avoided or mitigated occurs during state SHPO, agency, and tribal consultations as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.2.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible or potentially NRHP-eligible historic properties and traditional cultural properties, both direct and indirect, will likely occur during land-disturbing activities related to building an ISL uranium recovery facility. Buried cultural features and deposits that were not visible on the surface during initial cultural resources inventories might also be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions, increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL facility.

Because of the localized nature of land-disturbing activities related to construction, impacts to cultural and historical resources are anticipated to be SMALL, unless the facility is located adjacent to a known resource. Wyoming historical sites listed in the NRHP and traditional cultural properties are provided in Section 3.2.8.4. In addition, the Wind River Indian Reservation is located in the northwest corner of the Wyoming West Uranium Milling Region. Based on current information, the potential ISL facility closest to the Wind River Indian Reservation is about 16 km [10 mi] away at Sand Draw. Proposed facilities or expansions adjacent to an ISL facility would be likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording, and archiving samples) and additional (NRC) consultations with the Wyoming SHPO and affected Native American tribes would be needed to reduce the impacts. From the standpoint of cultural resources, the most significant impacts to

sites that are present will occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impact to any cultural resources that might be present. Impacts would be expected to be SMALL, MODERATE, or LARGE, depending on the presence or absence of cultural and historical resources at a specific site.

4.2.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Impacts during operation are expected to occur through new earth-disturbing activities, new construction, maintenance, and repair.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations would be expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.2.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration would be expected to be less than those during construction, as aquifer restoration activities are generally limited to the existing infrastructure and previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.2.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties on or near the site of decommissioning activities may potentially occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during decommissioning. Overall impacts to cultural and historical resources during

decommissioning would be expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project activities. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.2.9 Visual/Scenic Resources Impacts

4.2.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Wyoming West Uranium Milling Region would result from well field development, when drilling rig masts contrast with the general topography. Visual impacts from facilities construction (e.g., drilling and land disturbance) would generally be temporary (short term), and visual impacts from buildings would be SMALL. Additional construction impacts would include dust that occurs during clearing for parking, access roads, well sites, storage pads, retention or evaporation ponds, monitoring wells, and piping. The potential visual and scenic impacts would be expected to be greatest for new ISL facilities developed in rural, previously undeveloped areas. This is because the baseline visual landscape is likely to be less disturbed for these areas than for more developed settings that may have existing uranium recovery facilities, may be located in urban environments, or may be located near highways. Therefore, in a previously undeveloped area, ISL construction would be expected to present more contrast with the existing landscape. For this reason, this analysis considers impacts compared to the typical baseline visual landscape for rural areas to be bounding.

Because of the number of wells that may be involved in an ISL operation, multiple drill rigs are likely to be operating during well field construction. For example, at the proposed Crownpoint ISL site, it was estimated that four or more drill rigs could be operating at each well field (NRC, 1997), and at the Smith Ranch ISL facility, drilling peaked during construction with 20 drill rigs in operation (Freeman and Stover, 1999). Because of limitations in deploying equipment, well fields at Crownpoint were estimated to be placed into production at about 2 ha [5 acres] at a time. This estimate suggests that drilling activities would affect only a small percentage of each project site at any one time. As an example of the duration of drilling activities, NRC (1997) estimated that drilling would typically be conducted 12 hours/day for more shallow deposits, but could be conducted 24 hours/day where the uranium deposit is deeper (NRC, 1997; Hydro Resources, Inc., 1995, 1993). For nighttime operation, the drill rigs would be lighted, and this would create a visual impact because the drill rigs would be most visible and provide the most contrast if they were located on elevated areas.

A typical truck-mounted rotary drill rig may be about 9–12 m [30–40 ft] tall (USACE, 2001). Once a well is completed and conditioned for use, the drill rig would be moved to a new location to drill the next hole. Because temperatures in the affected environment in the Wyoming West Uranium Milling Region drop below freezing during the winter, wellheads for completed wells would be covered to prevent freezing and protect the well. These covers would be low structures {1–2 m [3–6 ft] high} and present only a slight contrast with the existing landscape. Unless the topography is extremely flat and void of vegetation, it is likely that these structures would not be visible from distances on the order of 1 km [0.6 mi] or more. Actual boundaries of well fields and the number of wells would not be known until final preoperational exploration was

completed. Planned access roads, pipelines, and potential locations of retention ponds would also be uncertain within each well field.

Most visual and scenic impacts associated with earth-moving activities during construction would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.2.9, most of the areas in the affected environment of the Wyoming West Uranium Milling Region are identified as Visual Resource Management (VRM) Class II through Class IV according to the BLM classification system. This classification allows for an activity to contrast with basic elements of the characteristic landscape to a limited extent (VRM Class II) or to a much greater extent (VRM Class IV). Depending on the location of a proposed ISL facility relative to viewpoints such as highways, process facility construction and drill rigs could be visible. In the Wyoming West Uranium Milling Region, facilities located near the Class II areas surrounding the Wilderness Study Areas in the southwestern corners of the region or on the eastern border near the Class I Ferris Mountains Wilderness Study Area (see Figure 3.2-20) would be the most sensitive. These areas are not, however, closer than about 24 km [15 mi] to the current understanding of where potential uranium ISL facilities would be located (see Section 3.2.9). In addition, there are no Prevention of Significant Deterioration Class I areas located within the Wyoming West Uranium Milling Region. During construction of ISL well fields and facilities, mitigation through best management practices (e.g., dust suppression and coloration of well covers) would further reduce overall visual and scenic impacts of project construction so that total impacts would be SMALL.

4.2.9.2 Operation Impacts to Visual/Scenic Resources

An ISL facility in a previously undeveloped area would be expected to present more contrast with the existing landscape. The potential visual and scenic impacts from ISL operations in the Wyoming West Uranium Milling Region would be expected to be greatest for new facilities operating in rural, previously undeveloped areas. Existing uranium processing facilities or satellite facilities would constitute Class IV areas for visual resources, and operations in existing facilities are unlikely to produce additional contrast. For this reason, this analysis considers operational impacts to the visual landscape for rural areas to be bounding.

Most of the pipes and cables associated with well field operation are anticipated to be buried to protect them from freezing, and they will not be visible during operations. Because well fields would be phased into operation as uranium reserves are defined, there is generally not a large expanse of land undergoing development at one time (NRC, 1997). Because the location of uranium deposits is typically irregular, the network of pipes, wells, and power lines {6 m [20 ft] tall} would not be regular in pattern or appearance (i.e., not a grid), reducing visual contrast and associated potential impacts. The wellhead covers would be typically low {1–2 m [3–6 ft]} structures, and the overall visual impact of an operating well field would be SMALL.

Centralized processing plants, satellite facilities, and pump houses would be the main operational facilities affecting the visual landscape. Because of the rolling topography of most of the Wyoming West Uranium Milling Region, the visibility of aboveground infrastructure would vary, depending on the location of the observer, intervening topography, distance, and lighting considerations (NRC, 1997). The potential visual impacts would be greatest for facilities located near the Class II areas surrounding the Wilderness Study Areas in the southwestern corners of the region or on the eastern border near the Class I Ferris Mountains Wilderness Study Area (see Figure 3.2-18). However, these areas are more than 24 km [15 mi] from the closest

potential uranium ISL facility, based on current indications (see Section 3.2.9). Mitigation through best management practices (e.g., dust suppression) would further reduce overall visual and scenic impacts of operations so that total impacts would be SMALL.

4.2.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Aquifer restoration would not occur until after an ISL facility has been in operation for a number of years. Much of the same equipment (e.g., pumps and ion exchange columns) and infrastructure used during the operational period would be employed during aquifer restoration, so impacts to the visual landscape in the Wyoming West Uranium Milling Region would be expected to be similar or less than during operations. In the well fields, the greatest source of visual contrast would be from equipment used when production and injection wells are plugged and abandoned. Because there is no active drilling, potential visual impacts during aquifer restoration are anticipated to be less than those during construction (see Section 4.2.9.1) and of short duration. As with construction impacts, the anticipated impacts to the visual landscape from aquifer restoration activities would be expected to be greatest for new ISL facilities developed in rural, previously undeveloped areas or near the sensitive viewsheds identified in Section 3.2.9. These areas are more than 24 km [15 mi] from the closest potential uranium ISL facility, based on current indications (see Section 3.2.9). Mitigation through best management practices (e.g., dust suppression) would further reduce overall visual and scenic impacts of aquifer restoration so that total impacts would be SMALL.

4.2.9.4 Decommissioning Impacts to Visual/Scenic Resources

Once project operations are completed, all facilities would be decommissioned and removed. Reclamation efforts are intended to return the visual landscape to baseline contours and should result in reducing the impacts from operations and minimizing permanent impacts to visual resources. Before the NRC license is terminated, the licensee must submit an acceptable site reclamation plan according to 10 CFR Part 40. Recontouring disturbed surfaces (including access roads) and reseeding them with vegetation that can adapt to the climate and soil conditions will help return the facility to undisturbed conditions. The major limiting factor to establishing vegetation in the Wyoming West Uranium Milling Region would be available moisture. Timing of seeding is therefore critical and would generally be synchronized with periods of highest expected precipitation (April to June; see Section 3.2.6) to increase the likelihood that the vegetation would become established.

During decommissioning and reclamation, temporary impacts to the visual landscape would be expected to be similar to or less than those during the construction period (see Section 4.2.9.1). For example, equipment used to dismantle buildings and milling equipment, remove any contaminated soils, or grade the surface as part of reclamation activities would generate temporary visual contrasts. Overall impacts to the visual landscape would be expected to be SMALL and temporary; once decommissioning and reclamation activities were complete, the visual landscape would be returned to baseline with the potential exception of equipment related to longer term monitoring activities. Potential visual/scenic impacts would be greatest for facilities located near the Class I and Class II resource areas or the Wind River Indian Reservation, as described in Section 3.2.9, but based on current understanding, the closest potential uranium ISL would be located more than 24 km [15 mi] away. Mitigation through best management practices (e.g., dust suppression) would further reduce overall visual and scenic impacts of aquifer restoration so that total impacts would be SMALL.

4.2.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility could reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). In Wyoming, the workforce frequently commutes long distances to work, sometimes from out of state. For example, each of the counties in the Wyoming West Uranium Milling Region experienced net inflows during the fourth quarter of 2005, ranging from about 370 for Carbon County to 10,600 for Natrona, primarily for jobs related to the energy industry (Wyoming Workforce Development Council, 2007). Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Wyoming West Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in Wyoming is about 2.5 (U.S. Census Bureau, 2008), the number of people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.2.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Wyoming West Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Wyoming West Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Carbon County (population 15,600) and the towns of Jeffrey City (100) and Bairoil (100). However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure. Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Wyoming West Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities were developed concurrently, the potential for impact upon the labor force would still be SMALL. For example, Carbon County has the smallest labor force (7,744) in the region. It would require four ISL facilities to be constructed simultaneously to affect the labor market of Carbon County by more that 10 percent, if all the workers came from Carbon County. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Jeffrey City and Bairoil) and counties (Freemont) could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE, if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction is filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates, such as Laramie, Wyoming, due to the potential increase in job opportunities. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Communities such as Fremont County and the Northern Arapaho and Eastern Shoshone Tribes of the Wind River Indian Reservation would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. Though Wyoming does not have an income tax, it does have a state sales tax (4 percent), a lodging tax (2–5 percent), and a use tax (5 percent). Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, and more significant, is the "ad valorem tax" the state imposes on mineral extraction. In 2007 for uranium alone, the state collected $1.2 million from this tax (Wyoming Department of Revenue, 2008). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as they are already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL. Accidents resulting from construction of an ISL facility are not expected to be different than those from other types of similar industrial facilities.

4.2.10.2 Operational Impacts to Socioeconomics

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements is filled by a workforce from outside the region, assuming a multiplier of about 0.7 (see text box),

> **Economic Multipliers**
> The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 140, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region. However, because an outside workforce would be more likely to settle into a more populated area with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for, at least, the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7 economic multiplier) are required to relocate into the Wyoming West Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Lander and Riverton (within the region) and Rawlins (located just outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Wyoming West Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles.

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce would be SMALL to MODERATE relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Wyoming West Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 140 (including families), there would only be about 30 school-aged children involved. While the influx of new students would be the greatest in the smaller school districts, even in these districts the impacts are anticipated to be SMALL. For example, the city of Lander has one school district with 1,930 students (elementary through high school) in 12 schools. With an average of 160 students per school, even if all the ISL workers' children attended the same school (which is unlikely), the increase in that school's student population would be less than 20 percent.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.2.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.2.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar work force (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Wyoming West Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE.

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community.

Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus, would be considered SMALL.

4.2.11 Public and Occupational Health and Safety Impacts

4.2.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction activities involve building well fields, surface processing structures, and support roads (Section 2.3). Fugitive dust would result from construction activities and vehicle traffic but would likely be of short duration. For the Smith Ranch facility in Converse County, Wyoming (NRC, 2006), radiation measurements for soil show low levels of radionuclides. Therefore, inhalation of fugitive dust would not result in any significant radiological dose. Construction equipment would likely be diesel powered and would result in diesel exhaust, which includes small particles. The impacts from these emissions would be expected to be SMALL because the releases are usually of short duration and are readily dispersed into the atmosphere (Sections 2.7, 4.2.6.1). Construction would be expected to have a SMALL impact on the workers and general public.

4.2.11.2 Operation Impacts to Public and Occupational Health and Safety

4.2.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

Licensees are required to implement radiological monitoring and safety programs that comply with 10 CFR Part 20 requirements to protect the health and safety of workers and the public. NRC periodically inspects those programs to ensure compliance (Section 2.9).

Radionuclides can be released to the environment during ISL facility operation. As discussed in Section 2.7.1, radon gas is emitted from ISL well fields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology. Quarterly and biannual measurements of downwind concentrations of radon at an operational ISL facility boundary from 1991 to early 2007 were below 74 Bq/m^3 [2.0 pCi/L] with a majority of measurements below 37 Bq/m^3 [1 pCi/L] {an exception during the second half of 2003 where potentially anomalous results peaked at 137 Bq/m^3 [3.7 pCi/L]} (Crow Butte Resources, Inc., 2007). For comparison, these measured values are well below the NRC effluent limit for radon at 10 CFR Part 20, Appendix B of 370 Bq/m^3 [10 pCi/L].

Argonne National Laboratory developed the MILDOS-AREA computer code (Argonne National Laboratory, 1989) to calculate radiation doses to individuals and populations from releases occurring at operating uranium recovery facilities. The code is capable of modeling airborne radiological effluent releases applicable to ISL facilities (Section 2.7.1) including radon gas from well fields and processing facilities and yellowcake particulates from thermal drying operations, were applicable. MILDOS-AREA considers a variety of environmental pathways: external and inhalation and ingestion of soil, plants, meat, milk, aquatic foods, and water. Because a vacuum dryer system is assumed, the only releases are radon. MILDOS-AREA uses a sector-average Gaussian plume dispersion model to estimate downwind concentrations which assume the concentration is the same across the width of the sector. Historical environmental impact statements and environmental assessments were reviewed to provide a range of estimated offsite doses from various ISL facilities that are either currently active or were active in the past.

For the purposes of assessing doses to the general public from an ISL facility, annual estimated doses to offsite individuals are shown for various facilities in Table 4.2-2. This table also shows a descriptor of the location of the receptor as shown in the referenced report. Calculated doses in Table 4.2-2 are solely for radon releases for all sites listed except the Christensen Ranch and Irigaray sits that include radon and uranium particulate releases from drying operations. The remaining sites listed in Table 4.2-2 that have no yellowcake emissions use vacuum dryer technology or are satellite well fields that do not involve drying operations. The highest dose was reported for Reynolds Ranch in Converse County, Wyoming, but was for a potential receptor at an unoccupied house. All doses reported are well within the 10 CFR Part 20 annual radiation dose limit for the public of 1 mSv [100 mrem/yr] and within the EPA fuel cycle annual limit of 0.25 mSv [25 mrem], which does not include dose due to radon and its progeny. The dose received by the offsite individual is directly proportional to the amount of radioactive material released from the ISL facility. Variations in the size of the facility, the number of well fields in operation and restoration at any one time, and the facility processing flow rates can affect the dose. Downwind dose also decreases as a function of distance as discussed in Section 2.7.1. While receptor distances were not provided for all locations, doses could be

Table 4.2-2. Dose to Offsite Receptors From *In-Situ* Leach Facilities

Facility	Offsite Maximum Dose (mSv/mrem)	Description of Receptor	Reference
Crow Butte	0.317/31.7	0.4 km [0.25 mi] northeast of Central Plant site	Crow Butte Resources, Inc.*
Crow Butte	0.058/5.8	Closest resident downwind of North Trend Satellite Plant	Crow Butte Resources, Inc.*
Smith Ranch/ Sunquest Ranch	0.175/17.5	Nearest resident	NRC, 2007†
Smith Ranch/ Vollman Ranch	0.135/13.5	Nearest resident	NRC, 2007†
Reynolds Ranch	0.04/4	Nearest resident at Reynolds Ranch	NRC, 2006‡
Reynolds Ranch	0.27/27	Unoccupied Mason House	NRC, 2006‡
Gas Hills	0.07/7	Hypothetical individual on eastern boundary	NRC, 2004§
Christensen Ranch	0.006/0.6	Adult nearest resident	NRC, 1998‖
Irigaray	0.004/0.4	Adult nearest resident	NRC, 1998‖

*Crow Butte Resources, Inc. "License Renewal Application: SUA–1534." Crawford, Nebraska: Crow Butte Resources, Inc. 2007.
†NRC. "Environmental Assessment Construction and Operation of *In-Situ* Leach SR–2 Amendment No. 12 to Source Materials License No. SUA–1548 Power Resources, Inc. Smith Ranch-Highland Uranium Project (SR_HUP) Converse County, Wyoming." Docket No. 40-8964. Washington, DC: NRC. 2007.
‡NRC. "Environmental Assessment for the Addition of the Reynolds Ranch Mining Area to Power Resources, Inc.'s Smith Ranch/Highlands Uranium Project Converse County, Wyoming." Source Material License No. SUA–1548. Docket No. 40-8964. Washington, DC: NRC. 2006.
§NRC. "Environmental Assessment for the Operation of the Gas Hills Project Satellite *In-Situ* Leach Uranium Recovery Facility." Docket No. 40-8857. Washington, DC: NRC. 2004.
‖NRC. "Environmental Assessment for Renewal of Source Material License No. SUA–1341. Docket No. 40-8502. Washington, DC: NRC. 1998.

expected to decrease as the receptor becomes further away from the source. Because of the distance to offsite receptors, radiological doses from normal operations are expected to have a SMALL impact on the general public.

It is expected that worker doses from ISL facilities would be similar regardless of the facility's location. This is because workers are expected to be involved in similar activities regardless of geographic location. As an example of dose to workers, the license renewal application for the Crow Butte ISL facility in Davis County, Nebraska (Crow Butte Resources, Inc., 2007), reports the average individual total effective dose equivalents for monitored employees for 1994–2006. This facility is assumed to be representative of an operating u0ranium recovery facility using ISL methods because it is a commercial facility with many years of operating history. The largest annual average dose during the time period was 7.00 mSv [700.0 mrem] in 1997. More recently, the maximum total effective dose equivalents were reported for 2005 and 2006 as 6.75 and 7.13 mSv [675 and 713 mrem], respectively. These doses represent 15 and 14 percent of the annual dose limit for workers of 0.05 Sv [5 rem], respectively.

As part of the Crow Butte ISL facility's license renewal application (Crow Butte Resources, Inc., 2007), average individual exposure levels for radon daughter products are provided for 1994–2006. Exposure to radon daughters is reported as working-level months, which is a unit commonly used in occupational environments and refers to exposure to a set concentration of radon and its associated progeny. The annual occupational exposure limit is 4 working-level months. Maximum individual internal exposure for radon daughters was 0.643 working-level months in 1997. Maximum values ranged from 0.213 working-level months to 0.643 for the entire 13-year period. Averages ranged from 0.101 working-level months to 0.467 working-level months for the period with the maximum of the averages occurring in 1997. Because these average and maximum exposure levels range from 2.5 to 16 percent of the occupational exposure limit of 4 working-level months, doses from normal radon releases would be expected to have a SMALL impact on the workers.

4.2.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

A radiological hazards assessment was performed by Mackin, et al. (2001) that considered the various stages within the ISL process. Consequences from accident scenarios were conservatively modeled and if the analyses revealed sufficiently small consequences, no further assessment was needed. If consequences were greater than regulatory limits, mitigating actions were explored. Likelihood of the accidents was not discussed.

Thickeners are used to concentrate the yellowcake slurry before it is transferred to the dryer as discussed in Section 2.4.2.3. Radionuclides could be inadvertently released to the atmosphere through a thickener failure and spill. For the purposes of the analysis, Mackin, et al. (2001) assumed a tank failure or pipe break that caused the tank contents to spill, with 20 percent of the thickener content being spilled inside and outside the building. Mackin, et al. (2001) analyzed this scenario for a variety of wind speeds, stability classes, release durations and receptor distances. For receptor distances of 100 and 500 m [330 and 1,600 ft] doses from such spills were calculated to be 0.25 and less than 0.01 mSv [25 and 1 mrem], respectively. Both of these are less than 25 percent of the 10 CFR Part 20 annual dose limit for the public of 1 mSv [100 mrem]. Because dose estimates increase for closer distances, smaller consequences would be expected to members of the public in urban developments. There could be external doses from the spill to workers, but offsite individuals would be too far away to

observe any effects. Doses to the unprotected worker could exceed the 0.05 Sv [5 rem] annual dose limit specified in 10 CFR Part 20 if workers did not evacuate the area soon enough after the accident. ISL facilities are designed to contain controls to possibly reduce the exposure to individuals in the event of an accident, and spills or leaks would normally be detected by loss of system pressure, observation, or flow imbalance. Operating procedures are developed for spill response. Air samples are also routinely collected and action levels are set at 25 percent of limits so that samples can be taken more frequently and investigations can be undertaken.

