4.0 Potential Environmental Impacts

Potential impacts have been evaluated with regard to the Proposed Action. After a complete site specific analysis of the potential impacts of the Proposed Action Powertech (USA) concludes that such potential impacts fall within the scope of the analysis and conclusions in NUREG-1910 regarding the South Dakota-Nebraska Region.

4.1 Potential Impacts of the No-Action Alternative

The potential impacts of the no-action alternative include the lost opportunity to produce a large resource of domestic uranium for use in the commercial nuclear fuel cycle from an ISL-amenable source. In addition, failure to license the Proposed Action will result in the failure to realize substantial positive effects on the economic growth of Custer and Fall River Counties through job creation and tax collections in the State of South Dakota. As discussed in the Cost-Benefit Analysis, Section 7.0, the project is expected to have significant positive economic impacts.

In 2007, total domestic U.S. uranium production was approximately 4.5 million pounds U_3O_8. During the same time domestic U.S. uranium consumption was approximately 51 million pounds U_3O_8. The project represents a significant new source of domestic uranium supplies that are essential to provide a continuing and economically viable source of nuclear fuel to domestic electric power electrical generation facilities thus reducing dependence on foreign energy supplies.

4.2 Potential Impacts of the Proposed Action

4.3 Potential Land Use Impacts

4.3.1 Potential Land Use Impacts of Proposed Action

Rangeland and pastureland are the primary land uses within the PAA and the surrounding 2 km review area. The PAA encompasses 10,580 acres (4,282 ha). Under the proposed action, this land will be temporarily converted from its previous use as rangeland and pastureland to ISL use on a progressive, "phased" basis. The PAA encompasses 10,580 acres, the land potentially disturbed by the Proposed Action will be approximately 68 acres (facilities, piping, ponds, well fields and roads) during the year proceeding operation. The potentially disturbed area during the life of the project (production to restoration) is estimated to increase over time to a maximum of 108 acres. If the maximum area for land application of treated wastewater is included in the

footprint of the Proposed Action, then a maximum of additional 355 acres potentially would be affected by the Proposed Action for most of the project life. The maximum potential land disturbance at any given time is expected to be 463 acres. The CPP acreage is estimated at 6.7 (2.7 ha) located in the Burdock area. The satellite facility is estimated to consume 2.9 acres (1.2 ha) located in the Dewey area.

By way of reference, permitted areas for past and current-ISL operations have varied in size. Facilities' size range from about 2,552 acres (1,034 ha) for the proposed Crownpoint facility in McKinley County, New Mexico, to over 16,000 acres (6,480 ha) for the Smith Ranch property in Converse County, Wyoming. However, much of the permitted area of a site is undisturbed, and surface operations (wells, processing facilities) affect only a small portion of it (NUREG-1910, 2008).The land will likely experience an increase in human activity also contributing little to land disturbance. The disturbance associated with drilling, laying of pipeline, and facility construction will be limited and temporary as vegetation will be re-established through concurrent reclamation. The construction of new access and secondary roads will be minimized to the extent possible.

4.3.2 Potential Land Use Impacts of Operations

The primary land use within the PAA is rangeland. Operation of the project facilities will restrict the use of land as rangeland for the duration of the project. Following production and restoration, the PAA will be returned to rangeland use.

The Proposed Action will temporarily impact recreational use, which is limited primarily to large game hunting, within the project boundary., Within the PAA, hunting is currently open to the public on approximately 5,689 acres (2,302 ha). Approximately 240 acres (97.12) are owned by the Bureau of Land Management (BLM); the South Dakota Game Fish and Parks (SDGFP) lease around 3,069 acres (1,241 ha) annually of privately owned land and currently designate this acreage as walk-in hunting areas.

Additional land use impacts will include the disruption to livestock grazing within the PAA. Approximately 9.4 acres (3.8 ha) will be removed from grazing on the BLM land. This disturbance will be temporary in the area until the area is released for unrestricted use. Potential impacts include surface soil contamination from leaks or spills in well fields or from pipelines, but site reclamation will ensure that such impacts are temporary. Given the relatively small size of the area impacted by operations the exclusion of grazing from well field areas over the course of the project is expected to have minimal impact on local livestock production.

4.3.3 Land Use Regulations

Compliance with land use regulations of Custer and Fall River Counties in South Dakota as well as the most current version of BLM's Resource Management Plan for South Dakota will be necessary. The PAA is not located within lands withdrawn from mineral exploration and development. The Proposed Action will be reviewed by the BLM Field Office in Belle Fourche SD to ensure that the Proposed Action is compatible with management objectives for the area lands.

4.4 Potential Transportation Impacts

4.4.1 Potential Access Road Construction Impacts

There are only a few residences in the vicinity of the proposed project. Most of the land in the surrounding 2.0 km radius of the project is devoted to rangeland. The Dewey Road is the primary access road into the Proposed Action Area; this road runs primarily in a north- south direction through the Proposed Action Area (Figure 1.4-1). Dewey Road is a county road and is maintained by the county. Secondary roads within the Proposed Action Area will be constructed from the Dewey Road to the CPP, SF and header houses to the extent necessary. The Proposed Action will include establishing roads to individual wells. Off-site transportation routes will include federal, state, and county roads.

4.4.2 Potential Traffic Impacts

The predominant land use in the area is rangeland; other land uses include grazing, crop land, hunting and wildlife habitat. Due to the low population density within the region, the limited use of large machinery and vehicles and the infrequent movement of transport vehicles to and from the project site, no significant noise or congestion impacts are anticipated within the surrounding 2.0-km area during operations. There will be some increased traffic, noise and dust on the county road between the site and Edgemont during construction activities. However, these impacts will be minimal and temporary.

Radioactive materials have been shipped safely in this country for more than 50 years. As with other shipments, radioactive materials shipments have been involved in accidents. However, no deaths or injuries have resulted from exposure to their radioactive contents (USDOT, 1999). Powertech (USA) will design training programs and standard procedures in accordance with Department of Transportation (DOT) regulations found in CFR Titles 49 and 10 and will strictly enforce them in order to maintain compliance and to keep a safe transportation record.

Powertech (USA) intends to provide relevant state and local authorities with information concerning transportation emergency response procedures.

4.4.3 Material Shipments

All shipments of materials and supplies to, from and within the Proposed Action Area will be transported by only properly licensed and certified drivers and subject to both federal and state transportation regulations. Four classifications of shipments will be sent or received during pre-operational and operational phases of the project:

1. Non-radioactive materials such as: Construction materials, office supplies, process chemicals, other related materials from vendors concerning onsite activities.
2. Shipments of loaded resin to the CPP and eluted (stripped) resin to SF's.
3. Shipments of dried and packaged yellowcake to a conversion facility.
4. Shipments of waste material to an appropriate licensed facility.

Impacts would differ according to material type, quantities, and concentrations. The separate scenarios are discussed below.

The following section discusses the transportation risks of the four materials classified above. Mitigation and monitoring to eliminate or reduce the potential environmental impacts of a transportation accident are discussed in Section 5.2.

4.4.3.1 Shipments of Process Chemicals and Fuel

Over the course of the operational life of the facility several shipments of chemical, fuel, and supplies will be made per working day. Process chemicals delivered to the project will include carbon dioxide, oxygen, salt, soda ash, barium chloride, hydrogen peroxide, sulfuric acid, hydrochloric acid, caustic soda (sodium hydroxide), and fuel. All applicable DOT hazardous materials shipping regulations and requirements will be followed during shipment of process chemicals and fuel to prevent a possible transportation accident. Powertech (USA) will develop procedures to ensure compliance with applicable regulation to mininmize impacts to human health and the environment. Analyses of documented accidents involving shipments have shown that secure containers have prevented spills (NMA, 2007).

4.4.3.2 Ion Exchange Shipments

The project will have resin stripping facilities; therefore only shipments involving the barren or eluted resin will be transported to the PAA. The consequences are likely to be lower for trucks transporting barren or eluted resin because the risk of contamination is minimal. Both barren and eluted resin shipments will be handled in accordance with NRC and DOT regulations. Powertech (USA) will transport loaded and eluted resin back and forth between the Dewey satellite and the Burdock CPP. This transportation will occur on-site at an estimated rate of one loaded resin truck from the SF to the CPP and one eluted from the CPP to the SF per day.

The same general shipping procedures outlined for the shipment of yellowcake (Section 4.2.3.1) will be followed for resin shipments.

The ion exchange resin will be shipped to and from the project in a tank truck. The NRC calculated the probability of an accident involving a truck transporting uranium-loaded resin from a satellite plant to a main processing plant at 0.009 in any year (U.S. Nuclear Regulatory Commission, 1997a).

The main environmental impacts from an accident involving the shipment of ion exchange resin would potentially be primarily impacts to the top soil in the area contaminated by the spill and the subsequent modification to the vegetation structure and the salvage of the top soil. This is scenario would only take place if drums were ruptured.

4.4.3.3 Yellowcake Shipments

The yellowcake will be loaded into a gasketed and sealed 55-gallon (208-L) drums which will be trucked to a conversion facility via qualified and certified carrier. Specific routes are to be determined by contract with the carrier. The carrier will meet all safety controls and regulations promulgated by 10 CFR 71.5. With a production rate of 1,000,000 lbs per year at the Proposed Action Area, shipments are estimated to weigh approximately 40,000 lbs per load and would require an estimated 25 shipments per year. Smaller or partial loads could require additional shipments.

According to NUREG/CR 6733 earlier analyses concluded that the probability of a truck accident, involving the transport of yellowcake, for any given year was 11 percent for each uranium extraction facility. This calculation used average accident probabilities (4.0×10^{-7}/km rural interstate, 1.4×10^{-6}/km rural two-lane road, and 1.4×10^{-6}/km urban interstate) that are

considered conservative compared to other NRC transportation risk assessment (NUREG/CR 6733).

The worst case accident scenario involving yellowcake shipments would involve the release of yellowcake into the environment due to the breach of one or more drums containing yellowcake during transportation. In an accident involving a similar ISL facility and the shipment of yellowcake through Kansas (SRI International, 1979b), approximately 1,800 pounds or 4 percent of the yellowcake onboard the truck was spilled; no dose estimates were reported, the spill was quickly contained and all the yellowcake was thought to have been recovered.

Yellowcake shipments will be classified as Low Specific Activity (LSA) material and will be handled in accordance with NRC and DOT regulations. Powertech (USA) will develop an Emergency Preparedness Program that will be implemented should a transportation accident occur. The team training will provide technical instruction on field monitoring, sampling, decontamination procedures, communication, and other related skills necessary to safely handle a transportation emergency concerning shipments of yellowcake.

Before a shipment is approved for transportation, proper packaging including Marking/Labeling and Placarding must be accomplished within DOT regulations; Inspections of the vehicle and load will be performed; routing the shipment to minimize radiological risk and contacting Emergency Preparedness personnel are among the duties performed before a shipment would be approved to leave the facility.

4.4.3.4 Shipments of Waste Materials

Depending on classification of waste material the waste will be sent to different disposal sites. The categories are:

- Non-hazardous solid wastes shipped to a permitted landfill
- Hazardous solid or liquid wastes shipped to a permitted hazardous waste disposal facility
- 11e.(2) Byproduct material disposed of at a licensed or permitted facility

Most of the solid waste shipping will occur during the site reclamation and decommissioning phases. The probability of an accident while transporting 11e.(2) waste for any given trip is similar to the probability discussed in Section 4.2.3.1. The potential risks, however, for exposure are less because 11e.(2) waste is generally less radioactive than dried yellowcake and much of

the waste will consists of solid material that in the event of an accident would be easy to contain. All applicable DOT shipping regulations and requirements will be followed before and during shipment of 11e.(2) wastes to prevent a possible transportation accident.

Liquid waste meeting the criteria of 11e.(2) will be disposed of via a waste disposal well (WDW) all applicable EPA and NRC regulations will be complied with. Transportation of liquid 11e.(2) will be accomplished via a pipeline or tanker truck from CPP area to the WDW.

4.4.3.5 Potential Post Operation Transportation Impacts

Before the on-site road reclamation begins, landowners will be contacted and given the option to retain the roads for their private use or have the roads reclaimed by Powertech (USA). If the roads are deemed beneficial to others (i.e., hunters, ranchers and residents) and the landowner agrees, the roads will not be reclaimed. Only roads related to the Proposed Action will be reclaimed.

4.4.3.6 Potential Cumulative Transportation Impacts

The cumulative volume of traffic associated with the Proposed Action is anticipated to be low, due to the relatively concentrated nature of the resources and the small workforce associated with ISL operations (NUREG-1910, 2008). Given this is the only ISL operation located in the state, and few industrial operations within the immediate region, therefore the cumulative transportation impacts will be insignificant.

4.5 Potential Geologic and Soil Impacts

4.5.1 Potential Geologic Impacts

Geologic impacts from the project are expected to be negligible or non-existent. The project is not expected to have a significant effect on ground subsidence or matrix compression because the net withdrawal of fluid (bleed) from the extraction zone is generally on the order of 3 percent or less, and the ISL process does not remove matrix material or structure. After restoration is complete, the groundwater levels are expected to return to pre-operational levels, and should therefore not have any significant effects on the quantity of groundwater.

Impacts are more likely to occur from other geologic factors such as earthquakes. As discussed in Section 3.3, the maximum magnitude earthquake estimated for the PAA is a VII on the Modified Mercalli Scale, corresponding to a Richter magnitude of 6.1

Due to the design of the project, no impacts are expected to subsurface geological strata. (NUREG-1910, 2008).

4.5.2 Potential Soil Impacts

There are two main drainage basins located in the PAA; each of the drainages have different soil types. The soil mapping unit descriptions are in Section 3.3. The Beaver Creek basin is composed of Haverson loam, and has 0-2 percent slopes throughout the drainage. The Cottonwood Gallery basin is composed of Barnum silt loam in the south half of the drainage and Barnum-Winetti complex, and has 0-6 percent slopes. The old mine pits were also classified as Barnum silt loam and Barnum-Winetti complex.

The ISL operation will disturb approximately 68 acres (27 ha) (facilities, piping, ponds, well fields and roads) in year one. Potential impacts include:

- These impacts potentially could occur via: Compaction
- Loss of productivity
- Loss of soil
- Salinity
- Soil contamination
- Clearing vegetation
- Compaction
- Excavation
- Leveling
- Redistribution of soil
- Stockpiling

Severity of impacts to soil is dependent upon type of disturbance, duration of disturbance and quantity of acres disturbed. Construction and operation activities have the potential to compact soils. Soils most sensitive to compaction, clay loams, are not present within the Proposed Permit Area, however; due to the use of heavy machinery and high volume within certain area some

soils have the potential for compaction. Compaction of the soil can lead to decreased infiltration thereby increasing runoff. Soils compacted during construction and operations will be restored (i.e., disced and reseeded) as soon as possible following use.

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the PAA varies from negligible to severe. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the very fine and clayey texture of the surface horizons throughout the majority of the PAA, the soils are more susceptible to erosion from water than wind. See Table 3.3-7 for a summary of potential wind and water erosion hazards within the PAA.

During land application disposal, there could be potential impacts to the soil and crops from total dissolved solids (TDS) and electrical conductivity (EC) values in the water to be used to irrigate crops as shown in Table 4.5-1. These levels pose low to moderate risk to the growth of moderately sensitive crops such as alfalfa and corn. The SAR levels are low and pose little risk to the infiltration of rain or snowmelt. There could be some salt deposition at the surface, however maintaining maximum vegetative cover will reduce the possibility of undesirable species. During the irrigation season, water application rates will be adjusted to optimize both evaporation and crop production.

Table 4.5-1: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Mining Ground Water Quality([a])

Constituent	Dewey					Burdock				
	(mg/L)	(meq/L)	ESP(1)	RSC(2)	SAR(3)	(mg/L)	(meq/L)	ESP(1)	RSC(2)	SAR(3)
CO_3	0.5	0.02				0.50	0.02			
HCO_3	25	0.41				25.00	0.41			
Cl	1,300	36.67				1,300	36.67			
SO_4	1,000	20.82				1,800	37.48			
Na	270	11.74				190	8.26			
Ca	730	36.43				970	48.40			
Mg	120	9.87	2.29	-45.87	2.44	220	18.09	0.85	-66.07	1.43
K	20	0.51				10	0.26			
Total Ion Bal.		0.54					0.29			
SAR (measured)	4.9					2.8				
pH (s.u.)	6.5-7.5					6.5-7.5				
TDS (mg/L)	4,500					4,500				
Elec. Cond. (µS/cm)	3,000					4,000				
As	0.01					0.01				
V	<10					6				

([a]) - Estimated by Powertech (USA) based on results of laboratory scale leach tests conducted on ore samples from the Fall River and Lakota sites, as well as from historical end-of-mining water quality data from other ISL sites in Wyoming and Nebraska, with adjustments as necessary to account for planned post-mining water treatment(s).

12. ESP = Exchangeable Sodium Percentage. Empirical relationship from Withers and Vipond (1980). $$ESP = \frac{100(-0.0126 + 0.01475 * SAR)}{1 + (-0.0126 + 0.01475 * SAR)}$$

13. RSC = Residual Sodium Carbonate (meq/L) $RSC = ([CO_3] + [HCO_3]) - ([Ca] + [Mg])$

14. SAR = Sodium Adsorption Ratio $$SAR = \frac{[Na]}{\sqrt{([Ca] + [Mg])/2}}$$

Facility development could displace topsoil, which could adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This could result in a reduction of natural soil productivity. Increased erosion and decreased soil productivity may cause a potential long-term declining trend in soil resources. Long-term impacts to soil productivity and stability could occur as a result of large-scale surface grading and leveling, until successful reclamation is accomplished. Reduction in soil fertility levels and reduced productivity could affect diversity of reestablished vegetative communities. Infiltration could be reduced, creating soil drought conditions. Vegetation could undergo physiological drought reactions (Lost Creek, 2007).

Overall, the potential environmental impacts to the soil within the PAA may be increased compared to areas outside the PAA but typically will not result from the ISL process itself, but rather from ancillary activities such as waste disposal and construction. In the past, ISL facilities adopt best construction practices to prevent or dramatically decrease erosion (NUREG-1910). Many facilities have been operated to minimize erosion and surface disturbance and then assiduously restored affected soils effectively leaving little impact on soils (NMA, 2007).

4.5.3 Monitoring Well Rings, Well Field and Associated Piping

The scale of monitoring well rings will have little impact on the amount of soil disturbance. Differences in disturbance to soil will depend on area of monitoring well ring and natural growth of vegetation within the specific well field. During construction of each well field, drilling activities will occur only on a small percentage of an ISL site at any one time (HRI, 1997a). The

amount of land disturbed at any time typically will range from 100 to 400 acres (EPA 2007); however, some ISL sites may be larger or smaller. Disturbance associated with drilling and pipeline and facility installation normally will be limited, as the affected area can be reclaimed and reseeded in the same season. Vegetation normally will be re-established over these areas within 2 years (NMA, 2007).

Subsurface soils will be excavated and removed from their native location. Excavated soils (drill cuttings) are returned to mud pits as TENORM.

Movement of drilling and construction equipment and installation of wellheads, piping systems, and other facilities will disturb small areas of surface soil. Vehicle movement could cause compaction, rutting, and other disturbances to the surface soil and rocks. Depending on the intensity and duration of construction activities, compaction and erosion of surface soil could alter drainage and cause accelerated erosion and degradation of surrounding surface water resources. However, good management practices likely will minimize, if not eliminate, any such potential impacts (NMA, 2007).

4.5.4 Wastewater Retention Ponds

Only very shallow surface soils in the immediate area could be disturbed during construction of the waste retention ponds, though excavated soils from other parts of the site typically will be imported and used to construct the foundation and walls of the ponds. Surface soils in the area will be compacted from the overlying weight of the pond.

Movement of construction equipment could disturb small adjacent areas of surface soil, and vehicle movement to and within the construction site could cause compaction, rutting, and other disturbances to the surface soil and rocks. Depending on the intensity and duration of construction activities, compaction and erosion of surface soil could alter drainage and cause accelerated erosion and degradation of surrounding surface water resources. However, good management practices will likely minimize any such potential impacts (NMA, 2007).

Wastewater produced during operations typically will be handled in one or a combination of two ways: deep well injection or land application. Storage ponds of suitable capacity will be needed for deep-injection well disposal and land application. Where such wells are not available, land application is the only disposal option. The size of the storage ponds required and the land impacts are significantly different depending on the method of disposal utilized.

4.5.5 WASTE DISPOSAL WELL

As deep-disposal wells are drilled, there will be disruption of soil, rock formation, and water flow processes; however, these potential impacts are minor and are similar to common drilling for water, oil and gas. EPA/state UIC regulations and permitting guidance require an evaluation of the seismic risk of a potential disposal well site, including evaluation of the potential pressure impacts to the injection zone. As such, current regulations are in place to ensure the seismic stability of the selected injection site. Changes caused by thermal (heat caused by drilling), chemical (possible reaction caused displaced chemicals during drilling), and mechanical alterations will be negligible and similar to most drilling projects. As the Class I or V UIC deep-disposal well permitting process is intended to ensure protection of USDWs, ISL solutions destined for deep-injection well disposal will require compliance with EPA/state UIC regulations and, as such, the potential impacts will be negligible (NMA, 2007).

4.5.6 WELL FIELDS

In addition, the injection of treated groundwater as part of uranium recovery or as part of restoration of the production zone is unlikely to cause changes in the underground environment except to restore the water quality consistent with baseline or other NRC approved limits and to reduce mobility of any residual radionuclides. Further, industry standard operating procedures, which are accepted by NRC and other regulating agencies for ISL operations, include a regional pump test prior to licensing, followed by more detailed pump tests after licensing for each individual area where uranium will be recovered prior to its production. Any potential variations in hydrogeology, due to disruption of soil or rock formation will be assessed and taken into account prior to commencing operations to ensure that operations will not impact adjacent, non-exempt drinking water resources in the region. Powertech's (USA) well field designs are substantially similar if not identical to those assessed in NUREG-1910. As a result, the potential impacts on soils from well fields will be within the scope of NUREG-1910's analyses and conclusions.

4.5.7 Uranium Processing Facilities

Standardized ISL processing facilities as assessed in NUREG-1910 will not impact geology and soils at the site after the construction of the facilities. An impact will occur only if there is an accident or a malfunction that spills or emits processing chemicals, leach solutions, loaded IX resins or yellowcake products (i.e., slurry or dried concentrate) onto site surface soils. Powertech's (USA) uranium processing facility designs are substantially similar if not identical

to those assessed in NUREG-1910. As a result, the potential impacts on soils from such facilities will be within the scope of NUREG-1910's analyses and conclusions.

4.5.8 Potential 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, (4) activities associated with land reclamation and cleanup of contaminated soils. 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 3 preproduction conditions to the extent practical, the overall long-term impacts to the geology 4 and soils would be SMALL (NUREG-1910, 2008). Powertech (USA)'s decommissioning plan has been prepared in accordance with NRC regulations and guidance as assessed in NUREG-1910. As a result, the potential impacts on soils from such activities will be within the scope of NUREG-1910's analyses and conclusions as the site can be released for unrestricted use.

4.6 Potential Water Resource Impacts

4.6.1 Potential Surface Water Impacts

The average annual runoff for this region is higher than that for the Wyoming West Region, therefore potential surface water impacts may be slightly higher in the Proposed Action Area (USGS, 2008 in NUREG-1910, 2008). The water quality of storm water is regulated under permits issued by South Dakota's Surface Water Quality Program in Pierre. Impacts to wetlands are negligible (See Section 3.5.5.2) and will be addressed through consultations and the permitting process (NUREG-1910, 2008). The surface water impacts overall would be small to moderate. All activities that could potentially affect surface water will be undertaken in such a way as to comply with applicable state and federal regulations and conditions of permit; through the use of best management practices and mitigation measures impacts to water quality will be reduced to small and/or moderate and determined by site specific conditions (NUREG-1910, 2008).

4.6.1.1 Potential Surface Water Impacts from Construction

Construction activities within the well fields, along the pipeline courses and roads, and at the process plant have the potential to increase the sediment yield of the disturbed areas. The impacts from increased sedimentation will be minimal because of the short-term nature of the disturbance (areas will be concurrently reclaimed) and the area of disturbance is small compared to the total drainage basin of Angostura Reservoir (total area 7143 mi^2) and because of the lack of dependable surface water supplies (DENR, 2007). A slight increase in sediment yields and total runoff can be expected during final reclamation; however, well field decommissioning and reclamation activities via best management practices and mitigation measures utilized throughout the life of the project will help to reduce the impacts. No direct disturbance to any wetlands or water sources is planned at this time. If, in the future, the proposed action should involve an impact to a jurisdictional wetland area or water source, the appropriate actions will be taken in accordance with Section 404 of the Clean Water Act and ACE regulations.

"Potential indirect impacts of ISL operations could include increased sediment deposition in streams, which could alter stream morphology and degrade the suitability of channel substrate for aquatic organisms. However, as stated previously, this issue is addressed by NPDES storm water requirements, and good management practices likely will minimize, if not eliminate, any such potential impacts" (NUREG-1910, 2008). Indirect impacts to surface water will be limited to uncommon precipitation or runoff events (e.g., a flood event).

There were 20 potential wetland sites evaluated by the ACE; the determination rendered four of the 20 evaluated as Jurisdictional sites (see Appendix 3.5-H). Descriptions of the jurisdictional determination: Ephemeral Tributary to Beaver Creek, Ephemeral Tributary to Pass Creek, Pass Creek (NonRPW), Beaver Creek (Perennial RPW). Beaver Creek is the only perennial stream within the proposed PAA and the rest of the natural water flow is ephemeral. Of the jurisdictional determinations within the Proposed Action Area, impact is expected to be small and none are expected to experience direct impact from the pre-operational or operational activities. Erosion potential is present due to the possible construction of the wells near the drainage area; however, disturbance is expected to be mild and short-term.

An old mine pit located at Waypoint 37 was determined to be a non-wetland area. Although surface water was present, there was no hydrophytic vegetation or hydric soils. This old mine pit is also located along a disturbance area. The concentration of old mine pits along the eastern

edge of the permit area contained small PUB wetlands (0.175 acres) that are a product of the old mine pits, that could be impacted by disturbance areas located along the old mine pits.

Mitigation measures employed in order to minimize potential impacts may include: best soil management practices (i.e., silt fencing, straw bales) if crossing the water body is necessary, timing of crossing will be evaluated, and only temporary crossing may be necessary, and type of equipment working near water body will be considered. 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 (NUREG-1910, 2008).

ISL operations do not involved the consumption of surface waters. Nor do the operations proposed require a long- term discharge to surface waters. For these reasons, no significant impacts to surface water quantity and use are anticipated.

4.6.1.2 Potential Surface Water Impacts from Operations

Potential impacts from accidental spills or permitted temporary discharge to surface water may include the release of process materials into the environment or a release or spill from the operation or well field (e.g., handling of fuels, lubricant, oily wastes, chemical wastes, sanitary wastes, herbicides, and pesticides). Surface water monitoring and spill response procedures will limit the impact of potential spills to surficial aquifers. The impact that may result from a spill is dependent upon several considerations such as: size of spill, remediation success, designated use of the surface water, location of spill relative to surface water, and any relative contribution an aquifer discharge may have to the surface water (NUREG-1910, 2008). A Storm Water Pollution Management Plan (SWMP) will be part of the NPDES permit issued and will describe potential sources of storm water contamination from the facility. The SWMP will include routes by which spills may leave the facility and the best management practices to be implemented as preventative measures to control storm water contamination (NUREG-1910, 2008).

Most ISL operations extract slightly more groundwater than they re-inject into the uranium bearing formation. 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. However, because most, if not all ISL operations are expected to occur where the ore-bearing aquifers are confined, local depletion of streams and springs is unlikely, and potential impacts would be anticipated to be SMALL (NUREG-1910, 2008).

Any water disposed of via land application methods must be treated in compliance with any established state and federal established concentration levels for specified constituents. According to 10 CFR Part 20, the NRC requirement is that the public and occupation dose limits are met during and post land application. An accumulation of some constituents and dissolved solids may develop within the soils and may potentially have an indirect impact on surface water. The degree of the potential impacts again, would depend on factors such as actual evapotranspiration rates, irrigation rates, precipitation quantities and sorpitive properties of specific soils with respect to constituents considered (NUREG-1910, 2008). Permit requirements will be in place to assure mitigation should any accumulations of residuals remain upon completion of the operations. At that time the land application areas would be subject to land surveys during decontamination efforts. If accumulation occurs, that does not meet permit conditions is discovered, the areas in exceedance will be remediated to meet the NRC regulations, consequently; potential impacts from permitted land application will be SMALL (NUREG-1910, 2008).

4.6.2 Potential Groundwater Impacts from Production Operations

During ISL operations, the following is a list of potential impacts to groundwater: (1) Alteration of groundwater quality from the addition of the proposed lixiviant oxygen and carbon dioxide to the groundwater in the exempted aquifer, (2) the addition of chloride to the groundwater by displacement from the ion exchange resin during the uranium loading process, (3) and the interaction of these chemicals with the mineral and chemical constituents of the aquifer being mined, primarily the oxidation of the pyrite in the ore body to form solubilized sulfate ion. The result is that during the proposed action, the concentration of most of the naturally occurring dissolved constituents in the ore zone(s) will be higher than their concentrations in the pre production groundwater. The ISL process does not introduce any constituents not already present within the groundwater. Procedures proposed in this application are designed to provide early detection of and to provide for remediation any excursions of leach fluids to adjacent non exempt USDWs. These procedures are consistent with those recommended in NUREG-1910 to address potential groundwater impacts; therefore will be no adverse impacts on human health and the environment from affected groundwater within the production zone.

4.6.2.1.1 Monitoring

To assess the potential impacts from production and restoration operations on local groundwater, the background water levels in regional monitoring wells installed by Powertech (USA) will be monitored before production and as required during operations.

4.6.2.2 Potential Impacts of Production on Ore Zone Groundwater Quality

Potential environmental impacts to groundwater are changes to water quality in well fields within the exempted aquifer. The impact, in and of itself, it is of limited significance, due to the fact that the groundwater quality is very poor prior to ISL operations; due to the presence naturally occurring radionuclides, heavy metals, and other constituents that exceed EPA and/or state drinking water limits. Accordingly, the exempted aquifer is not and can never serve as a USDW (HRI, 1997; NMA, 2007).

Powertech (USA) has proposed to use gaseous oxygen and carbon dioxide lixiviant. The interaction of the lixiviant with the mineral constituents of the exempted ore zone results in a slight increase in trace elements and primary constituents of sulfate, chloride, cations and TDS above pre production levels. There is no introduction of non-naturally occurring constituents from the leach fluids into the ore body.

The uranium present in the ore zone pre-operations is solubilized by oxidation via the ISL process. Uranium, when oxidized to the soluble valence, reacts with the bicarbonate ions to form a stable, soluble anion, uranyl bicarbonate. The dissolved oxygen in the leach fluid also oxidizes the pyrites (sulfides) to increase the concentration of sulfate (SO_4) ions in solution. The loading of uranyl bicarbonate ions onto the resin displaces chloride ions into the leach solution. Therefore, the leach process which recycles groundwater back to the ore zone increases the concentration of sulfate and chloride anions into the leach solution. The increase in sulfate and chloride anions in the leach solution increases the concentrations of sodium, calcium, potassium and magnesium cations in solution. These cations are exchanged off the clays within the ore body to balance the ion charges in the leach solution. Since these cations and anions are the principal constituents of TDS, therefore the TDS increases.

4.6.2.3 Potential Groundwater Impacts from Land Application

The wastewater applied to the land will be treated to meet EPA Primary Drinking Water Standards and NRC effluent criteria for radionuclides as referenced in 10 CFR part 20 Appendix B. Therefore, potential adverse impacts to groundwater are not anticipated.

Data from test pits 1, 2 and 5 were used to develop the soil profile used in the SPAW modeling for the Dewey site. The logs for these test pits indicated that bedrock was encountered at depths of 9 feet, 11 feet, and 8.5 feet respectively below the ground surface. The composite soil profile used to model the soil at the Dewey site had a total depth of 9.83 feet. The results of the SPAW modeling indicated that the soil moisture content at the base of this soil profile was less than field capacity for all cases that were modeled (28 15-year simulations) and that there was no percolation beyond the base of the soil profile (Appendix 4.6-A). Therefore, it is assumed that there would be no lateral movement of water along the bedrock surface, and no vertical movement of water into the bedrock, and therefore no leaching of trace elements beyond the base of the soil profile.

Data from test pits 8, 9 and 10 were used to develop the soil profile used in the SPAW modeling for the Burdock site. The logs for these test pits indicated that bedrock was encountered at depths of 7 feet and 5 feet below the ground surface in test pits 8 and 9. Test pit 10 was excavated to a total depth of 12 feet, with a clayey silt layer from 2 feet to 12 feet below the ground surface. The composite soil profile used to model the soil at Burdock had a total depth of 8 feet. The results of the SPAW modeling indicated that the soil moisture content at the base of this soil profile was also less than field capacity for all cases that were modeled (28 15-year simulations) and that there was no percolation beyond the base of the soil profile. Again it is assumed that no lateral movement of water would occur along the bedrock surface, and that water would not move vertically into the bedrock, and therefore there would be no leaching of trace elements beyond the base of the soil profile.

Based on the above information, there will be no migration pathway of waste water constituents to groundwater beneath the land application sites, thereby eliminating any potential of exposure and risk to human health and the environment.

4.6.2.4 Potential Groundwater Impacts from Deep Well Disposal Below Production Aquifer

Deep well injection involves the pumping of waste fluids into a deep confined aquifer. Aquifer water quality in the deep confined aquifer is often poor (e.g., high salinity or total dissolved solids) and does not meet drinking water standards. Licensees must obtain an UIC permit from EPA or the appropriate state agency. The approval process verifies that site-specific and regional characteristics limit the potential for contamination of local drinking water sources. This is accomplished by the licensee providing data that the aquifer is hydraulically separated

from the overlying aquifer systems. "Under these conditions, the potential environmental impacts would be SMALL" (NUREG-1910, 2008). NRC staff may also review the UIC application, even though the EPA or state give final approval. NRC has approved deep well injection for specific ISL sites as a method to dispose of particular process fluids such as reverse osmosis brine".

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. The impacts of discharging wastes to deep disposal well during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (NUREG-1910, 2008)

4.6.2.5 Potential Groundwater Impacts from Aquifer Restoration

Groundwater consumption is the primary impact of concern when considering aquifer restoration and waste management.

Groundwater transfer has minimal impact concerning groundwater consumption by replacing recovered well field groundwater with near baseline quality water. Whereas groundwater sweep has a larger impact since the process involves extracting the recovered well field water and pulling unaffected water into the aquifer to take its place. When utilizing RO, 70 percent to 99 percent of the water is suitable for reinjection into the formation depending on whether brine concentrate is used or not. This lowers groundwater consumptive use substantially during aquifer restoration.

All well fields do not undergo restoration simultaneously. A deliberate phased approach is utilized to keep groundwater impacts to a minimum throughout the life of the operation. 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 (NUREG-1910, 2008).

Deep well injection is one of the most common methods to dispose of the more heavily concentrated wastewater. Brine water treated via RO may also be disposed of via deep well injection. Aquifers utilized for deep disposal must meet federal and state standards such as: the aquifer must have poor water quality, low water yields, or be economically infeasible for production. Underground injection of wastewater requires an EPA permit and approval from the NRC. Impacts from deep well disposal are expected to be SMALL (NUREG-1910, 2008).

4.6.2.6 Potential Impacts of Groundwater Consumption During Operations and Restoration

The majority of groundwater used in the ISL process will be treated and injected. Based on a median case of bleed of one percent of 2,000 gpm (20 gpm), the potential impacts from consumptive use of groundwater in the Fall River and Lakota aquifers are calculated below. There are separate calculations for the Fall River aquifer assuming pumping at the first proposed well field at the Dewey Site, and for the Lakota aquifer assuming pumping at the first proposed well field at the Burdock Site.

The potential impacts due to drawdown are calculated at the locations of the nearest wells outside the proposed Permit Boundary Area that are expected to remain active during the life of the Project

4.6.2.6.1 Drawdown Estimates

The Theis analytical solution includes the following assumptions (Driscoll, 1986):

- The aquifer is homogeneous and isotropic (same hydraulic conductivity everywhere).
- The aquifer is confined with uniform thickness and has infinite extent.
- No recharge to the aquifer occurs.
- The pumping well is fully penetrating and receives water from the full thickness of the formation.
- All water removed from the well comes from aquifer storage which is discharged instantaneously when the head is lowered.

- The piezometric surface is horizontal prior to pumping.
- The well is pumped at a constant rate.
- The pumping well diameter is small so well bore storage is negligible.