Radon-222 released to the air, especially in an enclosed area without adequate ventilation, presents a potential hazard. A pipe or valve failure at the ion-exchange columns used in ISL processing facilities could be a source for such a hazard (Mackin, et al., 2001). Dose calculations were performed assuming the highest radon-222 concentration {3×10^4 Bq/L [8×10^5 pCi/L]} that was reported inside a uranium recovery facility, and all the radon-222 contained within the pregnant lixiviant was assumed to be instantaneously released into the facility. For a 30-minute exposure, doses to a worker within the building performing light activity without respiratory protection was 1.3×10^{-2} Sv [1.3 rem], which is 26 percent of the 0.05 Sv [5 rem] annual dose limit specified in 10 CFR Part 20. Mackin, et al. (2001) did not calculate doses to offsite individuals for this scenario. Even though radon concentration within the facility could be high if such a scenario occurred, only a small amount would be released to the environment to potentially expose a member of the public 500 m [1,640 ft] away, because not much radon is expected to leave the building. ISL facilities are designed to contain controls to possibly reduce the exposure to individuals in the event of an accident. Air samples are also routinely collected, and action levels are set at 25 percent of limits so that samples can be taken more frequently and investigations can be undertaken.

Dryers used to turn wet yellowcake into dry powder present another potential hazard at an ISL facility (NRC, 1980). The two main types of dryers used are multihearth dryers for the older facilities and rotary vacuum dryers for the new facilities. The multihearth dryers are assumed to be more hazardous than the rotary vacuum dryers because they operate at higher temperatures and may be direct gas-fired. An explosion in the dryer could disperse yellowcake into the central processing facility. Using a conservative assumption about the amount released {1 kg [2.2 lb]} and the fraction respirable (100 percent), the dose to offsite individuals at 200 m [656 ft] was below the 10 CFR Part 20 public dose limit of 1 mSv [100 mrem]. The analyses also showed that dose to a worker in a full-face-piece powered air-purifying respirator would result in a dose of 0.088 Sv [8.8 rem], which would exceed the annual worker dose limit of 0.05 Sv [5 rem] by 76 percent. ISL facilities are designed to contain controls to possibly reduce the exposure to individuals in the event of an accident. Emergency response procedures would be in place to direct employees what to do in the event of an accident. As part of worker protection, respiratory protection programs would be in place.

In the unlikely event of an unmitigated accident, doses to the workers could have a MODERATE impact depending on the type of accident, but doses to the general public would have only a SMALL impact.

In addition to the mitigation items discussed after each accident, additional measures would be in place to protect workers and members of the public. Employee personnel dosimetry programs are required. As part of worker protection, respiratory protection programs are in place as well as bioassay programs that detect uranium intake in employees. Contamination control programs involve surveying personnel, clothing, and equipment prior to their removal to an unrestricted area.

4.2.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), small risks would be expected in the use and handling of these chemicals during normal operations at ISL facilities. However, accidental releases of these hazardous chemicals can produce significant consequences and impact public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.2.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

ISL facilities use hazardous chemicals to extract uranium, process wastewater, and restore groundwater quality. As described in Section 2.4.2 and shown in Table 2.11-2, the following 11 hazardous chemicals are typically used at ISL facilities in the largest quantities:

- Ammonia
- Sodium hydroxide
- Sulfuric acid
- Hydrochloric acid
- Oxygen
- Hydrogen peroxide
- Carbon dioxide
- Sodium carbonate
- Sodium chloride
- Hydrogen sulfide
- Sodium sulfide

If released, these chemicals could pose significant hazards to public and occupational health and safety. As with other industrial operations, releases of hazardous chemicals of sufficient magnitude to adversely impact public and occupational health and safety are possible, but are generally considered unlikely, given commonly applied safety practices and the history of safe use of these chemicals at NRC-regulated ISL facilities.

An accident analysis for each of these chemicals is provided in Appendix E. As shown in the accident analyses, chemicals commonly used at ISL facilities can pose a serious safety hazard if not properly handled. In addition, strong bases such as ammonia (NH_3) and sodium hydroxide (NaOH) and strong acids such as sulfuric acid (H_2SO_4) and hydrochloric acid (HCl) will strongly react with each other, and with water, if accidentally mixed. During operations, precautions are taken to ensure that these chemicals do not inadvertently come into contact with each other. Oxidizers such as hydrogen peroxide (H_2O_2) and oxygen (O_2) also can react strongly with natural gas (piped to the ISL facility) should a spark or ignition source be present.

Potential hazards to workers or the public due to specific types of high consequence, low probability accidents (e.g., a fire or large magnitude sudden release of chemicals from a major tank or piping system rupture) are not specifically analyzed in Appendix E. The application of common safety practices for handling and use of chemicals is expected to lower the likelihood of these severe release events and therefore lower the risk to acceptable levels. The use of

hazardous chemicals at ISL facilities is not regulated by NRC, but rather by government agencies such as the Mine Safety and Health Administration, the Occupational Safety and Health Administration, and EPA.

Standards for handling and managing hazardous chemicals in the workplace have been developed by relevant regulatory agencies and industries. NRC's authority does not include developing, modifying, or critiquing these standards. Nonetheless, NRC inspectors of ISL facilities report any concerns about the use of hazardous chemicals to these agencies. The standards generally apply to all types of facilities including uranium ISL facilities. Specific quantities or uses of chemicals that require certain controls, procedures, or safety measures are defined in these standards. Key aspects of five applicable regulations are presented here:

- 40 CFR Part 68, Chemical Accident Prevention Provisions. This regulation lists regulated toxic substances and threshold quantities for accidental release prevention.

- 29 CFR 1910.119, Occupational Safety and Health Administration Standards—Process Safety Management of Highly Hazardous Chemicals. This regulation lists highly hazardous chemicals and toxic and reactive substances (chemicals that can potentially cause a catastrophic event at or above the threshold quantity).

- 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response. This regulation instructs employers to develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program shall be designed to identify, evaluate, and control safety and health hazards and provide for emergency response for hazardous waste operations.

- 40 CFR Part 355, Emergency Planning and Notification. This regulation lists extremely hazardous substances and their threshold planning quantities so that emergency response plans can be developed and implemented. There are about 360 extremely hazardous substances. Over a third of them are also Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) hazardous substances. This regulation also lists reportable quantity values for these substances for reporting releases. The reportable quantities are for any CERCLA hazardous substances identified in 40 CFR Part 302, Table 302.4.

- 40 CFR 302.4, Designation, Reportable Quantities, and Notification—Designation of Hazardous Substances. This regulation lists CERCLA hazardous substances. There are approximately 800 of these substances, and they are compiled from the (1) Clean Water Act, Sections 311 and 307(a); (2) Clean Air Act, Section 112; (3) Resource Conservation and Recovery Act, Section 3001; and (4) Toxic Substance Control Act, Section 7.

Requirements from these regulations for the chemicals in use at uranium ISL facilities are summarized in Table 4.2-3. Comparing these requirements with typical onsite quantities shown in Table 2.10.3 indicates there is a potential that some of the chemicals may exceed the minimum reporting quantities in Table 4.2-3. This would trigger an increased level of regulatory oversight regarding possession, storage, use, and subsequent disposal of these chemicals. Compliance with the necessary requirements (see Appendix E) would reduce the likelihood of a

release. Offsite impacts would be SMALL, while impacts to workers involved in response and cleanup could receive MODERATE impacts that would be mitigated by establishing procedures and training requirements.

4.2.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Because the activities during aquifer restoration overlap with similar operational activities (e.g., operation of well fields, wastewater treatment and disposal), the types of impacts on public and occupational health and safety are expected to be similar to operational impacts. The reduction of some operational activities (e.g., yellowcake production and drying, remote ion exchange) further limits the relative magnitude of potential worker and public health and safety hazards. Therefore, aquifer restoration is expected to have a SMALL impact on workers (primarily from radon gas) and the general public.

Table 4.2-3. Pertinent Regulations for Chemicals Used at *In*-Situ Leach Facilities

Chemical	Regulations	Minimum Reporting
Ammonia (NH_3)	Threshold Quantity from Clean Air Act for 40 CFR Part 68 Risk Management Planning	4,536 kg [10,000 lb]
	Threshold Quantity for Occupational Safety and Health Administration (OSHA) 29 CFR 1910.119 Process Safety Management	4,536 kg [10,000 lb]
	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans	227 kg [500 lb]
	Reportable Quantity for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) from 40 CFR 302.4	45.4 kg [100 lb]
Sulfuric Acid (H_2SO_4)	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans	454 kg [1,000 lb]
Hydrogen Peroxide (H_2O_2)	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans (concentration >52%)	454 kg [1,000 lb]
	Threshold Quantity for OSHA for 29 CFR 1910.119 Process Safety Management (concentration >52%	3,402 kg [7,500 lb]
Oxygen (O_2)	Not Listed in any of the four regulations	NA*
Carbon Dioxide (CO_2)	Not listed in any of the four regulations	NA
Sodium Carbonate (Na_2Co_3)	Not listed in any of the four regulations	NA
Sodium Chloride (NaCl)	Not Listed in any of the four regulations	NA
Barium Chloride ($BaCl_2$)	Not listed in any of the four regulations	NA

Table 4.2-3. Pertinent Regulations for Chemicals Used at *In*-Situ Leach Facilities (continued)		
Chemical	**Regulations**	**Minimum Reporting**
Hydrochloric Acid (HCl)	Threshold Quantity from Clean Air Act for 40 CFR Part 68 Risk Management Planning (concentration >37%)	6,804 kg [15,000 lb]
	Threshold Quantity from OSHA for 29 CFR 1910.119 Process Safety Management (for anhydrous HCl)	2,268 kg [5,000 lb]
	Reportable Quantity for CERCLA from 40 CFR 302.4	2,268 kg [5,000 lb]
Hydrogen Sulfide (H_2S)	Threshold Quantity from CAA for 40 CFR Part 68 Risk Management Planning	4,536 kg (10,000 lb)
	Threshold Quantity from OSHA for 29 CFR 1910.119 Process Safety Management	680 kg (1,500 lb)
	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans	227 kg (500 lb)
	Reportable Quantity for CERCLA from 40 CFR 302.4	45.4 kg (100 lb)
Sodium Sulfide (Na_2S)	Not Listed in any of the four regulations	NA
*NA = Not applicable		

4.2.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

There can be SMALL environmental impacts during ISL facility decommissioning that would be expected to decrease as hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed.

To ensure the safety of workers and the public during decommissioning, the NRC requires licensed facilities submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license conditions where necessary, and (3) regular NRC inspection and enforcement activities to ensure compliance with radiation safety requirements constrain the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions to SMALL levels.

4.2.12 Waste Management Impacts

ISL facilities generate radiological and nonradiological liquid and solid wastes that must be handled and disposed of properly. Waste streams and waste management practices applicable to ISL facilities are described in Section 2.7. Radiation safety associated with the collection, handling, and storage of waste materials is maintained at all ISL facilities through the application of an NRC approved radiation safety program compliant with the requirements at 10 CFR Part 20 (Section 2.9). Before operations begin, NRC requires an ISL facility to have an agreement in place with a licensed disposal facility to accept 11e.(2) byproduct wastes that would be

associated with facility operations, aquifer restoration, and decommissioning. Such agreements ensure sufficient disposal capacity for 11e.(2) byproduct wastes would be available throughout the life of the facility. Transportation impacts associated with waste management are discussed in Section 4.2.2, which characterizes impacts as SMALL. Overall, waste management impacts would be SMALL. Specific impact discussions for each phase of the ISL facility lifecycle are discussed in the following sections.

4.2.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility, provides some insight into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that would be generated during construction of a new ISL facility, waste management impacts from construction would be SMALL.

4.2.12.2 Operation Impacts to Waste Management

As discussed in Section 2.7, operational wastes are primarily liquid waste streams consisting of process bleed (1 to 3 percent of the process flow rate) and aquifer restoration water. Wastes would also be generated from well development, flushing of depleted eluant to limit impurities, resin transfer wash, filter washing, uranium precipitation process wastes (brine), and plant washdown water. The methods used for handling and processing these wastes include water treatment (with barium chloride, and reverse osmosis), followed by disposal methods involving evaporation ponds, land application, deep well injection, and surface water discharge. The treatment and disposal methods are effective at separating wastes to reduce waste volumes destined for disposal at an approved facility, thereby reducing waste-related environmental impacts. State permitting actions, NRC license conditions, and NRC inspections ensure the proper practices would be used to comply with safety requirements to protect workers and the public, and overall impacts would be SMALL.

Both surface discharge and deep well injection are liquid wastewater disposal methods that require special approval and permits designed to limit potential impacts to either surface or ground waters. Licensees must obtain a UIC permit from EPA or the appropriate state agency, and obtain NRC approval (Section 1.7.2). Surface discharge of treated wastewaters to local waterways, including ephemeral stream channels, would be approved by the NPDES permitting process (Section 1.8). Water discharged in this way must be treated to remove contaminants to meet state and federal water quality standards. These permit approval processes provide confidence that potential environmental impacts would be limited. Therefore, impacts would be SMALL, whether from surface discharge or deep well injection activities.

Evaporation ponds (Section 2.7.2) would be constructed, operated, and monitored for leakage in accordance with NRC regulations at 10 CFR Part 40, Appendix A. Leaks may still occur over the operational life of a pond; however, the pond design helps to contain leaks and the monitoring would detect leaks before a significant release of material to the environment occurs. The licensee is also required to maintain sufficient reserve capacity in the retention pond system to enable the contents of a pond to be transferred to other ponds in the event of a leak. The residual solid waste materials normally remain in ponds until the ponds are decommissioned and sludges are disposed of as 11e.(2) byproduct material at a licensed disposal facility (Section 2.6). The aforementioned required agreement with a licensed facility prior to

operations ensures disposal capacity is available to accept evaporation pond waste when an ISL facility is eventually decommissioned. As a result, impacts from the use of ponds would be SMALL.

Land application of treated wastewater (Section 2.7.2) could potentially impact soils by allowing accumulation of residual radiological or chemical constituents in the irrigated soils that were not removed from the water during treatment. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive and other constituents (e.g., arsenic, selenium, molybdenum) within allowable release standards. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to ensure release limits would be met and soil sampling to establish background and monitor for uranium, radium, and other metals. Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted (contaminated) areas would be appropriately characterized and remediated, as necessary, in accordance with NRC regulations. Because of the NRC review of site-specific conditions prior to approval, the routine monitoring program, and the inclusion of irrigated areas in decommissioning surveys, the impacts from land application of treated wastewater would be SMALL.

Solid wastes generated from operations that are classified as 11e.(2) byproduct wastes can be sent to a licensed facility for disposal. Contaminated materials, equipment, and buildings would be similarly disposed or decontaminated and released for unrestricted use according to NRC requirements. Nonradioactive hazardous wastes would be segregated and disposed of at a hazardous waste disposal facility. Nonradiological uncontaminated wastes are disposed of as ordinary solid waste at a municipal solid waste facility. Disposal impacts would be SMALL for radioactive wastes as a result of required preoperational disposal agreements. Impacts for hazardous and municipal waste would also be expected to be SMALL, assuming the amount of contaminated soil is SMALL. For remote areas with limited available disposal capacity, such wastes may need to be shipped greater distances to facilities that have capacity; however, the number of such shipments would still be low (Section 2.8).

4.2.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.2.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.2.12.4 Decommissioning Impacts to Waste Management

There can be SMALL environmental impacts during ISL facility decommissioning, even though the overall goal is to reduce impacts by removing facilities and restoring disturbed lands to preoperational conditions.

Waste disposal is an unavoidable, but SMALL, impact associated with decommissioning an ISL facility. 11e.(2) byproduct wastes from decommissioning ISL facilities (including contaminated excavated soil, evaporation pond bottoms, process equipment) can be disposed at a licensed facility. NRC regulations (10 CFR Part 40, Appendix A, Criterion 2) require that 11e.(2) byproduct material be disposed at existing disposal sites unless such offsite disposal is impractical or the benefits of onsite disposal clearly outweigh those of reducing the number of waste disposal sites. Licensees are required to have an agreement in place with a licensed disposal facility prior to starting operations. Requiring such an agreement ensures sufficient disposal capacity will be available for 11e.(2) byproduct wastes generated by decommissioning activities.

Ensuring safe handling, storage, and disposal of decommissioning wastes is addressed by requiring licensed facilities to submit a decommissioning plan for NRC review (Section 2.6) prior to starting decommissioning activities. Such a plan would include details of how a 10 CFR Part 20 compliant radiation safety program (Section 2.9) would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. NRC and NRC licensee actions provide assurance that potential radiation safety impacts associated with waste management during decommissioning are minimized. These actions include (1) the licensee's conduct of decommissioning in accordance with an NRC-approved plan; (2) the licensee's compliance with site-specific NRC license conditions, as needed; and (3) regular NRC inspection activities to determine compliance with the appropriate radiation safety regulations and requirements. Therefore, the potential waste management radiation safety impacts from ISL facility decommissioning would be SMALL.

The estimated volume of decommissioning wastes for a large ISL facility (i.e., Smith Ranch, Table 2.11-1) is provided in Table 2.6-1. The total volume of estimated byproduct waste is approximately 4,593 m^3 [6,008 yd^3] or about 300 truckloads. To state this another way, this volume would occupy a hypothetical cube that is approximately 17 m [18 yd] on each side. This waste would be generated over an estimated period of 2 to 3 years for completion of decommissioning activities. The more concentrated waste material such as pond sludge from decommissioning an ISL facility is the equivalent of about three truckloads of waste material (Sections 2.6 and 2.7). Section 4.2.2 addresses potential impacts from transportation of waste materials. Nonradioactive, uncontaminated solid wastes are recycled, buried onsite, or disposed of as municipal waste. If buried onsite, a state permit (authorization) would be required. The total volume of solid wastes estimated for a large ISL facility (i.e., Smith Ranch, Table 2.11-1) is approximately 715 m^3 [935 yd^3] {e.g., this volume would occupy a hypothetical cube that is approximately 9 m [10 yd] on each side} or about 47 truckloads. The nature of potential impacts associated with disposal of uncontaminated solid wastes from decommissioning would be similar to those described for operations in Section 4.2.12.2 because the waste management practices are the same. The magnitude of uncontaminated solid wastes from decommissioning is larger than comparable operational waste volumes but would not present any unique problems regarding available disposal capacity. Facilities in locations with limited solid waste disposal capacity may need to ship waste for longer distances, but the number of shipments would be similar to that for a similarly sized site in a region with ample disposal capacity. The

required preoperational agreement for disposal of byproduct material and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.2.2.

4.2.13 References

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4.3 Wyoming East Uranium Milling Region

4.3.1 Land Use Impacts

Information on ISL facility size (Section 2.11) and the types of potential impacts to land use described for the Wyoming West Uranium Milling Region in Section 4.2.1 would also generally apply for ISL facilities in the Wyoming East Uranium Milling Region.

4.3.1.1 Construction Impacts to Land Use

The overall landscape and land uses in the Wyoming East Uranium Milling Region are similar to those of the Wyoming West Uranium Milling Region. Therefore, the types of construction impacts to land use from new ISL facilities in the Wyoming East Uranium Milling Region would be expected to be similar to those described for the Wyoming West Uranium Milling Region. Construction activities would (1) change and disturb the land uses, (2) restrict access and establish right-of-way for access, (3) affect mineral rights, (4) restrict livestock grazing areas, (5) restrict recreational activities, and (6) alter ecological, cultural, and historical resources (Section 4.2.1.1). Land use impacts would differ in that the Wyoming East Uranium Milling Region has a larger percentage of private land surface ownership than the Wyoming West Uranium Milling Region. Consequently, there are likely more split-estate situations in this east region than in the west region. This could lead to potential impacts that would need to be resolved through arrangements (e.g., leases, mineral rights sales, royalties) with individual land owners. The uranium districts in this region are generally located in a mix of private lands and lands managed by the BLM and U.S. Forest Service.

Potential impacts to most aspects of land use from the construction of an ISL facility would be SMALL. This is because (1) the amount of area disturbed by the construction would be small in comparison to the available lands; (2) the majority of the site would not be fenced; (3) potential conflicts over mineral access would be expected to be negotiated and agreed upon; (4) only a small portion of the available land would be restricted from grazing; and (5) the open spaces for hunting and off-road vehicle access would be minimally impacted by the fencing associated with the ISL facility. Potential impacts to historic and cultural resources would range from SMALL to LARGE, depending on site-specific conditions, as resources not previously identified could be altered or destroyed during excavation, drilling, and grading activities.

4.3.1.2 Operation Impacts to Land Use

The type of land use impacts for operational activities is expected to be similar to construction impacts regarding access restrictions because the infrastructure would be in place. Additional land disturbances would not be expected from conducting the operational activities described in Section 2.4.. During the operational period of an ISL facility, the primary changes to land use would be the development (sequencing) of well fields from one area of the site to another; this is addressed as a construction impact in Section 4.3.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be restored and fully reopened for grazing or recreation while a new well field is being developed elsewhere, which would have impacts similar to those described in the preceding section for the construction phase. Because access restriction and land disturbance impacts would be similar to or less than those expected for

construction, the overall potential impacts to land use from operational activities would be SMALL.

4.3.1.3 Aquifer Restoration Impacts to Land Use

During aquifer restoration, the land use impacts described previously for the construction phase and the operations phase would be similar. In terms of specific activities, aquifer restoration uses the same infrastructure as the operations phase and maintenance would be at a similar level. Land use impacts from aquifer restoration would decrease as fewer wells and pump houses are used and overall equipment traffic and use diminish. Thus, the overall potential impacts to land use during the aquifer restoration phase are comparable to those of the operations phase and would be SMALL.

4.3.1.4 Decommissioning Impacts to Land Use

The types of decommissioning impacts to land use would be similar to the impacts described for this region during the construction, operations, and aquifer restoration phases, but the intensity of activities disturbing the land uses would temporarily increase relative to operations due to increased use of earth- and material-moving equipment and other heavy equipment. As decommissioning and reclamation proceed, the amount of disturbed land would decrease, and the overall potential impacts to land use during the decommissioning phase would range from SMALL to MODERATE.

4.3.2 Transportation Impacts

Truck and automobile use is associated with all activities during the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8), when compared with local traffic volumes in the Wyoming East Uranium Milling Region (Section 3.3.2), is not expected to significantly change the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak employment (during construction), would have greater impacts when roads with the lowest levels of current traffic are traveled. These low traffic roads may also be more susceptible to wear and tear from increased traffic. Localized intermittent and temporary SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions including the proximity of local residential housing, other regularly occupied structures, wildlife habitat, farming, or grazing areas to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC site-specific environmental review. Potential local impacts include loss of forage palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle is provided in the following sections.

4.3.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Sections 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation

(Section 2.8) is expected to vary depending on the size of the facility; however, when considered with the regional traffic counts provided in Section 3.3.2, most roads that would be used for construction transportation in the Wyoming East Uranium Milling Region would not gain significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. Roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak employment. The limited duration of construction (12–18 months) activities suggest impacts would be of short duration in many areas where an ISL facility would be sited. Temporary SMALL to MODERATE dust, noise, and incidental livestock or wildlife kill impacts are possible on or in the vicinity of access roads used for construction transportation.

4.3.2.2 Operation Impacts to Transportation

The discussion of impacts in Section 4.2.2.2 for the Wyoming West Uranium Milling Region also applies to the Wyoming East Uranium Milling Region because (1) the same types of transportation activities would be conducted regardless of location, (2) the same regulatory controls and safety practices apply, (3) the same magnitude of transportation activities would be conducted, and (4) the assessment of accident risks is generally applicable to all regions. Applicable transportation conditions for the Wyoming East Uranium Milling Region are discussed in Section 3.3.2. The magnitude of existing traffic conditions in the region is similar to that described for Wyoming West with regard to potential impacts, and therefore operational traffic related impacts would be similar: SMALL to MODERATE. The methods and assumptions considered in the accident analysis in Section 4.2.2.2 for yellowcake shipments are applicable to the Wyoming East Uranium Milling Region, and therefore the impact from yellowcake, resin transfer, and byproduct waste shipments would be SMALL. The same practices and requirements that serve to limit the risks from chemical shipments for the Wyoming West Uranium Milling Region would also apply to the Wyoming East Uranium Milling Region and would result in SMALL impacts.

4.3.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than those described for construction and operations because transportation activities would be primarily limited to supplies (including chemicals), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE.

4.3.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments, which are small compared to average annual daily traffic counts provided in Section 3.3.2. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing

to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected during decommissioning, impacts would be SMALL.

4.3.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities and processes at ISL facilities may impact geology and soils. The potential impacts on geology and soils from these activities in the Wyoming East Uranium Milling Region are discussed in the following sections.

4.3.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts on geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures
- Excavating and backfilling trenches for pipelines and cables
- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Wyoming East Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities would result in only SMALL (on average, approximately 15 percent of permitted site area) and temporary (months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons would be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance will be limited to drill pad grading, mud pit excavation, well completion, and constructing access roads.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). For example, soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles are typically located, shaped, and seeded with a cover crop by the operator to control erosion. Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas;

using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only small and temporary disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated rock and soil and graded to surrounding ground topography.

Based on the above discussion, the impacts of construction activities on geology and soils at ISL facilities in the Wyoming East Uranium Milling Region would be SMALL, because of the duration of the activity (months), the limited affected area (on average, approximately 15 percent of the permitted site area), and the relatively shallow depth of excavation involved {1.2–1.8 m [4–6 ft]}.

4.3.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting "pregnant" lixiviant, which now contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. In addition, the source formations for uranium in the Wyoming East Uranium Milling Region occur at depths of hundreds of meters [hundreds of feet] (Section 3.3.3) and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick (Section 3.1.2). At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts on geology from ground subsidence are expected to be SMALL, if any.

The pressure of the producing aquifer is decreased by injecting solutions during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the spread of contamination. This change in pressure theoretically could impact the transmissivity of faults in permitted areas. However, because uranium-producing sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on

historical ISL operations, reactivation of faults is not anticipated in the Wyoming East Uranium Milling Region.

A potential impact to soils arises from the necessity to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can be released and (1) pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater. For example, from 2001 to 2007, the operators of the Smith Ranch-Highlands uranium recovery facility in Converse County, Wyoming, reported spills ranging from a 190- to 380-L [50- to 100-gal] spill in February 2004 to a 751,400-L [198,500-gal] spill in June 2007 (WDEQ, 2007; NRC, 2006). The spills most commonly involved injection fluids {0.5 to 3.0 mg/L uranium [0.5 to 3.0 parts per million]}, although spills of production fluids {10.0 to 15.5 mg/L uranium [10.0 to 15.5 parts per million]} also have occurred. The predominant cause for these spills has been the failure of joints, flanges, and unions of pipelines as well as failures at wellheads (NRC, 2006). The large June 2007 release involved a spill of injection fluids resulting from a failed fitting. The spill flowed into drainage and continued downstream for about 700 m [2,300 ft], affecting an estimated area of 0.44 ha [1.08 acres] (WDEQ, 2007).

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). Upon detection, licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soil for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Wyoming East Uranium Milling Region must also comply with applicable WDEQ requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these spills to both NRC and WDEQ. License conditions also may require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA.

In the short term, impacts to soils from spills could range from SMALL to LARGE depending on the volume of soil affected by the spill. Because of the required immediate responses, spill

recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils would be expected to be SMALL.

Uranium mobilization and processing during ISL operations produce excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts of and requirements for discharging treated waste streams to surface water bodies during ISL activities in the Wyoming East Uranium Milling Region are discussed in Section 4.3.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Waste streams discharged to evaporation ponds can contain radionuclides and other metals that may become concentrated during evaporation. Therefore, evaporation pond liner failures and pond embankment failures could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are required to be monitored and inspected in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the federal Dam Safety program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be evapotranspired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium or other metals) to accumulate in the soils, thereby degrading the site's potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.3.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by recirculation of treated groundwater, and therefore it is very unlikely that ISL operations will reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts to geology in the Wyoming East Uranium Milling Region from aquifer restoration are expected to be SMALL, if any.

The main impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Wyoming East Uranium Milling Region are also required to comply with WDEQ requirements for spill response and reporting. The short-term impact on soils from spills of contaminated groundwater could range from SMALL to LARGE depending on the volume of the affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils would be expected to be SMALL.

During aquifer restoration, the groundwater is passed through a semipermeable membrane that yields a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal. In addition, treated wastewater may be applied to the land.

If reject water is sent to an evaporation pond, failure of the pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated wastewater during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to

reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and also soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.3.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes (1) dismantling process facilities and associated structures, (2) removing buried piping, and (3) plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Wyoming East Uranium Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee's spill documentation—an NRC requirement—would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary (short term) and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions, to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.3.4 Water Resources Impacts

4.3.4.1 Surface Water Impacts

4.3.4.1.1 Construction Impacts to Surface Water

The potential causes and nature of construction impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.1.1). Although the average annual precipitation in the Wyoming East Uranium Milling Region is slightly greater than that in the Wyoming West Uranium Milling Region, the average annual surface runoff is similar to or slightly less than that in the Wyoming West Uranium Milling Region (Gebert, et al., 1987). Thus, the potential for surface water impacts due to storm water runoff will be similar to those in the Wyoming West Uranium Milling Region. Compliance with applicable federal and state regulations and permit conditions and use of best management practices and required mitigation measures would reduce construction impacts to surface waters, and overall impacts would be expected to be SMALL.

4.3.4.1.2 Operations Impacts to Surface Water

Surface water impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts described for the Wyoming West Uranium Milling Region (Section 4.2.4.1.2). Except for the Shirley Basin area, there are fewer perennial streams in the Wyoming East Uranium Milling Region than in the Wyoming West Uranium Milling Region. For sites within the Platte River Basin, any impacts of groundwater pumping on surface water that might affect fish and wildlife would be assessed and mitigated as required by the Platte River Recovery Implementation Plan in consultation with the U.S. Fish and Wildlife Service (Platte River Recovery Implementation Plan, 2006). Compliance with permit conditions during operations would reduce impacts to surface water from storm water runoff and discharges of treated water. For these reasons, potential impacts to surface waters from operations would be SMALL.

4.3.4.1.3 Aquifer Restoration Impacts to Surface Water

The potential causes and nature of impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.1.3). Except for the Shirley Basin area, there are fewer perennial streams in the Wyoming East Uranium Milling Region (see Section 3.3.4.1) than in the Wyoming West Uranium Milling Region. For sites within the Platte River Basin, any impacts of groundwater pumping on surface water that might affect fish and wildlife would be assessed and mitigated as required by the Platte River Recovery Implementation Plan in consultation with the U.S. Fish and Wildlife Service (Platte River Recovery Implementation Plan, 2006). Compliance with permit conditions during aquifer restoration would reduce impacts to surface water from storm water runoff and discharges of treated water. For these reasons, the potential impacts to surface waters during aquifer restoration would be SMALL.

4.3.4.1.4 Decommissioning Impacts to Surface Water

The potential causes and nature of impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.1.4). Except for the Shirley Basin area, there are fewer perennial streams in the Wyoming East Uranium Milling Region than in the Wyoming West Uranium Milling Region. Compliance with permit conditions during decommissioning would reduce impacts to surface water from storm water runoff and discharge of treated water. For these reasons, the potential impacts to surface waters would be SMALL.

4.3.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Wyoming East Uranium Milling Region can occur during all phases of the ISL facility's lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production

aquifers, degradation of water quality from changes in the production aquifer's chemistry, and waste management practices involving land application, evaporation ponds, or deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.3.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, injection of drilling fluids and muds during well drilling, and spills of fuels and lubricants from construction equipment (Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small and would have a SMALL and temporary impact to groundwater supplies. Groundwater quality of near-surface aquifers during construction is protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts to groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.3.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (Section 2.4). Disposal of processing wastes by deep well injection (Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.3.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers. The potential environmental impacts of pipeline, valve, or well integrity failures could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)

- The shallow aquifers are important sources for local domestic or agricultural water supplies

- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydraulically separated from other locally and regionally important aquifers.

In some parts of the Wyoming East Uranium Milling Region, local shallow aquifers (alluvium type) exist, and they usually yield small quantities of water only for local uses [e.g., in the vicinity of the Reynolds Ranch area (Power Resources, Inc., 2005)]. Hence, potential environmental impacts due to spills and leaks from pipeline networks or failures of well integrity in shallow aquifers would be expected to be SMALL to MODERATE, depending on site-specific conditions. Potential impacts would be reduced based on flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well MIT (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.3.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term "consumptive use" refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed

from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Wyoming East Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L/ha [4.36 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 18 ha [44 acres] in Wyoming for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by causing a lowering water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would significantly overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). In this extreme case, drawdowns at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from the hypothetical well (representing the well field) would be 88, 70, and 52 m [289, 230, and 171 ft] after 10 years of operation. These values were calculated using the Theis Equation (McWhorter and Sunada, 1977) with transmissivity and storage coefficient values of 8.8 m^2/day [95 ft^2/day] and 1.5×10^{-5}, respectively (chosen from the ranges discussed in Section 3.3.4.3). As discussed in Section 4.3.4.2.2.2, drawdowns are more sensitive to the aquifer transmissivity than storage coefficient.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield significant overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use could be MODERATE if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well isolated from other aquifers that are used locally. However, because localized drawdown near well fields would dissipate after pumping stops, these localized effects are expected to be temporary. The long-term impacts would be expected to be

SMALL in most cases, depending on site-specific conditions. Important site-specific conditions would include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. In order for ISL operations to occur, the uranium-bearing production aquifer must be exempted as an underground source of drinking water through the Wyoming UIC program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to baseline or preoperational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. This remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or in the producing aquifer outside of the well field to be affected by excursions during ISL operations.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal excursions can occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone and the well field. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL production zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to the NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be affected during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer, and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1997; Driscoll, 1986). The vertical hydraulic conductivity of the upper confining layer of the ore-bearing K unit at the Christensen Ranch ISL site ranges from

8.2×10^{-6} to 1.1×10^{-4} m/day [27×10^{-6} to 3.6×10^{-4} ft/day] (see Section 3.3.4.3). For the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction and a vertical hydraulic conductivity of 1.1×10^{-4} m/day [3.6×10^{-4}] (representing the most leaky condition), a leaching solution would move vertically upward from the production unit to an overlying aquifer, J unit (Cogema Mining, Inc., 1998), at a rate of nearly 0.4 cm/yr [0.16 in/yr]. If the vertical migration rate of a leaching solution is assumed to be constant in the next 10 years, then the leaching solution would move 4 cm [1.6 in] away from the production zone. Because the thickness of the upper confinement is 23 m [76 ft] (Section 3.3.4.3) at the Christensen Ranch ISL site, the excursion would not be expected to enter the overlying aquifer in the next 10 years. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying J unit or the underlying L unit of the Wasatch Formation, which may enhance potential vertical excursions from the production zone (the K unit of the Wasatch Formation) at the Christensen Ranch ISL site. Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could also lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology and the proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters and the UCL for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

WDEQ noted that monitoring wells should be completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As described in Section 3.3.4.3.2, in the Reynolds Ranch area in Converse County, the Wasatch Formation is above the ore-bearing aquifer and the Lance Formation is below the ore-bearing aquifer.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts could be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine how to remediate it.

At the Christensen Range ISL site, the ore-bearing unit (the K unit of the Wasatch Formation, corresponding to upper Irigaray sandstone at the Irigaray ISL site) is confined below and above by continuous and at least 20-m [65-ft]-thick confining layers at the Christensen Ranch and Irigaray Ranch ISL sites (Cogema Mining, Inc., 1998). At the Smith Ranch and Reynolds Ranch ISL sites, the ore-bearing aquifer (the Fort Union Formation that contains the U/S sand) is confined below and above by continuous and thick confining layers. The thickness of the aquitards is reportedly variable in the region (NRC, 2006). As noted in Section 3.3.4.3.2, aquifer tests revealed that the confining shale members would effectively limit the vertical excursions at the ISL facility in the Reynolds Ranch area (Power Resources, inc., 2005). Preliminary calculations discussed previously suggest that the confinements would effectively restrict potential vertical excursions. Additionally, if the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be expected to be SMALL.

4.3.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act and the Safe Drinking Water Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from the EPA (Section 1.7.2) or an authorized state-administered UIC program. As discussed in Section 1.7.5.1, Wyoming requires UIC Class III permits for injection wells in areas not previously mined using conventional mining and milling. UIC Class V permits are required for injection wells leaching from older conventional uranium recovery operations.

In the Wyoming East Uranium Milling Region, the Paleozoic aquifers are deeply buried in most places and contain little fresh water. The Paleozoic aquifers are hydraulically separated from the aquifer sequence that includes, from the shallowest to deepest, the Wasatch Formation, the Fort Union Formation, the Lance Formation, and the Fox Hills Formation by thick low permeability confining layers that include the Pierre Shale, the Lewis Shale, and the Steele Shale (Whitehead, 1996). Hence, nonkarstic Paleozoic aquifers (e.g., Tensleep Sandstone)

can be investigated further for suitability of disposal of leaching solutions. Karstic (e.g., those with large dissolution features) Paleozoic aquifers are likely to be excluded from consideration, because flow directions and rates in karstic aquifers (e.g., Madison Limestone) are highly uncertain and flow rates are commonly much higher than in nonkarstic aquifers.

The potential environmental impacts of injection of leaching solutions into deep aquifers below ore-bearing aquifers would be expected to be SMALL, if water production from deep aquifers is not economically feasible or the groundwater quality from these aquifers is not suitable for domestic or agricultural uses (e.g., high salinity), and they are confined above by sufficiently thick, low permeability layers. In the Wyoming East Uranium Milling Region, considering relatively low water quality in and less water yields from nonkarstic Paleozoic aquifers (e.g., Tensleep Sandstone) and the presence of thick and regionally continuous aquitards confining them above (Section 3.3.4.3), the potential environmental impacts due to deep injection of leaching solution into nonkarstic Paleozoic aquifers could be SMALL. The Pierre Shale was reported to be fractured in some places at the regional scale (Whitehead, 1996), although it was reported to be continuous and nonfractured based on available field data in the Reynolds Ranch area. Considering potential heterogeneities in hydrogeological properties of the Pierre Shale, the potential impacts could be SMALL to MODERATE where the Pierre Shale might be locally fractured.

4.3.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following methods: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These methods are discussed in more detail in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from the well field commencing milling. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from the well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because up to 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired flow of water from outside of the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than during ISL operations (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

As discussed in Section 2.5, restoration typically is performed as well fields end production, so all of the well fields do not undergo groundwater sweep at the same time. For example, at the Irigaray Mine (Cogema Mining, Inc., 2004), average pumping rates for groundwater sweep ranged from approximately 100 L/min [27 gal/min] to pump 120 million L [31 million gal] from two well fields between June 1991 and August 1993 to 380 L/min [100 gal/min] to pump 190 million L [49 million gal] from three well fields between May 1990 and April 1991. At the Smith Ranch/Highland Uranium Project in Converse County, Wyoming, an average pumping rate of approximately 38 L/min [10 gal/min] was used to pump 3.2 pore volumes {49 million L [13 million gal]} from the A-Wellfield during almost 3 years of groundwater sweep (Power Resources, Inc., 2004).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].

At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in 1 year. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L/ha [4.36 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in 1 year of restoration would be roughly equivalent to the water used to irrigate 21 ha [53 acres] in Wyoming for 1 year.

Potential environmental impacts are dependent on the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility. The potential environmental impacts of groundwater consumptive use during restoration could be SMALL to MODERATE. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the wastewater treatment system. The impacts of discharging wastes to solar

evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.3.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from EPA or the authorized state and approval from NRC. Additionally, the briny slurry produced during reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injections must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.3.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills. Based on consideration of best management practices to minimize water use and spills, impacts to the groundwater resources in shallow aquifers from decommissioning would be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitors, injection, and recovery wells will be plugged and abandoned in accordance with the Wyoming UIC program requirements. The wells will be filled with cement and clay and then cut off below plow depth to ensure that groundwater does not flow through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

4.3.5 Ecological Resources Impacts

4.3.5.1 Construction Impacts to Ecological Resources

Vegetation

Vegetation in the region is similar to the vegetation found in the Wyoming West Uranium Milling Region. As a result, potential impacts to terrestrial vegetation from ISL uranium recovery facility construction within the Wyoming East Uranium Milling Region would also be similar (SMALL to MODERATE), as described in Section 4.2.5.

Wildlife

The potential impacts from an ISL uranium recovery facility construction on terrestrial wildlife in the Wyoming East Uranium Milling Region would also be similar to those found in the Wyoming West Uranium Milling Region as described in Section 4.2.5 (SMALL to MODERATE), depending on site-specific conditions.

Disturbed areas would be revegetated with a seed mixture of grasses, forbs, and shrubs approved by the WDEQ, Land Quality Division, to further mitigate impact to wildlife after construction of the well fields and facility infrastructure.

Crucial wintering and year-long ranges vital for survival of local populations of big game and sage-grouse leks or breeding ranges are also located within the region (Figures 3.3-8 through 3.3-14). For facilities to be located within these ranges, guidelines have been issued by the Wyoming Game and Fish Department (2004) for the drilling associated with the development of oil and gas resources. Because many of the activities (e.g., drilling, access roads) would be similar between oil and gas and ISL facility construction, these guidelines would also be expected to apply to ISL facility construction. Consultation with the Wyoming Game and Fish Department would be conducted, as well as a site-specific analysis to determine potential impacts from the facility to these species.

Aquatic

Because the reported aquatic species are the same, potential impacts from ISL uranium recovery facility construction to aquatic resources would be expected to be similar to those found in the Wyoming West Uranium Milling Region (SMALL). Consultation with the Wyoming Game and Fish Department is expected to be conducted, as well as a site-specific analysis to determine impacts from the facility to theses species.

Threatened and Endangered Species

Numerous threatened and endangered species and State Species of Concern are located within the region. These species with habitat descriptions are provided in Section 3.3.5.3. After a specific ISL site has been selected, the habitats and impacts would be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff would consult with the U.S. Fish and Wildlife Service and Wyoming Game and Fish Department for potential survey requirements and explore ways to protect these resources. If any of the species are identified in the project site during surveys, impacts could

range from SMALL to LARGE depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be developed. Many of these species have been discussed previously for the Wyoming West Uranium Milling Region (Section 4.2.5.1). Other species noted in the Wyoming East Uranium Milling Region are described next.

- The Colorado butterfly plant typically occurs on subirrigated, stream-deposited soils on level floodplains and drainage bottoms. Potential impacts to this species could be MODERATE to LARGE if construction activities remove vegetation along flood plains and drainage bottoms.

- The Wyoming toad is only found in Albany County, Wyoming. Potential impact to this species could occur if construction activities remove riparian and wetland vegetation found along streams, seeps, and floodplains.

Threatened and endangered species discussed in the Wyoming West Uranium Milling Region (Section 4.2.5.1) that are also identified within the Wyoming East Uranium Milling Region include

- Black-footed ferret
- Blowout penstemon
- Bonytail
- Canada lynx
- Colorado pikeminnow
- Humpback chub
- Interior least tern
- Pallid sturgeon
- Piping plover
- Preble's meadow jumping mouse
- Razorback sucker
- Ute ladies' tresses orchid
- Western prairie fringed orchid
- Whooping crane
- Yellow-billed cuckoo (candidate)

4.3.5.2 Operation Impacts to Ecological Resources

Because the ecoregions are similar, the types of potential impacts to ecological resources from the operation of an ISL facility in the Wyoming East Uranium Milling Region are expected to be similar to those described in the Wyoming West Uranium Milling Region. Additional land-disturbing activity would be less than expected during the construction phase (SMALL) and would be evaluated during the site-specific environmental review.

4.3.5.3 Aquifer Restoration Impacts to Ecological Resources

Because the existing infrastructure would be used during aquifer restoration, potential impacts to ecological resources would be similar to impacts from ISL facility operations; therefore, they would be SMALL.