Possible barrier boundaries for the aquifer system include the respective outcrops of the Fall River and Lakota formations generally east and north of the property boundary, as well as the Dewey Fault to the north and east of the property boundary. However, the Dewey Fault is considered likely to terminate both the Fall River and Lakota aquifers at some distance to the west. Therefore, just the outcrop was assumed to be a straight line barrier boundary and modeled with "image" pumping wells (e.g. Fetter, 1988) having the same pumping rates as the production wells for the Fall River and Lakota aquifers. A spreadsheet developed by the U.S. Geological Survey to calculate drawdown according to the Theis equation (Halford and Kuniansky, 2002) was used to make the confined aquifer prediction calculations.

4.6.2.6.2 Drawdown Impact – Fall River Aquifer

The following is a summary of available aquifer parameter (transmissivity, storativity) determination in successful pumping tests.

- 1979 TVA tests at Burdock area (Bogg and Jenkins, 1980):
  - Formation transmissivity: 54 ft^2/day
  - Formation storativity: 1.4×10^{-5}
- 2008 Powertech (USA) tests at Dewey area (Knight Piésold, 2008):
  - Formation transmissivity: 255 ft^2/day
  - Formation storativity: 4.6×10^{-5}

To quantify the impact of the Project on the Fall River Formation aquifer the following assumptions were used together with the range of aquifer parameters above:

- Production/restoration: 8 years
- Average net consumptive use: 20 gpm
- Location of pumping centroid: NW ¼ of Section 32, T6S, R1E
- Distance from pumping well to barrier boundary (Fall River outcrop): 14,610 ft

- Observation radius: 15,075 feet (nearest domestic well, Hydro ID = 18), SW ¼ of SW ¼ of Section 9, T7S, R1E

- Image well observation radius: 39,350 ft

For the 1979 TVA test parameters, the calculated drawdown at the nearest domestic well after 8 years of pumping at 20 gpm due to the pumping well alone is 26.8 feet. The calculated drawdown at the nearest domestic well due to the image well is 16.0 feet. Thus the estimated drawdown at the nearest domestic well is 42.8 feet after 8 years of continuous pumping at a rate of 20 gpm.

For the 2008 Powertech (USA) test parameters, the calculated drawdown at the nearest domestic well after 8 years of pumping at 20 gpm due to the pumping well alone is 6.1 feet. The calculated drawdown at the nearest domestic well due to the image well is 3.8 feet. Thus the estimated drawdown at the nearest domestic well is 9.9 feet after 8 years of continuous pumping at a rate of 20 gpm.

Therefore, based on available pumping test data, the range of possible drawdown estimates at the nearest domestic well, located 15,075 feet from the approximate center of pumping is 9.9 to 42.8 feet.

4.6.2.6.3 Drawdown Impact – Lakota Aquifer

The following is a summary of available aquifer parameter (transmissivity, storativity) determination in successful pumping tests.

- 1979 TVA tests at Burdock area (Bogg and Jenkins, 1980):
  - Formation transmissivity: 190 ft^2/day
- Formation storativity: 1.8 x 10-4
- 1982 TVA tests at Dewey area (Boggs, 1983):
  - Formation transmissivity: 590 ft^2/day
  - Formation storativity: 1.0×10^{-4}

- 2008 Powertech (USA) tests at Burdock area (Knight Piésold, 2008):
    - Formation transmissivity: 150 ft^2/day
    - Formation storativity: 1.2×10^{-4}

To quantify the impact of the Project on the Lakota Formation aquifer the following assumptions were used:

- Production/restoration: 8 years
- Average net consumptive use: 20 gpm
- Location of pumping centroid: SW ¼ of Section 11, T7S, R1E
- Distance from pumping well to barrier boundary (Lakota outcrop): 17,610 ft
- Observation radius: 10,915 feet (nearest domestic well, Hydro ID = 13) NE ¼ of NE ¼ of Section 4, T7S, R1E
- Image well observation radius: 36,170 ft.

For the 1979 TVA test parameters, the calculated drawdown at the nearest domestic well after 8 years of pumping at 20 gpm due to the pumping well alone is 6.6 feet. The calculated drawdown at the nearest domestic well due to the image well is 2.9 feet. Thus the estimated drawdown at the nearest domestic well is 9.5 feet after 8 years of continuous pumping at a rate of 20 gpm.

For the 1982 TVA test parameters, the calculated drawdown at the nearest domestic well after 8 years of pumping at 20 gpm due to the pumping well alone is 3.0 feet. The calculated drawdown at the nearest domestic well due to the image well is 1.8 feet. Thus the estimated drawdown at the nearest domestic well is 4.9 feet after 8 years of continuous pumping at a rate of 20 gpm.

For the 2008 Powertech (USA) test parameters, the calculated drawdown at the nearest domestic well after 8 years of pumping at 20 gpm due to the pumping well alone is 8.7 feet. The calculated drawdown at the nearest domestic well due to the image well is 3.9 feet. Thus the estimated drawdown at the nearest domestic well is 12.6 feet after 8 years of continuous pumping at a rate of 20 gpm.

Therefore, based on available pumping test data, the range of possible drawdown estimates at the nearest domestic well, located 10,915 feet from the approximate center of pumping is 4.9 to 12.6 feet.

4.6.2.7 Potential Impacts from Simultaneous Operational and Restorational Groundwater Consumption

4.6.2.7.1 Operational Water Use

During ISL operations (including both production and restoration) nominal bleed rates of .5-1 percent are expected to be maintained over the life of the project. Instantaneous rates may vary in the range of 0.5 percent to 3 percent for short durations, from days to months. All effluent systems for treating bleed streams are designed for continuous operation at the maximum bleed rate of 3 percent. However, over the life of the project, a reasonable estimate of .5-1 percent, or slightly less, bleed is believed appropriate and sufficient to maintain a the cone of depression necessary within any production or restoration activity In situ mining circulates significant quantities of water through the ore zone but consumes only a small fraction of that amount because most water is reinjected back into the deposit. During operations, 0.5 to 3 percent of the solution extracted from the aquifer will be "bled" from the system to ensure a cone of depression is maintained and that no leach fluids are released from the production area.

It is anticipated that no more than two well fields, typically one at the Dewey site and one at the Burdock site will be in production at one time, with another two in restoration. Reclamation will begin as soon as each mining unit has been depleted of uranium, beginning approximately two years after the start of operations. When one well field is depleted, it will be reclaimed at the same time production continues in another well field along the ore front.

4.6.2.7.2 Water Requirements for the Proposed Action Facilities

Water requirements of the CPP and other facilities are estimated to have a maximum requirement of 65 gpm. As this requirement is relatively large, it is expected that most of this water will be derived from a water supply well in the Madison formation. Some of this water may be withdrawn from the Inyan Kara formation, but if so, it will not occur in a fashion to affect any well field operations.

4.6.2.7.3 Water Usage with Reverse Osmosis and without Reverse Osmosis

Total net water use for production operations (as wellfield purge) will be in the range 20-120 gpm from the Inyan Kara. Each production site will consume between 10 and 60 gpm as well field purge. During restoration operations, water consumption will be greater from the Inyan Kara. However, net withdrawal from the Inyan Kara formation will also remain at the range of 0.5 to 3% of total restoration flow during groundwater treatment via RO method of restoration (Table 4.6-1). It is expected that the restoration activities will also be split between the two sites. Net withdrawal during these restoration operations (as well field purge) is expected to be a total of 2.5 to 15 gpm from the Inyan Kara. At each site, Dewey and Burdock, 1.25 to 7.5 gpm will be the net withdrawal during restoration operations. Net water usage from the Maddison using a (RO) unit to restore groundwater following production, approximately 167 gpm of the 500 gpm (without RO utilization; Table 4.6-2), will need to be made up with Madison aquifer water.

The actual flow rates of water leaving the Inyan Kara formation during restoration operations is expected to be in the range of 150-500 gpm. Nearly all of this water will be "made-up" by injection of water from these two sources:

Madison formation

The Madison aquifer is a source of fresh water and could potentially be utilized for the Proposed Action. Powertech (USA) would utilize the Madison Limestone, which occurs at depth throughout the entire project boundary, as a source of fresh make-up water for restoration purposes. As described below, it is very likely that the Madison aquifer can provide a source of water at the desired rate and quality sufficient for the needs of Powertech (USA) to ensure timely and successful ISL restoration goals. Depending on the exact aquifer restoration process Powertech (USA) may need to produce up to 500 gpm from the Madison aquifer. In the case of land application disposal of water during restoration, 500 gpm of make-up water will be required from the Madison aquifer. Utilizing RO, approximately one-third (or 167 gpm) of the 500 gpm will need to be made up with Madison aquifer water.

Inyan Kara formation

This is providing that make-up water is withdrawn from wells that are located far enough from operating well fields so as to not affect the cone of depression within the operating well fields.

The actual net difference between fluid produced and fluid injected must be maintained at a rate equivalent to the 0.5-3 percent bleed rates described above. With RO process used for treating well field bleed streams, permeate will be reinjected and will substantially lower the requirement for makeup waterform the Madison; such use of RO typically reduces make-up water requirements to approximately 1/3 of the water that would be required without RO (Table 4.6-2).

Table 4.6-1: Net Water Usage with Reverse Osmosis

INYAN KARA	Net Water Usage at nominal bleed rate (with RO in restoration)										Cumulative water Usage (million gallons)	Percentage of Recharge 350 gpm recharge	520 gpm recharge
Years	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			
Production operations													
production flow	4000	4000	4000	4000	4000	4000	4000						
injection flow	3965	3965	3965	3965	3965	3965	3965						
net production withdrawal	35	35	35	35	35	35	35	0	0	0			
bleed rate	0.88%	0.88%	0.88%	0.88%	0.88%	0.88%	0.88%						
Restoration operations													
restoration flow	0	0	500	500	500	500	500	500	500	500			
injection flow			495	495	495	495	495	495	495	495			
Permeate flow			350	350	350	350	350	350	350	350			
Recharge from Madison			145	145	145	145	145	145	145	145			
net restoration withdrawal			5	5	5	5	5	5	5	5			
bleed rate			1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%			
Net Usage from Iyan Kara	35	35	40	40	40	40	40	5	5	5	150	8%	5%
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			
INYAN KARA	Consumptive Usage - with RO and re-injection of permeate												
Production operations	35	35	35	35	35	35	35	0	0	0	129	7%	5%
Restoration operations*	0	0	150	150	150	150	150	150	150	150	631	34%	23%
Inyan Kara Total	35	35	185	185	185	185	185	150	150	150	759	41%	28%
MADISON	Consumptive Usage - with RO and re-injection of permeate												
Process Water	65	65	65	65	65	65	65	65	65	65	342		
Recharge of Inyan Kara	0	0	145	145	145	145	145	145	145	145	610		
Madison Total		65	210	210	210	210	210	210	210	210	917		

* assumes all restoration make-up water from outside of INYAN KARA

Table 4.6-2: Net Water Usage without Reverse Osmosis

INYAN KARA	Net Water Usage at nominal bleed rate (without RO in restoration)										Cumulative water Usage (million gallons)	Percentage of Recharge 350 gpm recharge	520 gpm recharge
Years	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			
Production operations													
production flow	4000	4000	4000	4000	4000	4000	4000						
injection flow	3965	3965	3965	3965	3965	3965	3965						
net production withdrawal	35	35	35	35	35	35	35	0	0	0			
bleed rate	0.88%	0.88%	0.88%	0.88%	0.88%	0.88%	0.88%						
Restoration operations													
restoration flow	0	0	500	500	500	500	500	500	500	500			
injection flow			495	495	495	495	495	495	495	495			
Permeate flow			0	0	0	0	0	0	0	0			
Recharge from Madison			495	495	495	495	495	495	495	495			
net restoration withdrawal			5	5	5	5	5	5	5	5			
bleed rate (%)			1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%			
Net Usage from Iyan Kara	35	35	40	40	40	40	40	5	5	5	150	8%	5%
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			
INYAN KARA	Consumptive Usage - without RO and re-injection of permeate												
Production operations	35	35	35	35	35	35	35	0	0	0	129	7%	5%
Restoration operations*	0	0	500	500	500	500	500	500	500	500	2102	114%	77%
Inyan Kara Total	35	35	535	535	535	535	535	500	500	500	2231	121%	82%
MADISON	Consumptive Usage - without RO and re-injection of permeate												
Process Water	65	65	65	65	65	65	65	65	65	65	342		
Recharge of Inyan Kara	0	0	495	495	495	495	495	495	495	495	2081		
Madison Total	65	65	560	560	560	560	560	560	560	560	2423		

* assumes all restoration make-up water from outside of INYAN KARA

4.6.2.8 Potential Groundwater Quality Impacts from Accidents

4.6.2.8.1 Potential Excursions

Monitoring wells within the monitoring well ring are designed and installed to detect an excursion of leach fluids outside the well field within the aquifer exempted area. Neither historical excursions nor excursions within active ISL projects have "resulted in any significant adverse impacts to USDWs" (NMA, 2007). This demonstrates the protective capabilities of operators to detect and control excursions. Operators are mandated by permitting conditions to employ practices to protect adjacent, non-exempted aquifers. With that stated, importance is placed upon the understanding that the UIC Class III permit issued by the EPA and the uranium recovery license issued by the NRC are written and enforced to protect USDWs. The permit and license also ensures the operational processes such as: monitoring, pump tests, and maintenance of well field bleed are all geared toward protecting USDWs (NMA, 2007).

Well field imbalance is the most common cause of excursions. Imbalance can cause lixiviant to migrate outside the well field pattern toward the monitoring well ring; therefore it is crucial to characterize the groundwater within each separate well field before lixiviant is introduced into the groundwater. This well field specific groundwater data is then used to establish UCLs used for determination of properly functioning well field. One example of how an excursion is declared is "if any two excursion indicators in any monitor well exceed their respective UCLs, or a single excursion indicator exceeds its UCL by 20 percent (NMA, 2007; NUREG-1910, 2008).

Common procedure during routine sampling of monitoring wells is:

- If two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20 percent, the well will be re-sampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample will be taken within 48 hours. If neither the second or third sample results exceeded the UCLs, the first sample will be considered in error.

- If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, NRC Project Manager is notified by telephone or email within 48 hours and notified in writing within thirty (30) days.

- If an excursion is verified, the following methods of corrective action will be instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation will be completed to determine the probable cause.
- Extraction and/or injection rates in the vicinity of the monitor well will be adjusted as necessary to generate an effective net over-recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells will be pumped to enhance recovery of leach fluids.
- Injection into the production zone area adjacent to the monitor well may be suspended, while extraction continues, thus increasing the overall bleed rate and the recovery of ore zone solutions.
- In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to weekly. An excursion will be considered resolved when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive one-week samples. Accordingly, while a real potential short-term impact, excursions during operations can be identified and controlled such that impacts are expected to be minimal.
- Impacts of excursions include the potential to contaminate groundwater outside of the well field or in aquifers above or below the production zone. However, it is noted that, in spite of excursions at virtually every operating ISL site, no significant, adverse impacts to USDWs have been documented throughout the history of ISL operations in the United States, which indicates that operators have the capability to recover errant solutions (NMA, 2007).

There are two types of excursions: vertical and horizontal. A vertical excursion is movement of solution into overlying or underlying aquifers. A horizontal excursion is a lateral movement of leach fluids outside the ore zone of the ore-body aquifer.

Maintaining injection pressures below casing and formation rupture pressures prevent the well casing from rupturing and potentially causing a vertical excursion. Well field operating pressures are monitored at the header houses via instrumentation equipped with alarms and interlocks to prevent an excursion due to excessive pressure. Consistent monitoring of well field pressures minimizes the potential for impacts to shallow and deep aquifers. MIT's have all but eliminated potential impacts from excursions to shallow aquifers (NMA, 2007).

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. 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. Licensees also must conduct pre-operational 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 (NUREG-1910, 2008).

During normal ISL operations, inward hydraulic gradients are maintained by production bleed such that groundwater flow is towards the production zone from the edges of the well field. This inward gradient prevents the chance of a horizontal excursion occurring. To reduce the likelihood and minimize the consequences of potential horizontal excursions, a ring of monitoring wells are installed encircling the well field pattern to enable early detection of excursions. Monitoring will be conducted for both vertical and horizontal excursions. Thus, potential *non*-radioactive contamination of groundwater beyond the production zone can have short-term impacts, but such impacts likely will be minimal and readily controllable (NMA, 2007).

4.6.2.8.2 Potential Spills

Types of spills that could potentially impact groundwater during operations include: a leak in a storage pond, a release of pregnant and/or barren lixiviant, a release of injection or production solutions from associated piping, spills and potential well rupture. Potential impacts of contamination to shallow aquifers and surrounding soils may result from one or a combination of these types of spills. The likelihood of spills is minimized by way of rigorous safety training, and employing all necessary preventative procedures such as maintaining injection pressures below casing and formation rupture pressures, monitoring pressure in the header houses with instrumentation equipped with alarms and interlocks for early warning, and maintaining operating pressures so as to minimize the likelihood for potential impacts to shallow aquifers. The potential environmental impacts from spills and mitigation measures are discussed in further detail in Section 5.4.

4.7 Potential Ecological Resource Impacts

Potential impacts to ecological resources from construction, operations, aquifer restoration and decommissioning are expected to be SMALL (NUREG-1910, 2008; BKS, 2007; ICF Jones and Stokes 2008).

Despite the relatively limited surface disturbance associated with ISL production, operations can have potential direct and indirect impacts on local wildlife populations. These potential impacts can be both short-term and long-term (persisting beyond successful completion of reclamation). However, the latter category is not expected to be substantial due to the relatively limited habitat disturbance associated with this industry and this PAA (NUREG-1910, 2008). The direct impacts of ISL production on wildlife include: injuries and mortalities caused by collisions with project-related traffic or habitat removal actions such as topsoil stripping, particularly for smaller species with limited mobility such as some rodents and herptiles; and restrictions on wildlife movement due to construction of fences (ICF Jones and Stokes, 2008). The likelihood for the impacts resulting in injury or mortality potentially would be greatest during the construction phase due to increased levels of traffic and physical disturbance during that period. Speed limits will be enforced during all construction and maintenance operations to reduce impacts to wildlife throughout the year, but particularly during the breeding season.

As indicated, most of the habitat disturbance associated with the ISL process itself will consist of scattered confined drill sites for well heads that will not result in large expanses of habitat being dramatically transformed from its original character, as is the case with other surface mining operations (NUREG-1910, 2008). Therefore, most indirect impacts would relate to the displacement of wildlife due to increased noise, traffic, or other disturbances associated with the development and operation of the project, as well as from small reductions in existing or potential cover and forage due to habitat alteration, fragmentation, or loss. Indirect impacts typically persist longer than direct impacts. However, because ISL production results in fewer large-scale habitat alterations, the need for reclamation actions that can also result in dramatic differences between pre-construction and post-construction vegetative communities is also reduced.

Multiple site visits and targeted surveys conducted over the last year, combined with existing agency databases that encompass the PAA and input from local residents, indicate that the PAA and surrounding vicinity is occupied by a wide variety of common wildlife and fish species, with only a few species of particular concern occurring in the area. The most notable species of

interest is the bald eagle, which is still considered threatened at the state level. Bald eagle winter roost sites and a successful nest site were documented within the PAA during surveys conducted in 2007 and 2008. Two other species tracked by the SDNHP were confirmed or suspected to have nested in the PAA in 2008, the long-eared owl and long-billed curlew, respectively. Seven additional SDNHP species were documented in or near the PAA during baseline surveys, and one state threatened species was documented several miles northwest of the area, in extreme eastern Wyoming. However, those observations consisted of birds flying over the area, or sightings made in the surrounding perimeter. No grouse leks have been recorded within 6 miles of the PAA during agency or project-specific surveys completed in recent years.

Suitable habitat for all three nesting SDNHP species (bald eagle, long-eared owl, long-billed curlew) occurs in the PAA. However, the nature of ISL production and the presence of apparently suitable (due to low density of other nesting individuals) alternate nesting habitat throughout the PAA and perimeter combine to minimize the potential for both direct and indirect impacts for those species, and others that require similar habitats. One of those species, the long-eared owl, nested within 75 m, but largely beyond view of, an existing gravel county road, suggesting the pair has at least some level of tolerance for vehicular traffic near active nest sites. Other wildlife species of concern, such as other nesting raptors, that occur in the area may also experience direct and/or indirect impacts from increased travel and noise in the area during project construction and operation. However, the presence of potential alternate nesting and foraging habitat in the immediate vicinity, the mobility of those species, and the location of most nest sites relative to planned disturbance combine to reduce impacts to most nesting SDNHP birds as well as other species of interest.

Some vegetative communities currently present in the PAA can be difficult to reestablish through artificial plantings, and natural seeding of those species would likely take many years. However, the current habitat of greatest concern (Big Sagebrush Shrublands) occurs only in scattered stands that are relatively small and widely-spread across the PAA. Results from lek searches, breeding bird surveys, and small mammal trapping, as well as regular site visits in all seasons over the last year, strongly suggest that sage obligates other than pronghorn occur in limited numbers in the PAA, if at all. The vegetative communities (Cottonwood Gallery and Ponderosa Pine) that indicated the strongest associations between terrestrial species and habitats during baseline surveys will not be physically impacted by construction or operation of the proposed ISL Uranium project. It is possible that the potential implementation of center-pivot irrigation using well field bleed and/or restoration water may enhance nesting, brood-rearing,

and/or foraging habitat for some species. Consequently, although individual animals associated with some specific habitats could be impacted by the proposed ISL operations, the relatively small percentage of projected surface disturbance within the PAA relative to its overall size, and the low density of nesting efforts relative to habitat presence in that area, suggest that their populations as a whole will experience insignificant impacts from the project. Advanced planning of construction siting and activities in concert with continued monitoring can further reduce impacts and assist with the development of mitigation options, if necessary. Potential impacts to these species and others are discussed in greater detail in the following sections.

4.7.1 Vegetation

Well field and production facilities will be constructed within Big Sagebrush Shrubland, Greasewood Shrubland, Ponderosa Pine Woodland, and Upland Grassland vegetation communities. Direct impacts include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types). Indirect impacts may include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; reduction in livestock forage; and changes in visual aesthetics. An estimated 295.17 acres within the following four communities: Big Sagebrush Shrubland, Greasewood Shrubland, Ponderosa Pine Woodland, and Upland Grassland would be affected by the construction disturbance under current development plans.

Construction activities and increased soil disturbance could stimulate the introduction and spread of undesirable and invasive, non-native species within the PAA. Non-native species invasion and establishment has become and increasingly important result of previous and current disturbance in South Dakota. No threatened or endangered vegetation species were observed within the PAA; therefore, no impacts are anticipated.

Mitigation measures to lessen impacts on native vegetation and control State-designated noxious weeds are discussed in Section 5.5.

4.7.2 Wildlife and Fisheries

4.7.2.1 Big Game Mammals

Big game could be displaced from portions of the PAA to adjacent areas, particularly during construction of the well field and facilities, when disturbance activities would be greatest. Disturbance levels would decrease during actual extraction operations, and would consist

primarily of vehicular traffic on new and existing improved and unimproved (two-track) roads throughout the PAA. Similar disturbance is already present in the area due to existing ISL exploration, ranching, and railroad operations. Pronghorn antelope would be most affected, as they are more prevalent in the area. However, no areas classified as crucial pronghorn habitat occur on or within several miles of the PAA, and this species is not as common in the general area as elsewhere within the region due to the limited presence of sagebrush in the area. Mule deer would not be substantially impacted given their somewhat limited use of these lands, the paucity of winter forage and security cover, and the availability of suitable habitat in adjacent areas. SDGFP does not consider the PAA to be within the crucial habitat range of any other big game species. Sightings of those species in that vicinity are often seasonal and less common.

4.7.2.2 Other Mammals

Medium-sized mammals (such as lagomorphs, canids, and badgers) may be temporarily displaced to other habitats during the initial ISL production activities. Direct losses of some small mammal species (e.g., voles, ground squirrels, mice) may be higher than for other wildlife due to their more limited mobility and likelihood that they would retreat into burrows when disturbed, and thus be potentially impacted by topsoil scraping or staging activities. However, given the limited area expected to be disturbed by the project, such impacts would not be expected to result in major changes or reductions in mammalian populations for small or medium-sized animals. "Displaced species may re-colonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and suitable habitats are reestablished" (NUREG-1910, 2000). Few bats were recorded in the area despite extra efforts to observe them during the baseline surveys. Those that were seen were near water bodies near treed habitats which are not currently scheduled for disturbance. The mammalian species known to be, or potentially, present in the PAA have shown an ability to adapt to human disturbance in varying degrees, as evidenced by their continued presence in other mining, industrial and residential areas of similar, or greater, disturbance levels elsewhere in the region. Additionally, small mammal species in the area have a high reproductive potential and tend to re-occupy and adapt to altered and/or reclaimed areas quickly.

4.7.2.3 Upland Game Birds

ISL production in the PAA would potentially impact the foraging and nesting habitat of mourning doves, though such disturbance is not expected to have any marked impacts on this species. No woody corridors will be disturbed by the proposed activities, and additional trees are

present in the cottonwood gallery along the Cheyenne River, located approximately 2 miles south of the PAA, where production is not projected to occur in the near future. Additionally, doves are not restricted to treed habitats, nor are they subject to any special mitigation measures for habitat loss.

Annual monitoring surveys conducted by SDGFP biologists and a year-round baseline study for the project have demonstrated that sage-grouse do not currently inhabit that area, and have not for many years. As described previously, those surveys encompassed the entire PAA (including the September 2008 configuration) and the vast majority of its 2.0 km (1.2 mi) perimeter, particularly as part of this baseline project. The nearest known sage-grouse lek is approximately 6.0 miles north of the PAA (SDGFP records). Given the lack of sage-grouse observations in the area, and the scattered stands of marginal quality sage-grouse habitat, the proposed project will not result in negative impacts to existing or potential sage-grouse leks, or important sagebrush habitats.

4.7.2.4 Other Birds

The project could impact nine avian species tracked by SDNHP that are known to, or could potentially occur as seasonal or year-round residents. Direct impacts could include injury or mortality due to encounters with vehicles or heavy equipment during construction or maintenance operations. Indirect impacts could include habitat loss or fragmentation, and increased noise and activity that may temporarily deter use of the area by some species. Surface disturbance would be relatively minimal and could be greatest during construction. Enforced speed limits and use of common right-of-way corridors will reduce impacts to wildlife throughout the year, particularly during the breeding season.

4.7.2.5 Raptors

ISL production in the PAA would not impact regional raptor populations, though individual birds or pairs may be affected. Production activity could cause raptors to abandon nest sites proximate to disturbance, particularly if activities encroach on active nests during a given breeding season. Within the current mine plan there are no planned activities that would encroach on identified raptor nests. Other potential direct impacts would be injury or mortality due to collisions with mine-related vehicular traffic. Construction activities that occur within or near active raptor territories could also cause indirect impacts such as reduction or avoidance of foraging habitats for nesting birds. However, surface disturbance will only occur in a small percentage of the overall PAA, and the low density of nesting raptors relative to the apparent availability of

suitable habitat suggests that alternate nesting habitat is available for all known nesting raptor species in the PAA.

Eight intact raptor nests were documented within the project survey area (PAA and 2.0 km perimeter) during 2008; the mid-July 2007 start date for this project precluded nesting data from being collected last year. Six of the eight nest sites are within the proposed PAA, with the remaining two located in the one-mile perimeter. USFWS guidelines recommend a non-disturbance buffer of 0.25 to 1.0 mile around active raptor nests for species known to nest, or suspected of nesting, in the PAA (USFWS, 1998). Buffer recommendations are lowest for the two owl species in the area, as they are typically more tolerant of human activities near active nest sites. The bald eagle has the greatest buffer distance around active nests, while a 0.5-mile buffer is recommended for red-tailed hawks and merlins. Nests of most other raptor species, including all others observed, but not documented nesting, in the proposed action area are typically buffered by a radius of 0.25 to 0.50 mile.

Except for the bald eagle, the same species that nest in the PAA are known to regularly nest and fledge young at or near other surface mines throughout the region, including ISL projects. Those efforts have succeeded due to a combination of raptors becoming acclimated to the relatively consistent levels of disturbance and gradual encroachment of mine operations, and successfully executed state-of-the-art mitigation techniques to maintain viable raptor territories and protect nest productivity. Some individuals nest on active mine facilities themselves, including both great horned owls and red-tailed hawks. The lack of bald eagle examples is more likely related to the general absence of nesting bald eagles in the vicinity, rather than an increased sensitivity to mine activities. Bald eagles will be discussed further in the T&E section later in this document. Due to the paucity of river cliffs in the PAA, falcons and other raptors known to nest in that habitat are not as abundant as those that nest in trees or even on the ground.

Based on the location of known nest sites relative to future construction sites, no raptor nests will be physically disturbed by the project during either construction or operations. Additionally, Powertech (USA) has incorporated the baseline wildlife information into their planning process and sited all plant facilities (areas of greatest sustained future disturbance) outside the recommended buffer zone for all raptor nests in the PAA, including the bald eagle nest site. Some new infrastructure will be located within the suggested buffer areas. However, pipelines will be buried, and new overhead power lines will be constructed using designs and specifications to reduce injuries and mortalities on overhead power lines. Center-pivot structures can be put into place prior to the nesting season, and run automatically with little human contact

once they are turned on. Additionally, new roads, power lines, and pipelines will be constructed in the same corridors to the extent possible to reduce overall disturbance, and in existing corridors when available to minimize new surface disturbance.

4.7.2.6 Waterfowl and Shorebirds

Construction and operation of the proposed project would have a negligible effect on migrating and breeding waterfowl and shorebirds. Existing habitat is limited and seasonally available in the PAA, so it does not currently support large groups or populations of these species. Multiple approaches are being considered to minimize impacts to wildlife that may be associated with the operation of ponds. Any new treated water sources could enhance current habitat conditions for these species, though such effects may be temporary in nature. Water quality within the ponds likely will not have any significant adverse impacts upon avian species because it is basically fresh water.

4.7.2.7 Reptiles, Amphibians, and Fish

As with waterfowl, potential habitat for aquatic and semi-aquatic amphibians and reptiles, is limited within the proposed PAA, and occurs primarily along Beaver Creek in the western portion of the area. Other water bodies are ephemeral, and thus offer only short-term habitat. Activities associated with the project are not expected to disturb existing surface water or alter the topography in the area. Those species residing in rocky outcrops located in potential disturbance areas could be impacted by construction and maintenance operations. However, few non-aquatic herptile species were observed in the PAA and surrounding perimeter. Any impacts that occur could affect individuals, but would not likely impact the population as a whole.

4.7.2.8 Fish and Macroinvertebrates

The planned locations for new facilities and infrastructure do not overlap any perennial aquatic features, no loss of aquatic habitat would occur as the result of their construction. The risk of impaired water quality will be reduced or avoided through project siting, and implementation of standard construction erosion and sediment control measures. The location of production facilities (processing plants, pipelines, new roads and power lines), as well as the proposed land application sites (center pivot irrigation sites) will avoid direct impacts to perennial streams.

Due to the arid climate and proposed location of new mine facilities, operation of the well fields is not expected to alter aquatic habitat or water quality in perennial streams. No surface water

will be diverted for use in the operation, and no process water will be discharged into aquatic habitat.

Pass creek provides only seasonal drainage and does not support fish or significant amphibian habitat. The proposed processing sites and land application sites are intentially located away from Beaver Creek, Pass Creek and other aquatic habitat, the primary aquatic habitat in the project vicinity. Therefore, aquatic habitat will not be directly affected by the well field operations or land application sites.

4.7.3 Threatened and Endangered, or Candidate Species and Species Tracked by SDNHP

4.7.3.1 Federally Listed Species

As described in the preceding sections of this document, no federally listed vertebrate species were documented in the project survey area (current PAA and 2.0 km perimeter) during the year-long survey period, or during previous targeted surveys conducted for the original claims (TVA 1979). Additionally, the USFWS has issued a block clearance for black-footed ferrets in all black-tailed prairie dog colonies in South Dakota except northern Custer County, and in the entire neighboring state of Wyoming. That clearance indicates that ferrets do not currently, and are not expected to, occupy the PAA. Only one small black-tailed prairie dog colony was present in the PAA itself during the 2007-2008 baseline surveys, and local landowners are actively working to remove the animals from their lands. Consequently, the proposed project will have no direct, indirect, or cumulative effects on black-footed ferrets.

4.7.3.2 State Listed Species

ISL within the project is not likely to adversely affect, bald eagles, the only state listed species known to inhabit the PAA. Bald eagles were documented at winter roosts and an active nest within the PAA for this project. However, most roost sites and the lone nest site are at least 1.0 mile from the nearest planned facility associated with this project. Additionally, no more than two or three bald eagles were observed during any given winter survey, despite the numerous available (and unoccupied) mature trees along Beaver Creek, Pass Creek, and the pine breaks located in and near the PAA. Three proposed land application sites (center pivot irrigation systems) would currently fall within the one-mile buffer of the bald eagle nest. However, those systems are typically automated, and the minimal disturbance associated with potential maintenance of those systems should not be significant enough to impact nesting or roosting bald eagles along Beaver Creek.

Direct impacts to bald eagles could include the potential for injury or mortality to individual birds foraging in the PAA due to electrocutions on new overhead power lines. Although not expected, disturbance activities near an active nest could result in abandonment and, thus, the loss of eggs or young. The increased human presence and noise associated with construction activities, if conducted while eagles are wintering within the area, could displace individual eagles from using the area during that period.

Given the low number of wintering and nesting bald eagles in the PAA, potential impacts of the proposed project would be limited to individuals rather than a large segment of the population. The use of existing or overlapping right-of-way corridors, along with best management practices will minimize potential direct impacts associated with overhead power lines. If necessary, the majority of other potential impacts could be mitigated if construction activities were conducted outside the breeding season and/or winter roosting months, or outside the daily roosting period, should eagles be present within one mile of construction. Any bald eagles that might roost or nest in the area once the mine is operational would be doing so in spite of continuous and on-going human disturbance, indicating a tolerance for such activities.

Indirect impacts as a result of noise and human presence associated from mine related operations could include area avoidance by avian species. Potential winter foraging habitat could be further fragmented by linear disturbances such as overhead power lines and new roads associated with the project. Given the size of the proposed project, those disturbances would occur within narrow corridors over relatively short distances. Nevertheless, the use of common right-of-way corridors to consolidate new infrastructure will reduce these potential indirect impacts.

The only other state-listed species recorded in the general area was the river otter. An otter carcass was discovered lodged in debris in the stream channel at fisheries sampling station BVC04 in mid-April 2008. That site is approximately 12 river miles upstream from the PAA boundary in eastern Wyoming. The carcass had washed away by the July 2008 fisheries sampling session. The monthly sampling at BVC04 during the monitoring period, confirmed no additional observations of otters. Likewise, no evidence of otters was report by biologists along any drainage elsewhere in the PAA (proposed permit area and 2.0 km perimeter) during the year-long baseline survey period (mid-July 2007 through early August 2008). Given the fact that no stream channels will be physically impacted in the PAA, the lack of otter sightings or sign in the PAA itself, and the stringent water processing and water quality monitoring that will occur, this project is not likely to directly or indirectly impact river otters.

4.7.3.3 Species Tracked by SDNHP

Ten terrestrial species tracked by the SDNHP were recorded during baseline surveys for the uranium project, including the bald eagle. Seven of the ten were observed within the PAA, and three were seen in the 2.0 km perimeter. One additional species, the plains topminnow, was observed in Beaver Creek and the Cheyenne River, at least 1.0 mile outside the PAA. Three SDNHP species are known or suspected to have nested in the PAA in 2008. However, two of the three nest sites are at least 1.0 mile from the nearest planned new facility, and all three were closer to existing disturbances in 2008 than they would be to new activities outside those existing areas.

The seven SDNHP species recorded in or flying over the PAA could potentially experience the same type of direct and/or indirect impacts from construction and operation of the Proposed Action as those described previously for other species: e.g., injury, mortality, avoidance, displacement and increased competition for resources. Those potential impacts will be minimized by the timing, extent, and duration of the proposed activities. Enforced speed limits during all phases of the project will further reduce potential impacts to wildlife throughout the year, particularly during the breeding season. Once facilities and infrastructure are in place, and hunting pressures decrease, animals remaining in the PAA could demonstrate an acclimation to those disturbances.

4.8 Potential Air Quality Impacts

4.8.1 Potential Air Quality Impacts of Construction

ISL process facilities do not typically affect air quality drastically (NUREG-1910, 2008). The impacts due to construction are classified as SMALL if 1) the gaseous emissions are within regulatory limits; 2) the air quality in the region of influence is in compliance with the National Ambient Air Quality Standards (NAAQS); and 3) the facility is not classified as a major source according to the New Source Review or operating permit programs. Because of the isolated location (13 miles northwest of Edgemont) and the atmospheric conditions of the PAA, the cumulative air quality impacts will be negligible.

The construction phase of ISL projects generally produces non-radiological gaseous emissions including fugitive dust and combustion emissions. Diesel emissions from construction equipment comprise the majority of the combustion emissions and are considered to be small, short-term effects.

Potential air quality impacts during construction activities at the project will include emissions from heavy equipment, vehicle and drill rig exhaust, dust from traffic, and dust from disturbing soil during drilling and ground-clearing activities. Mobile sources of emissions will be diesel engines on the drill rigs and diesel water trucks. All vehicles on-site will meet Environmental Protection Agency (EPA) and Department of Transportation (DOT) vehicle emission standards.

The greatest amount of dust will be generated from vehicular traffic on the unpaved roads; therefore, speed limits will be imposed for employee vehicles and transport trucks in order to mitigate the amount of dust generated from unpaved roads. Employee car pooling will be encouraged, which will keep the vehicular traffic at a minimum. Temporarily disturbed areas will be reseeded and restored as soon as possible to minimize erosion of soil and fugitive dust emissions.

4.8.2 Potential Air Quality Impacts of Operation

As a general matter, ISL operations are not a major point source emitters and are not expected to be classified as major sources of emissions (NUREG-1910, 2008). Emissions may be introduced during the operation phase of an ISL project including the release of pressurized vapor from well field pipelines. Other additional possible emissions include those that may be emitted during resin transfer or elution. Naturally occurring radon gas may also be released when the well pipeline system is vented. Non-radiological emissions from pipeline system venting, resin transfer, and elution are expected to have a minimal impact on air quality at the site due to the low volume of effluent produced and the rapid dispersion of the emissions (NUREG-1910, 2008).

Due to the utilization of the pressurized down-flow IX columns there are virtually no releases of radon to the atmosphere. Indeed, none of the IX process circuit is open to the atmosphere except for short periods during transfer of resin. During resin transfer, fans vent radon released from the resin transfer process from the CPP to the outside atmosphere.

Yellowcake drying operations can also produce gaseous effluents. The project yellowcake will be dried at approximately 450 °F in a rotary vacuum drying process. The impacts related to yellowcake drying will be to be SMALL because vacuum driers basically release no gaseous effluents other than water vapor (NUREG-1910, 2008).

Fugitive dust and emissions from on-site traffic associated with operations and maintenance will also be expected, but will amount to less than was produced during construction of the facilities at the site, so impacts are expected to be SMALL (NUREG-1910, 2008).

Impacts during aquifer restoration and decommissioning phases to air quality are expected to be similar (SMALL) to impacts during operations (NUREG-1910, 2008).

Section 5.6 discusses the mitigation measures for air quality impacts.

4.9 Potential Noise Impacts

4.9.1 Potential Noise Impacts of Construction

Because of the remote location of the project site and lack of sensitive receptors, noise impacts are not expected to increase beyond ambient levels due to plant operations. Likewise, no detrimental off-site noise impacts are anticipated due to the increase in commuter and truck traffic volumes or from construction. Noise levels generated during operation of the ISL project are not expected to result in any significant impacts to violate any noise standards. Open rangeland and pastureland are the primary land uses within the PAA and the surrounding 2.0-km area.

Outdoor noise levels at the nearest off-site receptors will be well within the 55-dBA daytime guideline, to protect against activity interference and annoyance (EPA, 1978). Noise levels during mine unit construction should cause no off-site impacts, since the PAA is not in close proximity to off-site receptors and will occur only during daylight hours.

Section 5.7 discusses the mitigation measures for noise impacts.

4.9.2 Potential Noise Impacts of Operations

Because of the remote location and lack sensitive receptors noise potential impacts are not expected to increase beyond ambient levels due to plant operations. Likewise, no detrimental off-site noise impacts are anticipated due to the increase in commuter and truck traffic volumes or from construction. Noise levels generated during operation and reclamation of the project are not expected to result in any significant potential impacts that would violate any noise standards. Exposure limits during operations will meet OSHA current permissible exposure limit for workplace noise (29 CFR 1910.95).

Outdoor noise levels at the nearest off-site receptors will be well within the 55-dBA daytime guideline, to protect against activity interference and annoyance (EPA, 1978). Noise levels during process operation and reclamation should cause no off-site impacts, since the PAA is not in close proximity to off-site receptors and will occur only during daylight hours.

Section 5.7 discusses the mitigation measures for noise impacts.

4.10 Potential Historic and Cultural Resources Impacts

A Level III Cultural Resources Evaluation was conducted in the PAA (Appendix 4.10-A). Personnel from the Archaeology Laboratory, Augustana College (Augustana), Sioux Falls, South Dakota, conducted on-the-ground field investigations between April 17 and August 3, 2007.

Augustana documented 161 previously unrecorded archaeological sites and revisited 29 previously recorded sites during the current investigation. Expansion of site boundaries during the 2007 survey resulted in a number of previously recorded sites being combined into a single, larger site. Twenty-eight previously recorded sites were not relocated during the current investigation. Excepting a small foundation, the non relocated sites were previously documented as either prehistoric isolated finds or diffuse prehistoric artifact scatters.

Prehistoric sites account for approximately 87 percent of the total number of sites recorded. Historic sites comprise approximately 5 percent of total sites recorded, while multi-component sites (prehistoric/historic) comprise the remaining 8 percent. Ten of the sites documented have only prehistoric and historic components.

The small number of Euro-American sites documented was not unanticipated given the peripheral nature of the PAA in relation to the Black Hills proper. The disparity existing between the number of historic and prehistoric sites observed in the PAA is also not unexpected; however, the sheer volume of sites documented in the area is noteworthy. The land evaluated as part of the Level III cultural resources evaluation has an average site density of approximately 1 site per 8.1 acres. Even greater site densities were reported in 2000 during the investigation of immediately adjacent land parcels for the Dacotah Cement/BLM land exchange (Winham et al., 2001). This indicates that the proposed Permit Area is not unique, in regards to the number of documented sites, and is typical of the periphery of the Black Hills.

As construction takes place any previously undetected historical or cultural resources will be reported to the proper agency. The site will be evaluated and released by the proper agency

before construction continues within the specific area. The phased approach that Powertech (USA) proposes will increase the likelihood of safeguarding historical and/or cultural resources. Another example of phasing is a license condition that requires cessation of any site activities and the conduct of a cultural resources inventory if previously undetected historic or cultural properties are discovered during the development and construction of wellfields. Thus, "phasing" is an essential and integral component of *all aspects* of ISL uranium recovery projects (NMA, 2007).

Powertech (USA) has executed a Memorandum of Agreement, (MOA), attached as Appendix 4.10-B to this document with the State Archeologist to ensure to preservation of any historical sites that may be present within the PAA. The MOA outlines all actions needed to ensure no significant historic, cultural, or archeological resources will be damaged during production activates.

Section 5.8 discusses the mitigation measures for historic and cultural resources impacts.

4.11 Potential Visual/Scenic Resources Impacts

Potential short term impacts to the visual resources produced during construction will come from the addition of access roads, electrical distribution lines, header houses as well as drilling. Temporary impacted areas will be reclaimed upon completion of construction and debris created during construction will be removed as soon as possible to limit the areal extent affected during construction.

The sources of potential long-term impacts to the visual resources will be the presence of the central plant, wellhead covers, access roads, a pipeline, holding ponds, and several ancillary buildings. These potential long-term visual impacts will remain present until the completion of restoration and reclamation, which will efface the presence of the visual impacts associated with the proposed action.

The proposed action will result in temporary, minor impacts to visual and scenic resources. The project will maintain the visual resource classification of the area. According to NUREG-1569, if the visual resource evaluation rating is 19 or less, no further evaluation is required. Based on the visual resource inventory conducted in June 2008, the total score of the two Scenic Quality Rating Units within the Proposed License Area were 11 and 13; therefore, no further evaluation of the existing scenic resources or future changes to the scenic resources of the area due to the proposed action will be required.

To minimize potential impacts to visual and scenic resources, building materials and paint will be selected that complement the natural environment, according to BLM guidelines. Construction and placement of structures will take into consideration the topography in order to conceal wellheads, plant facilities, and roads from public vantage points. In order to mitigate the visual impacts of roads constructed, the topography that the road follows as well as the area of disturbance will be considered.

Impacts during aquifer restoration and decommissioning phases to visual resources are expected to be the same or less (SMALL) to impacts during operations (NUREG-1910, 2008).

Section 5.9 discusses the mitigation measures for visual/scenic resources impacts.

4.12 Potential Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility range up to about 200 people, including construction (Freeman and Stover, 1999; NUREG-1508, 1997; Energy Metals Corporation, U.S., 2007) as stated in NUREG-1910. In general the number people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons per household) (NUREG-1910, 2008). The following section highlights potential socioeconomic impacts of the proposed project to Custer and Fall River Counties. A cost-benefit analysis for the proposed action is presented in Section 7.0. Overall, potential socioeconomic impacts from ISL facilities in the proposed project region would range from SMALL to MODERATE (NUREG-1910, 2008).

4.12.1 Construction

Assuming a peak workforce of about 86 payroll employees, the influx of workers is expected to result in a small to moderate impact in Custer and Fall River Counties because of the short duration of construction phase (18-24 months) and the small size of the workforce compared to the regional labor pool of 9,202 people working full and/or part-time jobs (SD-REAP, 2008). The impacts of worker influx will be mitigated by preferentially sourcing the labor force from the within the surrounding region.

The potential direct, indirect and induced effects on Custer and Fall River Counties' employment are shown on Table 4.12-1. The direct employment effects refer to the employment directly generated by the project. For the initial construction phase beginning in year one, the IMPLAN model estimated 171 additional non-payroll workers hired in Custer and Fall River Counties

based on the estimated 86 payroll workers engaged directly in construction activities and the $45.8 million in non-payroll capital expenditures incurred by the project per year.

Table 4.12-1: Employment Effects of the Project in Custer and Fall River Counties

Years	Employment			
	Direct	Indirect	Induced	Total
1-2	86	45	126	257
3-9	84	36	35	155
10-17	18	3	3	24

Potential indirect effects pertain to the inter-industry effects from the direct effects and could include increased labor demands, goods and services required to support the ISL project (e.g. retail and restaurant staff). In addition, new workers living within Custer and Fall River Counties would spend their income locally, which would induce additional income and employment. The sum of potential direct, indirect and induced effects represents the total potential employment impacts of the project.

These results indicate that the project has the potential to create a total of 257 jobs during the construction stage.

4.12.2 Operations Workforce

Assuming an operation phase workforce of about 84, the influx of workers is expected to result in a small to moderate impact in Custer and Fall River Counties, because of the small size of the workforce compared to the regional labor pool of 9,202 people working full and/or part-time jobs (SD-REAP, 2008). The impacts of worker influx will be mitigated by preferentially sourcing the labor force from the within the surrounding region.

For the operation phase of the project, the IMPLAN model estimated 71 additional non-payroll workers will be hired in Custer and Fall River Counties based on the estimated 84 payroll workers engaged directly in the operation activities and the $21.2 million in non-payroll capital expenditures incurred by the project per year. The economic impacts of these newly created 155 jobs during the operation phase of the project are not limited to Custer and Fall River Counties, but will likely affect the surrounding Counties of Weston, Niobrara, and Pennington because of increased commerce and capital exchange within the region.

4.12.3 Potential Effects to Housing

Because of the project's close proximity to the more populated communities of Custer City and Hot Springs, South Dakota and Newcastle, Wyoming with a combined population greater than 9,000 people, it can be assumed that much of the workforce would come from these localities. The remaining workforce would likely relocate from the surrounding area (e.g., South Dakota, Nebraska and Wyoming). The IMPLAN model results show that during the two year constructional stage, the Proposed Action has the potential to sustain the creation of 257 new jobs for two years. During the following 7 year operation stage the project has the potential to sustain the creation 155 jobs for seven years, and 24 jobs over the final seven years.

In the unlikely event that the entire direct payroll and non-payroll workforce relocated to Custer and Fall River counties, the population increase for the three stages of operations would be 619, 374 and 58, based on the average family size in South Dakota of 2.41 as of 2006. This increase in population would account for an increase of 6.9 percent (total population 15248) in the total population of Custer and Fall River counties. This is a very conservative estimate because it is likely that a large percentage of the workforce for operation and reclamation will be sourced from the existing workforce, thereby reducing the total population increase substantially. The impacts associated with an increase in population are expected to be dispersed because of the remoteness of the project site and the phased nature of construction, operation and reclamation. While this is a moderate increase in the overall percentage of the local population, this influx of immigration could be partially mitigated by implementing a preferential hiring scheme and using regional educational/training institutions to help train workers and to ensure that as many of the local residents are hired as possible.

4.12.4 Potential Effects to Services

There are several schools located within Custer and Fall River Counties. The Custer School District includes: Custer Elementary, Hermosa Elementary, Fairburn Elementary, Spring Creek Elementary, Custer Middle, and Custer High School. Total enrollment for the Custer School District is 991 students with a student to teacher ratio of 12.1 to 1. The Hot Springs School District includes: Hot Springs Elementary, Hot Springs Middle and Hot Springs High School. Total enrollment for the Hot Springs School District is 873 students with a student to teacher ratio of 12.9 to 1. The Edgemont School District includes: Edgemont Elementary, Edgemont Junior High and Edgemont High School with a total enrollment of 138 students and a student to teacher ratio of 8.8 to 1.

Families moving into the aforementioned school districts near the project site as a result of the project are not expected to strain the current school system because they presently under-capacity as shown by the combined student teacher ratio for the three school districts of 12.1:1 as compared to the State wide student teacher ratio of 13.4:1 and the national average of 15.7:1.

The costs associated with increased demand of public facilities and services are expected to be minimal. The need for additional water supply and waste disposal facilities are expected to be minimal based on adequate existing capacity. Existing emergency response and medical treatment facilities are capable of responding to any possible incident at the project site; therefore the basic services required to support the project already exist. Since the majority of the workforce will be local there are no significant changes or stresses anticipated for other public services, such as police, health care, or utilities.

4.12.5 Economic Impact Summary

According to the Cost-Benefit Analysis in Section 7, the most significant benefits of the Proposed Action are its potential to sustain the creation of 257 new jobs during construction, 155 jobs during operation, and 24 jobs during reclamation, all of which include the direct, indirect and induced effects on the local economies. In addition, an estimated $91.6 million during construction will be spent on non-payroll expenditures, $148.4 million during operation and 14.0 million during reclamation; and approximately $35.1 million in state and local tax revenue and $186.7 million in value added benefits are expected to be generated over the life of the Proposed Action (Table 4.12-2).

Table 4.12-2 summarizes the associated short-term and long-term cost of the Proposed Action. Impacts to the regional housing market should be minimal because of the large percentage of local workers, impacts to schools and public facilities should be negligible because of their present ability to absorb any associated regional influx, and the impact of noise and additional traffic presents little or no change compared to the no action alternative. Due to the remote location of the project Site and minimal surface disturbance, impacts to recreational activities and aesthetic values within the area should be negligible.

This CBA indicates that the construction and operation costs including capital costs of this project will result in positive economic benefits to the local and regional economy by the creation of hundreds of jobs and millions of dollars in tax revenue over the life of the project. The development the ISL project should present Custer and Fall River counties with net positive gain when compared to the no action alternative.

Table 4.12-2: Summary of Benefits and Costs for the Proposed Action

Benefits	Costs
▪ **Value Added** $186,697,204 ▪ **Tax Revenue** $35.1 million ▪ **Potential to create temporary and permanent jobs** 257 jobs over two years during construction 155 jobs over seven years during operation 24 jobs over eight years during reclamation ▪ **Increased knowledge of the local environment and natural resources**	▪ **Housing Impacts** Little or no change ▪ **Schools and Public Facilities** Negligible ▪ **Noise and Congestion** None ▪ **Impairment of Recreation and Aesthetic Values** Negligible ▪ **Land Disturbance** Minor ▪ **Groundwater Impacts** Controlled through mitigation ▪ **Radiological Impacts** Controlled through mitigation

4.13 Potential Environmental Justice Impacts

The U.S. Census 2000 Decennial Population program provides information about race and poverty characteristic for Census Tracts for the areas surrounding the PAA. The 2000 Census Tract data for South Dakota was used to compare the demographic data for the counties surrounding the PAA. These data were also used to determine if there was a disproportionate percentage of minorities or low-income populations that might be affected by the PAA relative to the State.

As shown in Table 4.13-1, minorities make up less than 7.0 and 11.0 percent of the total population for Custer and Fall River Counties, respectively, which is less than the state average of 12.0 percent. No concentration of minorities was identified to reside near the PAA, which is located in a rural area, while most of the minority population lives urban centers such as Custer City (Census Tract 9952) or Hot Springs (Census Tract 9942).

Census Tract information regarding median household incomes and poverty statistics for Custer and Fall River counties is only available from the decennial federal census. Median household income levels were $36,303 for Custer County and $29,631 for Fall River County compared with $35,282 for the State average. The two census tracts within Fall River County (9941 and 9942) are below the State average for median household income levels, but they are all well above the

2000 poverty level of $17,603 for a family of four, while the average of Custer Counties two census tracts was well above the State's average. The poverty rate in Custer County was 9.4 percent and 13.6 percent in Fall River County. Compared to the state-wide average of 13.2 percent, Fall River's poverty rate is only slightly higher, while Custer County is well below the state-wide; therefore, there is not a disproportionate concentration of low-income populations within the study area compared to the State as a whole (USCB, 2000).

Table 4.13-1: Race and Poverty Characteristics for Areas Surrounding the Proposed Action

	Custer County CT - 9951	Custer County CT- 9952	Custer County	Fall River County CT - 9941	Fall River County CT - 9942	Fall River County	State of South Dakota
White, non-Hispanic Population	95.0	90.8	93.4	92.4	87.5	89.3	88.0
Total Racial Minority Population	5.0	9.2	6.6	7.6	12.5	10.7	12.0
White, Hispanic Population	1.4	1.7	1.5	1.3	2.0	1.7	1.4
Native American Population	2.1	4.8	3.1	4.1	7.2	6.1	8.3
Median Household Income in 1999 dollars	$37,083	$34,837	$36,303	$31,759	$27,337	$29,631	$35,282
Percent Below Poverty Level	10.0	8.4	9.4	13.3	13.8	13.6	13.2
Total Population	4,517	2,758	7,275	2,767	4,686	7,453	754,844

It is possible that some low-income individuals or minorities may reside within the study area, but not disproportionately compared with the state-wide averages. Also, since the proposed project is not expected to generate any significant adverse environmental impacts to the area's natural resources, there will not be any disproportionate environmental consequences to minority groups or low income populations.

4.14 Potential Public and Occupational Health Impacts

Powertech (USA) is 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. Powertech (USA) will employ the principles of ALARA at all times concerning activities covered under the NRC license. NRC will periodically inspect Powertech (USA) programs to ensure compliance (NUREG-1910, 2008).

4.14.1 Potential Nonradiological Impacts

The area within an 80-kilometer (50-mile) radius surrounding the PAA includes portions of counties within western South Dakota, eastern Wyoming, and northeastern Nebraska, as discussed in Section 3.10. Section 3.0 also discusses population distribution for the 80 km radius around the PAA. Figure 3.10-1 provides the population sector block analysis up to 80 km from the center of the proposed project. The nearest resident is located approximately 1.4 km from the center of the proposed project in the south sector.

4.14.1.1 Potential Chemical Impacts

In general, most ISL facilities utilize chemicals during the extraction process and during restoration of groundwater quality. Bulk chemicals will be stored on-site in areas at a distance from the processing facilities that will pose no significant hazard to the public or workers' health and safety. Powertech (USA) will have strict standard operating procedures regarding receiving, storing, handling, and disposal of chemicals to ensure the safety of the public and workers. Industrial safety aspects associated with the use of chemicals will be regulated by several agencies including the EPA, SD DENR and OSHA.

Process-related chemicals stored on-site will include anyhydrous ammonia, carbon dioxide, hydrogen peroxide, oxygen, sodium carbonate and sodium chloride, barium chloride, and sulfuric acid and hydrochloric acid. Risk assessments completed by the NRC in NUREG-6733 for ISL facilities identified anhydrous ammonia and bulk acid (sulfuric and hydrochloric) storage as the most chemicals with the greatest potential for impacts to chemical safety.

Potential health and safety impacts could result from an accidental release of these chemicals. Releases of these chemicals at levels greater than the reportable quantity level under the Community Right to Know Act (40 CFR 355) will be reported to the National Response Center, EPA, SDDENR, and NRC. Specific quantities or uses of chemicals that require certain controls, procedures, or safety measures are defined by statutes:

- 29 CFR Part 1910.119 and 1910.120
- 40 CFR Part 68, 302.4, and 355

Compliance with these necessary requirements will reduce the likelihood of a release. Offsite impacts would be SMALL, while impacts to workers involved in response clean up could be MODERATE. Any such impacts will be mitigated by implementing procedures and training requirements (NUREG-1910, 2008).

Restoration activities will at times overlap with some operational activities such as operation of well fields, wastewater treatment, and disposal. The occupational health and safety impacts are expected to be less than operational impacts due to the absence of some operational activity, such as yellowcake drying operations and IX. Therefore, aquifer restoration is expected to have a SMALL impact to workers and the general public (NUREG-1910, 2008).

4.14.2 Potential Radiological Impacts

Potential radiological impacts:

- Well fields
- Processing facilities
- Unplanned release
- Land application

Using the required RESRAD and MILDOS models, the potential radiological impacts were assessed.

4.14.2.1 Exposure Pathways

The potential exposure pathways from all potential sources on-site are presented on Figure 4.14-1. Atmospheric Rn-222 is one pathway for impacts on human and environmental

media. Radon-222 has a relatively short half-life (3.2 days) and its decay products are short lived, alpha emitting, nongaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. As Figure 4.14-1 shows, all potential exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radionuclides are evaluated by MILDOS-AREA.

POWERTECH (USA) INC.

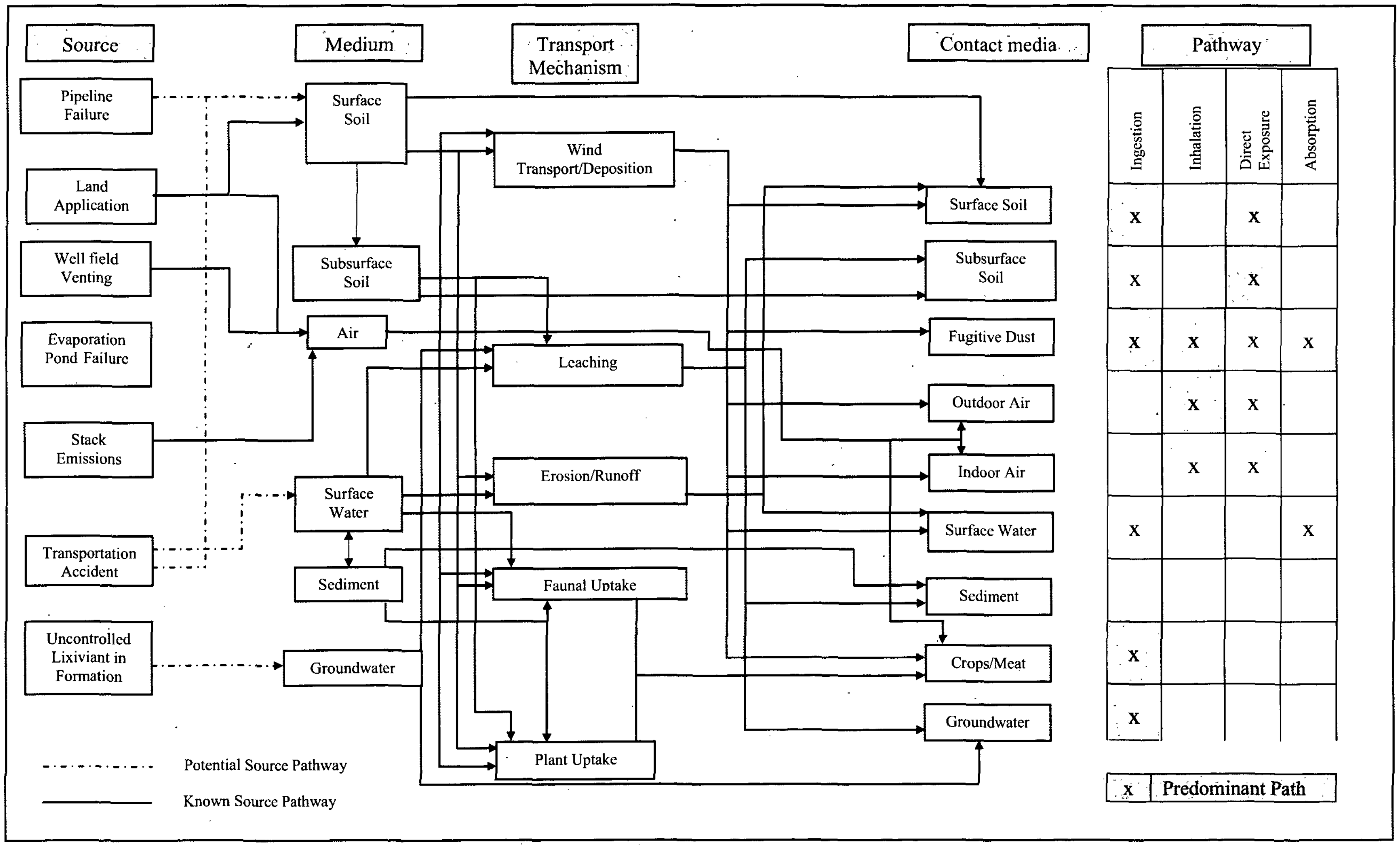

Figure 4.14-1: Human Exposure Pathways

4.14.2.2 Exposures from Water Pathways

The leach fluids in the ore zone will be controlled and monitored to ensure that there is no migration to surface waters or adjacent non-exempt USDWs.

Two methods of waste disposal at the facility are being considered: Either treatment to remove radium and subsequent injection in a Class I or V disposal well, or by the same treatment followed by land application.

The uranium IX, precipitation, drying and packaging facilities will be located on curbed concrete pads to prevent any liquids from entering the environment. Solutions used to wash down equipment drain to a sump and are either pumped back into the processing circuit or to wastewater treatment and disposal. The pads will be of sufficient size to contain the contents of the largest tank in the event of a rupture.

4.14.2.3 Exposures from Air Pathways

Sources of radionuclide emissions are Pb-210, natural uranium, Ra-226, and Th-230 released into the atmosphere from the land application areas. The land application areas could also be a source of Rn-222. Since the radium is precipitated before water is used in land application, this further reduces the potential impact to human health and the environment. The total effective dose equivalent (TEDE) to nearby residents in the region and at the facility boundaries was estimated using MILDOS-AREA. The parameters used to estimate releases are provided in Table 4.14-1.

Table 4.14-1: Parameters Used to Estimate Radionuclide Releases from the Project Site

Parameter	Value	Unit	Variable Name	Source
Rate of land application - Dewey	3.05E-03	$m\ d^{-1}$	AR_{Dewey}	Application
Rate of land application - Burdock	2.29E-03	$m\ d^{-1}$	$AR_{Burdock}$	Application
Area of land application - Dewey	1.82E+06	m^2	LA_{Dewey}	Application
Area of land application - Burdock-1	1.01E+05	m^2	$LA_{Burdock-1}$	Application
Area of land application - Burdock-2	1.82E+06	m^2	$LA_{Burdock-2}$	Application
Area of land application - Burdock-3	5.06E+05	m^2	$LA_{Burdock-3}$	Application
Time of land application in a year	136	d	t_d	Application
Years of land application	15	y	t_y	Application
Concentration of natural uranium in water	300	$pCi\ L^{-1}$	$[U\text{-}nat]_{water}$	Application (NRC effluent values)
Concentration of thorium-230 in water	100	$pCi\ L^{-1}$	$[Th\text{-}230]_{water}$	Application (NRC effluent values)
Concentration of radium-226 in water	60	$pCi\ L^{-1}$	$[Ra\text{-}226]_{water}$	Application (NRC effluent values)
Concentration of lead-210 in water	10	$pCi\ L^{-1}$	$[Pb\text{-}210]_{water}$	Application (NRC effluent values)
Density of soil - Dewey	1.28	$g\ cm^{-3}$	$\square_{Dewey}$	Application
Density of soil - Burdock	1.24	$g\ cm^{-3}$	$\square_{Burdock}$	Application
Depth of contamination	0.15	m	x	Assumption
Distribution coefficient of natural uranium in loam soil	15	$cm^3\ g^{-1}$	$K_{d,U\text{-}nat}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of thorium-230 in loam soil	3300	$cm^3\ g^{-1}$	$K_{d,Th\text{-}230}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of radium-226 in loam soil	36000	$cm^3\ g^{-1}$	$K_{d,Ra\text{-}226}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of lead-210 in loam soil	16000	$cm^3\ g^{-1}$	$K_{d,Pb\text{-}210}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Soil volume water content - Dewey	0.91	unitless	w_{Dewey}	Application
Soil volume water content - Burdock	0.80	unitless	$w_{Burdock}$	Application
Rate of resuspension of radionuclides in surface soil	4E-06	h^{-1}	ARR	DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy

4.14.2.3.1 Source Term Estimates

The source terms used to estimate natural uranium, Pb-210, Ra-226, and Th-230 releases from the land application areas are calculated. The parameters used to estimate releases are provided in Table 4.14-1. In cases where site-specific information was not available, conservative values based on published information were used.

For purposes of modeling in MILDOS-AREA, the land application areas are consolidated into clusters. All the land application areas in Dewey are grouped into one cluster called "Dewey". The land application areas in Burdock are sorted into three clusters. One cluster, "Burdock-1", consists of one land application area northwest of the main plant. Another cluster, "Burdock-2", consists of twelve land applications areas between the main plant and the Burdock-1 cluster. The last cluster, "Burdock-3", consists of three land application areas southwest of the main plant. The locations of the sources representing the clusters are the centroids of the clusters.

The land application areas in Dewey have different soil properties than the land application areas in Burdock. As a result, the source terms for releases of the radionuclides are calculated separately for clusters in Dewey and Burdock. The radionuclide release rates are calculated using Equation 7.1 (from DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy, modified by adding a factor converting h^{-1} to y^{-1}):

$$ST_{cluster,nu} = MAR_{cluster,nu} * DR * ARR * RF * LPF * 8760 \qquad \text{(Equation 7.1)}$$

Where:

ST	=	Radionuclide (nu) release rate (Ci y^{-1})
MAR	=	Amount of radionuclide in soil (Ci)
DR	=	Fraction of radionuclides available for resuspension
ARR	=	Rate of resuspension of radionuclides in surface soil (h^{-1})
RF	=	Respirable fraction of resuspended radionuclides in surface soil
LPF	=	Fraction of resuspended radionuclides passing through filtering, if any
cluster	=	Dewey, Burdock-1, Burdock-2, or Burdock-3
8760	=	Factor to convert h^{-1} to y^{-1}

In order to be conservative, all of the radionuclides in the soil of the land application clusters are assumed to be available for resuspension and there is no filtering. Therefore, both DR and LPF are assumed to be 1.

In the DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities", the listed ARR for a homogenous bed of powder exposed to ambient conditions is 4E-05 hr^{-1}. However, that value is for "freshly deposited material" and "it would be inappropriate to use" this value for "releases for long-term contamination (i.e. months to years)." The experiment from which the ARR of 4E-05 hr^{-1} was found measured a range of ARR's of 4E-05 hr^{-1} to 4E-07 hr^{-1}. For calculations in this application, the mid-range value of 4E-06 hr^{-1} was used for the ARR.

Since land application is proposed to occur on several areas spread across the site, calculations of source terms are performed separately for Dewey and Burdock.

The radionuclide soil inventories resulting from land application are calculated using Equation 7.2:

$$MAR_{cluster,\,nu} = [nu]_{soil,\,cluster} * M_{cluster} * 10^{-12} \qquad \text{(Equation 7.2)}$$

Where:

$[nu]_{soil}$	=	Concentration of radionuclide (nu) in soil (pCi g^{-1})
M	=	Mass of soil with radionuclide (g)
10^{-12}	=	Factor to convert pCi to Ci

The mass of soil contaminated in the land application at Dewey is different from the mass of soil contaminated in the land application at Burdock due to different soil densities.

The mass of soil contaminated in each land application cluster is calculated using Equation 7.3:

$$M_{cluster} = \rho_{area} * x * LA_{clsuter} * 10^{6} \qquad \text{(Equation 7.3)}$$

Where:

ρ	=	Density of soil (g cm^{-3})
area	=	Dewey or Burdock
x	=	Depth of contamination (m)
LA	=	Area used in land application (m^2)
10^6	=	Factor to convert cm^{-3} to m^{-3}

The concentrations of the various nuclides in the land application soils at Dewey and Burdock are calculated using Equation 7.4 (from "MILDOS-AREA: An Update with Incorporation of *In Situ* Leach Uranium Recovery Technology" by Faillace et al.):

$$[nu]_{soil,\,cluster} = \frac{[nu]_{water} * V_{cluster} * R_{s,area,nu} * 10^{-3}}{LA_{cluster} * x * \rho_{area}} \qquad \text{(Equation 7.4)}$$

Where:

$[nu]_{water}$	=	Concentration of radionuclide in treated water (pCi L^{-1})
V	=	Volume of treated water used in land application (m^3)
R_s	=	Fraction of radionuclide in treated water retained in soil
10^{-3}	=	Factor to convert L^{-1} to cm^{-3}

The volume of treated water used in land application is calculated using Equation 7.5:

$$V_{cluster} = AR_{area} * t_d * t_y * LA_{cluster} \qquad \text{(Equation 7.5)}$$

Where:

AR	=	Rate of land application (m d^{-1})
t_d	=	Time of land application in a year (d y^{-1})
t_y	=	Time of land application (y)

The area of land application is calculated in Equation 7.6:

The fraction of radionuclide in treated water retained in soil is calculated using Equation 7.6 (from "MILDOS-AREA: An Update with Incorporation of *In Situ* Leach Uranium Recovery Technology" by Faillace et al.):

$$R_{s,\,area,\,nu} = 1 - \frac{1}{R_{d,area,nu}} \qquad \text{(Equation 7.6)}$$

Where:

R_d	=	Retardation factor

The retardation factor is calculated using Equation 7.7 (from "MILDOS-AREA: An Update with Incorporation of *In Situ* Leach Uranium Recovery Technology" by Faillace et al.):

$$R_{d,\,area,\,nu} = 1 + \frac{\rho_{area} * K_{d,\,nu}}{w_{area}} \qquad \text{(Equation 7.7)}$$

Where:

K_d	=	Distribution coefficient (cm^3 g^{-1})
w	=	Soil volume water content

Using the parameters in Table 4.14-1 and Equations 7.1-7, the release rates are calculated for natural uranium (U-Nat), thorium-230 (Th-230), radium-226 (Ra-226), and lead (Pb-210) and shown in Table 4.14-2.

Table 4.14-2: Estimated Soil Concentrations (pCi g^{-1}) and Release Rates (Ci y^{-1}) from the Project Site

Location	X (km)	Y (km)	U-Nat		Th-230		Ra-226		Pb-210	
			Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate
Land Application - Dewey	-5.67	4.09	9.28	0.114	3.24	0.0397	1.94	0.0238	0.324	0.00397
Land Application - Burdock-1	-1.48	2.31	7.22	0.00476	2.51	0.00165	1.51	0.000992	0.251	0.000165
Land Application - Burdock-2	-0.90	1.10	7.22	0.0857	2.51	0.0298	1.51	0.0179	0.251	0.00298
Land Application - Burdock-3	-1.57	-1.50	7.22	0.0238	2.51	0.00828	1.51	0.00497	0.251	0.000828

4.14.2.3.2 Source Term Estimates – Rn-222

Sources of radon emanation are the land application areas, the well fields, the CPP, and resin transfers in the SF. The well fields consist of production well fields, restoration well fields, and new well fields. In order to be conservative, the well field in Dewey closest upwind to a receptor (Mining Unit 5) was modeled in MILDOS-AREA. Likewise, the mining unit in Burdock closest upwind to a receptor (Mining Unit 2) was modeled in MILDOS-AREA.