4.3.5.4 Decommissioning Impacts to Ecological Resources

Because similar types of earth-moving activities would be involved, potential impacts as result of decommissioning would, in part, be similar to those discussed in the construction of the facility (see Section 4.3.5). However, these impacts would be temporary (generally, 18–30 months) in nature. The removal of piping would impact vegetation that has reestablished itself. Wildlife or endangered and threatened species could come in contact with heavy equipment. During decommissioning, reclamation activities would revegetate previously disturbed areas and restore streams and drainages to their preconstruction contours. It is expected that temporarily displaced wildlife would return to the area after the completion of decommissioning and reclamation activities. As a result, the potential impacts to ecological resources during decommissioning would be expected to be SMALL.

Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted (contaminated) areas would be appropriately characterized and remediated, as necessary, in accordance with NRC regulations. Because of the NRC review of site-specific conditions prior to approval, the routine monitoring program, and the inclusion of irrigated areas in decommissioning surveys, the ecological impacts from land application of treated waste water would be SMALL.

4.3.6 Air Quality Impacts

For the Wyoming East Uranium Milling Region, potential nonradiological air impacts from activities during all four uranium milling phases would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.6.

In general, ISL milling facilities are not major nonradiological air emission sources, and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence was is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

The Wyoming East Uranium Milling Region is classified as attainment for NAAQS (see Figure 3.3-15). This also includes the counties immediately surrounding this region. The Wyoming East Uranium Milling Region does not include any Prevention of Significant Deterioration Class I areas (see Figure 3.3-16). Therefore, the less stringent Class II area allowable increments apply.

4.3.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration to construction activities and result in small, short-term effects. The Wyoming East Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels

from an ISL facility are expected to comply with applicable regulatory limits and restrictions (Section 3.2.6.2). Therefore, construction impacts for ISL facilities would be SMALL.

4.3.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution are small. Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. In general, nonradiological emissions from yellowcake drying would be SMALL due to the volume of effluent produced.

Other potential operation phase nonradiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified earlier in the construction phase. ISL operations phase fugitive dust emissions sources include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions associated with well field construction. Therefore, operations phase impacts would be less than the construction phase impacts.

The Wyoming East Uranium Milling Region is in attainment for NAAQS and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts for ISL facilities would be SMALL.

4.3.6.3 Aquifer Restoration Impacts to Air Quality

Potential nonradiological air impacts during the aquifer restoration phase (Section 2.11.5) include fugitive dust and combustion emissions from many of the same sources identified earlier in the operations phase. The plugging and abandonment of production and injection wells would use equipment that generates gaseous emissions. These emissions would be expected to be limited in duration and result in small, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not be expected to exceed those of the construction phase. Therefore, aquifer restoration phase impacts would be SMALL.

4.3.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase nonradiological air impacts include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified earlier in the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Decommissioning

phase impacts would be expected to be similar to construction phase impacts. Therefore, decommissioning phase impacts would be SMALL.

4.3.7 Noise Impacts

4.3.7.1 Construction Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.1. The three uranium districts in the Wyoming East Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, construction activities and associated traffic would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities. Construction worker hearing would be protected by compliance with Occupational Safety and Health Administration noise regulations. During construction, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

4.3.7.2 Operation Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.2. Overall, because most activities will be conducted inside buildings, potential noise impacts during ISL operations are anticipated to be less than those during construction. The three uranium districts in the Wyoming East Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, operations activities and associated traffic would have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During operations, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Compared to existing traffic counts, truck traffic associated with yellowcake and chemical shipments and traffic noise related to commuting would have a SMALL, temporary impact on communities located along the existing roads. Some country roads with the lowest average annual daily traffic counts would be expected to have higher relative increases in traffic and noise impacts, in particular, when facilities are experiencing peak employment (these impacts would be MODERATE). Therefore, overall noise impacts during operations would be SMALL to MODERATE.

4.3.7.3 Aquifer Restoration Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.3. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, aquifer restoration activities

and associated traffic would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during aquifer restoration would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during aquifer restoration would be SMALL to MODERATE.

4.3.7.4 Decommissioning Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.4. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, decommissioning activities and associated traffic would be expected to have only SMALL and short-term noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during decommissioning would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During decommissioning, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during decommissioning would be SMALL to MODERATE.

4.3.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Wyoming East Uranium Milling Region is provided in Sections 3.2.8 and 3.3.8. Construction involving land-disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, would be expected to be the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, applicants would review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area and all its related facilities and components would be subjected to a comprehensive cultural resources inventory (performed by the licensee or applicant) that meets the requirements of responsible federal, state, and local agencies (e.g., the Wyoming SHPO). The literature and records searches help identify known or potential cultural resources and Native American sites and features. The cultural resources inventory would be used to identify the previously documented sites and any newly identified cultural resources sites. The eligibility evaluation of cultural resources for listing in the NRHP under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties would be conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. Long linear features such as the Bozeman National Historic Trail in the Wyoming East Uranium Milling Regions require detailed assessment of potential construction and operation impacts. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding

cultural resources and traditional cultural properties would also occur during the site-specific environmental review process. Consultation to determine whether significant cultural resources would be avoided or mitigated would occur during state SHPO, agency, and tribal consultations as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.3.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible or potentially NRHP-eligible historic properties and traditional cultural properties, both direct and indirect, would be expected to occur during land-disturbing activities related to constructing an ISL uranium recovery facility. Buried cultural features and deposits that were not visible on the surface during initial cultural resources inventories might also be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions, increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL uranium recovery project.

Because of the localized nature of land disturbing activities related to construction, impacts to cultural and historical resources would be expected to be SMALL, but could be MODERATE or LARGE if the facility is located on a known resource. Wyoming historical sites listed in the NRHP and traditional cultural properties are provided in Section 3.2.8. Proposed facilities or expansions adjacent to these properties would be likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording and archiving samples) and additional consultations with the Wyoming SHPO and affected Native American tribes would be needed to assist in reducing the impacts. From the standpoint of cultural resources, the most significant impacts to any sites that are present would occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impact to any cultural resources that might be present.

4.3.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural

resources are possible during operation of an ISL uranium recovery project. Potential impacts during operation would be expected to occur through new earth-disturbing activities, new construction, maintenance, and repair.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations are expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites), and would be SMALL.

4.3.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Potential impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration would be expected to be less than those during construction, as aquifer restoration activities are generally limited to existing infrastructure in previously disturbed areas (e.g., access roads, central processing facility, well sites), and would be SMALL.

4.3.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Potential impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties in or near the site of decommissioning activities may occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction would be expected to continue during decommissioning and reclamation. Overall impacts to cultural and historical resources during decommissioning are expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project activities. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.3.9 Visual/Scenic Resources Impacts

4.3.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Wyoming East Uranium Milling Region would be similar to those in the Wyoming West Uranium Milling Region (see Section 4.2.9.1). Most visual and scenic impacts associated with drilling and other land-disturbing construction activities would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.3.9, no VRM Class I areas are identified in the Wyoming East Uranium Milling Region, and most of the areas are identified as VRM Class II through Class IV according to the BLM classification system. Visual contrast during construction would be the least intrusive in those areas that are already developed such as the region around Casper or in the natural-gas-producing areas of the Powder River Basin to the north. VRM Class II areas are located in the southern part of the region within view of sensitive areas in the Bighorn and Laramie Mountains, historic trails (Bozeman, Oregon, and Bridger), or along the North Platte River. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas. Visual/scenic impacts introduced by ISL construction in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.9.2 Operation Impacts to Visual/Scenic Resources

Similar to the visual impacts described for the Wyoming West Uranium Milling Region in Section 4.2.9.2, the potential visual and scenic impacts from ISL operations in the Wyoming East Uranium Milling Region would be SMALL and less than those impacts associated with construction. The greatest potential for visual impacts would be for new facilities operating in rural, previously undeveloped areas or within view of the sensitive regions described in Section 4.3.9.1. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas. Visual/scenic impacts introduced by ISL operations in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region in Section 4.2.9.3, the potential visual and scenic impacts from ISL aquifer restoration operations in the Wyoming East Uranium Milling Region would be SMALL. Aquifer restoration would not occur until after the facility had been in operation for a number of years, and additional potential impacts would be the same as or less than those during the construction or operations periods. Although overall impacts from aquifer restoration activities would be SMALL, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 4.3.9.1. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas. Visual/scenic impacts introduced by ISL aquifer restoration in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.9.4 Decommissioning Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.4, the potential visual and scenic impacts from decommissioning and reclaiming ISL facilities in the Wyoming East Uranium Milling Region would be SMALL. Decommissioning and reclamation activities would occur after the facility had been in operation for a number of years, and one of the purposes of the decommissioning process is to remove surface infrastructure and reclaim the area to preoperational conditions, resulting in less visual contrast for the facility. Overall impacts from decommissioning and reclamation activities would be the same as, or less than, those for construction and operation. Potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 4.3.9.1. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located more than 32 km [20 mi] from VRM Class II areas, within VRM Class III through Class V/Rehabilitation areas. Visual/scenic impacts introduced by ISL decommissioning and reclamation operations in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility could reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). In Wyoming, the workforce frequently commutes long distances to work, sometimes from out of state. For example, each of the counties in the Wyoming East Uranium Milling Region experienced net inflows during the fourth quarter of 2005, ranging from about 1600 for Johnson County to 7,600 for Campbell County. These inflows were primarily for jobs related to the energy industry (Wyoming Workforce Development Council, 2007). Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Wyoming East Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in Wyoming is about 2.5 (U.S. Census Bureau, 2008), the number of people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.3.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Wyoming East Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Wyoming East Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Johnson County (population 8,100) and Weston County (6,644) and the towns of Lynch (200) and Edgerton (175). However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure.

Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Wyoming East Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities were developed concurrently, the potential for impact upon the labor force would still be SMALL. For example, Weston County has the smallest labor force (3,183) in the region. It would require at least two ISL facilities to be constructed simultaneously to affect the labor market of just Weston County by more that 10 percent, if all the workers came from Weston County. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Lynch and Edgerton) and counties (Johnson and Weston) could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE, if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction are filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of an outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates, such as Laramie, Wyoming, due to the potential increase in job opportunities. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Counties such as Campbell and Albany would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. Though Wyoming does not have an income tax, it does have a state sales tax (4 percent), a lodging tax (2–5 percent), and a use tax (5 percent). Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, and more significant, is the "ad valorem tax" the state imposes on mineral extraction. In 2007 for uranium, alone, the state collected $1.2 million from this tax (Wyoming Department of Revenue, 2008). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as they are already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL. Accidents resulting from construction of an ISL facility are not expected to be different than other types of similar industrial facilities.

Economic Multipliers
The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

4.3.10.2 Operation Impacts to Socioeconomics

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements is filled by a workforce from outside the region, assuming a multiplier of about 0.7 (see text box), there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 140, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region. However, because an outside workforce would be more likely to settle into a more populated area with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for at least the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7 economic multiplier) are required to relocate into the Wyoming East Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Casper and Douglas (within the region), and Gillette and Sheridan (located outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Wyoming East Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles.

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure, and these would be similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce impact would be SMALL to

MODERATE relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Wyoming East Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 140 (including families), there would only be about 30 school-aged children involved. While the influx of new students would be the greatest in the smaller school districts, even in these districts the impacts are anticipated to be SMALL. For example, Weston County has 1,134 students (elementary through high school) in 5 schools. With an average of 227 students per school, even if all the ISL workers' children attended the same school (which is unlikely), the increase in that school's student population would only be 13 percent.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.3.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.3.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar workforce (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Wyoming East Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE.

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community. Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus would be considered SMALL.

4.3.11 Public and Occupational Health and Safety Impacts

4.3.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction impacts on public and occupational health and safety for the Wyoming East Uranium Milling Region would be similar to those discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.1.

4.3.11.2 Operation Impacts to Public and Occupational Health and Safety

4.3.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

A potential ISL facility would be required by its NRC license to implement a radiation safety program that complies with the requirements of 10 CFR Part 20 (Section 2.9). Estimated doses to members of the public would be reported for a variety of commercial-scale and satellite facilities in Section 4.2.11.2.1. These doses are well below the 10 CFR Part 20 public dose limit of 1 mSv/yr [100 mrem/yr] and the 40 CFR Part 190 annual limit of 0.25 mSv [25 mrem]. Doses at other locations would depend on a variety of factors including receptor location, topography, and weather conditions. When releases occur from ground level, doses decrease the farther the receptor is away from the release location because the radioactive material is diluted as the wind mixes it. The amount of dilution, which is referred to as dispersion, is determined by the weather (meteorological conditions). For areas in which meteorological conditions are more stable (less turbulent), a higher dose could occur. As the radioactive material travels via the wind, changes in topography can affect the dose received by the receptor. Doses for the various ISL facilities shown in Table 4.2-2 are at least a factor of three below the regulatory limit, and most are less than that. Based on operational history and dose-modeling results, doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and overall potential radiological impacts from ISL operations would be SMALL.

4.3.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

The consequences of potential accidents would be similar regardless of an ISL facility's location and are described in Section 4.2.11.2.2. Distance to the nearest receptor, topography, and

meteorological data account for potential differences in resulting dose. For facilities in which the maximally exposed offsite individual would be closer, there would be higher doses for ground-level releases. Changes in topography would also have an impact on the resulting dose because this could allow the receptor to be closer to, or farther away from, the radioactive material as it travels by wind. Meteorological conditions vary based on location and could result in a higher or lower dose. Compliance with the required radiological safety program that includes monitoring and emergency response procedures, potential impacts resulting from a potential unmitigated accident would have a SMALL effect on the general public and, at most, a MODERATE impact to workers.

4.3.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), SMALL risks would be expected in the use and handling of these chemicals during normal operations. However, releases of these hazardous chemicals could produce significant consequences and affect public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.3.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

Because the same chemicals would be handled, nonradiological impacts to public and occupational health and safety for the Wyoming East Uranium Milling Region from releases of hazardous chemicals would be expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.2.4. The likelihood of releases would be low based on historical operational experience and required safety procedures. Overall impacts to public and occupational health and safety would be SMALL.

4.3.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Because the existing infrastructure is used, aquifer restoration impacts on public and occupational health and safety would be similar to operational impacts discussed in Section 4.3.11.2, with overall SMALL impacts to public and occupational health and safety.

4.3.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

During ISL facility decommissioning, as hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed, there would be a SMALL potential for environmental impact.

To ensure the safety of workers and the public during decommissioning, the NRC requires licensed facilities to submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license conditions where necessary, and (3) regular NRC inspection and enforcement activities to ensure compliance with radiation safety requirements would be expected to reduce the magnitude of potential public and

occupational health impacts from ISL facility decommissioning actions. Therefore, potential impacts to public health and safety would be SMALL.

4.3.12 Waste Management Impacts

Waste management impacts for the Wyoming East Uranium Milling Region would be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another.

4.3.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities would generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility, provides some insights into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that would be generated by ISL facility construction, waste management impacts from construction would be SMALL.

4.3.12.2 Operation Impacts to Waste Management

Operation waste management impacts for the Wyoming East Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.2 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. Operational waste management impacts would be SMALL, based on the required preoperational disposal agreement for byproduct material; regulatory controls including applicable permitting, license conditions, and inspection practices; and typical facility design specifications and management practices including waste treatment and volume reduction techniques, pond leak detection, and other routine monitoring activities.

4.3.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.3.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for

disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.3.12.4 Decommissioning Impacts to Waste Management

Decommissioning waste management impacts for the Wyoming East Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.4 because the waste volumes and management practices, waste management safety and environmental concerns, waste management regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. The required preoperational agreement for disposal of 11e.(2) byproduct material, NRC review and approval of a decommissioning plan and radiation safety program, and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.3.2.

4.3.13 References

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4.4 Nebraska-South Dakota-Wyoming Uranium Milling Region

4.4.1 Land Use Impacts

Information on ISL facility size (Section 2.11) and the types of potential impacts to land use previously described for the two Wyoming regions (see Sections 4.2.1 and 4.3.1) would also generally apply for ISL facilities in the Nebraska-South Dakota-Wyoming Uranium Milling Region.

4.4.1.1 Construction Impacts to Land Use

The overall land uses in the Nebraska-South Dakota-Wyoming Uranium Milling Region are similar to the Wyoming East Uranium Milling Region with predominantly private land ownership and also land managed by federal and state agencies (e.g., USFS grasslands, Custer State Park, Devil's Tower National Monument). The type and intensity of construction impacts to land use from new ISL facilities in this region would, therefore, be anticipated to be similar to those described for the two Wyoming regions. Construction activities would also (1) change and disturb the land uses, (2) restrict access and establish right-of-way for access, (3) affect mineral rights, (4) restrict livestock grazing areas, (5) restrict recreational activities, and (6) alter ecological, cultural, and historical resources. In this region, the uranium districts are located predominantly on grassland and forest land managed by the USFS, while in the two Wyoming regions, land use is predominantly BLM lands. In addition, almost 60 percent of the land in the Nebraska-South Dakota-Wyoming Uranium Milling Region is privately owned. This could lead to potential impacts that would need to be resolved through arrangements (e.g., leases, mineral rights sales, royalties) with individual land owners. Because the amount of area affected by an ISL facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to that in the two Wyoming regions, and only a small portion of that area would be fenced, access would be minimally affected. As a result, potential impacts to most aspects of land use from the construction of an ISL facility would be SMALL. Potential impacts to historic and cultural resources would range from SMALL to LARGE, depending on site-specific conditions, as resources not previously identified could be altered or destroyed during excavation, drilling, and grading activities.

4.4.1.2 Operation Impacts to Land Use

The types of land use impacts for operational activities would be expected to be similar to construction impacts regarding access restrictions, primarily because the infrastructure would be already in place. Additional land disturbances would not be expected during the operational activities described in detail in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the movement (sequencing) of well fields from one area to another; this is addressed as a construction impact in Section 4.4.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be restored and reopened for grazing or recreation while a new well field is being developed, which would have impacts similar to those described in the preceding section for the construction phase. Because access restriction and land disturbance impacts would be expected to be similar to, or less than, those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.4.1.3 Aquifer Restoration Impacts to Land Use

During aquifer restoration, the land use impacts described previously for the construction phase and the operations phase would be similar. In terms of specific activities, the aquifer restoration uses the same infrastructure as the operations phase and maintenance would be at a similar level. Land use impacts from aquifer restoration would decrease as fewer wells and pump houses are used and overall equipment traffic and use diminish. Thus, the overall potential impacts to land use during the aquifer restoration phase are comparable to those of the operations phase and would be SMALL.

4.4.1.4 Decommissioning Impacts to Land Use

The types of decommissioning impacts to land use in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to the construction, operations, and aquifer restoration impacts. As previously described, the level of decommissioning activities disturbing the land uses would increase during this phase because greater use of earth- and material-moving equipment and other heavy equipment would occur. As decommissioning and reclamation proceed, the amount of disturbed land would decrease. Consequently, the overall potential decommissioning impacts to land use in the Nebraska-South Dakota-Wyoming Uranium Milling Region would range from SMALL to MODERATE.

4.4.2 Transportation Impacts

Truck and automobile use is associated with all phases of the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8), when compared with local traffic volumes in the Nebraska-South Dakota-Wyoming Uranium Milling Region (Section 3.4.2), is not expected to significantly affect the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak employment (during construction), would have greater impacts when roads with the lowest levels of current traffic are traveled. This impact would be more pronounced in the Nebraska-South Dakota-Wyoming Uranium Milling Region owing to the relatively lower traffic counts in this region. These low-trafficked roads may also be more susceptible to wear and tear from increased traffic. Localized, short-term, and intermittent SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions, including the proximity of residences, other regularly occupied structures, wildlife habitat, farming, or grazing areas to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC site-specific environmental review. Potential local impacts include loss of forage palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle follows.

4.4.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Section 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation (Section 2.8) is expected to vary depending on the size of the facility. However, when

compared to the regional traffic counts provided in Section 3.4.2, most roads that would be used for construction transportation in the Nebraska-South Dakota-Wyoming Uranium Milling Region would not cause significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. The roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak (construction) employment. The limited duration of ISL construction activities (12–18 months) suggests impacts would be of short duration. Temporary SMALL to MODERATE dust, noise, and incidental livestock or wildlife impacts are possible on, or in the vicinity of, access roads used for construction transportation.

4.4.2.2 Operations Impacts to Transportation

The discussion of impacts in Section 4.2.2.2 for the Wyoming West Uranium Milling Region also applies to the Nebraska-South Dakota-Wyoming Uranium Milling Region because the same types of transportation activities would be conducted regardless of location, the same regulatory controls and safety practices apply, the same magnitude of transportation activities would be conducted, and the assessment of accident risks is generally applicable to all regions. Applicable transportation conditions for the Nebraska-South Dakota-Wyoming Uranium Milling Region are discussed in Section 3.4.2. With the magnitude of existing traffic conditions in the region somewhat less than in the other milling regions, the intensity of traffic-related impacts would be similar and range from SMALL to MODERATE considering potential peak employment commuting impacts to low traffic roads. The methods and assumptions considered in the accident analysis in Section 4.2.2.2 (Wyoming West Uranium Milling Region) for yellowcake shipments are applicable to the Nebraska-South Dakota-Wyoming Uranium Milling Region, and therefore the impact from yellowcake, resin transfer, and byproduct waste shipments would be similar (SMALL). The same practices and requirements that serve to limit the risks from chemical shipments also apply to the Nebraska-South Dakota-Wyoming Uranium Milling Region and would also result in SMALL impacts.

4.4.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than those described for construction and operations because transportation activities will be primarily limited to supplies (including chemicals), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE.

4.4.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments, which are small compared to average annual daily traffic counts provided in Section 3.4.2. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing

to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected during decommissioning, impacts would be SMALL.

4.4.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities and processes at ISL facilities may impact geology and soils. The potential impacts to geology and soils from these activities in the Nebraska-South Dakota-Wyoming Milling Region are discussed in the following sections.