4.14.2.3.3 Land Application Releases

In addition to natural uranium, Ra-226, Pb-210, and Th-230; the land application areas are also sources of Rn-222. The radon source term is calculated using Equation 7.8 and the parameters listed in Table 4.14-1:

$$ST_{cluster} = J_{cluster} * A_{cluster} * 3.15 * 10^{-5} \qquad \text{(Equation 7.8)}$$

Where:

J	=	Radon flux (pCi m^2 s^{-1})
$3.15 * 10^{-5}$	=	Factor to convert pCi s^{-1} to Ci y^{-1}

The radon flux is calculated using Equation 7.9 (from RG 3.64):

$$J_{cluster} = [Ra-226]_{soil,cluster} * \rho_{area} * E_{area} * \sqrt{\lambda * D_{area}} * 10^4 * \tanh\left(x * \sqrt{\frac{\lambda}{D_{area}}}\right) \quad \text{(Equation 7.9)}$$

Where:

E	=	Radon emanation coefficient
λ	=	Radon-222 decay constant (2.1E-06 s^{-1})
D	=	Radon diffusion coefficient ($cm^2\ s^{-1}$)
10^4	=	Factor to convert cm^{-2} to m^{-2}

The radon diffusion coefficient is calculated using Equation 7.10 (from RG 3.64):

$$D_{area} = 0.07 * e^{\left[-4*\left(w_{area} - n_{area}^2 * w_{area} + w_{area}^5\right)\right]} \quad \text{(Equation 7.10)}$$

Where:

n	=	Porosity

Using the parameters listed in Table 4.14-1 and Equations 7.8-10, the release rates of Rn-222 from land application are calculated. The releases are 7.43 Ci y^{-1} for Dewey, 0.38 Ci y^{-1} for Burdock-1, 6.88 Ci y^{-1} for Burdock-2, and 1.91 Ci y^{-1} for Burdock-3.

4.14.2.3.4 Production Releases

Plans are to have up to two mine areas which potentially could be mined concurrently. The potential Rn-222 releases from the production well fields were estimated using methods described in RG 3.59 as follows:

The yearly radon released to the production fluid is calculated using Equation 7.11:

$$Y = 1.44 * G * M_{production} * D * (1 - e^{-\lambda * t}) \quad \text{(Equation 7.11)}$$

Where:

Y	=	Yearly radon released to production fluid (Ci y^{-1})
G	=	Radon released at equilibrium (Ci m^{-3})
M	=	Lixiviant flow rate (L min^{-1})
D	=	Production days per year (d)
λ	=	Radon-222 decay constant (d^{-1})
t	=	Lixiviant residence time
1.44	=	Factor to convert L min^{-1} to $m^3\ y^{-1}$

Radon released (equilibrium condition) to production fluid from leaching is calculated using Equation 7.12:

$$G = R * \rho_{form} * E * \frac{(1 - n_{form})}{n_{form}} * 10^{-6} \qquad \text{(Equation 7.12)}$$

Where:

G	=	Radon released (Ci m^{-3})
R	=	Radium content of ore (pCi g^{-1})
E	=	Radon emanation coefficient
ρ_{form}	=	Formation density (g cm^{-3})
n_{form}	=	Formation porosity

Using Equations 7.11-12 and the parameters listed in Table 4.14-1, the yearly radon released to production fluid is 2117 Ci y^{-1}. RG 3.59 assumes all the Rn-222 that is released to the production fluid is ultimately released to the atmosphere which in the case of ion exchange columns operating at atmospheric pressure in an open system is an appropriate conservative assumption. In cases where pressurized downflow ion exchange columns are used, and well fields are operated under pressure, the majority of radon released to the production fluid stays in solution and is not released. The radon which is released is from occasional well field venting for sampling events, small unavoidable leaks in well field and ion exchange equipment, and maintenance of well field and ion change equipment. For this reason, estimated annual releases of 10 percent of the Rn-222 in the production fluid would occur in the well fields and an additional 10 percent in the ion exchange circuit was assumed. Given these assumptions, the annual Rn-222 released from production in the well field and at the main plant facility is 212 and 191 Ci y^{-1}, respectively. Since the satellite facility is planned to operate at the same parameters as the main plant facility, the annual Rn-222 released from production in the well field and at the satellite facility is also 212 and 191 Ci y^{-1}, respectively. This 10 percent release rate also includes Rn-222 released from the 1-5 percent bleed from the production well field.

4.14.2.3.5 Restoration Releases

Radon-222 releases resulting from well field restoration activities were estimated in the same manner as the production activities above (i.e. using Equations 7.11-12) but modified for the lower restoration flow rate listed in Table 4.14-1. The assumption of a 10 percent release in the well field and the main plant facility results in releases of 26.5 and 23.8 Ci y^{-1}, respectively. Since the satellite facility is planned to operate at the same parameters as the main plant facility,

the annual Rn-222 released from production in the well field and at the satellite facility is also 26.5 and 23.8 Ci y^{-1}, respectively.

4.14.2.3.6 New Well Field Releases

Radon-222 releases resulting from new well field development activities were estimated using methods described in NUREG-1569, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications* (NUREG-1569) by the US Nuclear Regulatory Commission as follows:

The yearly radon released new well field development is calculated using Equation 7.13:

$$Rn_{nw} = E * L * [Ra]_{ore} * T * m * N * 10^{-12} \qquad \text{(Equation 7.13)}$$

Where:

Rn_{nw}	=	Radon-222 release rate from new well field (Ci y^{-1})
$[Ra]_{ore}$	=	Concentration of radium-226 in ore (pCi g^{-1})
L	=	Decay constant of radon-222 (0.181 d^{-1})
T	=	Storage time in mud pit (d)
m	=	Average mass of ore material in the pit (g)
N	=	Number of mud pits generated per year (y^{-1})
10^{-12}	=	Factor to convert pCi to Ci

Using Equation 7.13 and the parameters listed in Table 4.14-1, the yearly radon released from new well field development is 3.6E-05 Ci yr^{-1}.

4.14.2.3.7 Resin Transfer Releases

Radon-222 releases resulting from resin transfers at the SF are estimated using methods described in NUREG-1569 as follows:

The yearly radon released new well field development is calculated using Equation 7.14:

$$Rn_x = 3.65 * 10^{-10} * F_i * C_{Rn} \qquad \text{(Equation 7.14)}$$

Where:

Rn_x	=	Radon release rate from resin transfers (Ci y^{-1})
F_i	=	Water discharge rate from resin unloading (L d^{-1})
C_{Rn}	=	Steady state radon-222 concentration in process water (pCi L^{-1})
$3.65 * 10^{-10}$	=	Factor to convert pCi d^{-1} to Ci yr^{-1}

The steady state radon-222 concentration in process water can be estimated using Equation 7.15:

$$C_{Rn} = \frac{Y * 1.9 * 10^6}{M} \qquad \text{(Equation 7.15)}$$

Where:

C_{Rn}	=	Steady state radon-222 concentration in process water (pCi L^{-1})
Y	=	Yearly radon released to production fluid (Ci y^{-1})
M	=	Lixiviant flow rate (L min^{-1})
$1.9 * 10^6$	=	Factor to convert Ci y^{-1} to pCi min^{-1}

The water discharge rate from resin unloading (F_i) can be estimated using Equation 7.16:

$$F_i = N_{resin} * V_i * P_i \qquad \text{(Equation 7.16)}$$

Where:

F_i	=	Water discharge rate from resin unloading (L d^{-1})
N_i	=	Number of resin transfers per day (d^{-1})
V_i	=	Volume of resin in transfer (L)
n_{resin}	=	Porosity of resin

Using Equations 7.13-16 and the parameters listed in Table 4.14-1, the yearly radon released from resin transfers at the SF is 0.523 Ci y^{-1}. This assumes the ore grade mined at the SF would yield the same radon concentration in production fluid as at the CPP.

4.14.2.3.8 Radon-222 Release Summary

A summary of estimated radon-222 releases from the site is presented in Table 4.14-3. The source coordinates in Table 4.14-3 are relative to the CPP. In the unlikely occurrence of an unmitigated event, 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 (NUREG-1910, 2008).

Table 4.14-3: Estimated Releases (Ci y^{-1}) of Radon-222 from the Project Site

Location	X (km)	Y (km)	Production	Restoration	Drilling	Resin Transfer	Land Application	Total
Production Mine Unit (5)	-3.86	3.48	212	26.5	3.6E-05	0	0	238.5
Production Mine Unit (2)	1.83	-0.56	212	26.5	3.6E-05	0	0	238.5
SF	-5.00	3.54	191	23.8	0	0.523	0	215.3
CPP	0	0	191	23.8	0	0	0	214.8
Land Application - Dewey	-5.67	4.09	0	0	0	0	7.43	7.43
Land Application - Burdock-1	-1.48	2.31	0	0	0	0	0.38	0.38
Land Application - Burdock-2	-0.90	1.10	0	0	0	0	6.88	6.88
Land Application - Burdock-3	-1.57	-1.50	0	0	0	0	1.91	1.91
Total			806	100.6	3.6E-05	0.523	16.60	924

4.14.2.3.9 Receptors

The receptors used in the MILDOS-AREA simulations are presented in Table 4.14-4 and include the property boundary in 16 compass directions of the CPP and SF, 7 residences, and the town of Edgemont.

Table 4.14-4: Project Receptor Names and Locations

Location	X (km)	Y (km)	Distance (km)
Boundary - CPP - N	0.00	2.82	2.82
Boundary - CPP - NNE	1.07	2.78	2.96
Boundary - CPP - NE	1.16	1.17	1.65
Boundary - CPP - ENE	2.64	1.01	2.83
Boundary - CPP - E	2.60	0.00	2.60
Boundary - CPP - ESE	2.53	-0.97	2.71
Boundary - CPP - SE	2.13	-2.14	3.02
Boundary - CPP - SSE	0.85	-2.25	2.41
Boundary - CPP - S	0.00	-2.87	2.87
Boundary - CPP - SSW	-1.09	-2.84	3.04
Boundary - CPP - SW	-2.44	-2.43	3.44
Boundary - CPP - WSW	-2.37	-0.90	2.54
Boundary - CPP - W	-2.32	0.00	2.32
Boundary - CPP - WNW	-2.29	0.87	2.45
Boundary - CPP - NW	-2.55	2.52	2.45
Boundary - CPP - NNW	-1.42	3.70	3.96
Boundary - SF - N	-4.92	5.28	7.22
Boundary - SF - NNE	-4.23	5.25	6.74
Boundary - SF - NE	-2.70	5.64	6.25
Boundary - SF - ENE	-3.35	4.01	5.23
Boundary - SF - E	-2.97	3.43	4.54
Boundary - SF - ESE	-3.00	2.69	4.03
Boundary - SF - SE	-2.81	1.30	3.10
Boundary - SF - SSE	-3.55	-0.15	3.55
Boundary - SF - S	-4.91	-0.25	4.92
Boundary - SF - SSW	-5.70	1.38	5.86
Boundary - SF - SW	-6.28	2.06	6.61
Boundary - SF - WSW	-6.24	2.92	6.89
Boundary - SF - W	-7.02	3.43	7.81
Boundary - SF - WNW	-6.98	4.21	8.15
Boundary - SF - NW	-6.24	4.69	7.81
Boundary - SF - NNW	-5.40	4.67	7.14
Resident - Daniels Ranch	2.13	0.02	2.13
Resident - Spencer Ranch	-2.00	1.21	2.34
Resident - BC Ranch	-6.64	3.81	7.66
Resident - Puttman Ranch	-5.16	7.23	8.88
Resident - Burdock School	-2.25	-1.96	2.98
Resident - Heck Ranch	1.73	-6.38	6.61
Resident - Englebert Ranch	0.30	-4.83	4.84
Town - Edgemont	11.03	-18.59	21.62

4.14.2.3.10 Miscellaneous Parameters

The meteorological data used in the MILDOS-AREA model is from the joint frequency distribution data presented in Section 3.6 of this application.

The population distribution used in the MILDOS-AREA model to estimate population doses is from the demographic information presented in Section 2.3 of this application.

4.14.2.3.11 Total Effective Dose Equivalent to Individual Receptors

In order to show compliance with the annual dose limit found in 10 CFR part 20.1301, Powertech (USA) has demonstrated by calculation that the total TEDE to the individual most likely to receive the highest dose from the project uranium in situ leach operation is less than 100 mrem y^{-1}. Additionally, the annual effective dose equivalent (EDE) limit found in 40 CFR part 190 of 25 mrem y^{-1} was not exceeded at any receptors. The results of the MILDOS-AREA simulation for each receptor in Table 4.14-4 are presented in Table 4.14-5. The output from the MILDOS-AREA simulation for the land application option is in Appendix 4.14-A. The output for the MILDOS-AREA simulation for the deep well disposal option in Appendix 4.14-B.

An evaluation of the TEDE calculations follows:

- The maximum 40 CFR part 190 EDE of 10.8 mrem y^{-1}, located at the property boundary north-northwest of the SF, is 43.2 percent of the public dose limit of 25 mrem y^{-1}. The 40 CFR 109 TEDE public dose limit is not exceeded at any boundary receptor. If the land application sources were excluded from the MILDOS-AREA model, no doses would exceed the 40 CFR part 190 dose limit since this limit specifically excludes sources of radon-222.

- The maximum total TEDE of 12.5 mrem per year, located at the property boundary north-northwest of the SF, is 12.5 percent of the 10 CFR 20 public dose limit of 100 mrem y^{-1}. The 10 CFR 20 public dose limit is not exceeded at any property boundary. If the land application sources were excluded form the MILDOS_AREA model, the TEDE at this location would be 2.5 mrem y^{-1}.

- The maximum 40 CFR part 190 EDE at a resident is 2.32 mrem y^{-1}, located at Spencer Ranch. This is 9.28 percent of the public dose limit of 25 mrem y^{-1}. None of the resident receptors have 40 CFR part 190 EDEs exceeding the 25 mrem y^{-1} public dose limit. None of these estimated EDEs exceed the 10 CFR 20 constraint rule for airborne effluents of 10 mrem y^{-1}. If the land application sources were excluded from the MILDOS-AREA model, no doses would exceed the 40 CFR part 190 dose limit for reasons discussed above.

- The maximum TEDE at a resident is 4.48 mrem y^{-1}, located at Spencer Ranch. It is 4.48 percent of the 10 CFR 20 public dose limit of 100 mrem y^{-1}. None of the residents have TEDEs exceeding the 100 mrem y^{-1}public dose limit. If the land application sources were excluded from the MILDOS-AREA model, the TEDE at this location would be 1.72 mrem y^{-1}.

Table 4.14-5: Estimated Total Effective Dose Equivalents (TEDE) to Receptors near the Project Site

Receptor	Distance from Main Plant (km)	40 CFR part 190 TEDE (mrem y^{-1})	Total TEDE (mrem y^{-1})
Boundary - CPP - N	2.82	1.20	2.32
Boundary - CPP - NNE	2.96	0.864	1.79
Boundary - CPP - NE	1.65	1.89	3.43
Boundary - CPP - ENE	2.83	1.06	2.17
Boundary - CPP - E	2.60	1.42	3.23
Boundary - CPP - ESE	2.71	1.49	5.11
Boundary - CPP - SE	3.02	1.59	5.39
Boundary - CPP - SSE	2.41	2.09	5.36
Boundary - CPP - S	2.87	2.13	4.59
Boundary - CPP - SSW	3.04	2.33	4.17
Boundary - CPP - SW	3.44	1.29	2.86
Boundary - CPP - WSW	2.54	1.76	3.65
Boundary - CPP - W	2.32	1.98	4.16
Boundary - CPP - WNW	2.45	2.30	4.59
Boundary - CPP - NW	2.45	2.15	4.72
Boundary - CPP - NNW	3.96	1.21	2.31
Boundary - SF - N	7.22	1.37	2.62
Boundary - SF - NNE	6.74	1.06	2.24
Boundary - SF - NE	6.25	0.727	1.52
Boundary - SF - ENE	5.23	1.79	3.54
Boundary - SF - E	4.54	1.90	4.30
Boundary - SF - ESE	4.03	2.23	6.08
Boundary - SF - SE	3.10	2.25	5.22
Boundary - SF - SSE	3.55	1.51	3.96
Boundary - SF - S	4.92	1.01	2.82
Boundary - SF - SSW	5.86	1.52	3.16
Boundary - SF - SW	6.61	1.41	2.59
Boundary - SF - WSW	6.89	2.23	3.38
Boundary - SF - W	7.81	1.08	1.85
Boundary - SF - WNW	8.15	1.23	1.90
Boundary - SF - NW	7.81	3.63	4.55
Boundary - SF - NNW	7.14	10.8	12.5
Resident - Daniels Ranch	2.13	1.64	3.43
Resident - Spencer Ranch	2.34	2.32	4.48
Resident - BC Ranch	7.66	1.23	2.06
Resident - Puttman Ranch	8.88	0.596	1.25
Resident - Burdock School	2.98	1.86	3.56
Resident - Heck Ranch	6.61	0.771	2.27
Resident - Englebert Ranch	4.84	0.978	2.74
Town - Edgemont	21.61	0.200	0.572

4.14.2.3.12 Population Dose

The annual population dose commitment to the population in the region within 80 km of the project site is also predicted by the MILDOS-AREA code. The results are contained in Table 4.14-6 where TEDE is expressed in terms of person-rems. For comparison, the dose to the population within 80 km of the facility due to background radiation has been included in the table. Background radiation doses are based on a North American population of 346 million and an average TEDE of 360 mrem.

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper, Wyoming, during the year 1978. The results of these calculations are included in Table 4.14-6. These calculations are also combined with the dose to the region within 80 km (50 miles) of the facility to arrive at the total radiological effects of one year of operation at the project site.

The maximum radiological effect of the project operation would be to increase the TEDE of continental population by 7.5E-6 percent.

Table 4.14-6: Total Effective Dose Equivalent to the Population from One Year's Operation at the Project Site

Criteria	TEDE (person rem/yr)
Dose received by population within 80 km of the facility	0.879
Dose received by population beyond 80 km of the facility	8.13
Total continental dose	9.01
Background North American dose	1.2E8
Fractional increase to background dose	7.5E-8

4.14.2.4 Exposure to Flora and Fauna

MILDOS-AREA estimates surface deposition rates of Ra-226 and its decay products as a function of distance from the source and calculates surface concentrations. Table 4.14-7 presents the highest surface concentrations of Ra-226 and its decay products predicted by MILDOS-AREA over a 100-year period. Soil concentrations were calculated based on a conservative assumption of 1.5 g cm^{-3} bulk soil density.

Table 4.14-7: Highest Surface Concentrations of Radium-226 and its Decay Products

Radionuclide	Distance from site (km)	Direction	Surface concentration ($pCi\ m^{-2}$)	Soil concentration in upper 15cm ($pCi\ g^{-1}$)
Radium-226	1.5	WNW	9.94E+03	0.0442
Polonium-218	1.5	WNW	9.94E+03	0.0442
Lead-214	1.5	WNW	9.94E+03	0.0442
Bismuth-214	1.5	WNW	9.94E+03	0.0442
Lead-210	15.0	S	254	1.13E-3

The largest increase in soil concentration is 0.0442 pCi g^{-1} of radium-226, polonium-218, lead-214, and bismuth-214. Recent site specific surface soil (0-15 cm) data show that the background concentration of radium-226 ranges from 0.76 (25 percentile) to 2.2 (75 percentile) pCi g^{-1} with a geometric mean of 1.3 pCi g^{-1} and geometric standard deviation of 1.3 pCi g^{-1}. The increase in soil radioactivity is less than the geometric mean soil radioactivity prior to operations and if added to the geometric mean (1.3 pCi g^{-1}) is still within normal background variability observed at the site. Assuming the most important pathways to flora and fauna exposure start with radionuclide concentrations in soil, the impacts from normal site operations would be minimal and probably not distinguishable from background.

4.14.3 Determination of Radium Benchmark Dose

RESRAD was used to model the ISL site and calculate the maximum annual dose rate from the current radium cleanup standard.

The following supporting documentation for determination of the radium benchmark dose and the natural uranium soil standard (explained in Section 4.14.3.1) is attached in the Appendix 4.14-B (Radium Benchmark Dose Assessment, ERG, Inc., Oct., 2008):

- The RESRAD Data Input Basis (Attachment 1 of Appendix 4.14- B) provides a summary of the modeling performed with RESRAD and the values that were used for the input parameters. A sensitivity analysis was performed for parameters which are important to the major component dose pathways and for which no site specific data was available.

- Selected graphs produced with RESRAD that present the results of the sensitivity analysis performed on the input parameters are attached (Attachment 2 of Appendix 4.14-B).

- A full printout of the final RESRAD modeling results for the resident farmer scenario with the chosen input values is attached (Attachment 3.0 and 3.1 of Appendix 4.14-B). The printout provides the modeled maximum annual dose for calculated times for the 1,000-year time span and provides a breakdown of the fraction of dose due to each pathway.

- Graphs produced with RESRAD that present the modeling results for the maximum dose during the 1,000 year time span for radium-226 and natural uranium. A series of graphs depicting the summed dose for all pathways and the component pathways that contributes to the total dose are attached (Attachment 4.0 and 4.1 of Appendix 4.14-B).

The maximum dose from Ra-226 contaminated soil at the 5 pCi/g above background cleanup standard, as determined by RESRAD, for the residential farmer scenario was 38.1 mrem/year. This dose was based upon the 5 pCi/g surface (0-6-inch) Ra-226 standard and was noted at time, t = 0 years. The two major dose pathways were external exposure and plant ingestion (water independent). For these two pathways, a sensitivity analysis was performed for important parameters for which no site specific information was available. The 38.1 mrem/year dose from radium is the level at which the natural uranium radiological end point soil standard will be based as described in the following section.

4.14.3.1 Determination of Natural Uranium Soil Standard

RESRAD was used to determine the concentration of U-nat in soil distinguishable from background that would result in a maximum dose of 38.1 mrem/year. The method involved modeling the dose from a set concentration of U-nat in soil. This dose was then compared to the radium benchmark dose and scaled to arrive at the maximum allowable U-nat concentration in soil.

For ease of calculations, a preset concentration of 100 pCi/g U-nat was used for modeling the dose. The fractions used were 49.2 percent (or pCi/g) U-234, 48.6 percent (or pCi/g) U-238 and 2.2 percent (or pCi/g) U-235. The distribution coefficients that were selected for each radionuclide were RESRAD default values. All other input parameters were the same as those used in the Ra-226 benchmark modeling.

Using a U-nat concentration in soil of 100 pCi/g, RESRAD determined a maximum dose of 7.1 mrem/year, at time, t = 0 years. The printout of the RESRAD data summary is provided in Attachment 3.1 of Appendix 4.14-B and the dose figures generated with RESRAD are provided in Attachment 4.1 of Appendix 4.14-B.

To determine the uranium soil standard, the following formula was used:

$$\text{Uranium Limit} = \left(\frac{100 \text{ pCi/g U - nat}}{7.1 \text{ mrem/yr U - nat dose}} \right) \text{x } 38.1 \text{ mrem/yr radium benchmark dose}$$

$$\text{Uranium Limit} = 537 \text{ pCi/g U - nat}$$

The U-nat limit is applied to soil cleanup with the Ra-226 limit using the unity rule. To determine whether an area exceeds the cleanup standards, the standards are applied according to the following formula:

$$\left(\frac{\text{Soil Uranium Concentration}}{\text{Soil Uranium Limit}} \right) + \left(\frac{\text{Soil Radium Concentration}}{\text{Soil Radium Limit}} \right) < 1$$

This approach will be used at the ISL site to determine the radiological impact on the environment from releases of source and byproduct materials.

4.14.3.1.1 Uranium Chemical Toxicity Assessment

The chemical toxicity effects from uranium exposure are evaluated by assuming the same exposure scenario as that used for the radiation dose assessment. In the benchmark dose assessment for the resident farmer scenario, it was assumed that the diet consisted of 25 percent of the meat, fruits, and vegetables grown at the site. No intake of contaminated food through the aquatic or milk pathways was considered probable. Also, the model showed that the contamination would not affect the groundwater quality. Therefore, the same model will be used in assessing the chemical toxicity. The intake from eating meat was shown to be negligible compared to the plant pathway and therefore is not shown here. This is confirmed by the results of the RESRAD calculations shown in Attachment 3.1 of Appendix 4.14-B and the figures generated with RESRAD shown in Attachment 4.1 of Appendix 4.14-B.

The method and parameters for estimating the human intake of uranium from ingestion are taken from NUREG/CR-5512 Vol. 1 (NRC, 1992). The uptake of uranium in food is a product of the uranium concentration in soil and the soil-to-plant conversion factor. The annual intake in humans is then calculated by multiplying the annual consumption by the uranium concentration in the food. Since the soil-plant conversion factor is based on a dry weight, the annual consumption must be adjusted to a dry-weight basis by multiplying by the dry-weight to wet-weight ratio. Parameters for these calculations are given in Section 6.5.9 of the

NUREG/CR-5512 Vol. 1 (NRC, 1992). Table 4.14-18 provides the parameters used in these calculation and results for leafy vegetables, other vegetables, and fruit. Annual intakes of 14 kg/year and 97 kg/year were assumed for leafy vegetables and other vegetables and fruit, respectively. Consistent with Attachment 3.1 of Appendix 4.14-B dose calculations, it was assumed that 25 percent of the food was grown on the site. It was also assumed that the uranium concentration in the garden or orchard was 537 pCi/g. This corresponds to the uranium Benchmark Concentration for surface soils. Using a conversion factor for U-nat of 1 mg = 677 pCi, then 537 pCi/g is equivalent to 793 mg/kg. The human intake shown in the first column of Table 5.1-1 is equal to the product of the parameters given in the subsequent columns. Table 4.14-8 shows that the total annual uranium intake from all food sources from the site is 52.4 mg/year.

The two-compartment model of uranium toxicity in the kidney from oral ingestion was used (ICRP, 1995) to predict the burden of uranium in the kidney following chronic uranium ingestion. This model allows for the distribution of the two forms of uranium in the blood, and consists of a kidney with two compartments, as well as several other compartments for uranium distribution, storage and elimination including the skeleton, liver, red blood cells (macrophages) and other soft tissues.

Table 4.14-8: Annual Intake of Uranium from Ingestion

Food Source	Human Intake (mg/yr)	Soil Concentration (mg/kg)	Soil to Plant Ratio (mg/kg plant to mg/kg soil)	Annual Consumption (kg)	Dry Weight Wet Weight Ratio
Leafy Vegetables	9.4	793	1.7E-2	3.5	0.2
Other Vegetables	36.1	793	1.4E-2	13	0.25
Fruit	6.9	793	4.0E-3	12	0.18
Total	52.4				

The total burden to the kidney is the sum of the two compartments. The mathematical representation for the kidney burden of uranium at steady state can be derived as follows (ICRP, 1995):

$$Q_P = \frac{IR \times f_1}{\lambda_P \left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pk} - f_{pk1}\right)}$$

Where:

Q_P = uranium burden in the plasma, μg

IR = dietary consumption rate, mg U/d

f_1 = fractional transfer of uranium from GI tract to blood, unitless

f_{ps} = fractional transfer of uranium from plasma to skeleton, unitless

f_{pr} = fractional transfer of uranium from plasma to red blood cells, unitless

f_{pl} = fractional transfer of uranium from plasma to liver, unitless

f_{pt} = fractional transfer of uranium from plasma to soft tissue, unitless

f_{pk1} = fractional transfer of uranium from plasma to kidney, compartment 1, unitless

λ_p = biological retention constant in the plasma, d^{-1}

The burden in kidney compartment 1 is:

$$Q_{k1} = \lambda_P \times Q_P \times \frac{f_{pk1}}{\lambda_{k1}}$$

Where:

Q_{k1} = uranium burden in kidney compartment 1, mg

λ_{k1} = biological retention constant of uranium in kidney compartment 1, d^{-1}

Similarly, for compartment 2 in the kidney, the burden is:

$$Q_{k2} = \lambda_P \times Q_P \times \frac{f_{pk2}}{\lambda_{k2}}$$

Where:

Q_{k2} = uranium burden in kidney compartment 2, μg;

λ_{k2} = biological retention constant of uranium in kidney compartment 2, d^{-1};

f_{pk2} = fractional transfer of uranium from plasma to kidney compartment 2, unitless.

The total burden to the kidney is then the sum of the two compartments is:

$$Q_{k1} + Q_{k2} = \frac{IR \times f_1}{\left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pt} - f_{pk1}\right)} \times \left(\frac{f_{pk1}}{\lambda_{k1}} + \frac{f_{pk2}}{\lambda_{k2}}\right)$$

The parameter input values for the two-compartment kidney model include the daily intake of uranium estimated for residents at this site, and the ICRP69 values recommended by the ICRP as listed below (ICRP, 1995). The daily uranium intake rate was estimated to be 0.14 mg/day (52.4 mg/year) from ingestion while residing at this site.

IR = 0.14 mg/day
f_1 = 0.02
f_{ps} = 0.105
f_{pr} = 0.007
f_{pl} = 0.0105
f_{pt} = 0.347
f_{pk1} = 0.00035
f_{pk2} = 0.084
λ_{k1} = ln(2)/(5 years*365 days/year)
λ_{k2} = ln(2)/7 days
where ln(2) = 0.693…

Given a daily uranium intake of 0.14 mg/day at this site and the above equation, the calculated uranium in the kidneys is 0.0093 mg U, or a concentration of 0.032 µg U/g kidney. This is 3.2 percent of the 1.0 µg U/g value that has generally been understood to protect the kidney from the toxic effects of uranium. Some researchers have suggested that mild effects may be observable at levels as low as 0.1 µg U/g of kidney tissue. Using 0.1 µg U/g as a criterion, then the intake is 32 percent of the level where mild effects may be observable.

The EPA evaluated the chemical toxicity data and found that mild proteinuria has been observed at drinking water levels between 20 and 100 µg/L. Assuming water intake of 2 L/day, this corresponds to an intake of 0.04 to 0.2 mg/day. Using animal data and a conservative factor of 100, the EPA arrived at a 30 µg/L limit for use as a National Primary Drinking Water Standard (Federal Register/Vol.65, No.236/ December 7, 2000). This is equivalent to an intake of 0.06 mg/day for the average individual. Naturally, since large diverse populations are potentially

exposed to drinking water sources regulated using these standards, the EPA is very conservative in developing limits.

This analysis indicates that a soil limit of 537 pCi/g of U-nat would result in an intake of approximately 0.14 mg/day. Using the most conservative daily limit corresponding to the National Primary Drinking Water standard, a soil limit of 230 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day. Therefore exposure to soils containing 230 pCi/g of natural uranium should not result in chemical toxicity effects. Since the roots of a fruit tree would penetrate to a considerable depth, limiting subsurface uranium concentrations to 230 pCi/g will be considered.

The ALARA principle requires an evaluation of, considering a cost benefit analysis and socio-economic impacts, the practicality of lowering established or derived soil cleanup levels. For gamma-emitting radionuclides, the cost and impacts becomes excessively high as soil concentrations, thus the gamma emission rates, become indistinguishable from background.

Cleanup of uranium mill sites has demonstrated that conservatively derived gamma action levels coupled with appropriate field survey and sampling procedures result in radium-226 soil concentrations near background levels. The presents of radium-226 and natural uranium in a mixture will tend to drive the cleanup to lower radium-226 concentrations. The ALARA principle is met by choosing conservatively derived gamma actions levels, thus no ALARA goals for radium-226 need to be established.

Powertech (USA) Uranium USA proposes an ALARA goal of limiting the natural uranium concentration in the top 15 cm soil layer to 150 pCi/g averaged over the impacted areas. Subsurface soil (greater than 15 cm) natural uranium concentrations should be limited to 230 pCi/g averaged over the impacted area based on chemical toxicity.

4.14.3.2 Potential Radiological Accidents

The following section discusses potential impacts from radiological accidents. Section 5.12 discusses the mitigation measures that will be taken to reduce or eliminate these potential impacts.

4.14.3.2.1 Potential Tank Failure

The tanks at the PAA will contain injection and production solutions, ion exchange resin, pregnant eluant, yellowcake, and liquid waste. All tanks will be constructed with the proper

material (e.g., fiberglass, steel or aluminum) to adequately contain to the stored material. Instantaneous tank failure is unlikely, but a small leak in the tank would be more probable. In the event of a leak, the tank would be repaired or replaced as necessary.

An NRC sponsored study contained in NUREG/CR-6733 evaluated the potential impacts from the failure of a yellowcake thickener, which resulted in the release of 20% of the thickener volume escaped outside the processing building, based on an event at the Irigaray ISL facility in 1994. NUREG/CR-6733 calculated that the public dose would be below the limits in 10 CFR Part 20 and the dose to an unprotected worker would exceed the 5 rem exposure limits from 10 CFR Part 20. This calculation contains several conservative assumptions, such as the yellowcake would become dry and transportable because no effort would be made to clean up the spill, and that the dose calculation negates the use of protective equipment, and finally, the dose was based on lung clearance class Y uranium, which produces the highest dose estimates.

This study also calculated the potential dose from a catastrophic release of the entire contents from an ion exchange column and the subsequent release of radon gas. The calculated dose for a 30-minute period to a worker in the area would be 1.3 rem. NUREG/CR-6733 recommends that the use of ventilation or atmosphere-supplying respirators designed to protect against gases should be sufficient to mitigate such doses, that unprotected personnel should evacuate the spill areas near areas that have pregnant lixiviant feeds, such as the ion-exchange columns and report any spills immediately, and that ISL facilities maintain proper equipment, training, and procedures to respond to large lixiviant spills or IX column failure.

4.14.3.2.2 Potential Plant Pipe Failure

In the event of the rupture of a plant pipe, operating staff would easily detect rupture and would quickly contain and manage the spilled solution following the same procedures outlined for a tank failure.

4.14.3.2.3 Potential Well Field Spill

The failure of a process pipeline within the well field could result in the discharge of pregnant or barren lixiviant to the surface. In order to minimize the amount of process fluid that is lost should a failure occur, high and low pressure alarms and shutoffs as well as flowmeters will be installed on pipelines between the well field and the central processing plant. Should a failure occur and the amount and/or concentration of the process fluid lost constitute an environmental concern, then the affected area would have the contaminated soil surveyed and removed for

disposal. Pipeline failure is minimized by burying the pipeline two to five feet below ground surface and inspecting and testing the piping prior to burial. Pressure test results for the piping will be documented. Corrosion free high density polyethylene (HDPE) or similar piping will be used to further reduce the chance of pipeline failure.

Small leaks at pipe joints and fittings in the header houses or at wellheads may occur occasionally. These leaks may drip process solutions onto the underlying soil until they are identified and repaired. Powertech (USA) will implement a program of continuous well field monitoring by roving well field operators including periodic inspections of each well, in order to identify and remedy small leaks. Small leaks rarely result in contamination of the underlying soil. Following repair, Powertech (USA) will survey the affected soil for contamination, and, if contamination is detected, the soil will be appropriately removed.

4.15 Waste Management

4.15.1 Gaseous and Airborne Particulates

The main radioactive airborne effluent of concern at an ISL facility is radon-222 gas. Radon-222 is found in the pregnant lixiviant which is transported into the facility from the well field for uranium separation. Ion exchange (IX) units will be used to separate the uranium from the groundwater by passing the solution through IX units operated in a pressurized downflow mode. Small amounts of radon-222 may potentially be released during solution spills, filter changes, IX resin transfer, reverse osmosis (RO) system operation during groundwater restoration, and various maintenance activities. These potential minimal radon gas releases generally occur on an infrequent basis. An exhaust system installed to ventilate radon-222 gas to the atmosphere from the CPP will reduce employee exposure. The air in the CPP and other facilities will be sampled for radon daughters to assure that radon and radon daughters are maintained at concentration levels as low as reasonably achievable (ALARA).

4.15.2 Liquid Waste

Sources of liquid waste are collected as a result of in situ leach production. The following sections represent potential liquid waste sources at the project.

4.15.2.1 Liquid Process Waste

The primary source of liquid waste is the operation of the ion exchange process which generates production bleed. This bleed will be treated with ion exchange to remove uranium, arsenic and

vanadium, with ferric hydroxide coagulants to remove arsenic if necessary and finally with barium chloride to remove radium before being either injected in a deep disposal well or used to irrigate alfalfa within the PAA using center-pivot sprinklers. Other sources of liquid waste from the central plant include plant wash down water and the waste streams from the elution and precipitation circuits; however, these liquid waste streams make up a much smaller portion of the total liquid waste stream at the project facility.

4.15.2.2 Water Collected from Well Field Releases

Injection lixiviant or leach fluids recovered from areas where a liquid release has occurred from a pipeline or well will be placed into the wastewater system for treatment and disposal.

4.15.2.3 Disturbed Area Runoff

Runoff from disturbed areas will be prevented from entering local waterways. The permitting process through DENR and Powertech (USA)'s Storm Water Management Plan (SWMP) provides confidence that potential environmental impacts will be limited. Facility drainage will be designed to contain disturbed area runoff. The design of the project facilities, combined with engineering and procedural controls contained in a Best Management Practices (BMP) Plan, will ensure that the disturbed area runoff is not a potential source of pollution.

4.15.2.4 Liquid Waste Disposal

4.15.2.4.1 Deep Well Disposal

The use of deep well injection alone or in combination with land application is also being considered by Powertech (USA) to dispose of liquid waste. Figure 4.15-1 provides the facilities map depicting the deep well disposal option. There are suitable zones for deep well injection to the west of the Dewey-Burdock site in the Powder River Basin of Wyoming and to the south in northwestern Nebraska. The permitting of the wells will meet the criteria and standards promulgated by the Environmental Protection Agency under the regulatory provisions of 40 CFR Part 146, Underground Injection Control Program.

The physical and chemical properties of the wastes will be similar to the estimated quality of wastes provided in Table 4.15-1 for land application. The process waters for deep well injection will meet the regulatory provisions in 10 CFR 20.2002 and be within the dose limits in 10 CFR 20.1301.

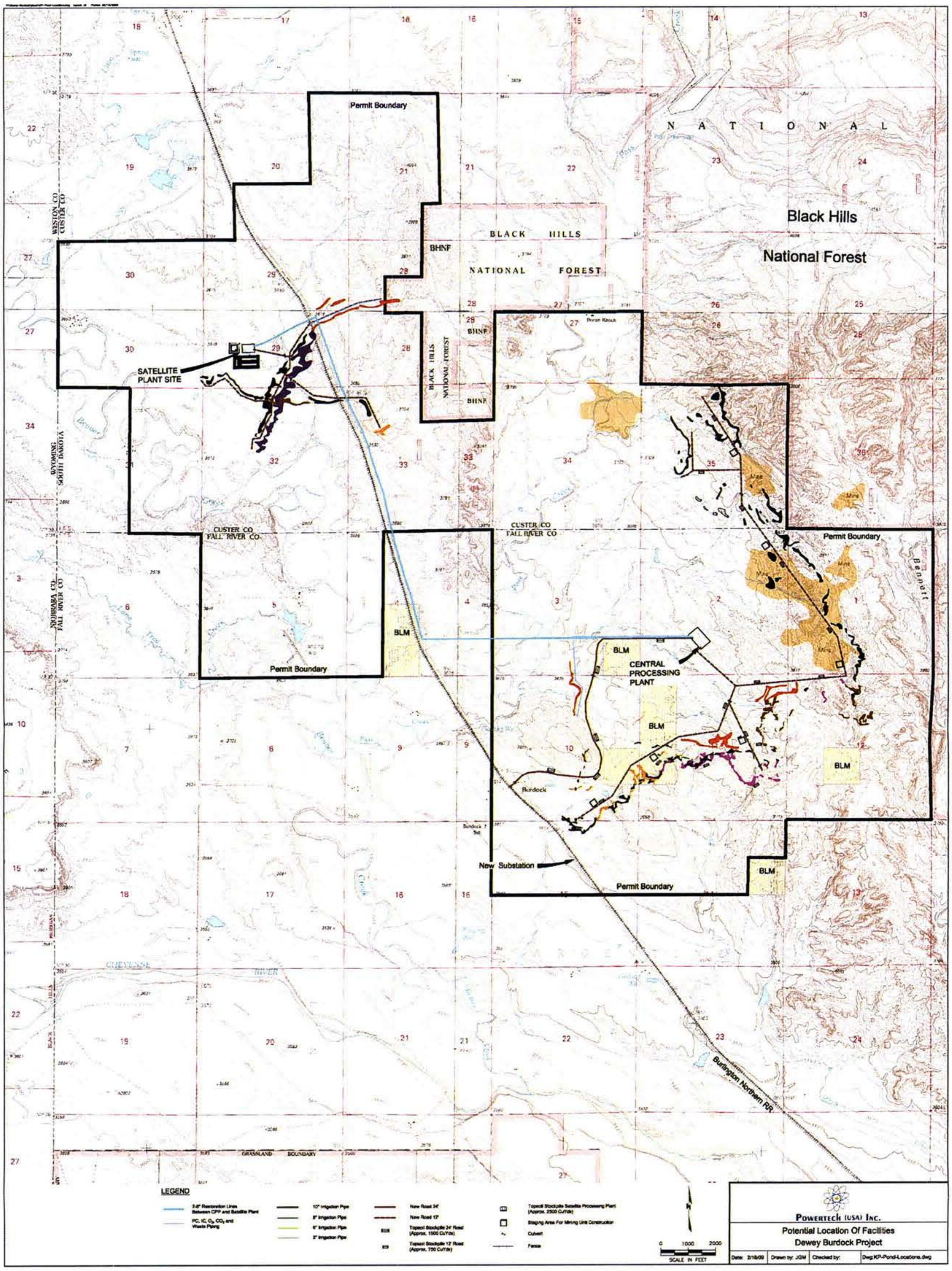

Figure 4.15-1: Facilities Map with Deep Well Disposal

4.15.2.4.2 Land Application

In the land application option of wastewater disposal, bleed water from the process circuit will be extracted and treated using ion-exchange columns to remove uranium and other metals. This water will be discharged to lined settling ponds, where radium will be precipitated with barium sulfate. Water from these ponds will then be pumped to center pivot sprinklers and used to irrigate alfalfa during the growing season (May 11 to September 24). Water from the ponds will be sampled before it is pumped to the sprinklers to ensure that it meets the applicable discharge standards for all constituents.

The design of the land application system was developed based on modeling using the SPAW model, which is described in the following sections. Two land application areas, one at the Dewey site and one at the Burdock site will be used. The land application areas and the settling ponds for the Dewey and Burdock sites are shown on Figure 4.15-2. The total irrigated area at any given time at the Dewey site will be 375 acres, consisting of six 50-acre pivots plus three 25-acre pivots. In addition, there will be one 50-acre pivot and one 25-acre pivot on standby (total pivots at Dewey is seven 50-acre pivots and four 25-acre pivots). Pumping at Dewey will occur for 24 hours every day during the growing season (May 11 to Sept 24). Pumping rates at Dewey will be 113 gpm on each 50-acre pivot and 57 gpm on each 25-acre pivot. This equals a total of 849 gpm pumped for 24 hours on every day of the growing season at Dewey.

The total irrigated area at any given time at the Burdock site will be 500 acres (eight 50-acre pivots plus four 25-acre pivots). In addition, there will be four 25-acre pivots on standby (or any combination of pivots equal to 100 acres capacity). The total pivots at Burdock will be eight 50-acre pivots and eight 25-acre pivots. Pumping at Burdock will also occur for 24 hours on every day of the growing season (May 11 to Sept 24). Pumping rates at Burdock will be 85 gpm on each 50-acre pivot and 42.5 gpm on each 25-acre pivot. This equals a total of 849 gpm pumped for 24 hours on every day of the growing season.

Four lined impoundments (ponds) with leak detection will be constructed at the Dewey site for settling of radium and temporary storage of the irrigation water. Each pond will be 560 feet x 560 x 33 feet deep including 3 feet of freeboard, with a total capacity of 157 acre-feet. Three of the ponds will be operational at any given time and one will be a backup pond.

Six lined ponds with leak detection will be constructed at the Burdock site for settling of radium and temporary storage of the irrigation water. Each pond will be 560 feet x 560 feet x 33 feet deep including 3 feet of freeboard, with a total capacity of 157 acre-feet. Five of the ponds will

be operational at any given time and one will be a backup pond. In addition there will be a central plant pond at the Burdock site for storing process water prior to treatment and/or disposal. The central plant pond will be 380 feet x 380 feet x 33 feet including 3 feet of freeboard, with a total capacity of 63 acre-feet

The following Table 4.15-1 provides the estimated water quality to be applied to crops at both the Dewey and Burdock land application sites. It is anticipated that trace metal concentrations will be at or below EPA Primary Drinking Water Standards. In addition, the effluent concentration limits for the release of radionuclides to the environment as contained in 10 CFR Part 20, Appendix B will be met.

4.15.2.4.2.1 SPAW Model Description

The SPAW (Soil-Plant-Atmosphere-Water) Model was developed by the U.S. Department of Agriculture (Saxton and Willey, 2006) to simulate the daily hydrologic water budgets of agricultural landscapes by two connected routines, one for farm fields and one for impoundments such as irrigation ponds. The field hydrology simulation is represented by: 1) daily climatic descriptions of precipitation, temperature, and evaporation; 2) a soil profile of interacting layers each with unique water holding characteristics; and 3) annual crop growth with management options for rotations, irrigation, and fertilization. The model output for the field hydrology routine includes a daily vertical, one-dimensional water budget depth for all major hydrologic processes such as runoff, infiltration, evapotranspiration, soil water profiles, and percolation. Water volumes for each component of the water balance are estimated by multiplying the water budget depth times the associated field area.

Table 4.15-1 Estimated Land Application Water Quality

Analyte	Units	Dewey Land Application Estimate	Burdock Land Application Estimate
pH	s.u.	6.5 - 7.5	6.5 - 7.5
Eh	mV	350	350
cond.	mS/cm	3	4
Major Ions			
Bicarbonate	mg/L	<50	<50
Calcium	mg/L	270	330
Carbonate	mg/L	<1	<1
Chloride	mg/L	300 - 1300	300 - 1300
Sodium	mg/L	270	190
Sulfate	mg/L	1000	1800
Solids	mg/L	4000 - 5000	4000 - 5000
Minor Ions			
Arsenic	mg/L	0.01	0.01
Barium	mg/L	0.42	0.42
Cadmium	mg/L	0.34	0.34
Chromium	mg/L	0.38	0.38
Copper	mg/L	0.28	0.28
Iron	mg/L	1.1	0.2
Lead - 210	mg/L	<10	<10
Magnesium	mg/L	120	220
Molybdenum	mg/L	<0.1	<0.1
Nickel	mg/L	340.34	340.34
Potassium	mg/L	20	10
Radium - 226	pCi/L	<60	<60
Selenium	mg/L	<0.2	<0.2
Thorium 230	pCi/L	<100	<100
U - Nat	pCi/L	<300	<300
Uranium	mg/L	<0.2	<0.2
Vanadium	mg/L	<10	<10
Sodium Absorption Ratio		4.9	2.8
Cations	meq/L	36	43
Anions	meq/L	30	47
Zinc	mg/L	-	-
A/C balance	%	8	-4
TDS Calc.	mg/L	2043	2908

Notes:
1) Estimates of land application water quality were based on the results of laboratory scale leach tests conducted on ore samples from the Dewey (Fall River) and Burdock (Lakota) sites, as well as from historical end - of - mining water quality data from other ISL sites in Wyoming and Nebraska, with adjustments as necessary to account for planned post - mining water treatments.
2) For the anion computation, a chloride concentration of 300 mg/L was used.
3) For the calculated TDS computation, a chloride concentration of 800 mg/L was used.

Pond hydrology simulations provide water budgets by multiple input and depletion processes for impoundments whose water source is runoff from agricultural fields and/or water produced by wells or other sources. Model outputs for the pond hydrology routine include daily values of depth, volume, precipitation, evaporation, and change in storage for the period of simulation. The version of the SPAW model used was Version 6.02.75. The model has been extensively tested by the developers using research data and real-world applications.

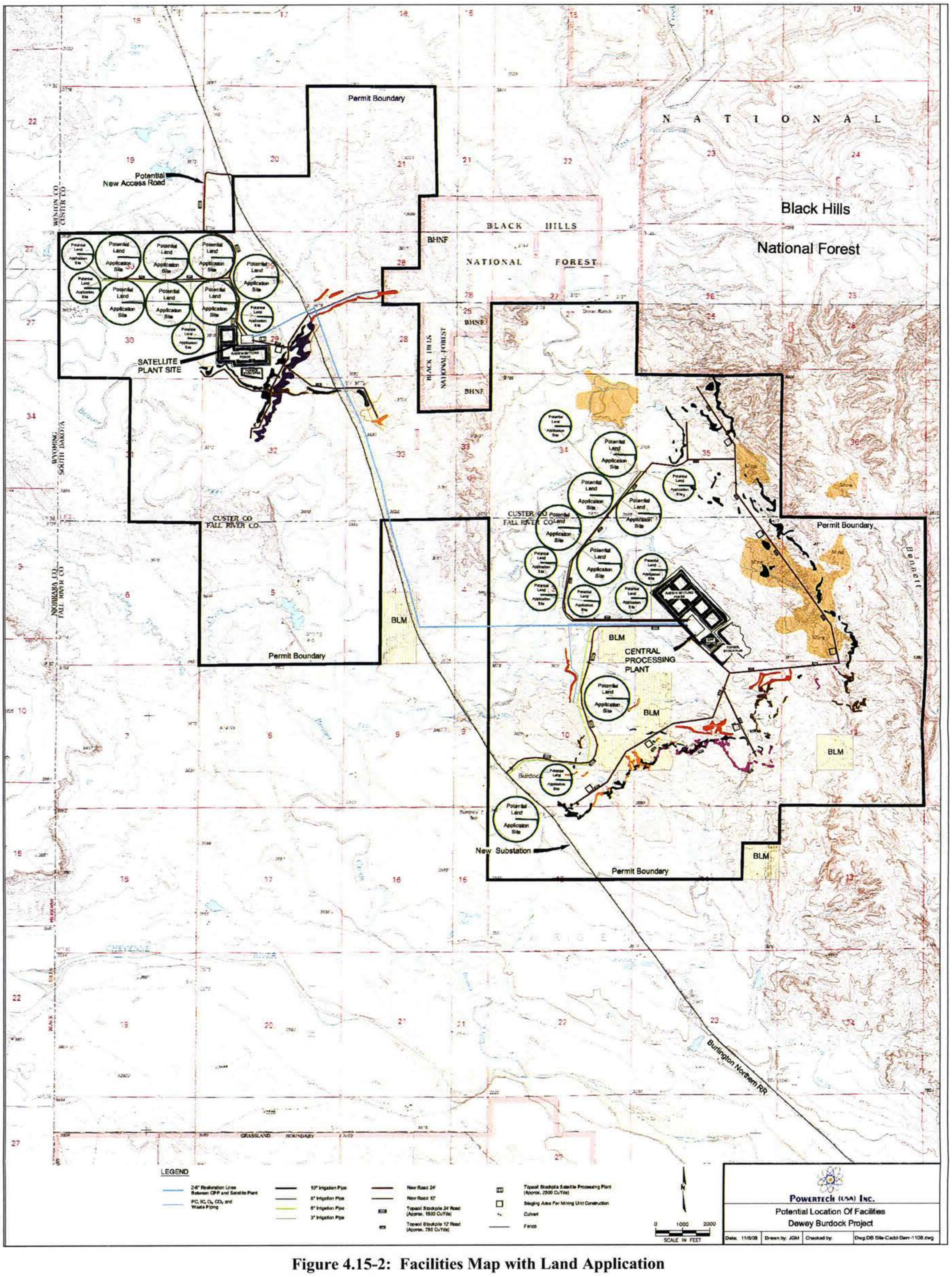

Figure 4.15-2: Facilities Map with Land Application

4.15.2.4.3 Domestic Liquid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the DENR. These systems are commonly used throughout the United States and the effect of the system on the environment is known to be minimal.

4.15.3 Solid Waste

4.15.3.1 Radioactive Solid Wastes

Solid radioactive waste generated at the site is expected to include impounded 11e.(2) byproduct material extracted directly from the ISL process (reverse osmosis units, spent resins, etc) as well as material contaminated with radionuclide byproducts (miscellaneous pipe, pumps, fittings and similar items contaminated with low levels of radioactive "scale" and precipitates). The radiological contaminant will be primarily residual natural uranium and radium 226 (NMA 2007, Brown 2007, 2008). As radium will follow the process calcium chemistry, process pH and related chemical parameters will play a role in determining where and how much residual byproduct material becomes deposited in process components. Mobilization of other radionuclides, in situ (Th 230, Pb 210), has been indicated to be minimal (Brown 1982).

4.15.3.2 Impounded Byproduct Material

Small volumes of solid radioactive wastes are typically generated at ISL facilities and need to be temporarily impounded at designated on-site locations pending further evaluation and/or shipment offsite. Temporary impoundment on-site typically involves designated ponds and/or tankage. Alternatively, the material may be drummed as produced.

These wastes result primarily from spent resins and process sludges, including pond sludges, reject streams/brine from reverse osmosis (RO) units, solid slurry precipitates from brine concentrators, spent sand and/or Cuno filters, filter back flush from similar process stream "polishing" activities and potentially small amounts of contaminated soil from leaks and/or spills, as well as contaminated equipment and supplies, such as personal protective equipment.

Byproduct material requiring offsite disposal in accordance with NRC requirements and/or license conditions will be transported off site to an NRC or Agreement State licensed 11e.(2) disposal facility. Powertech (USA) estimates that the proposed project will produce approximately 100 yd^3 of 11e.(2) byproduct material per year. These materials will be stored on-

site, properly labeled and posted inside the restricted area until such time that a full shipment can be transferred to a licensed 11e.(2) waste disposal facility in accordance with the requirements of the NRC. Powertech (USA) will have a contract with an approved disposal facility for disposal of 11e.(2) material in place prior to beginning licensed production operations.

4.15.3.3 Contaminated Materials

This category of solid radioactive waste includes process and other ancillary equipment and materials that have become contaminated with low levels of byproduct materials as a result of use and/or contact with process streams. Equipment and materials generated by this proposed project that may become contaminated with byproduct materials include items such as rags, trash, worn or replaced parts from equipment, piping, fittings, pumps, filters, and protective clothing. In some cases, reusable items with economic value may be decontaminated prior to release from the restricted area. If decontamination of equipment is deemed desirable and practical, this will be performed using strict decontamination and according to radiation release criteria. Decontaminated materials must have activity levels lower than those specified in Table 2 of NRC Regulatory Guide 8.30 (NRC, 2002).

4.15.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). On the basis of the processes and materials to be used on the project, it is likely that this project will be classified as a Conditionally Exempt Small Quantity Generator (CESQG), defined as a generator that generates less than 100 kilograms (kg) of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. Powertech (USA) expects that only used waste oil and universal hazardous wastes such as cleaning solvents and spent batteries will be generated at the project.

4.16 Potential Cumulative Impacts of Proposed Action

4.16.1 Potential Cumulative Impacts of Other Uranium Development Projects

The National Environmental Policy Act (NEPA) defines cumulative effects as "...impacts [that] can result from individually minor but collectively significant actions taking place over a period of time." The PAA is within the Nebraska – South Dakota – Wyoming Uranium Milling Region, which has a history of conventional uranium surface mining. According to the NUREG-1910,

there were no identified coal mines within this uranium milling region that might affect the cumulative impacts of the project or other uranium developments.

Within the Edgemont Uranium District, uranium was first discovered in 1951 and subsequently mined for a number of years using conventional surface mining methods. There are no Source Material Licenses for ISL uranium projects within fifty miles of the PAA. The nearest operational ISL facility is the Crow Butte ISL facility, SUA-1534, in Darrow County, near Crawford, Nebraska (U.S. NRC, 2008). Considering the distance between the existing projects and the proposed project and the almost half a century since the previous uranium development in the area, cumulative environmental impacts are considered to be small to negligible.

Powertech (USA) Inc. is currently investigating several prospective uranium ISL projects along with other companies within the Nebraska – South Dakota – Wyoming Uranium Milling Region. These projects are in various stages of development. At the time of this application Powertech (USA) is not aware of other licensing or permitting applications within the study area.

5.0 Mitigation Measures

Mitigation measures are those actions that can be taken to reduce potential adverse impacts and that will be incorporated into the Proposed Action and alternatives (40 CFR §§ Parts 1502.14(f) and 1508.20). The mitigation measures discussed in this Section are tangible and specific and cover the range of potential impacts of the Proposed Action. All relevant, reasonable mitigation measures that, to the extent practicable, can improve the Proposed Action are identified, even if they are outside NRC's jurisdiction. The anticipated effectiveness of the proposed mitigation measures in reducing potential adverse impacts, the technical feasibility, and the costs versus benefits of any recommended mitigation measures are discussed.

The following subsections provide greater detail on proposed mitigation measures that could be used to reduce potential adverse impacts presented in Section 4.0, including the following potential impacts of the Proposed Action: land use, transportation, geologic and soil, surface water, groundwater (hydrology), ecology, air quality, noise, historic and cultural resources, visual/scenic resources, socioeconomic resources, environmental justice, radioactive and non-radioactive risk and waste management.

As a general proposition and as will be shown below, active mitigation measures for ISL operations originate from two sources: (1) the nature of the ISL process and (2) NRC/Agreement State license conditions, which essentially are a series of protective or "mitigation" measures. Taken together, these measures will result in the licensed PAA exhibiting minimal, if any, evidence that site land and water (both surface and underground) resources will be impacted by licensed ISL operations.

5.1 Proposed Mitigation Measures for Potential Land Use Impacts from the Proposed Action

5.1.1 Surface Disturbance During Construction and Operation

As stated in Section 4.3.1, the average estimated land disturbed per year for the life of the operation is a maximum of 108 acres. The following proposed procedures will be used to minimize the impacts of surface disturbance during construction and operation discussed in Section 4.3:

- Disturbance will be limited to only what is necessary for operations.

- Development of Quality Assurance Quality Control (QA/QC) plan to monitor the effectiveness of mitigation methods.
- Restrict normal vehicular traffic to designated roads and keep required traffic in other areas of the wellfield to a minimum.
- Use Class I or V deep disposal wells for disposal of liquid wastes to mitigate potential land use impacts.
- Conduct site ISL reclamation in interim steps to minimize potential land use environmental impacts. As noted above, sequential wellfield development results in minimizing land area impacted at any one time.
- Stockpile topsoil from the well sites, evaporation ponds, and facilities. Shape, seed the piles with a cover crop or mulch the stockpiles to control erosion.
- Evaporation or water treatment ponds, if used, will be reclaimed and re-vegetated and the land returned to its previous uses, or as otherwise agreed with the regulatory body and landowners.
- After groundwater restoration is completed, properly decommission each wellfield and remove or decontaminate in place all wellfield lines and pipelines. Upon decommissioning, all wells will be sealed and capped. As areas are restored, they will be backfilled, contoured, and smoothed to blend with the natural terrain in accordance with the surface reclamation plan.
- All process facilities will be decontaminated and removed unless they are to be used for other future activities; the Permit Area will regain its pre-operational features.

Upon completion of final site D&D, including surface reclamation, landowners will be contacted and given the option to retain the roads for their private use or have the roads reclaimed by Powertech (USA). If the roads are deemed beneficial to others (i.e., hunters, ranchers and residents) and the landowner agrees, the roads will not be reclaimed. Only roads related to the Proposed Action will be reclaimed.

5.2 Porposed Mitigation Measures for Potential Transportation Impacts from the Proposed Action

5.2.1 Mitigation of Access Road Construction Risk

The primary potential impacts associated with access road construction are relatively minor and consist mainly of air quality impacts from equipment exhaust and dust. The following proposed procedures will be used to minimize the impacts from transportation discussed in Section 4.4:

- Maintain access roads to minimize or eliminate truck accidents.
- Implement control of fugitive dust using water application and speed limits.
- Reduce maximum fugitive dust by coordinating construction and transportation activities.
- Maintain vehicles to meet applicable EPA emission standards.

5.2.2 Mitigation of Potential Impacts from Material Shipments of Supplies Sent and Received via the Process Facilities

The following proposed procedures will be used to minimize the impacts of the shipment activities discussed in Section 4.4.3:

- Compliance with all applicable NRC and DOT packaging and transport requirements.
- Use of SOPs for transportation and emergency response.
- Use dedicated tanker trucks for transporting loaded or barren/eluted (stripped) resins to and/or from CPP or SF facilities.
- Proper training will be required for relevant transport contractor personnel on how to respond to a transportation accident based on the specific material(s) shipped. Written procedures (SOPs) will accompany all drivers to ensure proper response to accidents and spill containment.
- Prior to each shipment of loaded or barren/eluted (stripped) resin or yellowcake the exterior and cab of the shipping truck will be surveyed for radiological contamination.
- Emergency response kits will be supplied to both the receiving and shipping facilities.
- Each resin or yellowcake transport vehicle will carry an emergency spill kit to help contain any spilled material.
- Shipping records (bill of landing) will be maintained to identify and quantity of material shipped.
- Both the transport vehicle and shipping facilities will be equipped with communication devices to enable direct communication with relevant Powertech (USA) personnel.
- For radiological accidents, notification will be provided to NRC in compliance with the requirements of 10 CFR €€ 20.2202 & 20.2203.
- Communication with local and State authorities on transportation and emergency response procedures.

When IX resins are fully loaded at the Dewey SF, such resins will be pumped (transferred) into dedicated tanker trucks and will be transported to the Burdock CPP where it will be pumped (transferred) into the CPP elution circuit. Trained Powertech (USA) personnel will comply with all Powertech (USA) SOPs for such activities to minimize potential impacts.

After proper cooling, yellowcake will be loaded into gasketed and sealed 55-gallon (208-L) steel drums at the Burdock CPP and will be transported to a conversion facility for further refining and conversion. A properly licensed and certified transportation contractor will transport resin and/or yellowcake from the PAA to a conversion facility in a manner consistent with all applicable NRC and DOT regulations and requirements.

In addition, all shipments of process chemicals, fuel and non-AEA radioactive materials will comply with applicable DOT hazardous materials shipping regulations and NRC requirements to further mitigate the potential impacts of a transportation accident.

5.3 Proposed Mitigation Measures for Geologic and Soil Impacts from the Proposed Action

Potential impacts to soils during all phases of the Proposed Action include soil compaction, loss of productivity, loss of soil, increased salinity, and soil contamination.

As noted in Section 4 of this ER, ISL production has not in the past and is not in the future expected to contribute to any potential, significant geological impacts. The following proposed measures will be used to minimize the potential impacts to soil resources discussed in Section 4.5:

- Salvage and stockpile soil from disturbed areas.
- Reestablish temporary or permanent native vegetation as soon as possible after disturbance utilizing the latest technologies in reseeding and sprigging, such as hydroseeding.
- Decrease runoff from disturbed areas by using structures to temporarily divert and/or dissipate surface runoff from undisturbed areas.
- Retain sediment within the disturbed areas by using silt fencing, retention ponds, and hay bales.
- Fill pipeline and cable trenches with appropriate material and re-grade surface soon after completion.

- Drainage design will minimize potential for erosion by creating slopes less than 4 to 1 and/or provide rip-rap or other soil stabilization controls.
- Construct roads using techniques that will minimize erosion, such as surfacing with a gravel road base, constructing stream crossings at right angles with adequate embankment protection and culvert installation.
- Use a spill prevention and cleanup plan to minimize soil contamination from vehicle accidents and/or wellfield spills or leaks;Collect and monitor soils and sediments for potential contamination including areas used for land application of treated wastewater, transport routes for yellowcake and ion exchange resins, and well field areas where spills or leaks are possible.

5.4 Proposed Mitigation Measures for Surface Water Impacts from the Proposed Action

Potential surface water impacts due to storm events during all phases of the Proposed Action include increased sedimentation and changes in water quality. The following procedures will be used to minimize the impacts to surface waters as discussed in Section 4.6:

- Minimize disturbance of surface areas and vegetation which, in turn, will minimize erosion and run-off rates.
- Minimize physical changes to drainage channels unless changes are made to upgrade drainage.
- Use erosion and run-off control features such as proper placement of pipe, grading to direct run-off away from water bodies, and use of riprap (broken rock and/or concrete) at these intersections to make bridges or culverts more effective, if necessary.
- Use sediment trapping devices such as hay or straw bales, fabric fences, and devices to control water flow and discharges to trap sediments moved by run-off.
- Train employees in the handling, storage, distribution, and use of hazardous materials.
- Maintain natural contours as much as possible, stabilizing slopes and avoiding unnecessary off-road travel with vehicles; maintaining natural contours as much as possible, stabilizing slopes and avoiding unnecessary off-road travel with vehicles.
- Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills.
- The land application of treated waste water will be applied in a manner consistent with local conditions to avoid excess irrigation run-off into surface water.

- Ponds will be designed with underdrains and leak detection systems to detect and mitigate any impact from a potential leak.
- Fueling operations and storage of hazardous materials and chemicals will be conducted in bermed/curbed areas and in a manner that minimizes potential impacts to surface water.
- Prepare and implement a Storm Water Pollution Prevention Plan that is consistent with state and federal standards for construction activities.
- Surface piping will avoid any identified 100-year or 500-year flood plain levels.
- Curbing relevant facilities and structures at CPP to minimize or eliminate escape of process fluids during spills.

Best management practices will be utilized in all phases of the Proposed Action.

5.4.1 Porposed Mitigation Measures for Potential Groundwater Impacts from the Proposed Action

Potential groundwater impacts during all phases of the Proposed Action include the following: groundwater consumption (Section 4.6.2.1), alteration of ore zone groundwater quality (Section 4.6.2.2), potential groundwater quality impacts from accidents (Section 4.6.2.3), potential groundwater impacts from land application (Section 4.6.2.4), and potential aquifer restoration impacts (Section 4.6.2.5) will be used to minimize the impacts to groundwater as discussed in Section 4.6.2: The following is a list of potential mitigation measures for such potential impacts measures to mitigate impacts to groundwater.

- Minimize groundwater use during operations.
- Monitor well pressures to detect leaks.
- Install monitoring wells as an early warning system for potential lixiviant excursions or leaks from the relevant CPP or SF.
- Maintain pumping and injection rates (well field balance) to ensure radial hydraulic flow into and through the production zone.
- Monitor to detect and define unanticipated surface spills, releases, or similar events that may infiltrate into the groundwater system.
- Implement a spill prevention and cleanup plan to minimize impacts to groundwater, including rapid response cleanup and remediation capability, techniques, procedures, and training;

- Recycle groundwater collected for use in dust suppression and other activities;
- Monitor closest private domestic, livestock, and agricultural wells as appropriate during operations;
- Provide alternate sources of water to landowners in the event of significant drawdown impacts from the proposed action, to domestic wells adjacent to the PAA;
- Select restoration method to minimize water consumption during groundwater restoration;
- Monitor area downgradient from land application sites to determine potential vertical and lateral seepage.
- During restoration, monitor groundwater using standard industry practices to determine the progression and effectiveness of restoration;

5.5 Proposed Mitigation Measures for Potential Ecological Resources Impacts from the Proposed Action

Potential ecologic impacts during all phases of the Proposed Action ISL operations could include the following: impacts to vegetation (Section 4.7.1), such as alteration of vegetative density, reduction of wildlife habitat, reduction of livestock forage, and changes in visual aesthetics; impacts to wildlife and fisheries (Section 4.2.2), such as, loss of habitat, increased soil erosion and human contact; potential impacts to threatened and endangered, or candidate species and species tracked by SDNHP (Section 4.3.7), such as, increased human presence and disturbances, and lost of habitat: The following is a list of proposed mitigation measures for such potential impacts:

- Fencing designed to permit big game passage to the extent practicable.
- Use existing roads when possible, and limit construction of new primary and secondary roads to provide for to access to more than one drill site, if possible.
- Enforced speed limits to minimize collisions with wildlife, especially during the breeding season.
- Adherence to timing and spatial restrictions within specified distances of active raptor nests during the breeding season as determined by appropriate regulatory agencies, (February 1 – July 31);
- If direct impacts to raptors or other migratory bird species of concern occur a Monitoring and Mitigation Plan for those species will be prepared and approved by the USFWS, including one or more of the following provisions:

- Relocation of active and inactive raptor nests that could be impacted by construction or operation activities in accordance with the approved raptor monitoring and mitigation plan

- Creation of raptor nests and nesting habitat through enhancement efforts such as nest platforms to mitigate other nest sites impacted by ISL operations

- Obtaining appropriate permits for all removal and mitigation activities

- Establishing buffer zones protecting raptor nests where necessary and restricting ISL-related disturbances from encroaching within buffers around active raptor nests from egg-laying until fledging to prevent nest abandonment, or injury to eggs or young

- Reestablishing the ground cover necessary to attract and sustain a suitable raptor prey base after drilling, construction, and future ISL operations and site D&D;

- Required use of raptor-safe construction for overhead power lines according to current guidelines and recommendations by the USFWS

- Restoration of pre-ISL native habitats for species that nest and forage in those vegetative communities.

- Restoration of diverse landforms, direct topsoil replacement, and the construction of brush piles, snags, and/or rock piles to enhance habitat for wildlife.

- Conduct weed control as needed to limit the spread of undesirable and invasive, non-native species on disturbed areas

Adjusting the timing of various construction, operational, and D&D activities to avoid the breeding season can also be an effective way to minimize impacts related to such activities in the PAA. As a practical matter, worker crews conducting construction or D&D activities only work during daylight hours; so, potential impacts to year-round residents, particularly more nocturnal species such as bats, rodents, and others should not be increased significantly. Following completion of construction in a given area, access roads would be blocked with berms or fencing to prevent use by casual traffic. Site D&D, including surface reclamation will be completed in the same manner, with activities timed to minimize disturbance to nesting or migrating species. Relevant agency standards for reclamation will be followed and this phased, systematic approach will allow more mobile wildlife species to relocate into adjoining, undisturbed habitat and then return following completion of construction or D&D in a particular area. Thus, the sequential, phased nature of this approach will decrease potential direct and indirect impacts on all wildlife species and their habitat.

5.6 Proposed Mitigation Measures for Potential Air Quality Impacts from the Proposed Action

Potential impacts to air quality during all phases of the Proposed Action (Section 4.8) include the generation of non-radioactive particulate emissions and fugitive dust. Typical air quality protection measures that will be implemented at the project site may include the following:

- Reduce fugitive dust emissions via standard dust control measures (e.g., water application, speed limits)
- Reduce maximum fugitive dust by coordinating dust-producing activities during construction
- Maintain vehicles to meet applicable EPA emission standards.
- Use of a Yellow Cake vauum dryer virtually eliminates to assure compliance with 40 CFR Part 190.

These proposed mitigation measures will reduce fugitive dust to levels equal to or less than current conditions and ensure that applicable emission standards will be met.

5.7 Proposed Mitigation Measures for Potential Noise Impacts from the Proposed Action

Potential noise impacts during all phases of the Proposed Action (Section 4.9) include the generation of noise resulting from operating heavy equipment and process machinery. Noise from process machinery will be contained within process structures and, as such, should have no discernible impacts on the public or the environment. With respect to potential noise impacts from heavy equipment, typical mitigation measures that will be implemented at the project to minimize noise impacts may include the following:

- Avoid construction activities during the night;
- Use sound abatement controls on operating equipment and facilities;
- Use personal hearing protection for workers in any high noise areas.

These proposed mitigation measures will ensure that noise levels will remain within relevant EPA guidelines for off-site receptors and OSHA standards for workers.

5.8 Proposed Mitigation Measures for Potential Historic and Cultural Resources Impacts

Potential impacts to historical and cultural resources could occur during construction and operations (Section 4.10) Mitigation measures that will be implemented at the project site to minimize impacts to historical and cultural resources may include the following:

- Consultation with appropriate SHPO and THPO;
- A Memorandum of Agreement (MOA) has been negotiated and executed with the State of South Dakota Archaeologist to ensure the preservation of any historical, cultural, and archaeologicalsites that may be present within the PAA. Additional MOA mitigation measures have been prepared to ensure that no significant historical, cultural, or archaeological resources will be damaged during all phases of the Proposed Action;
- Conduct pre-construction surveys to ensure that work will not affect important historical, cultural, and archaeological resources;
- NRC License Conditions mandating phased identification of previously unidentified historical, cultural or archaeological resources and immediate response procedures for protecting such resources during all phases of the Proposed Action

5.9 Proposed Mitigation Measures for Potential Visual/Scenic Resources Impacts

Potential impacts to visual/scenic resources (Section 4.11) during all phases of the Proposed Action include the alteration of visual/scenic resources. Typical visual/scenic mitigation measures that could be implemented at the project site include the following:

- Use exterior lighting only where needed to accomplish facility tasks;
- Limit the height of exterior lighting units;
- Use shielded or directional lighting to limit lighting only to areas where it is needed;
- Construction and placement of structures taking into consideration the topography in order to conceal wellheads, plant facilities, and roads from public vantage points;
- Satisfy BLM guidelines by using building materials and paint that complement the natural environment;,
- During construction of roads, consider the topography that a given road follows as well as the potential area of disturbance.