4.4.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts on geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures
- Excavating and backfilling trenches for pipelines and cables
- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Nebraska-South Dakota-Wyoming Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities would result in only SMALL (on average, approximately 15 percent of the permitted site area) impacts and temporary (several months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons will be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance would be limited to drill pad grading, mud pit excavation, well completion, and access road construction.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). For example, soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles are typically located, shaped, and seeded with a cover crop by the operator to control erosion. Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas;

using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is typically constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only SMALL, short-term disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated material and graded to surrounding ground topography.

Based on the previous discussion, the impacts of construction activities on geology and soils at ISL facilities in the Nebraska-South Dakota-Wyoming Milling Region would be SMALL because of the limited time of the activity (months), the limited affected area (on average, approximately 15 percent of the permitted site are), and the shallow depth of excavation {1.2–1.8 m [4–6 ft]}.

4.4.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting "pregnant" lixiviant, which contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing rock formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. In addition, the source formations for uranium in the Nebraska-South Dakota-Wyoming Milling Region occur at depths of tens to hundreds of meters [hundreds of feet] (Section 3.4.3) and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick (Section 3.1.2). At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts to geology from ground subsidence would be expected to be SMALL.

The pressure of the producing aquifer is decreased during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the spread of contamination. This change in pressure theoretically could impact the transmissivity of faults in permitted areas. However, because uranium producing sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations in the Nebraska-South Dakota-Wyoming Milling Region, reactivation of faults is not anticipated.

A potential impact to soils arises from the need to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can be released and (1) pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater. For example, during 1996, the operator of the Crow Butte Uranium Project in Dawes County, Nebraska, logged 27 spill incidents, which ranged in volume from 45 to 65,000 L [12 to 17,305 gal] (NRC, 1998).

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). Licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soil for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the dose limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Nebraska-South Dakota-Wyoming Milling Region must also comply with any applicable state permitting agency requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these yellowcake or resin spills to both the NRC and the appropriate state permitting agency. License conditions also may require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA. At the Crow Butte Uranium Project in Nebraska, concrete berms that can retain the volume of the tank are used to contain spills from process chemical storage tanks and simplify cleanup (NRC, 1998).

Uranium mobilization and processing during ISL operations produces excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts and requirements for discharging treated waste streams to surface water bodies during ISL activities in the Nebraska-South Dakota-Wyoming Milling Region are discussed in Section 4.4.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Waste streams discharged to evaporation ponds can contain radionuclides and other metals that may become concentrated during evaporation. Therefore, soil contamination could result if either the liner or embankment of an evaporation pond was to fail. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. For example, several minor leaks were identified through the monitoring of the leak detection system at the Crow Butte Uranium Project, and repairs were made before contamination became an issue (NRC, 1998). The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are monitored and inspected by licensees in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the federal Dam Safety program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be transpired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium and other metals) to accumulate in the soils, thereby degrading the site's potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. For example, efforts to identify impacts to soil resulting from land application at the Crow Butte Uranium Project include (1) water analysis prior to release for land application to assure compliance with release limits; (2) soil sampling to establish background for uranium, radium, and other metals; (3) soil sampling for Ra-226 after each irrigation season; (4) groundwater sampling from monitoring wells near irrigation areas; and (5) surface water sampling from impoundments and streams near irrigation areas (NRC, 1998). Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be expected to be SMALL.

4.4.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by reinjection and recirculation of treated groundwater, and therefore it is very unlikely that ISL operations will reactivate local faults and extremely unlikely that any earthquakes would

be generated. Therefore, the impacts to geology in the Nebraska-South Dakota-Wyoming Milling Region from aquifer restoration are expected to be SMALL, if any.

The main impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the does limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Nebraska-South Dakota-Wyoming Milling Region are also required to comply with spill response and reporting requirements of the appropriate state permitting agency. The short-term impact on soils from spills of contaminated groundwater could range from SMALL to LARGE depending on the volume of affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

During aquifer restoration, the groundwater is passed through semipermeable membranes that yield a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal. In addition, treated wastewater may be applied to the land.

If reject water is sent to an evaporation pond, failure of the evaporation pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated wastewater during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in

decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.4.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes (1) dismantling process facilities and associated structures, (2) removing buried piping, and (3) plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Nebraska-South Dakota-Wyoming Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee's spill documentation, an NRC requirement, would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.4.4 Water Resources Impacts

4.4.4.1 Surface Water Impacts

4.4.4.1.1 Construction Impacts to Surface Water

The potential causes and nature of impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.1). Because the average annual runoff in the Nebraska-South Dakota-Wyoming Uranium Milling Region is similar to or less than that of most portions of the Wyoming West Uranium Milling Region, the potential for surface water impacts is no greater in the Nebraska-South Dakota-Wyoming Uranium Milling Region (Gebert, et al., 1987). Storm water runoff water quality is regulated by permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.5.2). Potential impacts to wetlands would be addressed through the appropriate consultations and permitting processes (e.g., USACE, state). As noted in Section 4.2.4.1.1, Wyoming has jurisdiction over isolated wetlands. While no state-administered permitting process is in place for wetlands in Nebraska, they are protected under Title 117 of the Nebraska Surface Water Quality Standards. Compliance with applicable federal and state regulations and permit conditions and use of best management practices and required mitigation measures would reduce impacts to SMALL to MODERATE, depending on site-specific conditions.

4.4.4.1.2 Operation Impacts to Surface Water

Because precipitation and the number of perennial streams is similar (Section 3.4.4.1), the potential causes and nature of impacts to surface water resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.2). Storm water runoff water quality and other discharges to surface water are regulated by state pollutant discharge elimination system permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.2.1). Compliance with permit conditions and use of best management practices and required mitigation measures would reduce operations impacts to surface water to SMALL to MODERATE, depending on local conditions.

4.4.4.1.3 Aquifer Restoration Impacts to Surface Water

Because precipitation and the number of perennial streams is similar (Section 3.4.4.1), the potential causes and nature of impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.3). Storm water runoff water quality and other discharges to surface water are regulated by state pollutant discharge elimination system permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.2.1). Compliance with permit conditions and use of best management practices and required mitigation measures would reduce impacts from aquifer restoration to surface water to SMALL to MODERATE, depending on local conditions.

4.4.4.1.4 Decommissioning Impacts to Surface Water

Because precipitation and the number of perennial streams is similar (Section 3.4.4.1), the potential causes and nature of impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.4). Storm water runoff water quality is regulated by state pollutant discharge elimination system permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.2.1). Compliance with permit conditions and use of best management practices and required mitigation measures would reduce decommissioning impacts to surface water to SMALL to MODERATE, depending on local conditions.

4.4.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region can occur during all phases of the ISL facility's lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers near the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer's geochemistry, and waste management practices involving land application of treated wastewater, evaporation

ponds, or deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.4.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment (Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small and would have a SMALL and temporary impact to groundwater supplies. Groundwater quality of near surface aquifers during construction is protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts to groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.4.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (Section 2.4). Disposal of processing wastes by deep well injection (Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.4.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers. The potential environmental impacts of pipeline, valve, or well integrity failures could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)
- The shallow aquifers are important sources for local domestic or agricultural water supplies

- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydrologically separated from other locally and regionally important aquifers.

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, local shallow alluvium aquifers exist. They are not important aquifers for water supplies in most areas, but are used for local supplies in some areas (Section 3.4.4.3.1). Hence, potential environmental impacts due to spills and leaks from pipeline networks or well integrity failures in shallow aquifers could be SMALL to MODERATE, depending on site-specific conditions. Potential impacts would be reduced by flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well MIT (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.4.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term "consumptive use" refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 5.16×10^{11} L [418,000 acre-ft] of water was used to irrigate 143,000 ha [354,000 acres] of land in South Dakota (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 3.60 million L/ha [1.18 acre-ft/acre]. Similarly, the average irrigation rate (for irrigated land) in Nebraska is 3.84 million L/ha [1.26 acre-ft/acre] (Hutson, et al., 2004). Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 67 ha [166 acres] in South Dakota or 63 ha [156 acres] in Nebraska for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by causing a lowering of water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would significantly overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). Drawdowns for this hypothetical case were calculated using the Theis Equation (McWhorter and Sunada, 1977) with representative values of the transmissivity and storage coefficient for the South Dakota and Nebraska sections of the Nebraska-South Dakota-Wyoming Uranium Milling Region. As discussed in Section 4.3.4.2.2.2, drawdowns are found to be more sensitive to the aquifer transmissivity than storage coefficient.

In the South Dakota section of the milling region, representative values of the transmissivity and storage coefficient of the Inyan Kara ore-bearing aquifer are 300 m^2/day [3,229 ft^2/day] and 5×10^{-4}, respectively (chosen from the range of respective parameter values discussed in Section 3.4.4.3). In this case, drawdowns resulting from bleed production at a constant rate over 10 years of ISL operations are 2.6, 2.0, and 1.5 m [8.5, 6.6, and 4.9 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from a hypothetical pumping well representing the withdrawals from an entire ISL facility.

In the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, representative values of the transmissivity and storage coefficient of the ore-bearing aquifer are 38 m^2/day [409 ft^2/day] and 5×10^{-4}, respectively (chosen from the range of respective parameter values discussed in Section 3.4.4.3). In this case, drawdowns resulting from bleed production (pumped water volume not returned to the ore-bearing aquifer) at a constant rate over 10 years of ISL operations are 19, 14, and 10 m [61, 47, and 33 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from a hypothetical pumping well representing the withdrawals from an entire ISL facility.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. The significance of recharge will depend on the isolation of the producing aquifer and the infiltration into any outcrops. For example, the Chadron Sandstone crops out in northwest Nebraska, where it is likely that recharge occurs (Collings and Knode, 1984). Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield significant overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use in the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region aquifer could be MODERATE if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well isolated from other aquifers that are used locally. In the South Dakota section of the region, short-term impacts are expected to be SMALL to MODERATE, depending on aquifer characteristics (e.g., transmissivity). In both sections of the region, these localized effects are expected to be temporary because drawdown near well fields would dissipate after pumping stops. Thus in both sections of the region, the long-term impacts are expected to be SMALL in most cases, depending on site-specific conditions. Important site-specific conditions include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. In order for ISL operations to occur, the uranium-bearing production aquifer would need to be exempted as an underground source of drinking water through the appropriate EPA or state-administered UIC program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to baseline or preoperational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. The remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or outside of the production zone of the producing aquifer to be impacted by excursions during ISL operation.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal hydraulic gradients can occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood

and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL product ion zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to the NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be impacted during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1977; Driscoll, 1986).

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, for example, for the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction between two aquifers (the overlying Mudstone and underlying Inyan Kara aquifer) and the vertical hydraulic conductivity of 4.0×10^{-7} m/day [1.3×10^{-6} ft/day] for the Skull Creek Shale (Section 3.4.4.3), a leaching solution would move vertically upward from the production aquifer (the Inyan Kara aquifer) to the overlying aquifer (Mudstone) at a rate of nearly 0.001 cm/yr [0.0004 in/yr]. If the vertical migration rate of a leaching solution is assumed be constant in the next 10 years, then the leaching solution would move 0.01 cm [0.004 in] away from the production zone. Because the thickness of Skull Creek Shale (the upper confinement) is 46–82 m [150–270 ft] (Section 3.3.4.3), the leaching solution would not be able to enter the overlying aquifer in the course of 10 years of ISL operation. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

In the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, for example, the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction between two aquifers and a vertical hydraulic conductivity of 5.0×10^{-7} m/day [1.6×10^{-6} ft/day] for an aquitard separating those two aquifers (representing the upper confinement of the Basal Chadron sandstone in Section 3.4.4.3), a leaching solution would move vertically upward from the production aquifer to an overlying aquifer at a rate of nearly 0.002 cm/yr [0.0008 in/yr]. If the vertical migration rate of a leaching solution is assumed be the same in the next 10 years, then the leaching solution would move 0.02 cm [0.008 in] away from the production zone. Because the thickness of upper confinement of the Basal Chadron Sandstone is up to 3–8 m [10–25 ft] (Section 3.3.4.3), the excursion would not be expected to enter the overlying aquifer during 10 years of ISL operation. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. Excursions typically are

reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying or underlying aquifers for water supply purposes in the vicinity of an ISL facility (e.g., from the overlying Newcastle Sandstone or the underlying Morrison Formation in the western South Dakota section of the milling region), which may enhance potential vertical excursions from the production aquifer (sandstone aquifers in the Inyan Kara Group). Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology, and the proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also to ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters, and the UCLs for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

Monitoring wells typically are completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As discussed in Section 3.3.4.3.2, the Basal Chadron Sandstone is underlain by a thick Pierre Shale and it is overlain by the Brule Formation.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts could be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., if they have high vertical hydraulic conductivities). To limit the likelihood of

vertical excursions, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine how to remediate it.

Briefly, the Inyan Kara aquifer is effectively confined above by the Skull Creek Shale and by the Pierre Shale below. Both confinements have small vertical hydraulic conductivities (Section 3.3.4.3.3), which could preclude downward vertical excursions from the production aquifer. Similarly, at the Crow Butte site in Nebraska, the Basal Chadron Sandstone is confined below by the thick Pierre Shale and above by the clay layers with a thickness up to 3–8 m [10–25 ft]. Both confinements have small vertical hydraulic conductivities (Section 3.3.4.3.3), which could preclude downward vertical excursions from the production aquifer. Preliminary calculations discussed previously suggest that the confinements in both sections of the uranium milling region would effectively restrict potential vertical excursions from the ore-bearing aquifers. Additionally, if the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be SMALL.

4.4.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act and the Safe Drinking Water Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from either the EPA or the authorized state (e.g. Nebraska or Wyoming) (Section 1.7.2).

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, all the aquifers between the Inyan Kara Group (ore mineralization zone) and the impermeable base rocks, including, from shallowest to deepest, the Minnekahta Limestone, the Minnelusa Formation, the Madison Formation, and the Deadwood Formation, are considered to be important aquifers for water supplies and reportedly have been extensively used for water supplies in the region (Williamson and Carter, 2001). Thus, none of the deep aquifers below the Inyan Kara Group appear to be suitable for deep injection in the region.

In the Nebraska section of the western Nebraska-South Dakota-Wyoming Uranium Milling Region, the Basal Chadron aquifer is underlain by thick Pierre Shale at the Crow Butte Uranium Project area (NRC, 1998). The UIC permit was granted for both Morrison and Sundance Formations below the Pierre Shale at the Crow Butte Facility in 1995. The Crow Butte ISL facility has been disposing liquid waste into the Morrison Formation since 1996. The total dissolved solids in the Morrison and Sundance Formations was reported to be as high as 24,000–40,000 mg/L at a regional scale, and these formations are not being used as water supplies in the area (request for modification of Class UIC Permit Crow Butte Project, Dawes County, Nebraska, March 27, 2000).

4.4.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following methods: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These methods are discussed in more detail in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from outside the well field. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because approximately 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired flow of water from outside of the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than during ISL operations (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

During aquifer restoration at Mine Unit 1 at the Crow Butte ISL facility, 6.5×10^6 L [1.7×10^6 gal], corresponding to 0.09 pore volume, was used between April 1994 and July 1994 during groundwater sweep. As part of restoration activities at Mine Unit 1 at the Crow Butte ISL facility, 57×10^6 L [15×10^6 gal] groundwater, corresponding to 0.89 pore volume, was transferred from Mining Unit 1 to other mining units between May 1994 and July 1997; $1{,}730 \times 10^6$ L [457×10^6 gal] groundwater, corresponding to 26.62 pore volume, underwent ion exchange treatment between September 1994 and February 1999; 390×10^6L [103×10^6 gal] groundwater, corresponding to 6.02 pore volume, underwent groundwater reverse osmosis treatment between October 1995 and July 1998; and 185×10^6 L [49×10^6 gal] groundwater,

corresponding to 2.85 pore volume, was recirculated from August 1998 through February 1999. By the end of the aquifer restoration, 2,370 × 10^6 L [626 × 10^6 gal] groundwater, corresponding to 36.47 pore volume, underwent ion exchange treatment between May 1994 and August 1999 (Crow Butte Resources, Inc., 2001).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min]. At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in one year. For comparison, in 2000, approximately 5.16 × 10^{11} L [418,000 acre-ft] of water was used to irrigate 143,000 ha [354,000 acres] of land in South Dakota (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 3.60 million L/ha [1.18 acre-ft/acre]. Similarly, the average irrigation rate (for irrigated land) in Nebraska is 3.84 million L/ha [1.26 acre-ft/acre] (Hutson, et al., 2004). Thus, the consumptive use of 280 million L [74 million gal] is roughly equivalent to the water used to irrigate 78 ha [190 acres] in South Dakota or 73 ha [180 acres] in Nebraska for 1 year.

Potential environmental impacts are affected by the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility. The potential environmental impacts of groundwater consumptive use during restoration could be SMALL to MODERATE. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the wastewater treatment system. The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.4.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from EPA or the authorized state and approval from the NRC. Additionally, the briny slurry produced during the reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injections must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for

groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.4.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills. Based on consideration of best management practices to minimize water use and spills, impacts on the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitor, injection, and recovery wells will be plugged and abandoned. The wells will be filled with cement and clay and then cut below plow depth to ensure that no groundwater flows through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

4.4.5 Ecological Resources Impacts

4.4.5.1 Construction Impacts to Ecological Resources

Vegetation

Because the ecoregions identified in the Nebraska-South Dakota-Wyoming Uranium Milling Region are similar to those found in the Wyoming West Uranium Milling Region and Wyoming East Uranium Milling Region, potential impacts to terrestrial vegetation from ISL uranium recovery facility construction would be SMALL to MODERATE, as described in Section 4.2.5.

Wildlife

Because of similar ecoregions, potential impacts of ISL uranium recovery facility construction on terrestrial wildlife identified in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those found in the Wyoming West Uranium Milling Region (SMALL to MODERATE), as described in Section 4.2.5.

Disturbed areas would be revegetated with a seed mixture of grasses, forbs, and shrubs approved by the WDEQ, Land Quality Division; South Dakota Department of Environment and

Natural Resources; and Nebraska Department on Environmental Quality to mitigate potential impacts to wildlife and habitat after construction of the wellfields and facility infrastructure. Crucial wintering and yearlong ranges vital for survival of local populations of big game and sage-grouse leks or breeding ranges are also located within the Wyoming portion of the region (Figures 3.4-12 through 3.4-18). If a potential ISL was to be located within these ranges, guidelines have been issued by the Wyoming Game and Fish Department (2004) for the development of oil and gas resources, which could be applied to construction activities associated with an ISL facility. Consultation with the Wyoming Game and Fish Department should be conducted, as well as a site-specific analysis to determine potential impacts from the facility to these species if located in Wyoming.

Aquatic

Impacts from an ISL uranium recovery facility construction to aquatic resources would be similar to those found in the Wyoming West Uranium Milling Region.

Threatened and Endangered Species

Numerous threatened and endangered species, as well as state species of concern are located within the region. These species with habitat descriptions are provided in Section 3.4.5.3. After a site has been selected, the habitats and impacts would be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff would (1) consult with the U.S. Fish and Wildlife Service, Wyoming Game and Fish Department, South Dakota Game and Fish Department, and the Nebraska Game and Park Commission for potential survey requirements and (2) explore ways to protect these resources. If any of the species are identified in a project site during surveys, impacts could range from SMALL to MODERATE to LARGE depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be expected to be developed. These endangered and threatened species have been reported in the Nebraska-South Dakota-Wyoming Uranium Milling Region and have been discussed previously in the Wyoming West Uranium Milling Region in Section 4.2.5.1.

- Black-footed ferret
- Blowout penstemon
- Interior least tern
- Piping plover
- Pallid sturgeon
- Ute ladies' tresses orchid
- Western prairie fringed orchid
- Whooping crane

4.4.5.2 Operation Impacts to Ecological Resources

Because much less land disturbance would be anticipated during the operations phase at an ISL facility, potential impacts to ecological resources from the operation of a ISL facility would be SMALL and similar to those discussed in the Wyoming West Uranium Milling Region.

4.4.5.3 Aquifer Restoration Impacts to Ecological Resources

Because the existing infrastructure would be used during aquifer restoration and no additional construction is expected, potential impacts to ecological resources would be similar to those of facility operation and therefore would be SMALL.

4.4.5.4 Decommissioning Impacts to Ecological Resources

Because the ecoregions are similar, the types of potential impacts to ecological resources from the operation of an ISL facility would be expected to be similar to those discussed in the Wyoming West Uranium Milling Region (SMALL). Additional land-disturbing activity would be less than expected during the construction phase and would be evaluated during the site-specific environmental review.

4.4.6 Air Quality Impacts

For the Nebraska-South Dakota-Wyoming Uranium Milling Region, the types of potential nonradiological air impacts for activities conducted as part of all four uranium milling phases would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.6. The Nebraska-South Dakota-Wyoming Uranium Milling Region analyses in this section are limited to modifying, supplementing, or summarizing the Wyoming West Uranium Milling Region analyses that are presented in Section 4.2.6, as appropriate.

In general, ISL milling facilities are not major nonradiological air emission sources, and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

The Nebraska-South Dakota-Wyoming Uranium Milling Region is classified as in attainment for NAAQS (see Figure 3.4-19). This also includes the counties immediately surrounding this region. The Nebraska-South Dakota-Wyoming Uranium Milling Region does include Wind Cave National Park that is classified as a Prevention of Significant Deterioration Class I area (see Figure 3.4-20). Current information indicates that the three uranium districts in the region are at least 40 km [25 mi] from Wind Cave. If applicable, information concerning Class I areas relevant to the location of the proposed site would be incorporated in the description of the affected environment at the site-specific environmental review level by NRC. As described in Section 1.7.2.2, NRC is not the regulatory authority for permitting. Permitting authorities are identified in Table 1.7-1. Specific requirements would be determined by the appropriate regulatory authority on a site-specific basis.