5.10 Proposed Mitigation Measures for Potential Socioeconomic Impacts from the Proposed Action

As discussed in Section 4.12, the overall impacts of the proposed project indicate that the project will result in positive socioeconomic benefits to the local and regional economy, with the potential to create of hundreds of jobs and millions of dollars in tax revenue. The potential impacts of increased population associated with the project are expected to be dispersed, due to the remoteness of the PAA and the phased nature of construction, operation, and site D&D. The proposed mitigation measures to minimize adverse socioeconomic impacts include the following:

- Use local vendors, employees, and contractors to the extent possible;
- Develop and deliver educational presentations and tours to interested groups in nearby communities to maintain community awareness of the nature of the Proposed Action.

5.11 Proposed Mitigation Measures for Potential Environmental Justice Impacts from the Proposed Action

As discussed in Section 4.13, the Proposed Action will not have any significant adverse impacts and, therefore, will not have significant disproportionate impacts on minorities or low-income individuals as compared with the state-wide averages; therefore, no mitigation measures need to be identified.

5.12 Proposed Mitigation Measures for Potential Public and Occupational Health Impacts from the Proposed Action

Potential impacts to pubic and occupational health (Section 4.14) during all phases of the Proposed Action include potential exposure to hazardous chemicals and radiological emissions such as radon-222. The proposed mitigation measures for potential public and occupational health impacts from the Proposed Action include the following:

- Use downflow, pressurized IX columns, and ventilation during resin transfers to keep occupational exposure to radon levels in process facilities as low as is reasonable achievable (ALARA);
- Use vacuum dryers, bag filters, and vapor filtration to reduce particulate emissions during yellowcake drying
- Use high-efficiency particulate air filters or similar controls for all particulates;
- Design SOPs to reduce potential accidents;

- Implement health and safety procedures and administrative controls to minimize workers risks during all phases of the Proposed Action

- Develop and implement training programs for Powertech (USA) personnel to enable them to respond to all potential emergencies.

- Develop emergency management procedures/SOPs that are consistent with standard and best management practices to satisfy applicable non-radiological exposure limits and to implement risk control recommendations contained in NUREG/CR-6733 analyses.

- Installation of engineering and administrative controls consistent with standard and best management practices to prevent both surface and subsurface releases to the environment, and to mitigate the effects in the event of an accident.

5.13 Proposed Mitigation Measures for Potential Waste Management Impacts from the Proposed Action

Potential impacts from waste management activities (Section 4.15) during all phases of the Proposed Action include potential exposure to hazardous and radiological emissions from such wastes. The proposed mitigation measures for potential impacts associated with waste management activities from the Proposed Action include the following:

- Recycle wastewater to reduce the amount of water needed for facilities and the amount of wastewater that could require disposal;

- Use decontamination techniques that reduce waste generation;

- Institute preventative maintenance and inventory management programs to minimize waste from breakdowns and overstocking;

- Recycle non-radioactive materials where appropriate;

- Encourage the reuse of materials and use of recycled materials;

- Avoid using hazardous materials when possible;

- Develop a spill prevention plan for petroleum products and other hazardous materials;

- Ensure that equipment is available to respond to spills and identify the location of such equipment;

- Inspect and replace worn or damaged components;

- Salvage extra materials and use them for other construction activities or for regrading activities;

- Install curbs or berms on all waste storage areas;
- Install leak detection and warning systems in all liquid waste facilities.

5.13.1 Proposed Mitigation Measures for Potential Impacts from Uncontaminated Solid Waste Management

The Proposed Action will generate non-radioactive (i.e., uncontaminated) solid wastes, which could include, but are not limited to: fluorescent tubes, and light ballasts, batteries not directly associated with uranium recovery, and waste paper, cardboard and other materials generally associated with office and equipment maintenance activities. These materials will be collected on a regular basis and disposed of in an appropriately permitted off-site disposal facility.

5.13.2 Proposed Mitigation Measures for Potential Impacts from 11e.(2) Byproduct Material Management

Byproduct material requiring offsite disposal in accordance with NRC requirements and/or license conditions will be transported off-site to an NRC-approved disposal facility.Powertech (USA) estimates that the Proposed Action will produce approximately 100-yd^3 of 11e.(2) byproduct material per year. These materials will be stored on-site to prevent any potential release, will be properly labeled, and will be isolated inside the restricted area until such time as a full shipment can be transferred to an NRC-approved disposal site;

5.13.3 Proposed Mitigation Measures for Potential Impacts from Hazardous Waste Management

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). On the basis of the processes and materials proposed to be used for the Proposed Action, it is likely that this project will be classified as a CESQG (a generator that generates less than 100 kg of hazardous waste in a calendar month) and will comply with all applicable hazardous waste program requirements. Powertech (USA) expects that only used waste oil and universal hazardous wastes such as cleaning solvents and spent batteries will be generated at the project. Powertech will develop management programs to meet the regulatory requirements for a CESQG. However, in the event it is not classified as a CESQG, Powertech (USA) will dispose of such wastes in a manner consistent with applicable regulations and requirements.

6.0 Environmental Measures and Monitoring Programs

6.1 Radiological Monitoring

For radiological characterization of the PAA three primary guides were utilized, NUREG-1569 "Standard Review Plan (SRP) for In Situ Leach Uranium Extraction License Applications" (NRC 2003), "NRC Regulatory Guide (RG) 4.14" (Revision 1), "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC 1980) to provide an acceptable basis for pre-operational radiological baseline evaluations, NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), 2000 was also considered where relevant.

Sample placement prescribed by RG 4.14 was modified in order to ensure the effort put forth in characterization of the PAA is adequate and assures an appropriate baseline determination of background radiation. Modification of the sampling program described in RG 4.14 is appropriate as RG 4.14 was developed to be used in design of an environmental monitoring program for conventional uranium mill and tailings sites and was not specifically intended to address ISL operations. The modified sampling program adequately characterized radiological aspects of the environment at the PAA and assists the applicant in the proper placement of operational monitoring sites to ensure standards for protection against radiation will be met during licensed operations. The sampling protocol was designed to achieve the goal of adequately protecting the public and the environment from unacceptable levels of radiation or radioactive materials that exceed background levels. See Section 6.1.3 for additional details.

Responsible operators achieve this goal, in part, by consulting NRC guidance documents such as NUREG-1575. By conducting a detailed environmental site survey, sampling and analysis program; the operator is able to establish baseline background levels and assess possible derived concentration guideline levels (DCGLs) via both historical site assessments (HAS) and the most recent site characterization. Historical and current data will be assessed prior to commencement of the Proposed Action's D&D (Decontamination and Decommissioning) program. By utilizing the immense experience of the industry, consultation with the appropriate regulators and utilization of applicable guidance, the licensee will be able to clean up any contamination that may result from ISL operations and release the site for unrestricted use.

6.1.1 Introduction

This section provides baseline radiological data for surface soils (0-5 and 0-15 cm), subsurface soils to a depth of 1 m, vegetation, cattle, direct gamma radiation, and radon-222 flux rates

radon-222 in air representative of the project property. The work was performed by Environmental Restoration Group (ERG) between August 2007 and July 2008.

Field investigations, sample collection, and other quality-related work performed were conducted in accordance with applicable ERG SOPs, listed below:

- SOP .010 Radon Flux Canister Deployment
- SOP 1.05 Calibration of Scaler, Ratemeters
- SOP 1.22 Determining the Concentration of Airborne Radioactive Particles
- SOP 1.51 Correlation between Gamma-Ray Count Rate and Exposure Rate
- SOP 2.02 General Equipment Decontamination
- SOP 2.07 Function Check of Equipment
- SOP 2.09 Correlation between Gamma-Ray Measurements and Radium-226 in Soil
- SOP 3.02 Sample Control and Documentation
- SOP 5.01 Setup and Operation of Trimble Pro XRS GPS Receiver with Trimble TSCe Datalogger
- SOP 5.02 Download, Correction, and Export of GPS Survey Data
- SOP 5.06 Creating, Uploading, and Navigating to Waypoints
- SOP 7.08 Surface and Shallow Subsurface Soil Sampling
- SOP 7.09 Vegetation Sampling

The baseline radiological field investigation consisted of the following activities:

- A GPS-based gamma survey conducted at 100 to 500 m transects spanning the PAA
- A second GPS-based gamma survey of two, collective land application areas conducted at 100 m transects
- Collecting surface soil (0-15 cm) samples at 75 randomly selected and at five biased locations spanning the PAA
- Collecting subsurface soil samples at nine randomly selected locations taken at depth intervals of 15-30 cm and 30-100 cm

- Collecting surface (0-15 cm) and subsurface samples at the same depth intervals at 17 randomly selected locations in the land application areas
- Collecting shallow (0-5 cm) surface soil samples at the eight AMS
- Vegetation sampling at each AMS during the summer, fall and spring
- Air monitoring at one background and seven additional locations
- Radon monitoring in air
- Radon flux measurements at locations coinciding with the subsurface samples
- Exposure rate monitoring, using a PIC and thermoluminescent detectors (TLDs)
- Collecting three samples of locally grazed livestock

Table 6.1-1 summarizes the scope of the field investigation and Plate 6.1-1 shows the sampling location and type of sampling performed in the PAA. All samples were shipped under chain-of-custody to a National Environmental Accreditation Conference-certified laboratory, Energy Laboratories, in Rapid City, South Dakota.

The units reported in the body, tables, and figures related to this section vary. NRC Regulatory Guide (RG) 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills*, has specific requirements for unit reporting in tables. For example, it recommends that radionuclide soil concentrations be reported in units of microcuries per gram (μCi/g). Where applicable, the tables adopt this unit. The main body of Section 6.1, however, adopts the unit pCi/g for this parameter, as this unit is used more generally and consistently by the uranium industry and public.

Table 6.1-1: Summary of Baseline Radiological Investigation Scope

Task Method/Endpoint	Baseline Investigation Scope	Parameters Evaluated
A.GPS-Based Gamma Surveys	GPS-based unshielded gamma-ray readings along 100 or 500 meter transects at ≤1.5 meters per second. A second survey covered land application areas along 100 meter transects.	Serve as basis to estimate pre-operational gamma emissions from land areas and exposure rates, surface soil radium-226 concentrations, and identify areas for biased soil sampling.
B. Biased Soil Sampling	Biased samples at five locations, all collected from 0 to 15 cm	Radium-226 for all samples Thorium-230, natural uranium, lead-210 for 2 locations
C. Random Soil Sampling	Random samples at 75 locations Nine of the 75 locations were sampled at depth (15-30 cm and 30-100 cm) Ten duplicates at 0 to 15 cm. One duplicate each at 15 to 30 cm and 30 to 100 cm.	Radium-226 for all samples Thorium-230, natural uranium, lead-210 (8 from 0 to 15 cm and one each at 15 to 30 cm and 30 to 100 cm
D. Soil sampling in land application areas	Random samples at 17 locations, all but one of which were sampled at 0 to 15, 15 to 30 and 30 to 100 cm. Refusal was encountered at 45 cm in the exceptional location. One duplicate each at 0 to 5, 15 to 30, and 30 to 100 cm.	Radium-226, thorium-230, natural uranium, and lead-210 for all samples
E. Exposure Rate Monitoring	Exposure rate determinations based on TLD and PIC measurements. TLD measurements collected for four quarters.	Exposure rates
F. Soil and Vegetation Sampling at Air Monitoring Stations	Eight locations: seven on-site (AMS-01 through AMS-07) and one located approximately 1.9 miles west of the southwest corner of the PAA (AMS-BKG). Vegetation samples collected for four quarters.	Vegetation: radium-226, thorium-230, natural uranium, lead-210 and polonium-210 Soil: All of the above except polonium-210
G. Air Particulate Sampling	Eight locations: seven on-site (AMS-01 through AMS-07) and one located approximately 1.9 miles west of the southwest corner of the PAA (AMS-BKG). Air particulate samples collected for four quarters.	Air filters: radium-226, thorium-230, natural uranium, lead-210 and polonium-210
H. Radon in air	16 locations: eight AMS and eight additional locations. Radon in air measurements taken for four quarters.	Radon-222
I. Radon Flux Measurements	Radon flux measurements at nine locations (collected at the biased subsurface soil sample locations in Task C) in summer, fall, and spring.	Radon-222
I. Locally Grazed Livestock Sampling	Three samples collected from one locally grazing cow.	Radium-226, thorium-230, natural uranium, lead-210 and polonium-210

6.1.2 Gamma Survey

6.1.2.1 Methods

6.1.2.1.1 Baseline GPS-Based Gamma Survey

GPS-based gamma surveys were conducted within the PAA and the historical surface mine areas of the project from September 13-27, 2007 and completed on July 14, 2008. Unshielded Ludlum Model 44-10 2"x 2" sodium iodide (NaI) detectors were coupled to Ludlum Model 2221 ratemeter/scalers (set in ratemeter mode) and a Trimble Pro XRS GPS Receiver with Trimble TSCe Datalogger. Survey transects were spaced at approximately 500-m intervals in the PAA and 100 m in the surface mine area. The transect spacing was reduced in the surface mine area in anticipation of finding a greater variation in gamma-ray emissions, due to historical mining in the area. The survey speed was maintained between 2 and 5 feet per second with x- and y-coordinates and gamma-ray count rates recorded every second. The detector height was held relatively constant at approximately 18 inches above ground surface. Depending on the terrain, field personnel surveyed using ATVs or by walking with the equipment in backpacks. See example of utilization of best technology available in regards to conducting the roving gamma survey at the PAA in Figure 6.1-1.

A second GPS-based gamma survey was conducted over the land application areas from July 17-19, 2008, using the Ludlum gamma-ray detection system described above with the same response characteristics as used in the initial survey. The scanning speed and detection height were unchanged from the initial survey and the transect spacing was 100 m.

The areas subject to GPS-based gamma surveys are shown on Figure 6.1-2.

Figure 6.1-1: Example of Best Technology Available Utilized for the Roving Gamma Survey at the Dewey-Burdock Project by ERG.

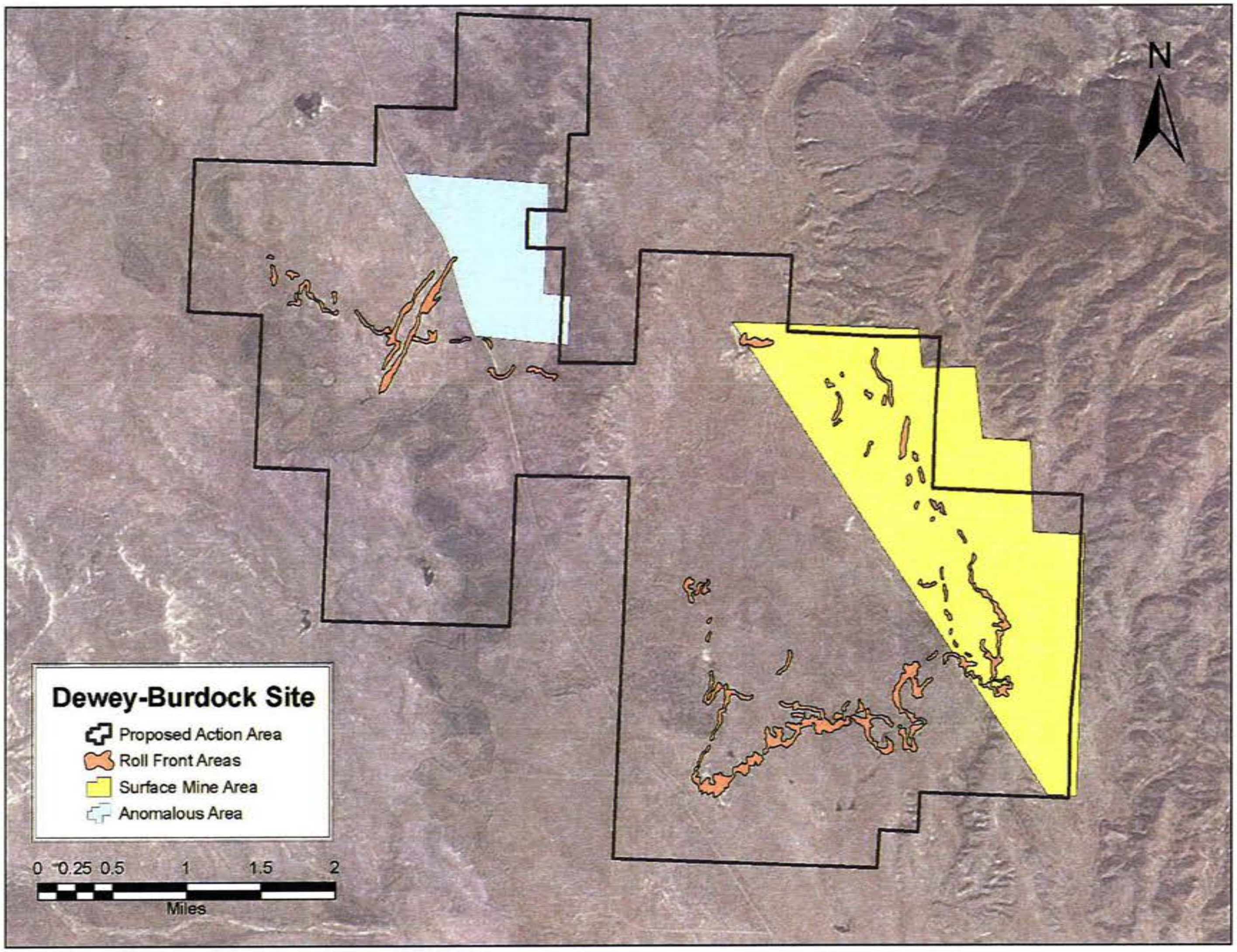

Figure 6.1-2: Areas Subject to GPS-Based Gamma Surveys

6.1.2.1.2 Cross-Calibration of Sodium Iodide Detectors and a High-Pressure Ionization Chamber

Both the sodium iodide detector and PIC measure gamma radiation. The sodium iodide detection system measures the rate that the gamma rays interact with the detector in counts per minute (cpm), has a lower sensitivity than the PIC and is energy dependent. The PIC is a highly accurate ionization chamber for measuring exposure rate in microoentgens per hour (μR/hr) but requires a longer count time. The PIC was used because it measures exposure rates directly and is considered a primary standard by NIST, when calibrated. The PIC measures gamma, X-rays, and cosmic radiation without discrimination. It is highly stable, relatively energy independent, and serves as an excellent tool to calibrate other survey equipment to measure exposure rates. Because of its portability and shorter measurement times, the sodium iodide detector is more efficient than the PIC for use in large area surveys. By performing the large area gamma surveys with sodium iodide detectors, then developing a correlation between the two instruments, exposure rates derived from the sodium iodide measurements can represent site wide gamma emissions from surface soils.

Powertech collected 12 co-located static gamma counts and exposure rate measurements to develop the correlation between gamma counts and exposure rates. The locations were biased towards areas where gamma shine was not relatively high; that is, where gamma count rates remained relatively constant at 18 inches, 1 m, and 2 m above ground surface. In addition, locations were chosen to encompass most of the range of sodium iodide detector readings observed in the GPS-based gamma surveys. The sodium iodide measurements were taken using one of the 2-inch by 2-inch sodium iodide detectors that were used in the baseline gamma survey. A 1-minute integrated count was taken at each of the 12 locations with the detector suspended at 18 inches above the ground surface. Exposure rate measurements were then collected at a 1-m height at each location, directly above the location where the sodium iodide detector was held. Exposure rates were determined after 20-minute integrated counts. The PIC and gross gamma measurements were performed on July 14 to 16, 2008 at the locations shown on Figure 6.1-3.

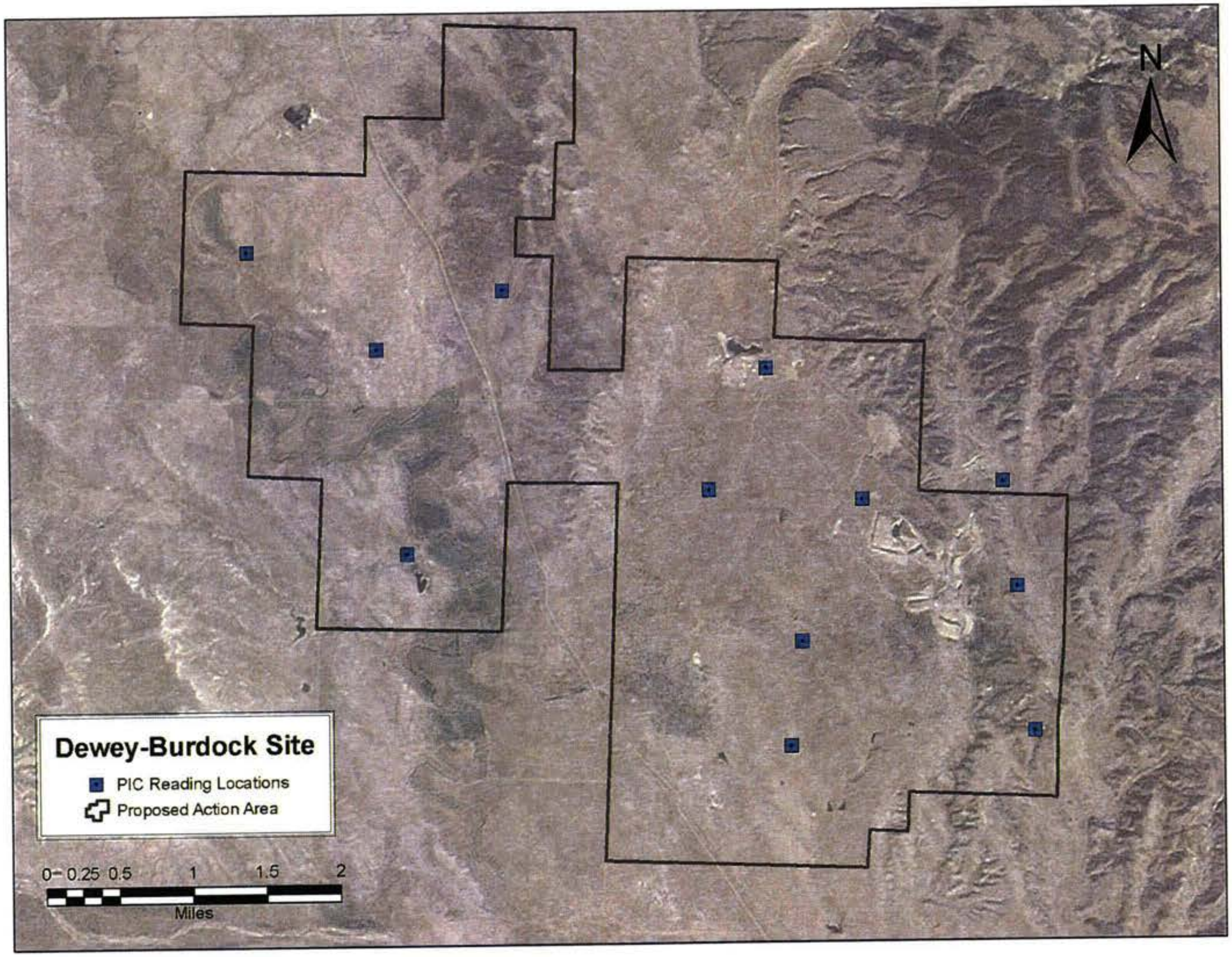

Figure 6.1-3: Locations of High Pressure Ion Chamber and Sodium Iodide Detector Measurements

6.1.2.1.3 Gamma/Radium-226 Correlation Grids

To estimate site-wide radium-226 concentrations at each of the GPS-based gamma survey points, a correlation was established by performing a regression between the surface soil analytical results for radium-226 in the 80 surface (0-15 cm) soil samples and one-minute integrated direct radiation measurements collected at each of these locations prior to sample collection. The measurements were collected with the same Ludlum 44-10/2221 2-in by 2-in sodium iodide gamma detection systems used in the GPS-based gamma survey.

The correlation was used to translate each of the gamma-ray count rates obtained in the GPS-based survey to predicted radium-226 concentrations. ArcView GIS then was used to generate average predicted radium-226 concentrations in 700 by 700 foot grid blocks covering the site.

6.1.2.1.4 Data Quality Assurance/Quality Control

All survey instruments were calibrated. The function of survey instruments was checked at the beginning and end of each work day using a National Institute of Standards and Technology-traceable cesium-137 source. Calibration sheets and function check data are provided in Appendix A of Appendix 6.1-A.

6.1.2.2 Gamma Survey Results

6.1.2.2.1 Baseline Gamma Survey Results

The gamma-ray count rate data obtained in the initial survey were first evaluated as an entire set and then subdivided into the main permit (the entire data set less the surface mine area) and surface mine areas.

The observed gamma-ray count rates are presented as colors representing ranges of counts in Figure 6.1-4. Three areas are shown on the figure: the main permit and surface mine areas, and an area of anomalous gamma-ray count rates located in the northern portion of the PAA.

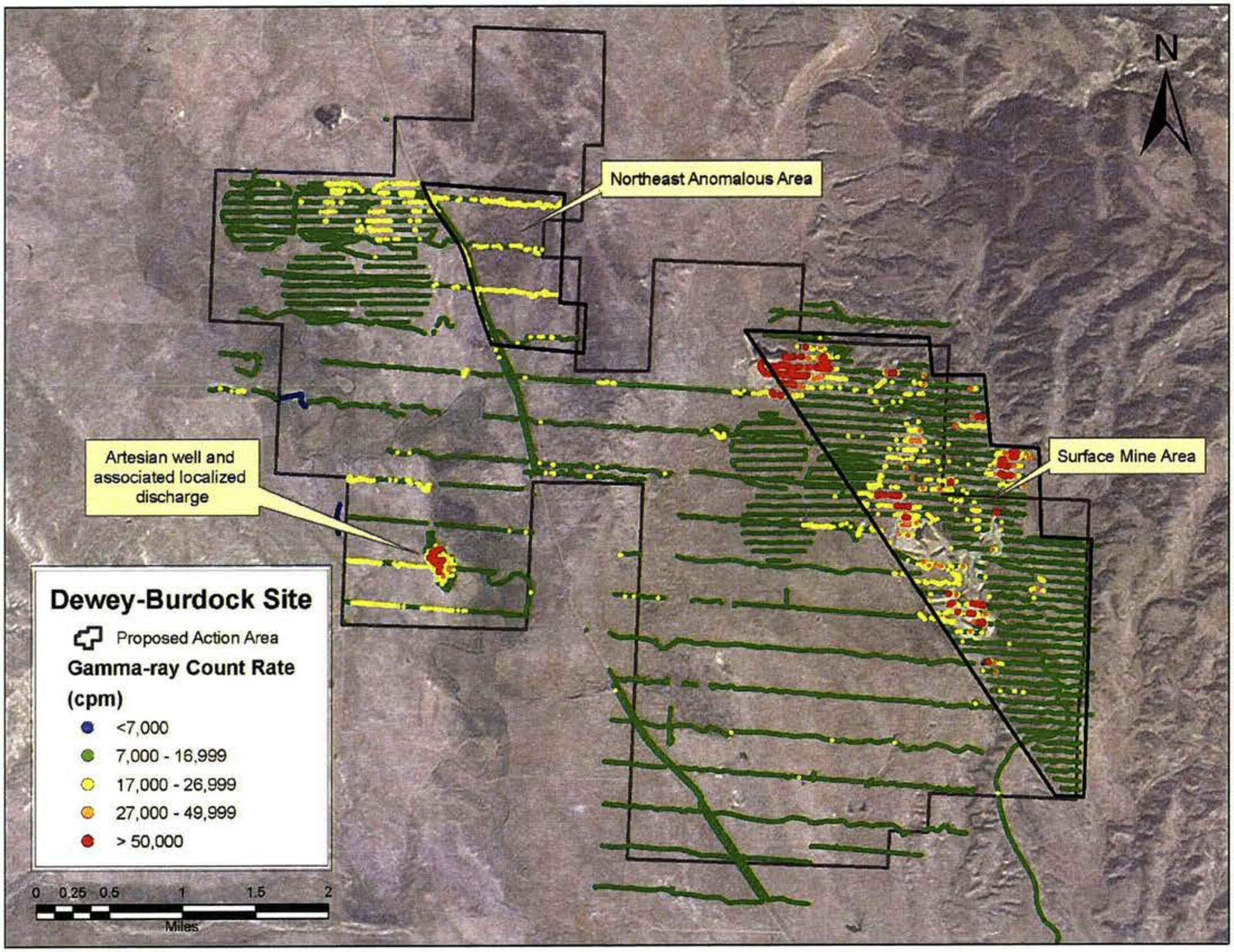

Figure 6.1-4: Gamma-Ray Count Rates Obtained During Initial GPS-Based Gamma Survey

None of the data sets: including the entire PAA and gamma data obtained in the main permit and surface mine areas are normal, lognormal, or exponentially distributed. Furthermore, normalizing data transformations were conducted and the transformed data did not follow standard distributions. For these reasons, data analysis and summaries were performed using non-parametric statistical methods, which are less sensitive to extreme observations typical of skewed data distributions.

The median and inter-quartile range (IQR) are non-parametric measures of central tendency and variability, respectively. The IQR is the difference between the first (Q1) and third (Q3) quartiles, i.e., 25 and 75 percent of the data area less than Q1 and Q3, respectively. Any datum that is outside the range of 1.5 times the IQR lower than Q1 and 1.5 times the IQR higher than Q3 is considered an outlier. Extreme outliers, or extremes, are those exceeding three times the IQR to the left and right from the first and third quartiles respectively (Ott and Longnecker, 2001).

The summary statistics of the GPS-based gamma-ray survey are listed in Table 6.1-2. The median of the gamma-ray count rates for the overall data set was 12,687 cpm. Field personnel collected 157,075 readings ranging from 5,550 to 460,485 cpm.

Table 6.1-2: Statistical Summary of Gamma-Ray Count Rates in Entire Data Set, Main Permit and Surface Mine Areas

	Gamma-Ray Count Rate (cpm)		
Estimator/Endpoint	**Entire Data Set**	**Main**	**Surface Mine Area**
Mean	15,025	13,073	16,823
Standard Deviation	17,095	2,995	23,377
Median	12,687	12,664	12,717
Mode	12,487 (n=53)	12,585 (n=35)	12,138 (n=31)
Minimum	5,550	5,883	5,550
Maximum	460,485	171,243	460,485
Q1	11,395	11,598	11,125
Q3	14,437	14,137	14,783
IQR	3,042	2,539	3,658
No. of Counts	157,075	75,345	81,757

Notes:
Entire data set does not include gamma-ray counts obtained along the eastern haul road. In addition, the sum of the counts in the main permit and surface mine areas is 27 counts greater than the counts in the entire data set, due to an overlap in counts within the two shapes placed as a layer in ArcView GIS to select the data sets.

Proposed Action Area

As shown in Table 6.1-3, the median gamma-ray count rate for the PAA data set was 12,664 cpm for 71,148 observations. The count rates ranged from 5,883 to 171,243 cpm. Low outliers in the PAA data set, count rates below 7,790 cpm, appear to be limited to two clusters. High outliers in the data set, count rates exceeding 17,946 cpm, appear to be limited to an approximately 600-acre located at the north end of the PAA, the area identified as an anomalous area on Figure 6.1-4.

Approximately 0.1 and 2 percent of the gamma-ray count rates observed in the PAA are comprised of low and high outliers, respectively.

The majority of high outliers are located in the north section of the PAA. The distribution of these anomalous gamma-ray count rate data is unknown. The count rates ranged from 8,863 to 22,130 cpm and the median was 15,503 cpm.

Surface Mine Area

In the surface mine area, the gamma-ray count rates ranged from 5,550 to 460,485 cpm and the median was 12,717 cpm. In general, clusters of higher readings are associated with un-reclaimed open pit uranium mines, waste rock, rocky outcrops, and drainages in the surface mine area. Approximately 0.004 and 9 percent of the gamma-ray count rates observed in the surface mine area are low and high outliers, respectively.

Discussion

There is sufficient evidence for the variances in the main permit and surface mine area gamma-ray count rates being distinct and thus represent distinct data populations. The variances in the main permit anomalous area are also distinct.

It is clear that the surface mine area in the eastern quarter of the site exhibits radiological impacts from historic and/or current anthropogenic activities within the area. In addition, gamma-ray count rates in the anomalous north area also are clearly distinct from those in the wider main PAA. The precise sources of the differences are not relevant in the context of this investigation since they are part of the baseline or background radiological characteristics of the site.

Land Application Areas

The summary statistics of the GPS-based gamma-ray survey of the proposed land application areas are listed in Table 6.1-3. The gamma-ray count rates obtained in the main PAA are listed in the table to facilitate comparison between the proposed land application areas and area in which they occur. The data are shown as ranges of count rates on Figure 6.1-5.

Gamma-ray count rates in the proposed land application areas are similar to those obtained in the larger main PAA. In the Dewey land application area, the median of the gamma-ray count rates was 12,523 cpm. Field personnel collected 23,480 readings ranging from 6,798 to 20,422 cpm. In the smaller, Burdock land application area, the median of the gamma-ray count rates was 12,232 cpm. Field personnel collected 13,647 readings ranging from 8,498 to 24,248 cpm.

Table 6.1-3: Statistical Summary of Gamma-Ray Count Rates in Proposed Land Application Areas

	Gamma-Ray Count Rate (cpm)		
		Land Application Area	
Estimator/Endpoint	**Main**	**Dewey**	**Burdock**
Mean	13,073	12,815	12,308
Standard Deviation	2,995	1,940	1,318
Median	12,664	12,523	12,232
Mode	12,585 (n=35)	11,778 (n=15)	12,266 (n=16)
Minimum	5,883	6,798	8,498
Maximum	171,243	20,422	24,248
Q1	11,598	11,437	11,504
Q3	14,137	13,993	12,958
IQR	2,539	2,556	1,454
No. of Counts	75,345	23,480	13,647

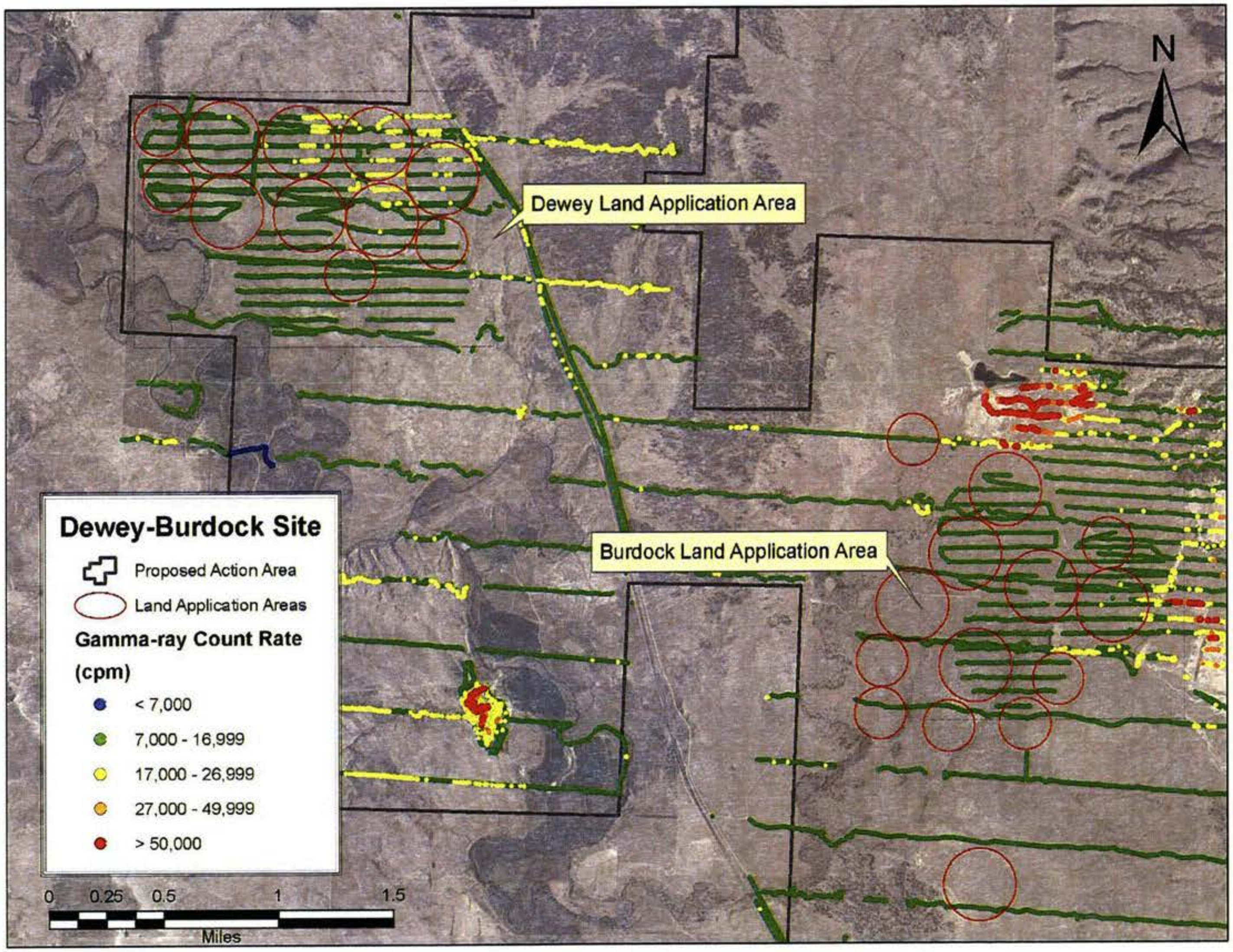

Figure 6.1-5: GPS-Based Gamma-Ray Count Rates in the Land Application Areas

6.1.2.2.2 Cross-Calibration of Sodium Iodine Detectors and a High-Pressure Ionization Chamber

The linear equation representing the correlation between exposure rates and gamma-ray count rates, determined using the PIC and average of the two sodium iodide detectors is:

$$Exposure\ Rate = 0.0007\ x\ Gamma\ Count\ Rate + 2.02$$

where the exposure rate is in gross μR/hr and the gamma count rate is in gross cpm.

The linear regression model for the average is a good fit, with an R^2 of 0.96. Nearly all of the data align along the slope of the line, as shown in Figure 6.1-6. The correlations are similar for the individual sodium iodide detectors and not discussed further.

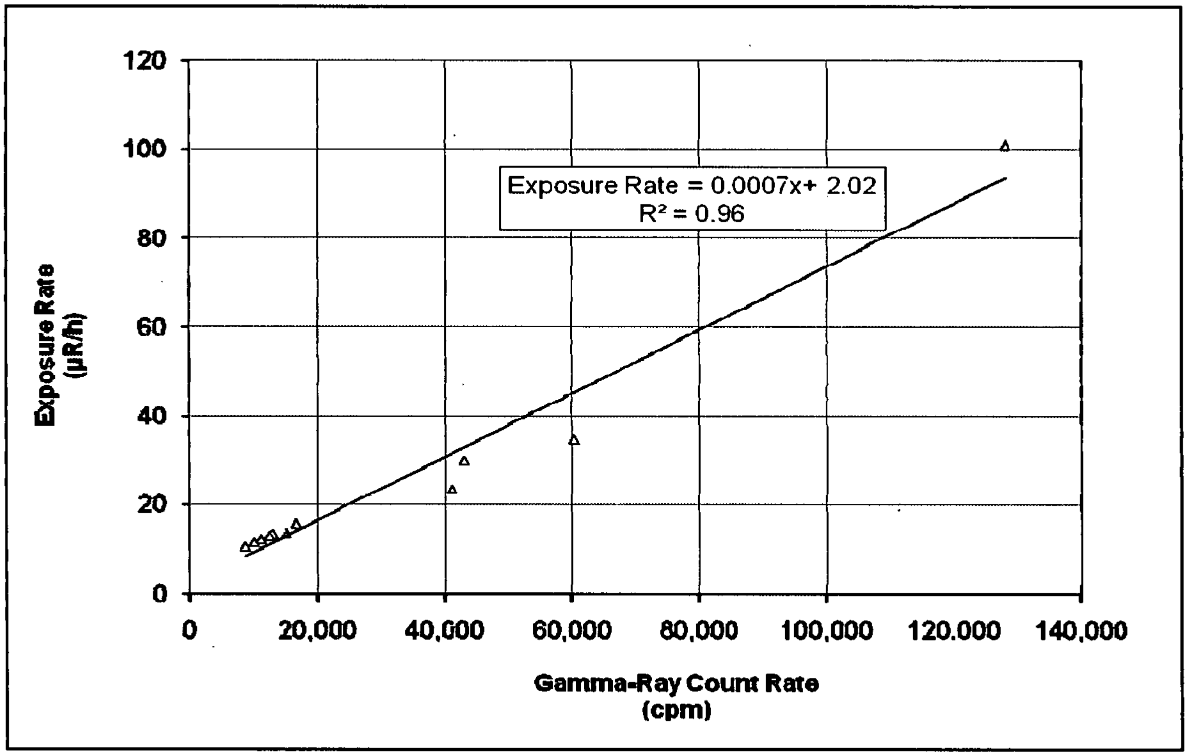

Figure 6.1-6: Linear Regression Model: Exposure Rates Correlated to Gamma-Ray Count Rates

The linear regression model predicts an average exposure rate of 10.9 μR/hr for the site. The range of predicted exposure rates is 5.9 to 324 μR/hr, based on the observed gamma-ray count rates at the site. The predicted site-wide exposure rates are shown as ranges of colors in 700 by 700 foot grid block averages on Figure 6.1-7.

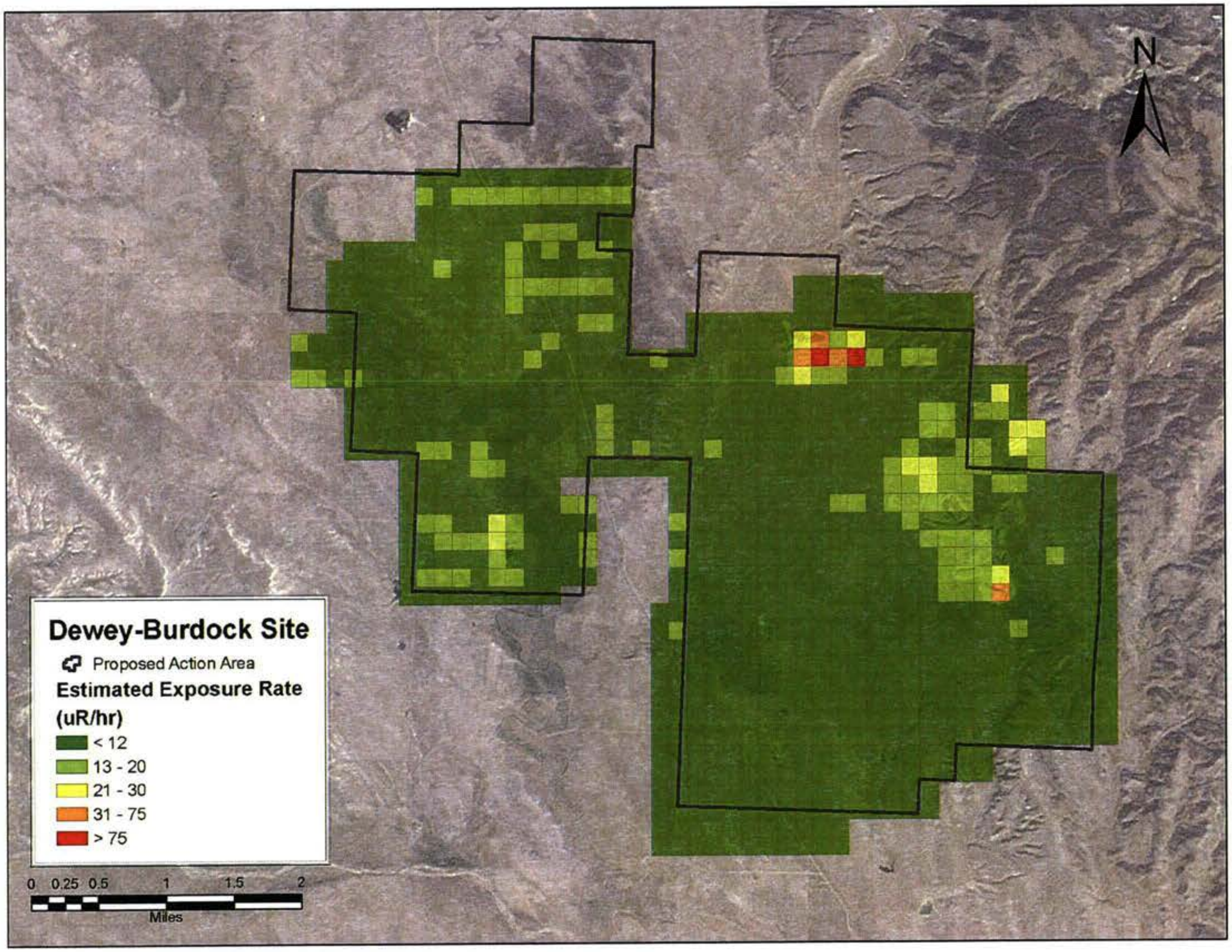

Figure 6.1-7: Predicted Site-Wide Exposure Rates, Grid Block Averages

6.1.2.2.3 Gamma-Ray Count Rate-Soil Ra-226 Concentration Correlation Grid Results

The relationship between gamma-ray count rates and radium-226 concentrations was determined to be appropriate after five outliers were removed from the set of 80 data points. The equation of the linear fit is:

$$Radium\text{-}226 = 1.9*10^{-4} \times Gamma\text{-}Ray\ Count\ Rate - 1.04$$

where the radium-226 concentration is in pCi/g and the gamma-ray count rate is in gross cpm.

This model has an R^2 of 0.43, with 0.43 accounting for 43 percent of the variance in the data set. Table 6.1-4 lists summary data for the predicted radium-226 concentrations in each of the major areas.

Of the 1,015 grid blocks covering the entire PAA, the majority (approximately 78 percent) of the interpolated surface radium-226 concentrations is less than 1.5 pCi/g. In the overall data set, the median predicted radium-226 concentration is 1.1 pCi/g and the range is 0.0 to 24.9 pCi/g. In the main PAA (excluding the anomalous area), the median predicted radium-226 concentration is 0.0 pCi/g and the range is 0.0 to 9.0 pCi/g. In the surface mine area, the median predicted radium-226 concentration is 1.5 pCi/g and the range is 0.0 to 24.9 pCi/g. In the anomalous portion of the main PAA, the median predicted radium-226 concentration is 1.4 pCi/g and the range is 0 to 2.3 pCi/g.

Table 6.1-4: Summary of Predicted Radium-226 Concentrations in Grid Blocks

		Predicted Radium-226 Concentration Based on Average of Counts Within Grid Block (pCi/g)					
Data Set	**No. of Grid Blocks**	**Median**	**Minimum**	**Maximum**	**Q1**	**Q3**	**IQR**
All Data	1,015	1.1	0	24.9	0	1.4	1.4
Surface Mine Area	171	1.5	0	24.9	1.1	1.8	0.7
Main without Anomalous Area	791	1.0	0	9.0	0	1.3	1.3
Anomalous Area	53	1.4	0	2.3	0	1.8	1.8

6.1.2.2.4 Final Gamma Exposure Rate Mapping

As stated in Section 2.9.2.2.2, the linear regression model correlating sodium iodide detector readings to PIC measurements predicts a site-wide average exposure rate of 10.9 μR/hr. The range of predicted exposure rates is 5.9 to 324 μR/hr, based on the observed gamma-ray count rates at the site. As indicated on Figure 6.1-7, predicted exposure rates ranging from 21 to greater than 75 μR/hr occur in the open pit mine areas, near the artesian well in Section 5 and its localized discharge areas, and in rocky outcrop areas in the northwest corner of the surface mine area. Predicted exposure rates in the anomalous area in the northern portion of the main PAA range from less than 12 to 30 μR/hr.

6.1.2.2.5 Soil Ra-226 Concentration Mapping

Predicted radium-226 concentrations in soil are shown as grid block averages on Figure 6.1-8. It is important to acknowledge that discrepancies between measured soil radium-226 concentrations reported by the laboratory and corresponding radium-226 concentrations estimated by gamma surveys are inevitable in a characterization survey of this nature and magnitude, given the heterogeneity of the site (at least in some areas) and differing detector-source geometry at various sample/survey locations.

At the same time, Figure 6.1-8 shows that without a gamma survey, reliance on a random soil sampling program alone would not have identified elevated areas of radioactivity at the site.

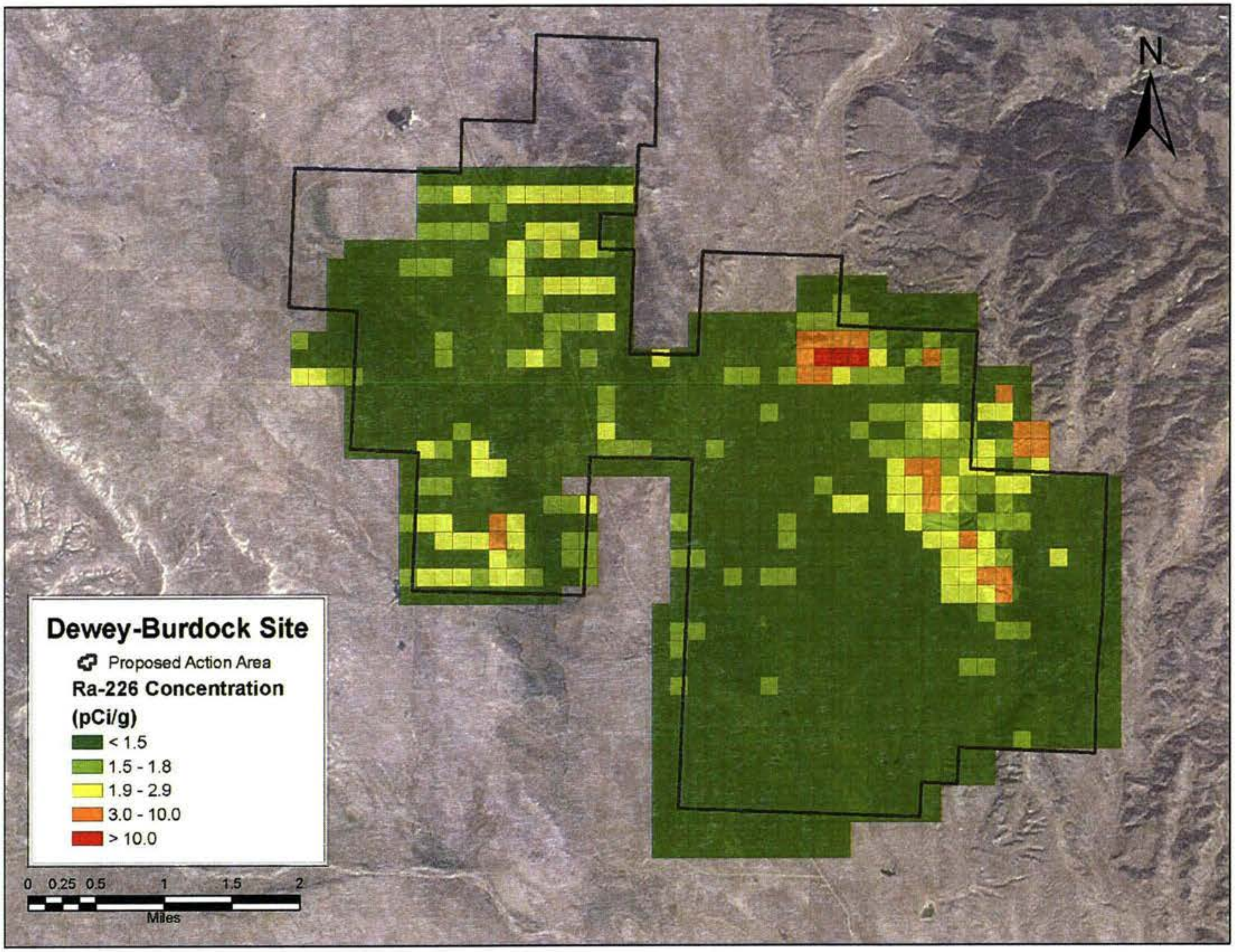

Figure 6.1-8: Predicted Site-Wide Radium-226 Concentrations, Grid Block Averages

6.1.3 Soil Sampling

6.1.3.1 Methods

6.1.3.1.1 Surface Soil Sampling

In the case of surface soil radiological characterization, sample placement prescribed by RG 4.14 was modified. RG 4.14 states that soil sampling locations start at a point halfway between proposed tailings and process areas, and 0-5 cm samples are collected every 300 m out to 1500 m in eight compass directions (40 samples) and one at each air monitoring station. This prescribed spacing largely ignores potentially varying site features such as soil types, drainages, outcrops, and the affects of historical activities. In addition, the soil sampling depth of 0-5 cm does not coincide with applicable cleanup standards. The NUREG-1569 requirements include collecting 0-15 cm samples to be consistent with the radium-226 cleanup standard of 5 pCi/g above background for the 0-15 cm soil horizon (10 CFR 40, Appendix A, Criterion 6(6)).

RG 4.14 suggests the collection of 40 samples from 0-5 cm and NUREG-1569 suggests the collection of samples at 0-15 cm. To avoid any ambiguity in the interpretation of these guidance documents, Powertech chose to collect 80 samples at 0-15 cm and supplementing the sampling effort with Global Positioning System (GPS)-based gamma radiation surveys. This sample size was determined to be adequate based on criteria in NUREG-1575. The GPS-based surveys allow orders of magnitude more data to be obtained with a similar effort. Owners of uranium recovery sites that have or are undergoing decommissioning are finding that extensive baseline data are invaluable. In conjunction with soil sampling and analysis and cross-reference to PIC measurements, the GPS-based gamma surveys can be used to predict site-wide concentrations of gamma-emitting radionuclides and/or exposure rates. Spatial trends in gamma emissions (and radionuclide concentrations as surrogates) are also far more apparent through the use of GPS-based gamma surveys than soil sampling alone. As will be shown below, reliance on a random soil sampling program alone would not have identified elevated areas of radioactivity at the site.

Main Permit and Surface Mine Areas

The soil sampling strategy for the main permit and surface mine areas of the project site consisted of biased and random sampling at the eight AMS locations shown in Figure 6.1-9 (this figure also shows the locations of the radon flux and track etch detector measurements, discussed below) and 80 additional locations shown in Figure 6.1-10. Biased samples were collected at five of the 80 locations; the remainder was placed randomly, using Visual Sampling Plan (VSP), Version 5.0. The biased samples were obtained in the surface mine area and selected to bound the upper range of radionuclide concentrations. The five biased samples are not sufficient to characterize radium-226 concentrations in impacted areas.

The additional 80 surface soil samples were collected from 0-15 cm below ground surface. Seventy-one of these samples were collected using a hand shovel. A hand auger was used to collect samples at 0-15, 15-30, and 30-100 cm at nine of the 80 locations. All of the soil samples were analyzed for radium-226. Ten of the 80 samples were also analyzed for natural uranium, lead-210, and thorium-230. Thirteen duplicate samples were collected: 11 with the surface set and 2 with the subsurface set. All duplicate samples were analyzed for radium-226 while two were also analyzed for natural uranium, thorium-230, and lead-210. The analytes and corresponding analytical methods were:

- Radium-226 via gamma spectroscopy or radon emanation: EPA Methods 901.1 and 903.1, respectively. *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA/600/4-80-032), August 1980. The majority of radium-226 analyses were performed using EPA Method 901.1.

- Thorium-230: EPA 907.0 *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA/600/4-80-032), August 1980.

- Natural Uranium: EPA 6020 ICP-MS, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846), June 2007

- Lead-210: EPA 909.0M *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA/600/4-80-032), 1980.

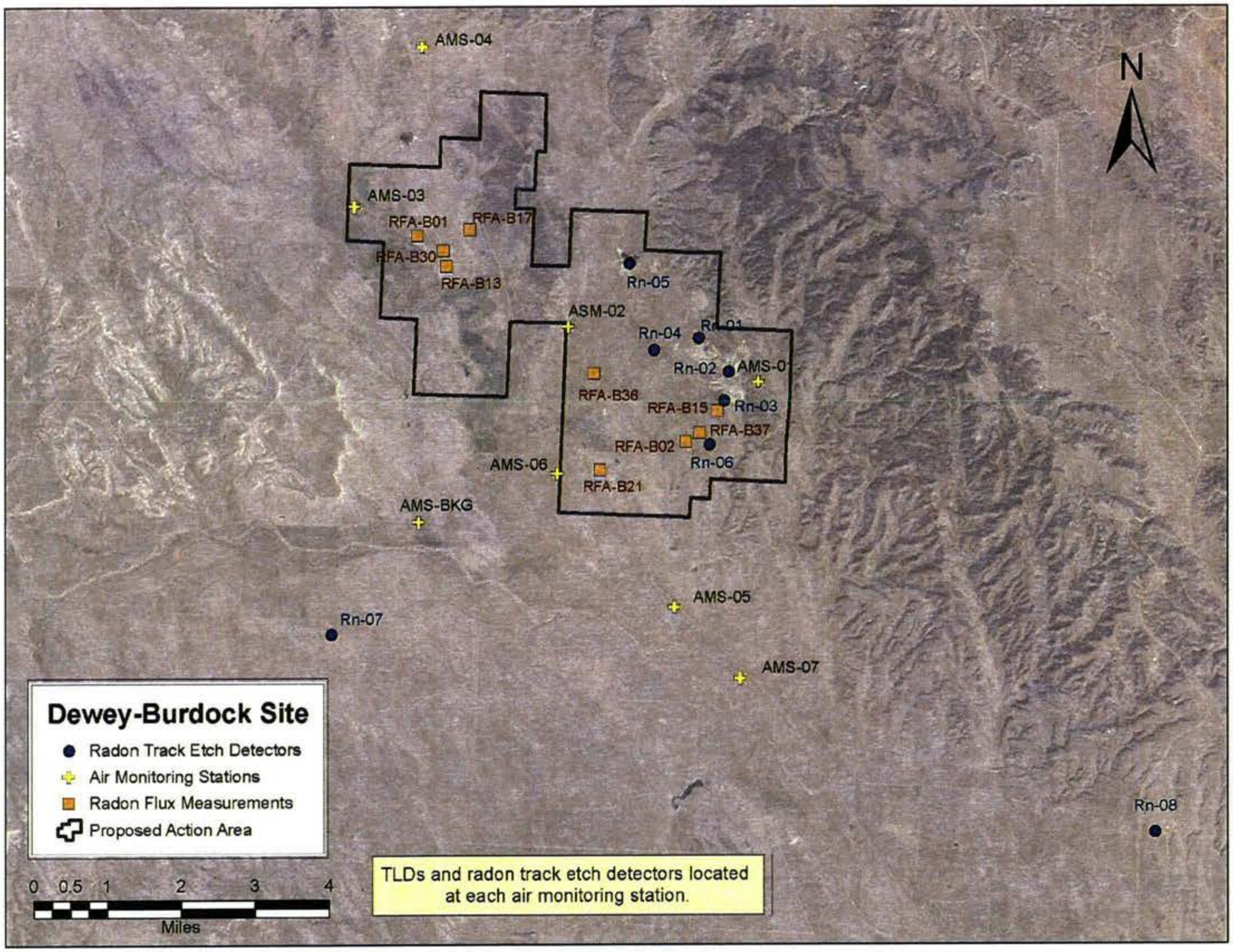

Figure 6.1-9: Air Monitoring Station, Ambient Radon, and Radon Flux Measurement Locations

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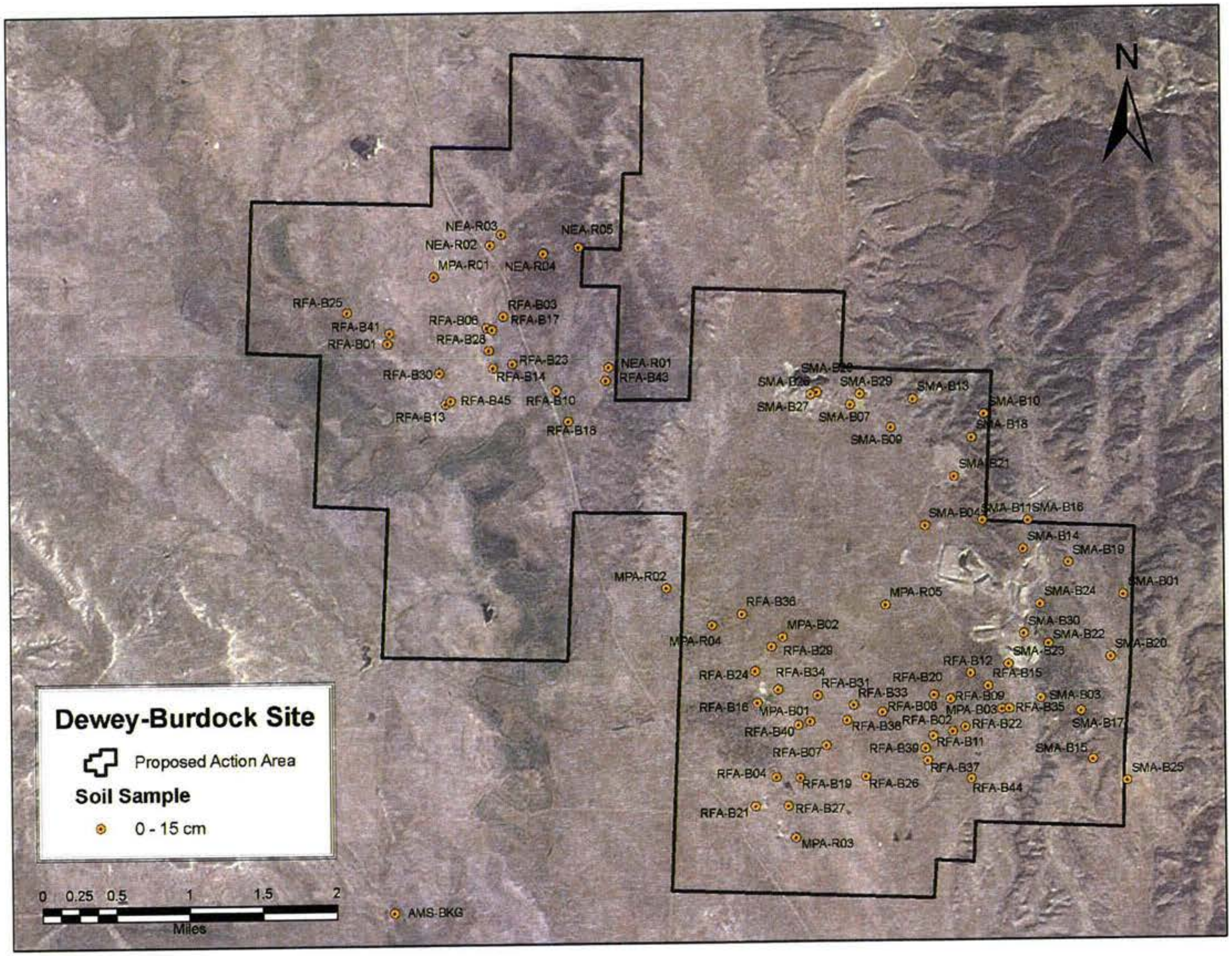

Figure 6.1-10: Surface Soil Sample Locations (80 Locations)

Land Application Areas

To characterize baseline radionuclide concentrations in soils in the land application areas, samples were collected at 17 locations, 10 in the northern and 7 in the southern area, from three intervals: 0-15, 15-30, and 30-100 cm. Refusal was encountered at 10 inches below ground surface (bgs) in LAN-008 and the lower interval was not collected. The sample locations, selected randomly using VSP Version 5.0, are shown on Figure 6.1-11. The samples were analyzed for radium-226, natural uranium, thorium-230, and lead-210.

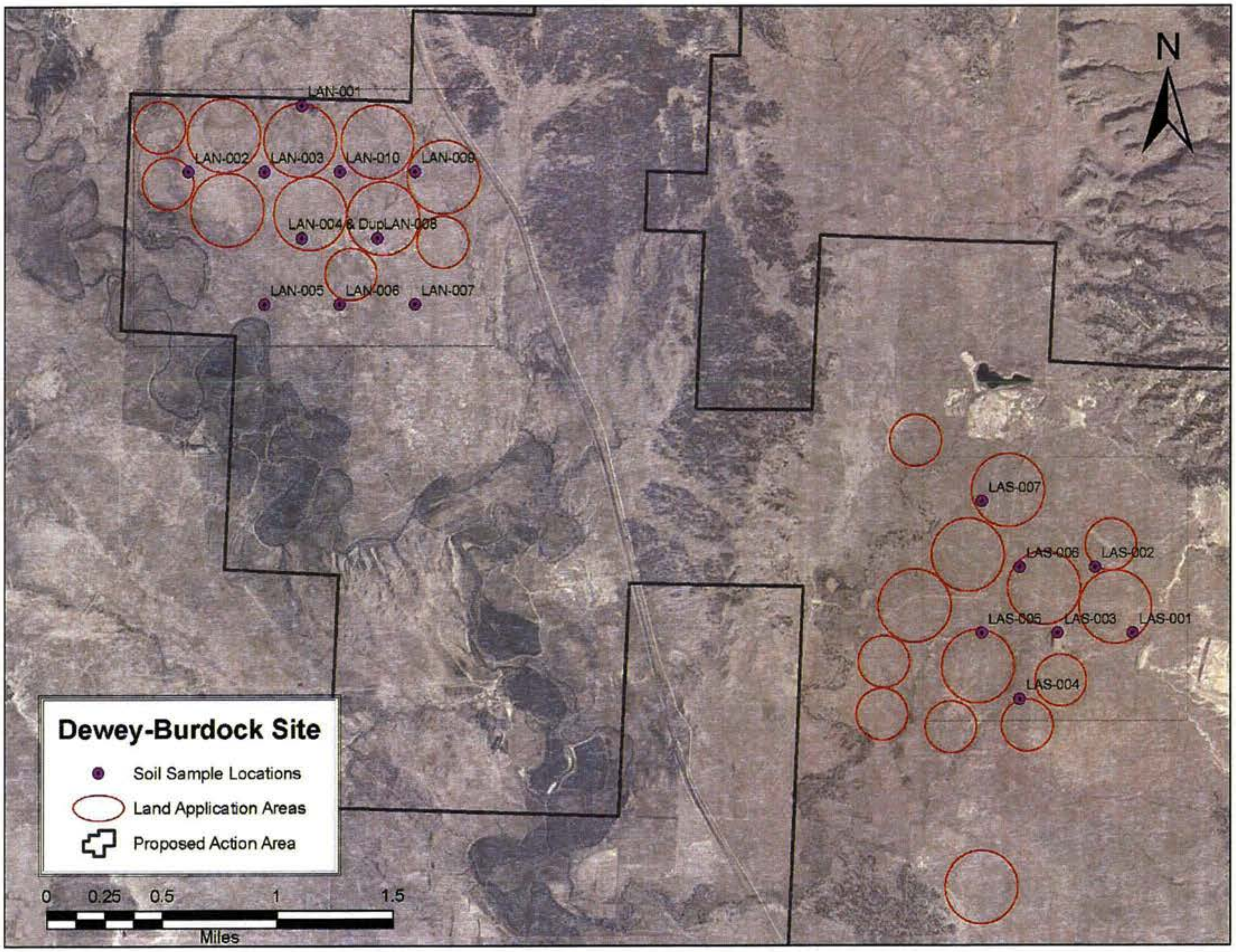

Figure 6.1-11: Soil Sample Locations in Land Application Areas

6.1.3.2 Soil Sampling Results

Table 6.1-5 presents the radium-226 concentrations in the soil samples collected in the main permit, surface mine, and land application areas. The results described in this section are those determined using only EPA Method 901.1. The laboratory analytical data reports are provided in Appendix B of Appendix 6.1-A.

Samples are identified as follows, with duplicates labeled as "dup":

- AMS: air monitoring station
- SMA: surface mine area
- MPA: main
- NEA: northeast area
- RFA: roll front area
- LAN: land application area north (Dewey)
- LAS: land application south (Burdock)

Table 6.1-5: Radionuclide Concentrations in All Soil Samples

Sample ID	Date Collected	Depth (cm)	1-minute Gamma-Ray Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)
AMS-1	9/27/2007	0-5	-	9.6E-07	2.0E-06	3.0E-07	4.0E-07	1.0E-07	1.4E-06	2.0E-07
AMS-2	9/27/2007	0-5	-	9.5E-07	3.0E-06	3.0E-07	5.0E-07	1.0E-07	1.1E-06	2.0E-07
AMS-3	9/27/2007	0-5	-	8.2E-07	2.0E-06	2.0E-07	4.0E-07	1.0E-07	1.5E-06	2.0E-07
AMS-4	9/27/2007	0-5	-	1.4E-06	2.0E-06	2.0E-07	8.0E-07	2.0E-07	1.5E-06	3.0E-07
AMS-5	9/27/2007	0-5	-	6.8E-07	2.0E-06	2.0E-07	6.0E-07	1.0E-07	1.3E-06	3.0E-07
AMS-6	9/27/2007	0-5	-	5.5E-07	1.0E-06	2.0E-07	4.0E-07	1.0E-07	8.0E-07	2.0E-07
AMS-7	9/27/2007	0-5	-	5.8E-07	2.0E-06	2.0E-07	3.0E-07	8.0E-08	1.1E-06	2.0E-07
AMS-BKG	9/27/2007	0-5	-	1.9E-06	2.0E-06	2.0E-07	9.0E-07	1.0E-07	2.4E-06	4.0E-07
MPA-B01	9/25/2007	0-15	13824	-	-	-	-	-	1.4E-06	3.0E-07
MPA-B02	9/25/2007	0-15	14176	-	-	-	-	-	1.1E-06	2.0E-07
MPA-B03	9/25/2007	0-15	13006	-	-	-	-	-	1.3E-06	3.0E-07
MPA-R01	9/24/2007	0-15	13749	-	-	-	-	-	1.4E-06	2.0E-07
MPA-R02	9/24/2007	0-15	16059	-	-	-	-	-	2.6E-06	3.0E-07
MPA-R03	9/24/2007	0-15	10796	7.5E-07	7.0E-07	1.0E-07	4.0E-07	1.0E-07	1.1E-06	2.0E-07
MPA-R04	9/24/2007	0-15	10810	-	-	-	-	-	9.0E-07	2.0E-07
MPA-R04-Dup	9/24/2007	0-15	-	-	-	-	-	-	8.0E-07	2.0E-07
MPA-R05	9/24/2007	0-15	11850	-	-	-	-	-	1.2E-06	2.0E-07
NEA-R01	9/24/2007	0-15	12302	9.1E-07	7.0E-07	2.0E-07	6.0E-07	1.0E-07	1.1E-06	2.0E-07
NEA-R02	9/24/2007	0-15	13176	-	-	-	-	-	1.3E-06	2.0E-07
NEA-R03	9/24/2007	0-15	16393	-	-	-	-	-	2.2E-06	3.0E-07
NEA-R04	9/24/2007	0-15	17356	-	-	-	-	-	2.3E-06	3.0E-07
NEA-R04-Dup	9/24/2007	0-15	-	-	-	-	-	-	2.5E-06	3.0E-07
NEA-R05	9/24/2007	0-15	17269	-	-	-	-	-	2.8E-06	3.0E-07
RFA-B01A	9/26/2007	0-15	13115	8.7E-07	1.0E-06	2.0E-07	7.0E-07	1.0E-07	1.2E-06	2.0E-07
RFA-B01A-Dup	9/26/2007	0-15	-	9.0E-07	8.0E-07	1.0E-07	7.0E-07	1.0E-07	1.1E-06	2.0E-07
RFA-B02A	9/26/2007	0-15	13360	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B03	9/25/2007	0-15	14253	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B04	9/25/2007	0-15	13963	-	-	-	-	-	1.5E-06	3.0E-07
RFA-B06	9/25/2007	0-15	13819	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B07	9/25/2007	0-15	12700	-	-	-	-	-	1.7E-06	2.0E-07
RFA-B08	9/25/2007	0-15	13433	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B08-Dup	9/25/2007	0-15	13528	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B09	9/25/2007	0-15	14825	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B10	9/25/2007	0-15	13366	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B11	9/25/2007	0-15	14253	8.8E-07	1.0E-06	2.0E-07	5.0E-07	1.0E-07	1.8E-06	3.0E-07
RFA-B12	9/25/2007	0-15	13135	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B13A	9/26/2007	0-15	13987	-	-	-	-	-	1.8E-06	3.0E-07
RFA-B02A	9/26/2007	0-15	13360	-	-	-	-	-	1.6E-06	2.0E-07
RFA-B14	9/25/2007	0-15	13872	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B15A	9/26/2007	0-15	13535	-	-	-	-	-	1.4E-06	3.0E-07
RFA-B16	9/25/2007	0-15	13675	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B17A	9/26/2007	0-15	16283	-	-	-	-	-	2.0E-06	3.0E-07