4.4.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (see Section 2.7.1). Most of the combustion emissions are diesel

emissions and are expected to be limited in duration to construction activities and result in small, short-term effects. For the purposes of evaluating potential impacts to air quality for a large, commercial-scale ISL facility, Table 2.7-2 contains the annual total releases and average air concentrations of particulate (fugitive dust) and gaseous (diesel combustion products) emissions estimated for the construction phase of the ISL facility proposed for Crownpoint, New Mexico, as documented in NRC (1997). The annual average particulate (fugitive dust) concentration was estimated to be 0.28 $\mu g/m^3$ [8×10^{-9} oz/yd^3] (NRC, 1997). However, this estimate did not categorize the particulates as PM_{10} or $PM_{2.5}$. This estimate is under 2 percent of the federal $PM_{2.5}$ ambient air standard, under 1 percent of the previous federal and current Nebraska and Wyoming PM_{10} ambient air standards, 7 percent of the Class I Prevention of Significant Deterioration allowable increment, and under 2 percent of the Class II Prevention of Significant Deterioration allowable increment. The annual average sulfur dioxide concentration was estimated to be 0.18 $\mu g/m^3$ [5×10^{-9} oz/yd^3] (NRC, 1997). This estimate is less than 1 percent of both the federal and more restrictive Wyoming ambient air standards, 9 percent of the Class I Prevention of Significant Deterioration allowable increment, and under 1 percent of the Class II Prevention of Significant Deterioration allowable increment. Finally, the annual average nitrogen oxide concentration was estimated to be 2.1 $\mu g/m^3$ [5.8×10^{-8} oz/yd^3] (NRC, 1997). This estimate is about 2 percent of the federal and state ambient air standards, 84 percent of the Class I Prevention of Significant Deterioration allowable increment, and under 9 percent of the Class II Prevention of Significant Deterioration allowable increment.

The Nebraska-South Dakota-Wyoming Uranium Milling Region is in attainment for NAAQS. This region does contain a Prevention of Significant Deterioration Class I area. There is a potential for elevated nitrogen oxide emission levels (see the levels estimated for the proposed Crownpoint ISL facility). However, the majority of the Nebraska-South Dakota-Wyoming Uranium Milling Region is categorized as a Class II area and gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. Therefore, construction impacts to air quality from constructing ISL facilities would be SMALL.

4.4.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution are SMALL. Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. Filters and baghouses are used to limit particulate emissions. In general, nonradiological emissions from yellowcake drying would be SMALL.

Other potential operation phase nonradiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified for the construction phase. The ISL operations phase fugitive dust emissions sources would be expected to include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel

emissions associated with well field construction. Therefore, operations phase impacts would be less than the construction phase impacts.

The Nebraska-South Dakota-Wyoming Uranium Milling Region is currently in NAAQS attainment. This region does, however, contain a Prevention of Significant Deterioration Class I area at Wind Cave National Park. There is a potential for elevated nitrogen oxide emission levels (see the levels estimated for the proposed Crownpoint ISL facility). However, as discussed previously, current information indicates that the closest potential ISL facility is at least 40 km [25 mi] from Wind Cave, and the majority of the Nebraska-South Dakota-Wyoming Uranium Milling Region is categorized as a Class II area. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts for ISL facilities would be SMALL.

4.4.6.3 Aquifer Restoration Impacts to Air Quality

Potential nonradiological air quality impacts from aquifer restoration activities (Section 2.11.5) include fugitive dust and combustion emissions from many of the same sources identified previously for the operations phase. The plugging and abandonment of production and injection wells use equipment that generates gaseous emissions. These emissions would be expected to be limited in duration and result in SMALL, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not be expected to exceed those of the construction phase. Therefore, aquifer restoration phase impacts would be SMALL.

4.4.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase nonradiological air impacts include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified previously for the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Decommissioning phase impacts would be expected to be similar to construction phase impacts and decrease as decommissioning and reclamation activities are completed. Therefore, decommissioning phase impacts would be SMALL.

4.4.7 Noise Impacts

4.4.7.1 Construction Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.1. There are additional sensitive areas that would be considered within this region (see Section 3.4.7), but because of decreasing noise levels with distance, construction activities would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas located more than about 300 m [1,000 ft] from specific noise-generating activities. The noise impacts associated with constructing either a central or satellite production facility would be of short duration compared to the operations period. Noise

impacts to workers during construction would be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During construction, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

4.4.7.2 Operation Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during ISL operations would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.2. There are additional sensitive areas that should be considered within this region (see Section 3.4.7), but because of decreasing noise levels with distance, operations at facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area would be expected to have only SMALL noise impacts. Because the same infrastructure would be used, noise-generating activities during aquifer restoration would be similar to the operation phase. Noise impacts to workers during operations would be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During operations, wildlife are anticipated to avoid areas where noise-generating activities are ongoing. Compared to existing traffic counts, truck traffic associated with yellowcake and chemical shipments and traffic noise related to commuting would have a SMALL, temporary impact on communities located along the existing roads. Some country roads with the lowest average annual daily traffic counts would be expected to have higher relative increases in traffic and noise impacts, in particular, when facilities are experiencing peak employment (these impacts would be MODERATE). Therefore, overall noise impacts during operations would be SMALL to MODERATE.

4.4.7.3 Aquifer Restoration Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.3. There are additional sensitive areas that should be considered within this region (see Section 3.4.7), but because of decreasing noise levels with distance, aquifer restoration activities at facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area would have only SMALL noise impacts. Noise impacts to workers during aquifer restoration would also be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife are anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during aquifer restoration would be SMALL to MODERATE.

4.4.7.4 Decommissioning Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.4. There are additional sensitive areas that should be considered within this region (see Section 3.4.7), but for facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area, decommissioning would have only SMALL noise impacts. Noise impacts to workers during decommissioning would also be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During decommissioning, wildlife would be

anticipated to temporarily avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during decommissioning would be SMALL.

4.4.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Nebraska-South Dakota-Wyoming Uranium Milling Region is provided in Sections 3.2.8 and 3.4.8. Construction involving land-disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, are expected to be the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, licensees and applicants would review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area and all its related facilities and components would be subjected to a comprehensive cultural resources inventory (performed by the licensee or applicant) that meets the requirements of responsible federal, state, and local agencies (e.g., the Nebraska, South Dakota, or Wyoming SHPO). The literature and records searches would help identify known or potential cultural resources and Native American sites and features. The cultural resources inventory would identify the previously documented sites and any newly identified cultural resources sites. The eligibility evaluation of cultural resources for listing in the NRHP under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties is conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties also occur during the site-specific licensing application and review process. Consultation to determine whether significant cultural resources would be avoided or mitigated would occur during consultations with the other agencies, state SHPO, and tribal representatives as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.4.8.1 *Construction Impacts to Historical and Cultural Resources*

Most of the potential for significant adverse effects to NRHP-eligible or potentially NRHP-eligible historic properties and traditional cultural properties, both direct and indirect, would likely occur during land-disturbing activities related to building an ISL uranium recovery facility. Buried

cultural features and deposits that are not visible on the surface during initial cultural resources inventories could be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions (see Section 4.4.9.1), increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL uranium recovery project.

Because of the localized nature of land-disturbing activities related to construction, impacts to cultural and historical resources are anticipated to be SMALL, but could be MODERATE to LARGE if the facility is located adjacent to a known resource. Wyoming historical sites listed in the NRHP and traditional cultural properties are provided in Section 3.2.8. South Dakota and Nebraska historical sites and traditional cultural properties are described in Section 3.4.8. Additional sensitive areas include properties under the management of the National Park Service such as Devils Tower, Jewel Cave, and Mt. Rushmore National Monuments, and Wind Cave National Park. Proposed facilities or expansions adjacent to these properties are likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording, and archiving samples) and additional consultations with the appropriate state (Wyoming, South Dakota, or Nebraska) SHPO and affected Native American tribes would be needed to assist in reducing the impacts. From the standpoint of cultural resources, the most significant impacts to any sites that are present will occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impacts to cultural resources that might be present.

4.4.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, impacts to NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Potential impacts during operation are expected to occur through new earth-disturbing activities, new construction, maintenance, and repair. Because fewer earth-disturbing activities are expected during operations, potential impacts would be SMALL (less than during construction). The three uranium districts in the Nebraska-South Dakota-Wyoming Uranium Milling Region are located more than 16 km [10 mi] from these sensitive areas, further reducing potential impacts.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations are expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.4.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Potential impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration are expected to be less than those during construction, as aquifer restoration activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.4.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Potential impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties in or near the site of decommissioning activities may potentially occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during decommissioning are expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of the decommissioning project. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.4.9 Visual/Scenic Resources Impacts

4.4.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those in the Wyoming West Uranium Milling Region. Most visual and scenic impacts associated with drilling and other land-disturbing construction activities would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.4.9, most of the areas in the Nebraska-South Dakota-Wyoming Uranium Milling Region are identified as VRM Class II through Class IV according to the BLM classification system or as having a low to moderate scenic integrity objective classification according to the USFS classification system. As described in Section 3.4.9, there are a number of potentially sensitive visual resources in the

Nebraska-South Dakota-Wyoming Uranium Milling Region. The existing and potential ISL facilities identified in the three uranium districts of the Nebraska-South Dakota-Wyoming Uranium Milling Region are generally located more than 16 km [10 mi] from VRM Class II areas and 40 km [25 mi] from the Prevention of Significant Deterioration Class I area located at Wind Cave National Park. The existing Crow Butte ISL facility in Dawes County, Nebraska, is located near the Pine Ridge unit of the Nebraska National Forest, but it has been in operation since the late 1980s and is an established part of the landscape. Visual/scenic impacts introduced by construction activities in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.9.2 Operation Impacts to Visual/Scenic Resources

Similar to the visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.2, the potential visual and scenic impacts from ISL operations in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be SMALL and the same as or less than those impacts associated with construction. The greatest potential for visual impacts would be for new facilities operating in rural, previously undeveloped areas or within view of the sensitive regions described in Section 3.4.9. Given the distances of existing and potential uranium ISL facilities from these areas, visual and scenic impacts introduced by ISL operations would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.3, the potential visual and scenic impacts from ISL aquifer restoration operations in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be SMALL. Aquifer restoration would not occur until after the facility had been in operation for a number of years, and potential impacts would be the same as or less than those during the construction or operations periods. Although overall impacts from aquifer restoration activities would be SMALL, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 3.4.9. Given the distances of existing and potential uranium ISL facilities from these areas, visual and scenic impacts introduced by ISL aquifer restoration activities would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.9.4 Decommissioning Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.4, the potential visual and scenic impacts from decommissioning and reclaiming ISL facilities in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be SMALL. Decommissioning and reclamation activities would occur after the facility had been in operation for a number of years, and one of the purposes of the decommissioning process is to remove surface infrastructure and reclaim the area to preoperational conditions. This would result in less visual contrast for the facility. Although overall impacts from decommissioning and reclamation activities would be the same as, or less than, those for construction and operation, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 3.4.9. Given the distances of existing and potential uranium ISL facilities from these areas, visual and scenic impacts

introduced by ISL decommissioning and reclamation activities would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility can reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). The workforce in this region frequently commutes long distances, many times out of state. Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Nebraska-South Dakota-Wyoming Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in Nebraska-South Dakota-Wyoming Uranium Milling Region is similar to that of the United States, the number is about 2.5 (U.S. Census Bureau, 2008). As a result, the number of people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.4.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Nebraska-South Dakota-Wyoming Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Sioux County, Nebraska (population 1,350); Niobrara County, Wyoming; and the towns of Osage, Wyoming (200), and Hill City, South Dakota (870). However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure. Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities were developed concurrently, the potential for impact upon the labor force would still be SMALL. Only in Sioux County, Nebraska, with the smallest labor force (749) in the region, would there be a MODERATE to LARGE impact if the entire workforce was to be derived from that county alone. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Osage, Wyoming, and Hill City, South Dakota) and Sioux County could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE, if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction is filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of an outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates, such as Laramie, Wyoming, due to the potential increase in job opportunities. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Communities such as Sioux County and the Oglala Sioux Tribe of the Pine Ridge Indian Reservation would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. Though Wyoming does not have an income tax, it does have a state sales tax (4 percent), a lodging tax (2–5 percent), and a use tax (5 percent). Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, and more significant, is the "ad valorem tax" the state imposes on mineral extraction. In 2007 for uranium, alone, the state collected $1.2 million from this tax (Wyoming Department of Revenue, 2008). Sources of revenue for the State of Nebraska come from the income, sales, cigarette, motor, and lodging taxes. Personal income tax rates for Nebraska range from 2.56 percent to 6.84 percent. The sales and use tax rate is 5.5 percent. Information on ad valorem taxes from the extraction of uranium is not available (Nebraska Department of Revenue, 2007). Sources of revenue for the State of South Dakota come from 36 different state taxes and are grouped into four main categories: (1) sales, use, and contractor's excise taxes; (2) motor fuel taxes; (3) motor vehicles fees and taxes; and (4) special taxes. Once collected, these tax revenues are distributed into the state's general fund, local units of government, and the state highway fund. South Dakota also imposes an energy minerals tax on owners of energy minerals (such as uranium). In 2006, the tax rate base was 4.5 percent of the taxable value and approximately 50 percent was dispersed to local government (South Dakota Department of Revenue and Regulation, 2007). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as they are already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL.

Accidents resulting from construction of an ISL facility are not expected to be different than those from other types of similar industrial facilities.

4.4.10.2 Operation Impacts to Socioeconomics

> **Economic Multipliers**
> The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements is filled by a workforce from outside the region, assuming a multiplier of about 0.7, there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 140, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region. However, because an outside workforce would be more likely to settle into more populated areas with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for at least the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7) are required to relocate into the Nebraska-South Dakota-Wyoming Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Spearfish and Hot Springs in South Dakota (within the region) and Rapid City, South Dakota (located just outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles (is housed).

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure, and these would be similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce would have a SMALL to MODERATE impact relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 140 (including families), there would only be about 30 school-aged children involved. While the influx of new students would be the greatest in the smaller school districts, even in these districts the impacts are anticipated to be SMALL. For example, with the exception of Sioux County, Nebraska, the smaller school districts average about 200–300 pupils per school (Section 3.4.10.6). Even if all the ISL workers' children attended the same school (which is unlikely), the increase in that school's student population would only be 10–15 percent.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.4.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.4.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar work force (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Nebraska-South Dakota-Wyoming Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE,

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community.

Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short-duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus would be considered SMALL.

4.4.11 Public and Occupational Health and Safety Impacts

Licensees are required to implement radiological monitoring and safety programs that comply with 10 CFR Part 20 requirements to protect the health and safety of workers and the public. NRC periodically inspects these programs to ensure compliance.

4.4.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction impacts on public and occupational health and safety for the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.1.

4.4.11.2 Operation Impacts to Public and Occupational Health and Safety

4.4.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

Estimated doses to members of the public are reported for a variety of commercial-scale and satellite facilities in Section 4.2.11.2.1. These doses are well below the 10 CFR Part 20 public dose limit of 1 mSv/yr [100 mrem/yr] and the 40 CFR Part 190 annual limit of 0.25 mSv [25 mrem]. Doses at other locations could be higher or lower depending on a variety of factors including receptor location, topography, and weather conditions. When releases occur from the ground level, doses decrease the farther the receptor is away from the release location because the radioactive material is diluted as the wind mixes it. The amount of dilution, which is referred to as dispersion, is determined by the weather (meteorological conditions). For areas in which meteorological conditions are more stable (less turbulent), a higher dose could occur. As the radioactive material travels via the wind, changes in topography can affect the dose received by the receptor. Doses for the various ISL facilities shown in Table 4.2-2 are at least a factor of three below the regulatory limit, and most are less than that. Doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and the overall potential radiological impacts from ISL operations would be SMALL.

4.4.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

The consequences of potential accidents are expected to be similar regardless of an ISL facility's location and are described in Section 4.2.11.2.2. Distance to the nearest receptor, topography, and meteorological data account for potential differences in resulting dose. For facilities in which the maximally exposed offsite individual would be closer, there would be higher doses for ground-level releases. Changes in topography could also have an impact on the resulting dose because this would allow the receptor to be closer to, or farther away from, the radioactive material as it travels by wind. Meteorological conditions vary based on location and could result in a higher or lower dose. The consequences resulting from a potential unmitigated accident would have a SMALL impact on the general public and, at most, a MODERATE impact on the workers.

4.4.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), SMALL risks would be expected in the use and handling of these chemicals during normal operations. However, accidental releases of these hazardous chemicals can produce significant consequences and impact public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.4.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

Nonradiological impacts to public and occupational health and safety for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.2.4. Compliance with applicable 10 CFR Part 20, EPA, and Occupational Safety and Health Administration requirements would ensure safe handling of radiological and hazardous materials. The likelihood of accidental releases would be reduced, and the potential impacts would be SMALL.

4.4.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Aquifer restoration impacts to public and occupational health and safety are expected to be similar to operational impacts discussed in Section 4.4.11.2. Compliance with applicable 10 CFR Part 20 (Section 2.9) and Occupational Safety and Health Administration requirements would ensure SMALL impacts.

4.4.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

During ISL decommissioning activities, hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed. During these activities, SMALL impacts could occur.

To ensure safety of workers and the public during decommissioning, the NRC requires licensed facilities to submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable

safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license and permit conditions where necessary, and (3) regular NRC and Occupational Safety and Health Administration inspection and enforcement activities to ensure compliance with applicable health and safety requirements constrain the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions to SMALL levels.

4.4.12 Waste Management Impacts

Waste management impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another.

4.4.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities is expected to generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility, provides insight into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that are generated by ISL facility construction, waste management impacts from construction would be SMALL.

4.4.12.2 Operation Impacts to Waste Management

Operation waste management impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.2 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. Operational waste management impacts would be SMALL, based on the required preoperational disposal agreement for byproduct material; regulatory controls including applicable permitting, license conditions, and inspection practices; and typical facility design specifications and management practices including waste treatment and volume reduction techniques, pond leak detection, and other routine monitoring activities.

4.4.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.4.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions,

Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.4.12.4 Decommissioning Impacts to Waste Management

Decommissioning waste management impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.4 because the waste volumes and management practices, waste management safety and environmental concerns, waste management regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. The required preoperational agreement for disposal of byproduct material, NRC review, and approval of a decommissioning plan and radiation safety program, and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.4.2.

4.4.13 References

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4.5 Northwestern New Mexico Uranium Milling Region

4.5.1 Land Use Impacts

Information on ISL facility size (Section 2.11) and the type of potential impacts to land use previously described for the two Wyoming and the Nebraska-South Dakota-Wyoming Uranium Milling Regions would also generally apply for ISL facilities in the Northwestern New Mexico Uranium Milling Region. For example, the total amount of land estimated to be impacted and disturbed by surface facilities and well fields at the proposed commercial-scale ISL facility at Crownpoint, New Mexico, was between 100 and 600 ha [247 and 1,483 acres] (NRC, 1997). These estimates fall within the range previously presented in Section 4.2.1 for the Wyoming West Uranium Milling Region.

4.5.1.1 Construction Impacts to Land Use

The types of land use in this region are similar in many respects to land uses in the Wyoming and Nebraska-South Dakota-Wyoming regions. Therefore, the types of construction impacts to land use from new ISL facilities in the region would also be similar. New construction activities would potentially (1) change and disturb the land uses, (2) restrict access and establish right-of-way for access, (3) affect mineral rights and land use by allottees and others, (4) restrict livestock grazing areas and revoke grazing permits, (5) restrict recreational activities, and (6) alter ecological, cultural, and historical resources.

Because of the complicated land use in the checkerboard region near tribal lands in the Northwestern New Mexico Uranium Milling Region, new ISL facilities could directly abut private land, allottees, and residences. Additional land use impacts could include denial of access to private land being leased for ISL operations and conflicts with other land uses that would need to be resolved with individual land owners and allottees. Such impacts, as is the case with most land use impacts due to construction and subsequent phases, could last for the life of the ISL facilities (NRC, 1997). In the Northwestern New Mexico Uranium Milling Region, overall potential construction impacts to land use from a potential ISL facility would range from SMALL to LARGE, depending on proximity to a sensitive land use.

4.5.1.2 Operation Impacts to Land Use

The types of land use impacts for operational activities would be expected to be similar to construction impacts regarding access restrictions, primarily because the infrastructure would already be in place. Additional land disturbances would not be expected during the operational activities described in detail in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the movement (sequencing) of well fields from one area to another within the permitted site, and this is addressed as a construction impact in Section 4.5.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be partly restored and reopened for grazing or recreation while a new well field is being developed, which would have impacts similar to those described in the preceding section for the construction phase. Because access restriction and land disturbance impacts would be similar to, or less than, those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.5.1.3 Aquifer Restoration Impacts to Land Use

The types of impacts to land use during aquifer restoration would be similar in nature to the potential impacts of the construction and operations phases, but because the existing infrastructure is used, they would be generally less frequent or intense. For example, as aquifer restoration activities proceed, impacts may shift from one well field area to another and allow certain access rights, grazing permits, and recreational activities to be restored. Overall, potential aquifer restoration impacts to land use are comparable to those of the operation phase and would be expected to be SMALL.

4.5.1.4 Decommissioning Impacts to Land Use

Potential types of decommissioning impacts to land use would be similar to the potential impacts seen during the construction, operation, and aquifer restoration phases. However, the frequency and intensity of certain activities disturbing the land uses would temporarily increase because there would be greater use of earth- and material-moving equipment and other heavy equipment. As decommissioning and reclamation proceed, the amount of disturbed land would decrease. Consequently, in the Northwestern New Mexico Uranium Milling Region, overall potential decommissioning impacts to land use would be greater than during the operation and aquifer restoration phases and would range from SMALL to MODERATE.

4.5.2 Transportation Impacts

Truck and automobile use is associated with all phases of the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8) is not expected to significantly affect the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak (construction) employment, would have greater impacts when roads with the lowest levels of current traffic. Low-trafficked roads may also be more susceptible to wear and tear from increased traffic are traveled. Localized intermittent and short-term SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions including the proximity of residences, or other regularly occupied structures, wildlife habitat, or grazing areas, to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC site-specific environmental review. Potential local impacts include loss of forge palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle follows.

4.5.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Sections 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation (Section 2.8) is expected to vary depending on the size of the facility. However, when compared with the regional traffic counts provided in Section 3.5.2, most roads that would be used for construction transportation in the Northwestern New Mexico Uranium Milling Region would not cause significant increases in daily traffic, and therefore traffic-related impacts would

be SMALL. A few roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak (construction) employment. The limited duration of ISL construction activities (12–18 months) suggests impacts would be of short duration. Temporary SMALL to MODERATE dust, noise, and incidental livestock or wildlife kill impacts are possible on, and in the vicinity of, access roads used for construction transportation.

4.5.2.2 Operation Impacts to Transportation

The discussion of impacts in Section 4.2.2.2 for the Wyoming West Uranium Milling Region also applies to the Northwestern New Mexico Uranium Milling Region because the same types of transportation activities would be conducted regardless of location, the same regulatory controls and safety practices apply, the same magnitude of transportation activities would be conducted, and the assessment of accident risks is generally applicable to all regions. Applicable transportation conditions for the Northwestern New Mexico Uranium Milling Region are discussed in Section 3.5.2. The magnitude of existing traffic conditions in the region is similar to that described for Wyoming West with regard to potential impacts, and therefore operational traffic-related impacts would be similar (SMALL to MODERATE). The methods and assumptions considered in the accident analysis in Section 4.2.2.2 (Wyoming West Uranium Milling Region) for yellowcake shipments are applicable to the Northwestern New Mexico Uranium Milling Region, and therefore the impact from yellowcake, resin transfer, and byproduct waste shipments would be similar (SMALL). The same practices and requirements that serve to limit the risks from chemical shipments also apply to the Northwestern New Mexico Uranium Milling Region and would also result in SMALL impacts.

4.5.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than those described for construction and operations because transportation activities would be primarily limited to supplies (including chemicals for reverse osmosis), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE considering the potential impacts of commuting during peak employment periods on low traffic roads.

4.5.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments, which are small compared to average annual daily traffic counts provided in Section 3.5.2. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment due to

cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected during decommissioning, impacts would be SMALL.

4.5.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities and processes at ISL facilities may impact geology and soils. The potential impacts on geology and soils from these activities in the Northwestern New Mexico Uranium Milling Region are discussed in the following sections.

4.5.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts to geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures
- Excavating and backfilling trenches for pipelines and cables
- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Northwestern New Mexico Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities will result in only SMALL (on average, approximately 15 percent of the permitted site area) impacts and temporary (several months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons will be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance would be limited to drill pad grading, mud pit excavation, well completion, and access road construction.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). Soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles would be specifically located, shaped, and seeded with a cover crop by the operator to control erosion. For example, during the construction of the proposed Crownpoint ISL facility, topsoil would be replaced in areas where it was temporarily removed and the areas would be revegetated once construction was completed (NRC, 1997). Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas; using silt fencing, retention ponds, and hay bales to retain sediment

within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is typically constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only a SMALL, short-term disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated material and graded to surrounding ground topography.

Based on the previous discussion, the impacts of construction activities on geology and soils at ISL facilities in the Northwestern New Mexico Uranium Milling Region would be SMALL.

4.5.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting "pregnant" lixiviant, which contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure. The source formations for uranium in the Northwestern New Mexico Uranium Milling Region occur at depths of hundreds of meters [hundreds of feet] below the ground surface. For example, the top of the uranium-bearing sandstone (Westwater Canyon Member of the Morrison Formation) at the Crownpoint and Church Rock sites near Crownpoint, New Mexico are at depths of 560 m [1,840 ft] and 140 to 230 m [460 to 760 ft], respectively (NRC, 1997). At these depths and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. However, ground subsidence at conventional underground mine workings has been cited as a potential issue (NRC, 1997).

The pressure of the producing aquifer is decreased during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the spread of contamination. This change in pressure theoretically could impact the transmissivity (e.g., resistance to flow) of faults in permitted areas. However, because sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations in the Northwestern New Mexico Uranium Milling Region, reactivation of faults is not anticipated.

A potential impact to soils arises from the necessity to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can be released and (1) pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater.

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). If the spill is allowed to dry, it can pose an ingestion or inhalation hazard to both humans and wildlife. Upon detection, licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soils for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Northwestern New Mexico Uranium Milling Region must also comply with any applicable state permitting agency requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these spills to NRC and the appropriate state permitting agency. License conditions also may require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA.

In the short term, impacts to soils from spills could range from SMALL to LARGE depending on the volume of soil affected by the spill. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

Uranium mobilization and processing during ISL operations produces excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts and requirements for discharging treated waste streams to surface water bodies during ISL operations in the Northwestern New Mexico Uranium Milling Region are discussed in

Section 4.5.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Waste streams discharged to evaporation ponds can contain radionuclides and other metals that may become concentrated during evaporation. Therefore, soil contamination could result if either the liner or embankment of an evaporation pond was to fail. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are monitored and inspected by licensees in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the Federal Dam Safety Program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be evapotranspired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. At the proposed ISL site near Crownpoint, New Mexico, the soil electrical conductivity of areas irrigated with treated wastewater would be monitored to mitigate the effects of soil salination.

Land application of the treated wastewater would also cause radiological and/or other constituents (e.g., selenium and other metals) to accumulate in the soils, thereby degrading the site potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive and toxic constituents within allowable release standards In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits. Areas of a site where land application of treated water has been used would also be included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine nature of the monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.5.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure that water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is

limited by recirculation of treated groundwater, and therefore it is unlikely that ISL operations would reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts to geology in the Northwestern New Mexico Uranium Milling Region from aquifer restoration are expected to be SMALL.

The main impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Northwestern New Mexico Uranium Milling Region are also required to comply with any applicable state permitting agency requirements for spill response and reporting. The short-term impact on soils from spills of contaminated groundwater could range from SMALL to LARGE depending on the volume of the affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

During aquifer restoration, the groundwater is passed through semipermeable membranes that yield a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal. In addition, treated wastewater may be applied to the land.

If reject water is sent to an evaporation pond, failure of the evaporation pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated wastewater during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that

concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.5.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes (1) dismantling process facilities and associated structures, (2) removing buried piping, and (3) plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Northwestern New Mexico Uranium Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee's spill documentation—an NRC requirement—would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.5.4 Water Resources Impacts

4.5.4.1 Surface Water Impacts

4.5.4.1.1 Construction Impacts to Surface Water

Potential impacts to Waters of the U.S. are regulated by permit under Section 404 of the Clean Water Act (Appendix B). The use of these permits also requires that the actions satisfy the individual state Section 401 certification with regard to water quality. In New Mexico, the Surface Water Quality Bureau of the New Mexico Environment Department has issued condition Section 401 Certification for discharges into ephemeral streams. In addition, the Surface Water Quality Bureau requires that a project-specific Section 401 Water Quality Certification must be obtained [see 33 CFR 330.4(c)] for discharges to any intermittent, perennial, and wetland surface waters and to any Outstanding National Resource Waters prior to construction. The Surface Water Quality Bureau requires a complete application and USACE permit verification prior to commencing the water quality certification review (New Mexico Surface Water Quality Bureau, 2007). If the project does not meet the requirements for a nationwide permit, then an individual Section 404 permit will be required.

Storm water runoff during construction would be controlled through a Storm Water Pollution Prevention Plan that is part of a NPDES permit issued by EPA (Section 1.7.2.1). Because average annual runoff in the Northwestern New Mexico Uranium Milling Region is less than in the Wyoming West Uranium Milling Region (U.S. Geological Survey, 2008), where the

construction impact to surface waters would be SMALL, the potential for surface water impacts in this region would also be SMALL.

4.5.4.1.2 Operation Impacts to Surface Water

The potential causes and nature of surface water impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to those discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.2). Because of the small number of perennial streams in the Northwestern New Mexico Uranium Milling Region, the potential impacts upon surface waters would be SMALL. Storm water runoff and other discharges to surface water in New Mexico are controlled by a Storm Water Pollution Prevention Plan and NPDES permit issued by EPA rather than a state agency (Section 1.7.2.1). Compliance with the requirements for these permits is expected to result in SMALL impacts to surface water from operations activities.

4.5.4.1.3 Aquifer Restoration Impacts to Surface Water

The potential causes and nature of surface water impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to those discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.3). Because of the small number of perennial streams in the Northwestern New Mexico Uranium Milling Region, the potential impacts from aquifer restoration would be SMALL. Storm water runoff and other discharges to surface water in New Mexico are controlled by a Storm Water Pollution Prevention Plan and NPDES permit issued by EPA rather than a state agency (Section 1.7.2.1). Compliance with the requirements for these permits would result in SMALL impacts to surface water from aquifer restoration.

4.5.4.1.4 Decommissioning Impacts to Surface Water

The potential causes and nature of impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.4). Because of the small number of perennial streams in the Northwestern New Mexico Uranium Milling Region, the potential impacts from decommissioning are expected to be SMALL. Storm water runoff and other discharges to surface water in New Mexico are authorized through a Storm Water Pollution Prevention Plan and NPDES permit issued by EPA rather than a state agency (Section 1.7.2.1). Compliance with the requirements for these permits would result in SMALL impacts to surface water from decommissioning.

4.5.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Northwestern New Mexico Uranium Milling Region can occur during all phases of the ISL facility's lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer, as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources from all phases of the ISL facility lifecycle can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the

production aquifer's geochemistry, and waste management practices involving deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.5.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment (Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small and would have a SMALL and temporary impact to groundwater supplies. Groundwater quality of near-surface aquifers during construction is protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts on groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.5.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (Section 2.4). Disposal of processing wastes by deep well injection (Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.5.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers. The potential environmental impacts of pipeline, valve, or well integrity failures could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)
- The shallow aquifers are important aquifers for local domestic or agricultural water supplies

- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts would be expected to be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydrologically separated from other locally and regionally important aquifers.

In some parts of the Northwestern New Mexico Uranium Milling Region, local shallow aquifers with small water yields exist and are often used for local water supplies. Hence, for some sites, potential environmental impacts due to spills and leaks from pipeline, valve, or well integrity failures to the shallow aquifers could be SMALL to MODERATE, depending on site-specific conditions. Potential impacts would be reduced based on flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well MIT (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.5.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term "consumptive use" refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Northwestern New Mexico Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 3.96 × 10^{12} L [3.21 million acre-ft] of water was used to irrigate 404,000 ha [998,000 acres] of land in New Mexico (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 9.81 million L/ha [3.22 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 24 ha [59 acres] in New Mexico for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by causing a lowering of water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). In this hypothetical case, drawdowns at locations 1, 10, and 100 m [3.3, 33, and 330 ft]away from a pumping well (representing the well field) would be 3.5, 2.8, and 2.1 m [3.5, 2.8, and 6.9 ft], respectively, after 10 years of operation. These estimates were calculated using the Theis Equation (McWhorter and Sunada, 1977) with transmissivity and storage coefficient values of 240 m^2/day (2,580 ft^2/day) and 8 × 10^{-5}, respectively (chosen from the range of respective parameter values discussed in Section 3.5.4.3). As discussed in Section 4.3.4.2.2.2, drawdowns are found to be more sensitive to the aquifer transmissivity than storage coefficient.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use is expected to be SMALL to MODERATE, depending on site-specific conditions (e.g., aquifer transmissivity). Impacts could be MODERATE in relatively low transmissivity aquifers if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well-isolated from other aquifers that are used locally. However, because localized drawdown near well fields would dissipate after pumping stops, these localized effects are expected to be temporary. The long-term impacts would be expected to be SMALL in most cases, depending on site-specific conditions. Important site-specific conditions would include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of

water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. For operations to occur, the uranium-bearing production aquifer would need to be exempted as an underground source of drinking water through the appropriate EPA or state-administered UIC program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to baseline or preoperational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. The remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or outside of the production zone of the producing aquifer to be impacted by excursions during ISL operation.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal excursions could occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL production zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to the NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be impacted during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1977; Driscoll, 1986).

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying or underlying aquifers for water supply purposes in the vicinity of an ISL facility (e.g., from the

overlying Dakota Sandstone or the underlying Cow Springs Sandstone), which may enhance potential vertical excursions from the production aquifer (the Morrison Formation including the ore-bearing Westwater Canyon aquifer). Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology and the proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also to ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine remediation actions. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters, and the UCLs for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

If excursions are observed at the monitoring wells, the licensee would increase sampling and commence corrective actions. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Monitoring wells typically are completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As described in Section 3.5.4.3.2, the Dakota Sandstone overlies the ore-bearing aquifer and the Cow Springs Sandstone underlies the ore-bearing aquifer in the vicinity of the existing ISL sites.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts could be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees conduct MIT of the injection and production wells to ensure that lixiviant

remains in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine remediation actions.

In the Northwestern New Mexico Uranium Milling Region, the ore-bearing aquifer (the Westwater Canyon aquifer in the Morrison Formation) is confined below and above by continuous and thick confining layers at the ISL sites. The thickness of the aquitards is reportedly variable in the milling region (NRC, 1997). There is no evidence on the fracture nature of these confining layers in the region. If the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be SMALL.

4.5.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act, the Safe Drinking Water Act, and the Clean Air Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from the EPA (Section 1.7.2).

At the proposed ISL facility site in Crownpoint, New Mexico, the Cow Springs Aquifer and Entrada Sandstone do not appear to be potential aquifers for deep injection, because data indicate that the Cow Springs Aquifer contains good quality water (Hydro Resources, Inc., 1996; NRC, 1997) and this aquifer is not hydraulically separated from the underlying Entrada Sandstone. Thus, no deep aquifer has been identified in that portion of the uranium milling region for deep injection of leaching solutions.

The potential environmental impacts of injection of leaching solutions into deep aquifers below ore-bearing aquifers would be expected to be SMALL if water production from deep aquifers is not economically feasible or the groundwater quality from these aquifers is not suitable for domestic or agricultural uses (e.g., high salinity), and they are confined above by sufficiently thick, low permeability layers. As discussed previously, licensees seeking to dispose of liquid effluents by deep well injection would need to be granted a permit to do so from the EPA or appropriate state agency.

4.5.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following methods: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These methods are discussed in depth in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other

contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from outside the well field. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because up to 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired for of water from outside the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than during ISL operations (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

As discussed in Section 2.5, restoration typically is performed as well fields end production, so all of the well fields do not undergo groundwater sweep at the same time. For example, at the Irigaray Mine, (Cogema Mining, Inc., 2004), average pumping rates for groundwater sweep ranged from approximately 100 L/min [27 gal/min] to pump 120 million L [31 million gal] from two well fields between June 1991 and August 1993 to 380 L/min [100 gal/min] to pump 190 million L [49 million gal] from three well fields between May of 1990 and April of 1991. At the Smith Ranch/Highland Uranium Project in Converse County, Wyoming, an average pumping rate of approximately 38 L/min [10 gal/min] was used to pump 3.2 pore volumes {49 million L [13 million gal]} from the A-Wellfield during almost 3 years groundwater sweep (Power Resources, Inc., 2004).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].

At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in 1 year. For comparison, in 2000, approximately 3.96×10^{12} L [3.21 million acre-ft] of water was used to

irrigate 404,000 ha [998,000 acres] of land in New Mexico (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 9.81 million L/ha [3.22 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in 1 year of restoration would be roughly equivalent to the water used to irrigate 29 ha [72 acres] in New Mexico for 1 year. Potential environmental impacts are affected by the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility or at the regional scale. The potential environmental impacts of groundwater consumptive use during restoration could be SMALL to MODERATE. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the wastewater treatment system. The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.5.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from EPA or the authorized state and approval from the NRC. Additionally, the briny slurry produced during the reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injection must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.5.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills. Based on consideration of best management practices to minimize water use and spills, impacts to the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitors, injection, and recovery wells will be plugged and abandoned. The wells will be filled with cement and clay and then cut off below plow depth to ensure that no groundwater flows through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

4.5.5 Ecological Resources Impacts

4.5.5.1 Construction Impacts to Ecological Resources

Vegetation

ISL uranium recovery facility construction primarily affects terrestrial vegetation through (1) the removal of vegetation from the milling site during construction (and associated reduction in wildlife habitat and forage productivity and an increased risk of soil erosion and weed invasion); (2) the modification of existing vegetative communities as a result of milling maintenance; (3) the loss of sensitive plants and habitats as a result of construction clearing and grading; and (4) the potential spread of invasive species and noxious weed populations as a result of construction.

ISL facilities typically are located on large tracts of land in remote areas. Permit areas of past facilities have ranges from 69 ha to 6,480 ha [170 to 16,000 acres] (Section 2.11.1). Typically, the amount of land disturbance within these permitted areas ranges from 49 to 750 ha [120 to 1,860 acres]. The percentage of vegetation removed (disturbed land) ranges from a low of 1 percent to as much as 70 percent, but is on average approximately 15 percent. This results in a relatively SMALL impact in relation to the total permit area and surrounding plant communities.

Clearing herbaceous vegetation during construction in an open grassland or shrub steppe community is anticipated to have a short-term impact. If active revegetation measures are used with seed mixtures approved by the New Mexico Environmental Department, colonization by annual and perennial herbaceous species in the disturbed staging areas and rights-of-way would restore most vegetative cover within the first growing season, and impacts from clearing would be SMALL.

Clearing woody shrubs and trees would have a longer-term impact than herbaceous clearing. While woody shrubs and trees would recolonize the temporary construction right-of-way and staging areas, they would recolonize more slowly than would herbaceous species. As natural succession is allowed to proceed in these areas, the early successional or forested communities that existed before construction would eventually be reestablished. Clearing trees in the milling site could affect forest vegetation growing along the edges of the cleared areas. Exposing some edge trees to elevated levels of sunlight and wind could increase evaporation rates and the probability of tree "knockdown." Due to the increased light levels penetrating the previously shaded interior, shade-intolerant species would be able to grow and the species composition of the newly created forest edge may change. Clearing could also temporarily reduce local competition for available soil moisture and light and may allow some early successional species to become established and persist on the edge of the uncleared areas adjacent to the milling

site. Impacts from clearing this community would be SMALL to MODERATE depending on the amount of surrounding wooded area.

Noxious weeds that may invade areas disturbed by construction would be controlled through the use of herbicides. Application would employ the use of hand sprayers or broadcasting using truck-mounted spraying equipment. If these methods are used, potential impacts from noxious weeds would be SMALL. Based on these considerations, potential impacts to wildlife would be SMALL to MODERATE.

Wildlife

There are three primary impacts of ISL uranium recovery facility construction on terrestrial wildlife: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and/or indirect mortalities from project construction and operation.

Construction activities in well fields would result in some loss of wildlife habitat; however, this loss can be minimized if disturbed areas are reseeded when construction is completed in that area. The impacts would expected to be greatest in vegetative communities where clearing is required to construct wells, access roads, header houses, and pipelines from the well fields to the header houses. In general, most wildlife, including the larger and more mobile animals, would disperse from the project area as construction activities approach. Displaced species may recolonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and a suitable habitat is reestablished. Some smaller, less mobile wildlife such as amphibians, reptiles, and small mammals may die during clearing and grading activities. Small mammals and songbirds dependent on shrubs and trees for food, nesting, and cover would be impacted in areas where clearing is needed for construction. Wildlife habitat fragmentation, temporary displacement of animal species, and direct or indirect mortalities is possible, therefore construction impacts would be SMALL to MODERATE.

Even if available habitat exists within the site and adjacent areas to support displaced individuals, some impact from competition for resources between preexisting species may occur. Some localized foraging areas may be avoided by big game during construction periods when workers are present. Noise, dust, and increased presence of workers in, or adjacent to, foraging areas may temporarily preclude use by wildlife (NRC, 2004). Habitat loss and fragmentation can be reduced if the percentage of land affected compared to the total undisturbed vegetative community acreage within the permitted area and or surrounding area is minimal. Standard management practices issued by the New Mexico Department of Game and Fish can help to minimize habitat fragmentation, wildlife stress, and incidental death.

Critical wintering habitat vital for the survival of local elk populations is located within the region (Figure 3.5-9). If a potential facility was to be located within these ranges, guidelines have been issued by the New Mexico Department of Game and Fish to limit the impacts to a SMALL magnitude. Consultation with the New Mexico Department of Game and Fish would be conducted, and a site-specific analysis performed to determine impacts from the facility to these species.

Well field operations would require the construction of power distribution lines. Lines would be supported by single-pole wood structures with a wooden cross arm. The conductors would be configured to assure adequate spacing between the shield wire (i.e., ground wire) and

conductors to avoid potential electrocution of raptors that land on the cross-arms. Construction of the distribution lines would follow guidance in Avian Power Line Interaction Committee (1996). Raptors breeding in the site may be impacted by construction activities or mining operations and may be temporarily impacted depending on the time of year construction activities occur. Potential impacts to this species would be SMALL.

To minimize impacts, where possible, the facility would avoid construction in areas within 0.8 km [0.5 mi] of active raptor nests and prior to fledging of young. Mitigation should be carried out in areas that cannot be avoided based on approval by the U.S. Fish and Wildlife Service and the New Mexico Department of Game and Fish. Proposed mitigation could include construction of alternate nest sites on natural features (e.g., trees, rock outcrops, and cliffs) and on mine high walls in the site and vicinity, and erection of appropriate nesting platforms on wooden poles (NRC, 2004).

Aquatic

ISL uranium recovery facility construction primarily affects aquatic resources through (1) short-term physical disturbances to stream channels; (2) short-term increases in suspended sediments from in-stream activities and erosion from adjacent disturbed lands; (3) increases in downstream sedimentation, during construction, from in-stream activities and erosion from adjacent disturbed lands; (4) potential fuel spills from equipment and refueling operations during construction; and (5) short-term reductions in habitat and potential loss of individual specimens from water appropriations if needed. Impacts to aquatic resources from construction would be similar in nature to those described for other milling regions (SMALL).

Threatened and Endangered Species

There are three primary impacts of ISL uranium recovery facility construction on threatened and endangered species: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and indirect mortalities from project construction and operation.

Numerous threatened and endangered species and state species of concern are located within the region. These species with habitat descriptions are provided in Section 3.5.5.3. After a site has been selected, the habitats and impacts would be expected to be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff consult with the U.S. Fish and Wildlife Service and New Mexico Department of Game and Fish for potential survey requirements and explore ways to protect these resources. If any of the species are identified in the project site during surveys, potential impacts could range from SMALL to MODERATE to LARGE depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be expected to be developed.