Table 6.1-5: Radionuclide Concentrations in All Soil Samples

Sample ID	Date Collected	Depth (cm)	1-minute Gamma-Ray Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)
RFA-B19	9/25/2007	0-15	13689	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B20	9/25/2007	0-15	13113	8.8E-07	1.0E-06	2.0E-07	5.0E-07	1.0E-07	1.3E-06	3.0E-07
RFA-B21A	9/26/2007	0-15	16641	-	-	-	-	-	5.6E-06	4.0E-07
RFA-B22	9/25/2007	0-15	14087	-	-	-	-	-	1.5E-06	2.0E-07
RFA-B23	9/25/2007	0-15	19674	-	-	-	-	-	3.6E-06	4.0E-07
RFA-B24	9/25/2007	0-15	12766	-	-	-	-	-	1.3E-06	2.0E-07
RFA-B25	9/25/2007	0-15	10300	6.7E-07	1.0E-06	2.0E-07	4.0E-07	1.0E-07	1.2E-06	2.0E-07
RFA-B26	9/25/2007	0-15	11791	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B27	9/25/2007	0-15	13794	-	-	-	-	-	1.5E-06	2.0E-07
RFA-B28	9/25/2007	0-15	15246	-	-	-	-	-	2.4E-06	3.0E-07
RFA-B28-Dup	9/25/2007	0-15	-	-	-	-	-	-	1.8E-06	3.0E-07
RFA-B29	9/25/2007	0-15	14345	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B30A	9/26/2007	0-15	12461	-	-	-	-	-	1.8E-06	2.0E-07
RFA-B31	9/25/2007	0-15	12221	-	-	-	-	-	1.3E-06	2.0E-07
RFA-B33	9/25/2007	0-15	13221	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B34	9/25/2007	0-15	13408	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B35	9/25/2007	0-15	12290	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B36A	9/25/2007	0-15	12465	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B37A	9/26/2007	0-15	11170	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B38	9/25/2007	0-15	11852	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B39	9/25/2007	0-15	11478	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B40	9/25/2007	0-15	12629	5.6E-07	1.0E-06	2.0E-07	3.0E-07	1.0E-07	1.1E-06	2.0E-07
RFA-B41	9/25/2007	0-15	11806	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B43	9/25/2007	0-15	13264	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B44	9/25/2007	0-15	11436	-	-	-	-	-	1.4E-06	2.0E-07
RFA-B45	9/25/2007	0-15	12242	-	-	-	-	-	1.6E-06	3.0E-07
SMA-B01	9/24/2007	0-15	10459	1.2E-06	6.0E-07	1.0E-07	5.0E-07	1.0E-07	9.0E-07	2.0E-07
SMA-B01-Dup	9/24/2007	0-15	-	1.5E-06	2.0E-06	2.0E-07	6.0E-07	1.0E-07	1.4E-06	3.0E-07
SMA-B03	9/24/2007	0-15	22410	-	-	-	-	-	1.5E-06	2.0E-07
SMA-B04	9/24/2007	0-15	15263	-	-	-	-	-	1.0E-06	2.0E-07
SMA-B07	9/24/2007	0-15	22925	-	-	-	-	-	3.2E-06	3.0E-07

Table 6.1-5: Radionuclide Concentrations in All Soil Samples

Sample ID	Date Collected	Depth (cm)	1-minute Gamma-Ray Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)
SMA-B09	9/24/2007	0-15	12879	-	-	-	-	-	1.2E-06	2.0E-07
SMA-B09-Dup	9/24/2007	0-15	-	-	-	-	-	-	1.7E-06	2.0E-07
SMA-B10	9/25/2007	0-15	13184	-	-	-	-	-	1.4E-06	2.0E-07
SMA-B11	9/24/2007	0-15	17346	-	-	-	-	-	2.3E-06	3.0E-07
SMA-B13	9/25/2007	0-15	13252	-	-	-	-	-	1.7E-06	3.0E-07
SMA-B14	9/24/2007	0-15	14483	-	-	-	-	-	1.4E-06	3.0E-07
SMA-B14-Dup	9/24/2007	0-15	-	-	-	-	-	-	1.6E-06	2.0E-07
SMA-B15	9/24/2007	0-15	8474	-	-	-	-	-	8.0E-07	2.0E-07
SMA-B16	9/24/2007	0-15	10235	-	-	-	-	-	9.0E-07	2.0E-07
SMA-B17	9/24/2007	0-15	10139	-	-	-	-	-	1.0E-06	2.0E-07
SMA-B18	9/25/2007	0-15	8511	-	-	-	-	-	5.0E-07	1.0E-07
SMA-B18-Dup	9/25/2007	0-15	-	-	-	-	-	-	4.0E-07	1.0E-07
SMA-B19	9/24/2007	0-15	10074	-	-	-	-	-	1.2E-06	2.0E-07
SMA-B20	9/27/2007	0-15	10897	-	-	-	-	-	9.0E-07	2.0E-07
SMA-B21	9/24/2007	0-15	16712	-	-	-	-	-	1.4E-06	2.0E-07
SMA-B22	9/24/2007	0-15	10618	-	-	-	-	-	8.0E-07	2.0E-07
SMA-B23	9/24/2007	0-15	16233	-	-	-	-	-	2.7E-06	3.0E-07
SMA-B23-Dup	9/24/2007	0-15	-	-	-	-	-	-	2.8E-06	3.0E-07
SMA-B24	9/24/2007	0-15	12662	-	-	-	-	-	1.3E-06	2.0E-07
SMA-B25	9/24/2007	0-15	9991	-	-	-	-	-	1.0E-06	2.0E-07
SMA-B26	9/28/2007	0-15	73243	-	-	-	-	-	1.1E-05	5.0E-07
SMA-B27	9/28/2007	0-15	130293	6.7E-05	3.0E-05	8.0E-07	3.0E-05	8.0E-07	4.0E-05	1.1E-06
SMA-B28	9/29/2007	0-15	39061	-	-	-	-	-	6.4E-06	4.0E-07
SMA-B29	9/28/2007	0-15	231041	1.6E-05	2.0E-05	7.0E-07	2.0E-05	6.0E-07	2.9E-05	9.0E-07
SMA-B30	9/28/2007	0-15	89139	-	-	-	-	-	3.4E-05	9.0E-07
LAN 001A	7/18/2008	0-15	-	1.8E-06	2.4E-06	2.3E-06	1.2E-06	6.0E-07	8.0E-07	9.0E-08
LAN 002A	7/18/2008	0-15	-	8.6E-07	3.4E-06	2.3E-06	9.0E-07	5.0E-07	9.0E-07	1.0E-07
LAN 003A	7/18/2008	0-15	-	7.8E-07	8.0E-07	2.2E-06	7.0E-07	6.0E-07	1.2E-06	1.0E-07
LAN 004A	7/18/2008	0-15	-	6.9E-07	1.0E-06	1.4E-06	6.0E-07	6.0E-07	1.9E-06	2.0E-07
LAN 004A-DUP	7/18/2008	0-15	-	7.2E-07	5.0E-07	1.4E-06	4.0E-07	3.0E-07	7.0E-07	1.0E-07
LAN 005A	7/18/2008	0-15	-	8.4E-07	1.2E-06	1.4E-06	9.0E-07	5.0E-07	4.4E-06	3.0E-07
LAN 006A	7/18/2008	0-15	-	7.1E-07	-5.0E-09	1.4E-06	3.0E-07	5.0E-07	1.1E-06	1.0E-07
LAN 007A	7/18/2008	0-15	-	8.1E-07	6.0E-07	1.4E-06	3.0E-07	5.0E-07	7.0E-07	1.0E-07
LAN 008A	7/18/2008	0-15	-	2.1E-06	1.0E-06	1.4E-06	1.0E-06	7.0E-07	9.0E-07	1.0E-07
LAN 009A	7/18/2008	0-15	-	1.1E-06	-4.0E-07	1.4E-06	3.0E-07	6.0E-07	8.0E-07	1.0E-07
LAN 010A	7/18/2008	0-15	-	1.6E-06	1.8E-06	1.2E-06	1.2E-06	6.0E-07	1.2E-06	2.0E-07
LAS 001A	7/19/2008	0-15	-	1.2E-06	1.6E-06	1.2E-06	6.0E-07	5.0E-07	9.0E-07	1.0E-07
LAS 002A	7/19/2008	0-15	-	4.8E-07	1.4E-06	1.2E-06	1.0E-07	5.0E-07	7.0E-07	1.0E-07

Table 6.1-5: Radionuclide Concentrations in All Soil Samples

Sample ID	Date Collected	Depth (cm)	1-minute Gamma-Ray Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)
LAS 003A	7/19/2008	0-15	-	5.0E-07	1.4E-06	1.2E-06	3.0E-07	4.0E-07	7.0E-07	1.0E-07
LAS 004A	7/19/2008	0-15	-	1.1E-06	1.2E-06	1.2E-06	6.0E-07	5.0E-07	8.0E-07	1.0E-07
LAS 005A	7/19/2008	0-15	-	1.2E-06	1.6E-06	1.2E-06	4.0E-07	3.0E-07	9.0E-07	1.0E-07
LAS 006A	7/19/2008	0-15	-	3.7E-07	7.0E-07	1.1E-06	6.0E-07	6.0E-07	7.0E-07	1.0E-07
LAS 007A	7/19/2008	0-15	-	4.3E-07	6.0E-07	1.5E-06	6.0E-07	1.0E-07	8.0E-07	1.0E-07
RFA-B01B	9/26/2007	15-30	13115	1.1E-06	2.0E-06	2.0E-07	9.0E-01	2.0E-01	1.7E-06	2.0E-07
RFA-B01B-Dup	9/26/2007	15-30	-	9.9E-07	9.0E-07	2.0E-07	9.0E-01	2.0E-01	1.5E-06	2.0E-07
RFA-B02B	9/26/2007	15-30	-	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B13B	9/26/2007	15-30	-	-	-	-	-	-	1.8E-06	2.0E-07
RFA-B15B	9/26/2007	15-30	-	-	-	-	-	-	1.5E-06	2.0E-07
RFA-B17B	9/26/2007	15-30	-	-	-	-	-	-	2.2E-06	3.0E-07
RFA-B21B	9/26/2007	15-30	-	-	-	-	-	-	1.3E-06	2.0E-07
RFA-B30B	9/26/2007	15-30	-	-	-	-	-	-	2.1E-06	3.0E-07
RFA-B36B	9/26/2007	15-30	-	-	-	-	-	-	1.1E-06	2.0E-07
RFA-B37B	9/26/2007	15-30	-	-	-	-	-	-	7.0E-07	2.0E-07
LAN 001B	7/18/2008	15-30	-	1.9E-06	4.6E-06	2.3E-06	1.4E-06	6.0E-07	8.0E-07	1.0E-07
LAN 002B	7/18/2008	15-30	-	7.5E-07	1.5E-06	2.3E-06	4.0E-07	4.0E-07	1.0E-06	1.0E-07
LAN 003B	7/18/2008	15-30	-	1.1E-06	2.4E-06	2.3E-06	8.0E-07	5.0E-07	1.2E-06	1.0E-07
LAN 004B	7/18/2008	15-30	-	7.9E-07	2.2E-06	1.4E-06	2.0E-07	5.0E-07	1.3E-06	2.0E-07
LAN 004B-DUP	7/18/2008	15-30	-	6.8E-07	-3.0E-07	1.4E-06	5.0E-07	4.0E-07	7.0E-07	1.0E-07
LAN 005B	7/18/2008	15-30	-	7.1E-07	9.0E-07	1.4E-06	6.0E-07	4.0E-07	1.6E-06	2.0E-07
LAN 006B	7/18/2008	15-30	-	7.5E-07	5.0E-07	1.4E-06	6.0E-07	4.0E-07	1.3E-06	1.0E-07
LAN 007B	7/18/2008	15-30	-	1.5E-06	6.0E-07	1.4E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07
LAN 008B	7/18/2008	15-30	-	3.5E-06	1.0E-07	1.4E-06	9.0E-07	7.0E-07	1.0E-06	1.0E-07
LAN 009B	7/18/2008	15-30	-	1.8E-06	-3.0E-07	1.4E-06	7.0E-07	5.0E-07	4.1E-06	3.0E-07
LAN 010B	7/18/2008	15-30	-	1.5E-06	1.1E-06	1.1E-06	7.9E-06	1.2E-06	1.4E-06	2.0E-07
LAS 001B	7/19/2008	15-30	-	8.6E-07	1.1E-06	1.2E-06	4.0E-07	5.0E-07	8.0E-07	1.0E-07
LAS 002B	7/19/2008	15-30	-	7.1E-07	7.0E-07	1.2E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07
LAS 003B	7/19/2008	15-30	-	1.2E-06	1.1E-06	1.1E-06	5.0E-07	4.0E-07	9.0E-07	1.0E-07
LAS 004B	7/19/2008	15-30	-	9.5E-07	1.3E-06	1.2E-06	5.0E-07	4.0E-07	8.0E-07	1.0E-07
LAS 005B	7/19/2008	15-30	-	1.6E-06	1.4E-06	1.1E-06	4.0E-07	4.0E-07	1.0E-06	2.0E-07
LAS 006B	7/19/2008	15-30	-	4.8E-07	1.4E-06	1.2E-06	3.0E-07	4.0E-07	7.0E-07	1.0E-07
LAS 007B	7/19/2008	15-30	-	4.5E-07	6.0E-07	1.5E-06	6.0E-07	1.0E-07	7.0E-07	1.0E-07
LAN 008B	7/18/2008	15-30	-	3.5E-06	1.0E-07	1.4E-06	9.0E-07	7.0E-07	1.0E-06	1.0E-07
LAN 009B	7/18/2008	15-30	-	1.8E-06	-3.0E-07	1.4E-06	7.0E-07	5.0E-07	4.1E-06	3.0E-07
LAN 010B	7/18/2008	15-30	-	1.5E-06	1.1E-06	1.1E-06	7.9E-06	1.2E-06	1.4E-06	2.0E-07
LAS 001B	7/19/2008	15-30	-	8.6E-07	1.1E-06	1.2E-06	4.0E-07	5.0E-07	8.0E-07	1.0E-07

Table 6.1-5: Radionuclide Concentrations in All Soil Samples

Sample ID	Date Collected	Depth (cm)	1-minute Gamma-Ray Count Rate (cpm)	U-nat (µCi/g)	Pb-210 (µCi/g)	Pb-210 Error (µCi/g)	Th-230 (µCi/g)	Th-230 Error (µCi/g)	Ra-226 (µCi/g)	Ra-226 Error (µCi/g)
LAS 002B	7/19/2008	15-30	-	7.1E-07	7.0E-07	1.2E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07
LAS 003B	7/19/2008	15-30	-	1.2E-06	1.1E-06	1.1E-06	5.0E-07	4.0E-07	9.0E-07	1.0E-07
LAS 004B	7/19/2008	15-30	-	9.5E-07	1.3E-06	1.2E-06	5.0E-07	4.0E-07	8.0E-07	1.0E-07
LAS 005B	7/19/2008	15-30	-	1.6E-06	1.4E-06	1.1E-06	4.0E-07	4.0E-07	1.0E-06	2.0E-07
LAS 006B	7/19/2008	15-30	-	4.8E-07	1.4E-06	1.2E-06	3.0E-07	4.0E-07	7.0E-07	1.0E-07
LAS 007B	7/19/2008	15-30	-	4.5E-07	6.0E-07	1.5E-06	6.0E-07	1.0E-07	7.0E-07	1.0E-07
RFA-B01C	9/26/2007	30-100	-	1.5E-06	6.0E-07	1.0E-07	8.0E-01	1.0E-01	1.2E-06	2.0E-07
RFA-B01C-Dup	9/29/2007	30-100	-	1.3E-06	1.0E-06	2.0E-07	1.0E+00	2.0E-01	1.7E-06	3.0E-07
RFA-B02C	9/26/2007	30-100	-	-	-	-	-	-	9.0E-07	2.0E-07
RFA-B13C	9/26/2007	30-100	-	-	-	-	-	-	1.6E-06	2.0E-07
RFA-B15C	9/26/2007	30-100	-	-	-	-	-	-	1.5E-06	3.0E-07
RFA-B17C	9/26/2007	30-100	-	-	-	-	-	-	2.5E-06	3.0E-07
RFA-B21C	9/26/2007	30-100	-	-	-	-	-	-	1.2E-06	2.0E-07
RFA-B30C	9/26/2007	30-100	-	-	-	-	-	-	1.7E-06	3.0E-07
RFA-B36C	9/26/2007	30-100	-	-	-	-	-	-	1.0E-06	2.0E-07
RFA-B37C	9/26/2007	30-100	-	-	-	-	-	-	1.1E-06	2.0E-07
LAN 001C	7/18/2008	30-100	-	1.9E-06	1.9E-06	2.2E-06	1.6E-06	7.0E-07	9.0E-07	1.0E-07
LAN 002C	7/18/2008	30-100	-	1.5E-06	1.1E-06	2.2E-06	3.0E-07	3.0E-07	1.2E-06	1.0E-07
LAN 003C	7/18/2008	30-100	-	2.0E-06	2.6E-06	2.3E-06	6.0E-07	3.0E-07	1.0E-06	1.0E-07
LAN 004C	7/18/2008	30-100	-	1.5E-06	8.0E-07	1.4E-06	7.0E-07	5.0E-07	1.0E-06	1.0E-07
LAN 004C-DUP	7/18/2008	30-100	-	1.3E-06	1.2E-06	1.4E-06	5.0E-07	4.0E-07	8.0E-07	1.0E-07
LAN 005C	7/18/2008	30-100	-	7.1E-07	6.0E-07	1.4E-06	5.0E-07	4.0E-07	1.5E-06	2.0E-07
LAN 006C	7/18/2008	30-100	-	1.1E-06	7.0E-07	1.4E-06	5.0E-07	3.0E-07	1.4E-06	2.0E-07
LAN 007C	7/18/2008	30-100	-	2.5E-06	1.0E-07	1.4E-06	8.0E-07	6.0E-07	4.0E-07	1.0E-07
LAN 009C	7/18/2008	30-100	-	1.6E-06	5.0E-07	1.4E-06	1.1E-06	6.0E-07	3.9E-06	3.0E-07
LAN 010C	7/18/2008	30-100	-	2.7E-06	1.9E-06	1.2E-06	1.9E-06	8.0E-07	1.5E-06	2.0E-07
LAS 001C	7/19/2008	30-100	-	6.1E-07	9.0E-07	1.1E-06	1.0E-07	3.0E-07	8.0E-07	1.0E-07
LAS 002C	7/19/2008	30-100	-	6.3E-07	4.0E-07	1.1E-06	4.0E-07	4.0E-07	7.0E-07	1.0E-07
LAS 003C	7/19/2008	30-100	-	9.3E-07	7.0E-07	1.2E-06	1.0E-06	5.0E-07	8.0E-07	1.0E-07
LAS 004C	7/19/2008	30-100	-	1.3E-06	1.2E-06	1.1E-06	5.0E-07	3.0E-07	9.0E-07	1.0E-07
LAS 005C	7/19/2008	30-100	-	9.8E-07	1.2E-06	1.1E-06	7.0E-07	5.0E-07	1.1E-06	2.0E-07
LAS 006C	7/19/2008	30-100	-	6.5E-07	-3.0E-07	1.5E-06	3.0E-07	9.0E-08	6.0E-07	1.0E-07
LAS 007C	7/19/2008	30-100	-	7.2E-07	-7.0E-07	1.5E-06	5.0E-07	1.0E-07	7.0E-07	1.0E-07

Notes:
All errors reported are ± 2σ.

6.1.3.2.1 Surface Soil Sample Results

Radium-226 Concentrations in the First Set of 80 Locations

In the set of 80 surface samples, the mean and median radium-226 concentrations are 2.9 and 1.3 pCi/g, respectively. Q1 and Q3 are 1.1 and 1.7 pCi/g, respectively. The IQR is 0.6. The mode is 1.1 pCi/g (12 observations). One result (0.45 pCi/g, Sample Location SMA-18) was a low outlier. Thirteen values exceeded 2.3 pCi/g, the cutoff for high outliers.

The soil data were fitted to normal and lognormal distributions. The p-values for both distributions are less than 0.005, indicating that at a 95 percent confidence level ($p = 0.05$), the distributions are non-normal and non-lognormal.

Considering that the data do not fit normal or lognormal distributions, and clear differences in the gamma-ray count rates obtained in the surface mine and main PAAs are indicative of differences in the levels of gamma-emitting radionuclides therein, the set of surface soil data was divided into surface mine and main PAA subsets, as discussed in the following sections.

Radium-226 Concentrations in the Surface Mine Area

Twenty-five surface soil samples were collected in the surface mine area. The data did not fit a parametric distribution. The median radium-226 concentration was 1.4 pCi/g. Five of the concentrations were outliers, exceeding a cutoff (1.5 times Q3) of 5.9 pCi/g. The outliers are the radium-226 concentrations in the five biased samples, all collected in the surface mine area.

The data set with the outliers removed fit a lognormal distribution. The central tendency and variability of a lognormal distribution are best represented by the geometric mean and geometric standard deviation, each of which is 1.3 pCi/g radium-226 in the case of the surface mine area data set. The data lie within a population range of 0.76 to 2.2 pCi/g.

Radium-226 Concentrations in the Main Area

Fifty-five surface soil samples were collected in the main PAA. The data did not fit a parametric distribution. The median radium-226 concentration was 1.3 pCi/g. Three of the concentrations were outliers, exceeding a cutoff (1.5 times Q3) of 2.6 pCi/g.

The data set with the outliers removed fit a lognormal distribution. The geometric mean and geometric standard deviation of the set of main PAA radium-226 concentrations are each 1.3 pCi/g. The data lie within a population range of 0.76 to 2.2 pCi/g.

Radium-226 Concentrations in the North Section of Main PAA

It was stated above that elevated gamma-ray count rates were observed in an approximately 600-acre area located at the north end of the main PAA. Considering that the elevated levels are likely due to relatively higher increased levels of one or more gamma-emitting radionuclides, radium-226 concentrations in soil samples collected from this area were evaluated.

Eight surface soil samples were collected in this area (MPA-R01, NEA-R02, NEA-R03, NEA-R04, NEA-R05, RFA-03, RFA-06, and RFA-17). One of these samples was considered an outlier of the main PAA data set (NEA-R05).

There are too few soil samples collected in this area to characterize it statistically. However, the gamma-ray count rates therein differ from the main PAA, with statistical significance.

Radium-226 Concentrations in the Proposed Land Application Areas

Radium-226 concentrations in surface soils in the land application areas are summarized as follows:

- Averaged 1.1 pCi/g and ranged from 0.7 to 4.4 pCi/g in both areas
- Averaged 1.3 pCi/g in the Dewey land application area
- Averaged 0.8 pCi/g in the Burdock land application area

The concentrations of surrogate radionuclides, uranium, lead-210, and thorium-230 concentrations are consistently lower in the Burdock than in the Proposed Dewey Land Application Area, indicating that the lower radium-226 concentration is not a laboratory artifact.

Discussion of Radium-226 Concentrations

Although the distributions of the main permit and surface mine area radium-226 concentration data sets are similar, the gamma-ray count rate distributions in these two areas differ, with statistical significance. The gamma-ray count rates observed in the anomalous portion of the main area also differ from the main area.

With outliers removed, both the surface mine and main area radium-226 concentration data sets fit a lognormal distribution. The geometric mean and geometric standard deviation of both data sets is 1.3 pCi/g. The data lie within a population range of 0.76 to 2.2 pCi/g. The mean of 1.3 pCi/g is representative of a general background value in the majority of the PAA surface soils. Exceptional areas include those in and around the artesian well discharge and historical open pit mines. At this time, radium-226 concentrations are not well characterized in the northern anomalous area in the main area and along the northwest edge of the surface mine area.

The range of radium-226 concentrations in the land application areas lies within the range of overall radium-226 concentrations, averaging 1.3 and 0.8 pCi/g in the Dewey and Burdock areas, respectively.

Other Radionuclides

Table 6.1-5 summarizes the analytical results for all samples analyzed for the extended suite of radiological parameters (all locations and depths combined). Although the sample number isn't sufficient to allow any definitive conclusions to be drawn regarding distributional characteristics or trends of non radium-226 parameters, a positive relationship between the concentrations of radium-226 and natural uranium, thorium-230, and lead-210 is apparent.

Limits of Detection

A summary of the results with respect to reporting limits and minimum detectable concentrations (MDCs) is as follows:

- The radium-226, lead-210, and thorium-230 lower limits of detection (LLD) (reported as MDCs or reporting limits) in the NEA, MPA, RFA, and SMA soil samples were all $1*10^{-7}$ µCi/g.
- The natural uranium LLDs in the NEA, MPA, RFA, and SMA samples ranged from $1.7*10^{-8}$ to $2.0*10^{-8}$ µCi/g.
- None of the results NEA, MPA, RFA, and SMA samples were below their respective LLDs.
- The lead-210 LLDs for the LAN and LAS samples ranged from $1.9*10^{-6}$ to $3.8*10^{-6}$ µCi/g. In all but one case, the lead-210 results were lower than their respective LLDs.

- The radium-226 LLDs for the LAN and LAS samples ranged from $4.0*10^{-8}$ to $1.0*10^{-7}$ μCi/g. All of the LAN and LAS results exceeded their respective LLDs.
- The thorium-230 LLD for the LAN and LAS samples was $1.0*10^{-7}$ μCi/g. Results for 17 of the 53 (surface and subsurface) samples were reported below $1.0*10^{-7}$ μCi/g.
- The natural uranium LLD for the LAN and LAS samples was $7.0*10^{-9}$ μCi/g. All of the results exceeded the LLD.

The LLD recommended in RG 4.14 for natural uranium, thorium-230, radium-226, and lead-210 in soils is $2*10^{-7}$ μCi/g. The only case for which the guidance was not followed was the LLD for lead-210 in the LAN and LAS samples.

6.1.3.2.2 Subsurface Soil Sample Results

Table 6.1-5 lists the subset of subsurface biased samples that were collected at depth in the project roll front areas: RFA-B01, RFA-B02 RFA-B13 RFA-B15, RFA-B17, RFA-B21, RFA-B30, RFA-B36, and RFA-B37. The table also lists results obtained in subsurface samples collected in the two land application areas: LAN-001 through LAN-009 and LAS-001 through LAS-007.

6.1.3.2.3 Data Uncertainty

This section briefly summarizes the results of the quality control (QC) samples collected for the baseline soil sampling program. The results of this QC effort are documented in Table 6.1-6, which lists the errors and LLDs for each duplicate pair. Table 6.1-6 documents associated comparisons, presenting the corresponding RPD (in the case of natural uranium) and/or Replicate Error Ratio (RER) for each QC pair. The calculation of RPDs and RERs is a standard technique used to evaluate laboratory precision.

The RPD is calculated as follows:

$$RPD = \frac{|A - B|}{\frac{A + B}{2}}$$

Where A and B are the sample and duplicate results, respectively.

The RER is calculated as follows:

$$RER = \frac{|S - R|}{\sqrt{(Sx0.15)^2 + (E_s)^2} + \sqrt{(Rx0.15)^2 + (E_R)^2}}$$

Where S and are the sample and duplicate concentrations, respectively. E_S and E_R are the sample (E_S) and duplicate errors (E_R). The factor of 0.15 accounts for any inherent systematic error which cannot be quantified. The acceptance criteria are an RPD and RER of less than 40 and 1 percent for data above the MDC, respectively, as established in a QAPP (ERG 2006). This data set shows four cases where the RER for lead-210 was greater than 1 and five cases where the RPD exceeded 40. There are three cases where the RER and RPD for radium-226 are exceeded (two concurrently).

Table 6.1-6: Quality Control Analysis for Soil Samples

		Relative Percent Difference (%)				Replicate Error Ratio		
Sample ID	**Depth (cm)**	**U-nat**	**Pb-210**	**Th-230**	**Ra-226**	**Pb-210**	**Th-230**	**Ra-226**
MPA-R04+Duplicate	0-15	-	-	-	11.8	-	-	0.2
NEA-R04+Duplicate	0-15	-	-	-	8.3	-	-	0.2
RFA-B01A+Duplicate	0-15	3.4	22.2	0.0	8.7	0.0	0.0	0.2
RFA-B01B+Duplicate	15-30	10.5	**75.9**	0.0	12.5	**1.8**	0.0	0.3
RFA-B01C+Duplicate	30-100	14.3	**50.0**	22.2	34.5	**1.0**	0.5	0.8
RFA-B08+Duplicate	0-15	-	-	-	0.0	-	-	0.0
RFA-B28+Duplicate	0-15	-	-	-	28.6	-	-	0.7
SMA-B01+Duplicate	0-15	22.2	**107.7**	18.2	**43.5**	**2.8**	0.4	0.8
SMA-B09+Duplicate	0-15	-	-	-	34.5	-	-	0.8
SMA-B14+Duplicate	0-15	-	-	-	13.3	-	-	0.3
SMA-B18+Duplicate	0-15	-	-	-	22.2	-	-	0.4
SMA-B23+Duplicate	0-15	-	-	-	3.6	-	-	0.1
LAN-004A+Duplicate	0-15	-4.3	**66.7**	40.0	**92.3**	0.5	0.6	**8.5**
LAN-004B+Duplicate	15-30	15.0	**263.2**	-85.7	**60.0**	**2.5**	0.9	**4.2**
LAN-004C+Duplicate	30-100	14.3	-40.0	33.3	22.2	0.4	0.6	**1.4**

Notes:
The radium-226, lead-210, and thorium-230 LLDs were all $1*10^{-7}$ µCi/g. All results are greater than 5 times their respective MDC, with the exception of radium-226 in Sample Location SMA-B18-Dup.
The natural uranium LLDs ranged from $1.7*10^{-8}$ to $2.0*10^{-8}$ µCi/g.
None of the results were below their respective LLDs.
Bolded values are anomalous QC results.

The consequences of one radium-226 and three lead-210 results exceeding the acceptance criteria are minimal since in each case the concentrations are low. In addition, lead-210 largely

has no impact when addressing the impact of the baseline radiological characteristics of the site and potential impacts from site operations.

There is close agreement for all other analytical results reported for each duplicate pair collected for all parameters. Overall, duplicate results are generally comparable for the majority of QC samples collected. Considering the low level of radioactivity observed in most of the QC pairs, the laboratory performance on blind duplicates is satisfactory.

6.1.3.3 Conclusions

Main permit and Surface Mine Areas

Main permit and surface mine areas' subsurface radium-226 concentrations, ranging from 0.7 to 5.6 pCi/g, are comparable to those observed in the 0-15 cm surface samples in the samples. There is no apparent trend with depth.

Land Application Areas

Subsurface concentrations in the land applications can be summarized as follows:

- Radium-226 concentrations range from 0.4 to 4.1 pCi/g, with a median of 0.9 pCi/g.
- Radium-226 concentrations in the project land application area have a median of 1.0 pCi/g.
- Radium-226 concentrations in the project land application area have a median of 0.8 pCi/g.

The subsurface results in both land application areas are comparable to those observed in the 0-15 cm surface samples. There is no apparent trend with depth.

6.1.4 Sediment Sampling

In June and August of 2008, baseline sediment sampling was conducted at the proposed project site in accordance with NRC Regulatory Guide 4.14 (NRC, 1980), which requires stream sediment samples during both seasonal runoff and low-flow conditions and one sediment sample at each impoundment to characterize radionuclide content. Stream sediment samples were collected at the same locations at which surface water quality sampling sites were located: upstream and downstream sites on Pass Creek, Beaver Creek, and the Cheyenne River, and one site on each of two ephemeral drainages located within the proposed project boundary.

Impoundment sediment samples were collected in the same impoundments at which surface water chemistry was sampled. Figure 6.1-12 and Table 6.1-7 provide sediment sampling locations.

Stream sediment samples were collected upstream and downstream sites on three primary streams (Pass Creek, Beaver Creek, and the Cheyenne River) and sites on two other ephemeral drainages.

Sediment samples were collected in June 2008 from 11 surface water impoundments located in the area. Impoundments primarily consist of stockponds but also include historical open pit mines within the proposed permit boundary. At the time of sampling, the majority of subimpoundments had water present. As indicated by NRC Regulatory Guide 4.14, a one-time sampling event is sufficient to document radiological conditions of surface water impoundment sediments.

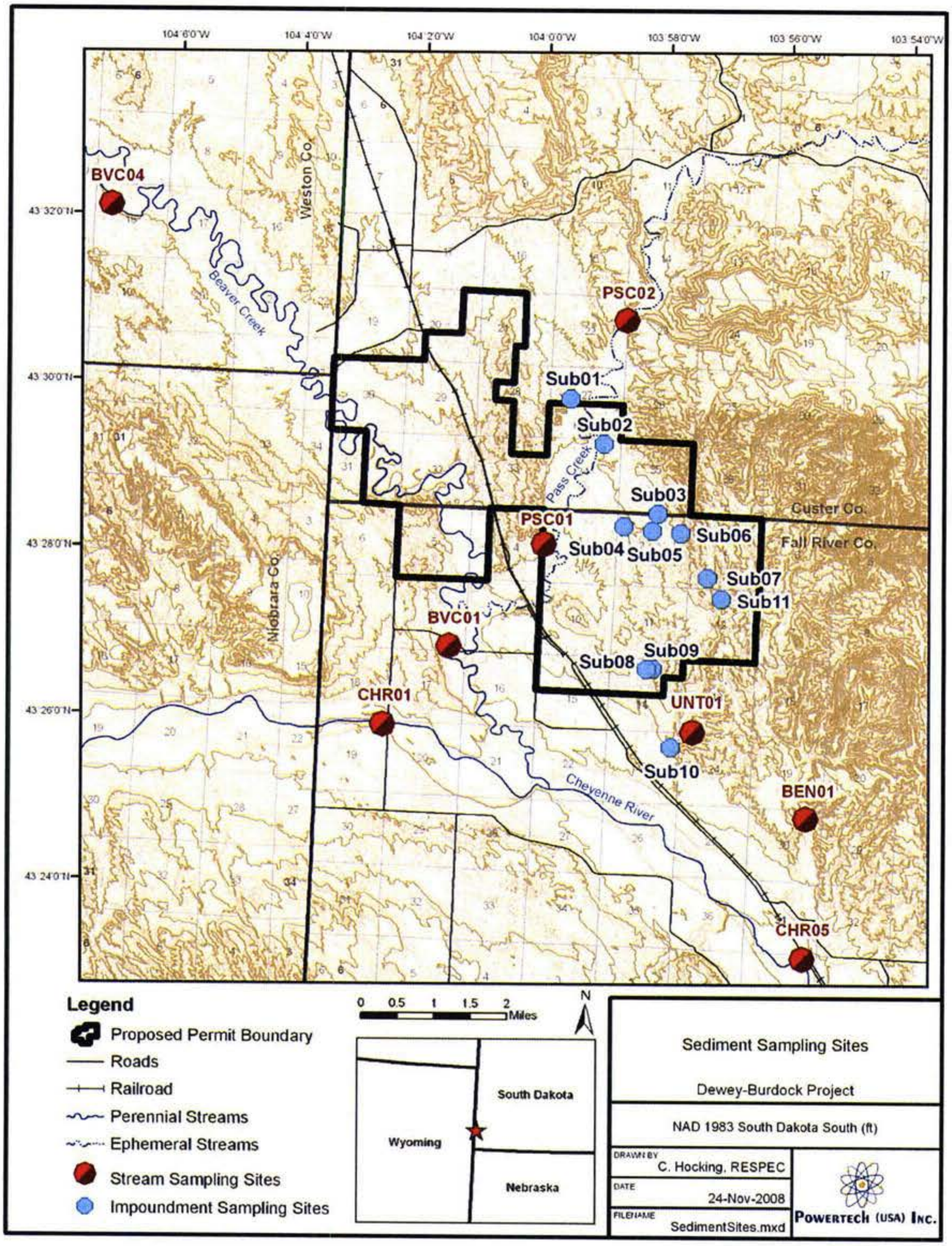

Figure 6.1-12: Sediment Sampling Sites

Table 6.1-7: Sampling Locations - Stream and Impoundment Sediment Sampling Locations

	Site ID	SD State Plane 1983		Type / Name	Groundwater Influence
		East (ft)	North (ft)		
Subimpoundments	Sub01	998654	446816	stock pond	
	Sub02	1001071	443526	Triangle Mine Pit	x
	Sub03	1005005	438448	mine dam	
	Sub04	1002542	437518	stock pond	
	Sub05	1004591	437191	mine dam	
	Sub06	1006665	437019	Darrow Mine pit - Northwest	
	Sub07	1009312	434360	stock dam	
	Sub08	1004195	427057	stock pond	x
	Sub09	1004640	427089	stock pond	
	Sub10	1005961	421367	stock pond	
	Sub11	1009659	432225	stock pond	
Streams	BVC01	989871	428716	Beaver Creek downstream	
	BVC04	965366	460922	Beaver Creek upstream	
	CHR01	985098	423010	Cheyenne River upstream	
	CHR05	1015626	405925	Cheyenne River