- The black-footed ferret is reported to be extirpated from New Mexico and is no longer present in the region. No impacts to black-footed ferrets are expected to occur from milling activities within this region.
- The bald eagle has been delisted and is undergoing monitoring. While not a listed species, the bald eagle is still offered protection, and impacts should be avoided.

Impacts to this species are unlikely if vegetation during construction removal avoids nesting and hunting habitat along riparian areas.

- The Mexican spotted owl has critical habitat designated within the region. Mexican spotted owls nest, roost, forage, and disperse in a diverse assemblage of biotic communities. In the region, owls occur primarily in rocky canyons. They nest in these areas on cliff ledges, in stick nests built by other birds, on debris platforms in trees, and in tree cavities. In southern Utah, Colorado, and some portions of northern New Mexico, most nests are in caves or on cliff ledges in rocky canyons. Potential large impacts may occur to this species from land disturbance and removal of woody vegetation from their designated habitat.

- The Pecos puzzle sunflower is found in areas that have permanently saturated soils, including desert wetlands (cienegas) that are associated with springs and potentially in stream and lake margins. The removal of vegetation for construction would have a large impact to this species if the species is found within the construction zone.

- Impacts to the Southwestern willow fly catcher would occur if patchy to dense riparian habitats along streams, reservoirs, or other wetlands were removed creating vegetative buffers and avoiding areas in which this species breeds would minimize impacts.

- The Zuni fleabane grows in selenium-rich clay soils derived from the Chinle and Baca formations. Plants are found at elevations from 2,230–2,440 m [7,300–8,000 ft] in pinyon-juniper woodland. Potential impact from vegetation removal may occur to this species as a result of the facility construction if this species is found at the facility.

- The Rio Grande silvery minnow is believed to occur only in one reach of the Rio Grande in New Mexico, a 280-km [174-mi] stretch of river that runs from Cochiti Dam to the headwaters of Elephant Butte Reservoir. SMALL to MODERATE impacts to this species could occur if vegetation removal, erosion, or sedimentation control measures are not followed during construction if the listed waterway occurs within the facility's boundaries.

- The yellow-billed cuckoo—(candidate) habitat is described in Section 3.2.5.3 of the Wyoming West Uranium Milling Region.

- Surveys conducted in 1990 determined the distribution of Zuni bluehead sucker (candidate) in New Mexico to be limited mainly to the Río Nutria drainage upstream of the mouth of the Rio Nutria Box Canyon. This included the mouth of Río Nutria Box Canyon, upper Río Nutria, confluence of Tampico Draw and Río Nutria, Tampico Spring, and Agua Remora. If the listed waterways occur within the permit area, potential impacts to this species may occur from construction of crossings and vegetation removal. These impacts would be temporary in nature if revegetation and or avoidance of these areas were employed.

4.5.5.2 Operation Impacts to Ecological Resources

The primary potential impacts of ISL uranium recovery facility operation on terrestrial wildlife are (1) habitat alteration and incremental habitat fragmentation; (2) displacement/stress of wildlife

from human activity; and (3) direct and/or indirect mortalities from project construction and operation.

Some impacts to wildlife would occur from direct conflict with vehicular traffic and the presence of onsite personnel. Generally these are SMALL impacts that would not affect the total population of a species. Mitigation guidelines with respect to noise, vehicular traffic, and human proximity have been established by the New Mexico Department of Game and Fish (New Mexico Department of Game and Fish, 2007).

Potential impacts to migratory birds and other wildlife from exposure to selenium concentrations and radioactive materials in the evaporation ponds may occur. No guidelines have been established concerning acceptable limits for radiation exposure for protection of species other than humans. It is generally agreed that radiation protection standards for humans are conservative for other species (NRC, 2004). The concentrations of radioactive materials in the evaporation ponds are not anticipated to be at levels that could result in significant radiation exposure to biota other than humans. Typically, evaporation ponds are lined with a synthetic liner that inhibits the growth of aquatic vegetation which might otherwise serve as a potential source of exposure to radioactive materials via a food pathway. Such vegetation could also potentially provide habitat for wildlife (NRC, 2004). Mitigation measures such as perimeter fencing, surface netting, and the infrequency of wildlife visitation would reduce potential impacts.

Impacts to the aquatic resources and vegetation from facility operations would be SMALL and generally result from spills around well heads and leaks from pipeline. These would be handled using best management practices (NRC, 2007). Leak detection systems and spill response plans to remove affected soils and capture release fluids would reduce the impact to aquatic systems. Impacts to federal threatened and endangered species beyond those that occurred during construction would be SMALL. The potential exists for contact with vehicles to occur during facility operations for those species which are mobile, if they occur in the area.

4.5.5.3 Aquifer Restoration Impacts to Ecological Resources

Impacts similar to those found from facility operation are expected as a result of this activity.

4.5.5.4 Decommissioning Impacts to Ecological Resources

Impacts as result of decommissioning would, in part, be similar to those discussed in the construction of the facility and would be short term. The removal of piping would impact vegetation that has reestablished itself, and wildlife could come in contact with heavy equipment. During decommissioning, reclamation activities would revegetate previously disturbed areas and restore streams and drainages to their preconstruction contours. It is expected that temporarily displaced wildlife would return to the area. As a result, the potential impacts to ecological resources during decommissioning would be expected to be SMALL.

4.5.6 Air Quality Impacts

For the Northwestern New Mexico Uranium Milling Region, potential nonradiological air impacts for all four uranium milling phases would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.6. The Northwestern New Mexico Uranium Milling Region analyses in Section 4.5.6 would be limited to the modification, supplementation, or

summarization of the Wyoming West Uranium Milling Region analyses presented in Section 4.2.6.

In general, ISL milling facilities are not major nonradiological air emission sources and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

The Northwestern New Mexico Uranium Milling Region is classified as attainment for NAAQS (see Figure 3.5-11). The city of Albuquerque in Bernalillo County is designated as maintenance for carbon monoxide. The northwest part of Bernalillo County is only several kilometers [miles] from the Northwestern New Mexico Uranium Milling Region border, however, Albuquerque is about 50 km [31 mi] from this border. The Northwestern New Mexico Uranium Milling Region does not include any Prevention of Significant Deterioration Class I areas (see Figure 3.5-12). Therefore, the less stringent Class II area allowable increments apply.

4.5.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration to construction activities and result in small, short-term effects. The Northwestern New Mexico Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. Therefore, construction impacts for ISL facilities would be SMALL.

4.5.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution are SMALL. Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. In general, nonradiological emissions from yellowcake drying would be SMALL.

Other potential operation phase nonradiological air quality impacts include fugitive dust and combustion emissions from many of the same sources identified earlier in the construction phase. ISL operations phase fugitive dust emissions sources include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions

associated with well field construction. Therefore, operations phase impacts would be expected to be less than the construction phase impacts.

The Northwestern New Mexico Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts for ISL facilities would be SMALL.

4.5.6.3 Aquifer Restoration Impacts to Air Quality

Potential aquifer restoration phase nonradiological air impacts include fugitive dust and combustion emissions from many of the same sources identified earlier in the operations phase. The plugging and abandonment of production and injection wells use equipment that generates gaseous emissions. These emissions would be limited in duration and result in SMALL, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not exceed those of the construction phase. Therefore, aquifer restoration phase impacts would be SMALL.

4.5.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase nonradiological air impacts include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified earlier in the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Decommissioning phase impacts would be expected to be similar to construction phase impacts. Therefore, decommissioning phase impacts would be SMALL.

4.5.7 Noise Impacts

4.5.7.1 Construction Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.1. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but because of decreasing noise levels with distance, construction activities would have only SMALL and short-term noise impacts for residences, communities, or sensitive areas located more than about 300 m [1,000 ft] from specific noise-generating activities. The noise impacts associated with constructing either a central or satellite production facility would be of short duration compared to the operations period. Noise impacts to workers during construction would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During construction, wildlife are likely to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

4.5.7.2 Operation Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during ISL operations would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.2. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but operations at facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area would have only SMALL noise impacts. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During operations, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Compared to daily traffic counts of more than 12,000 to 16,000 vehicles per day on Interstate 40 and U.S. Highway 491 near Gallup (New Mexico Department of Transportation, 2007; see also Section 3.5.7), additional traffic associated with ISL operations would have only a SMALL impact on noise levels near the highway. As noted in Section 4.2.7.1, noise levels measured at 78 dBA at 30 m [98 ft] would decrease with distance from the highway to 60 dBA at 360 m [1,180 ft] (Washington State Department of Transportation, 2006). Some country roads with low average annual daily traffic counts would have higher relative increases in traffic and noise impacts, in particular, when facilities are experiencing peak (construction) employment (these impacts would be MODERATE). Therefore, overall noise impacts during operations would be SMALL to MODERATE.

4.5.7.3 Aquifer Restoration Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.3. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but for facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area, aquifer restoration would be expected to have only SMALL noise impacts. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. Noise impacts to workers during aquifer restoration would also be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during aquifer restoration would be expected to be SMALL to MODERATE.

4.5.7.4 Decommissioning Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.4. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but for facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area, decommissioning would be expected to have only SMALL noise impacts. Noise impacts to workers during decommissioning would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During decommissioning, wildlife would avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during decommissioning would be SMALL.

4.5.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Northwestern New Mexico Uranium Milling Region is provided in Section 3.5.8. Construction involving land-disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, are the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, licensees and applicants review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area, and its related facilities and components, would be subjected to a comprehensive cultural resources inventory that meets the requirements of responsible federal, state, and local agencies (e.g., the New Mexico SHPO). The literature and records searches will help identify known or potential historical and cultural resources and Native American sites and features. The cultural resources inventory would identify the previously documented sites and any newly identified cultural resources sites.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance, or recording, and archiving samples) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, *if encountered. The eligibility evaluation of cultural resources for listing in the* NRHP under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties is conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties also occur during the site-specific licensing application and review process. Consultation to determine whether significant cultural resources would be avoided or mitigated occurs during state SHPO, agency, and tribal consultations as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC, licensees, and applicants may enter into memoranda of understanding with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.5.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible, or potentially NRHP-eligible, historic properties and traditional cultural properties, both direct and indirect, would likely occur during land-disturbing activities related to building an ISL uranium recovery facility. Buried cultural features and deposits that are not visible on the surface during initial cultural resources inventories could be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions, increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, such as Mt. Taylor, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL uranium recovery project.

Because of the localized nature of land disturbing activities related to construction, impacts to cultural and historical resources are anticipated to be SMALL, unless the facility is located adjacent to a known resource. New Mexico historical sites and traditional cultural properties are described in Section 3.5.8. Proposed facilities or expansions adjacent to these properties and other tribal lands would be likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording and archiving samples) and additional consultations with affected Native American tribes would be needed to reduce the impacts. From the standpoint of cultural resources, the most significant impacts to any sites that are present would occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impact to any cultural resources that might be present.

4.5.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Potential impacts during operation would be expected to occur through new earth-disturbing activities, new construction, maintenance, and repair.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations are expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.5.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural

resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Potential impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to historical and cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration are expected to be less than those during construction, as aquifer restoration activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.5.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Potential impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties in or near the site of decommissioning activities may potentially occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during decommissioning are expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project activities. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.5.9 Visual/Scenic Resources Impacts

4.5.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Northwestern New Mexico Uranium Milling Region would be similar to those in the Wyoming West Uranium Milling Region. Most visual and scenic impacts associated with drilling and other land-disturbing construction activities would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.5.9, most of the areas in the affected environment of the Northwestern New Mexico Uranium Milling Region are identified as VRM Class II through Class IV according to the BLM classification system. In the Northwestern New Mexico Uranium Milling Region, a number of VRM Class II areas surrounding the national monuments (El Morro and El Malpais), the Chaco Culture National Historic Park, and the sensitive areas managed within the Mt. Taylor district of the Cibola National Forest would have the most potential for impacts to visual resources. Most of these areas, however, are located to the north, south, and east of the potential ISL facilities, at distances of 16 km [10 mi] or more. The facilities would be located in VRM Class III and IV

areas. Current understanding indicates that several potential ISL facilities may be located near the Navajo Nation or near Mt. Taylor in the San Mateo Mountains. The general visual and scenic impacts associated with ISL facility construction are anticipated to be temporary and SMALL. However, from a Native American perspective, any construction activities are likely to result in adverse impacts to the landscape, particularly for facilities located in areas within view of tribal lands and areas of special significance such as Mt. Taylor.

4.5.9.2 Operation Impacts to Visual/Scenic Resources

Similar to the visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.2, the potential visual and scenic impacts from ISL operations in the Northwestern New Mexico Uranium Milling Region would be SMALL and the same as, or less than, those impacts associated with construction. For example, in a similar assessment for the Farmington Field Office area near Grants, New Mexico, BLM estimated that drilling associated with oil and gas lease development would minimally change the visual quality of the landscape (BLM, 2003). The greatest potential for visual impacts would be from new facilities developed in rural, previously undeveloped areas or within view of the sensitive regions described in Sections 3.5.9 and 4.5.9.1.

4.5.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.3, the potential visual and scenic impacts from ISL aquifer restoration operations in the Northwestern New Mexico Uranium Milling Region would be SMALL. Aquifer restoration would not occur until after the facility had been in operation for a number of years, and potential impacts would be the same as, or less than, during the operations period. Although overall impacts from aquifer restoration activities would be the same as, or less than, those for construction and operation, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Sections 3.5.9 and 4.5.9.1.

4.5.9.4 Decommissioning Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.4, the potential visual and scenic impacts from decommissioning and reclaiming ISL facilities in the Northwestern New Mexico Uranium Milling Region would be SMALL. Decommissioning and reclamation activities would occur after the facility had been in operation for a number of years, and one of the purposes of the decommissioning process is to remove surface infrastructure and reclaim the area to preoperational conditions. This would result in less visual contour for the facility. Although overall impacts from decommissioning and reclamation activities would be the same as or less than those for construction and operation, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Sections 3.5.9 and 4.5.9.1.

4.5.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility can reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). Depending on the

composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Northwestern New Mexico Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in New Mexico is about 3.6 (U.S. Census Bureau, 2008), the number of people associated with an ISL facility workforce could be as many as 720 (i.e., 200 workers times 3.6 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.5.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Northwestern New Mexico Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Northwestern New Mexico Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Tohatchi (population 1,000) in McKinley County and Laguna (400) in Cibola County. However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure. Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Northwestern New Mexico Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities be developed concurrently, the potential for impact upon the labor force would still be SMALL. For example, the town of Grants, Cibola County, has a labor force of 3,800. It would require two ISL facilities to be constructed simultaneously to affect the labor market of just the town of Grants by only 10 percent, if all the workers came from the town of Grants, alone. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Tohatchi and Laguna) could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction is filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The

use of an outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Communities such as the town of Grants and the Native American communities in the Indian Reservations (Acoma, Tohajiilee, Laguna, Navajo Nation, Ramah Navajo, and Zuni) would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. New Mexico has a personal income tax that ranges from 1.7 to 5.3 percent. In addition, it has a gross receipt sales tax. Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, state tax revenues generated from mineral (non-oil and gas) production activities include state trust land mineral lease royalties, rentals and bonuses and severance, as well as resource excise and conservation tax revenues. In 2006, revenues from mineral production activities other than oil and gas generated about $37.3 million for New Mexico (New Mexico Energy, Minerals and Natural Resources Department, 2007). Although there are no active uranium production facilities in New Mexico, in 2006 almost 130 people were employed in permitting, care, maintenance, and reclamation activities associated with closing historic uranium operations (New Mexico Energy, Minerals and Natural Resources Department, 2007). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as this workforce is already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL. Accidents resulting from construction of an ISL facility are not expected to be different than those from other types of similar industrial facilities.

4.5.10.2 Operation Impacts to Socioeconomics

Economic Multipliers
The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements are filled by a workforce from outside the region, assuming a multiplier of about 0.7, there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 200, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region.

However, because an outside workforce would be more likely to settle into a more populated area with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for at least the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7) are required to relocate into the Northwestern New Mexico Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Gallup and Grants (within the region) and Albuquerque (located outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Northwestern New Mexico Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles.

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure, and these would be similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce would have a SMALL to MODERATE impact relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Northwestern New Mexico Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 200 (including families), there would be about 90 school-aged children involved. There are five school districts in the region. If all of the ISL workers' children were to enroll in the Grants school district (the region's smallest, with only 2,414 pupils), there would only be a 4 percent increase in the student population.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.5.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.5.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar work force (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Northwestern New Mexico Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE.

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community.

Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short-duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus would be considered SMALL.

4.5.11 Public and Occupational Health and Safety Impacts

4.5.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction impacts to public and occupational health and safety for the Northwestern New Mexico Uranium Milling Region would be similar to those discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.1.

4.5.11.2 Operation Impacts to Public and Occupational Health and Safety

4.5.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

Estimated doses to members of the public are reported for a variety of commercial-scale and satellite facilities in Section 4.2.11.2.1. These doses are well below the 10 CFR Part 20 public dose limit of 1 mSv/yr [100 mrem/yr] and the 40 CFR Part 190 annual limit of 0.25 mSv [25 mrem]. Doses at other locations could be higher or lower depending on a variety of factors including receptor location, topography, and weather conditions. When releases occur from the ground level, doses decrease the farther the receptor is from the release location because the radioactive material is diluted as the wind mixes it. The amount of dilution, which is referred to as dispersion, is determined by the weather (meteorological conditions). For areas in which meteorological conditions are more stable (less turbulent), a higher dose could occur. As the radioactive material travels via the wind, changes in topography can affect the dose received by the receptor. Doses for the various ISL facilities shown in Table 4.2-2 are at least a factor of three below the regulatory limit, and most are much less than that. Doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and overall impacts to public and occupational health and safety would be SMALL.

4.5.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

The consequences of potential accidents are expected to be similar regardless of an ISL facility's location and are described in Section 4.2.11.2.2. Distance to the nearest receptor, topography, and meteorological data account for potential differences in resulting dose. For facilities in which the maximally exposed offsite individual would be closer, there would be higher doses for ground-level releases. Changes in topography could also have an impact on the resulting dose because this would allow the receptor to be closer to, or farther away from, the radioactive material as it travels by wind. Meteorological conditions vary based on location and could result in a higher or lower dose. The consequences resulting from a potential unmitigated accident would have a SMALL effect on the general public and, at most, a MODERATE effect on the workers.

4.5.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), SMALL risks would be expected in the use and handling of these chemicals during normal operations. However, accidental releases of these hazardous chemicals can produce significant consequences and

impact public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.5.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

Nonradiological impacts to public and occupational health and safety for the Northwestern New Mexico Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.2.4. Compliance with applicable 10 CFR Part 20, EPA, and Occupational Safety and Health Administration requirements would safe handling of radiological and hazardous materials. The likelihood of accidental releases would be reduced, and the impacts would be SMALL.

4.5.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Aquifer restoration impacts on public and occupational health and safety would be similar to operational impacts discussed in Section 4.5.11.2.

4.5.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

During ISL facility decommissioning, hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed. As a result of these activities, some SMALL impacts could potentially occur.

To ensure the safety of workers and the public during decommissioning, the NRC requires licensed facilities to submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license conditions where necessary, and (3) regular NRC inspection and enforcement activities to ensure compliance with radiation safety requirements constrain the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions to acceptable (SMALL) levels.

4.5.12 Waste Management Impacts

Waste management impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another.

4.5.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility provides insights into the magnitude of well field construction activities. As a result of

the limited volumes of construction waste that would be generated by ISL facility construction, waste management impacts from construction would be SMALL.

4.5.12.2 Operation Impacts to Waste Management

Operation waste management impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.2 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. Operational waste management impacts would be SMALL, based on the required preoperational disposal agreement for byproduct material; regulatory controls including applicable permitting, license conditions, and inspection practices; and typical facility design specifications and management practices including waste treatment and volume reduction techniques, pond leak detection, and other routine monitoring activities.

4.5.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.5.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.5.12.4 Decommissioning Impacts to Waste Management

Decommissioning waste management impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.4 because the waste volumes and management practices, waste management safety and environmental concerns, waste management regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. The required preoperational agreement for disposal of byproduct material, NRC review and approval of a decommissioning plan and radiation safety program, and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.5.2.

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NRC FORM 335
(9-2004)
NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER
(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG-1910, Vol. 1

2. TITLE AND SUBTITLE

Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities
Chapters 1 through 4

3. DATE REPORT PUBLISHED

MONTH	YEAR
May	2009

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

6. TYPE OF REPORT

Technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Division of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Programs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Wyoming Department of Environmental Quality, Land Quality Division (Cooperating Agency)
122 West 25th Street, Herschler Building
Cheyenne, Wyoming 82002

10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

This Generic Environmental Impact Statement (GEIS) was prepared in accordance with NRC regulations (10 CFR Part 51), which implement the National Environmental Policy Act of 1969, as amended (NEPA) provisions. The GEIS provides a starting point for NRC's site-specific NEPA review of a license application for an in-situ leach (ISL) uranium milling facility by assessing the potential environmental impacts associated with the construction, operation, groundwater restoration, and decommissioning of such a facility in four regions of the United States.

In the ISL process, a leaching agent, such as oxygen with sodium bicarbonate, is added to native groundwater for injection through wells into the subsurface ore body to dissolve the uranium. The leach solution, containing the dissolved uranium, is pumped back to the surface and sent to the processing plant, where ion exchange is used to separate the uranium from the solution. The underground leaching of the uranium also frees other metal and minerals from the host rock. Operators of ISL facilities are required to restore the groundwater affected by the leaching operations. The milling process concentrates the recovered uranium into the product known as "yellowcake," which is then shipped to uranium conversion facilities for further processing in the overall uranium fuel cycle.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Uranium Recovery
In-Situ Leach Process
Uranium
Environmental Impact Statement

13. AVAILABILITY STATEMENT

unlimited

14. SECURITY CLASSIFICATION

(This Page)
unclassified

(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE

Printed on recycled paper

Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS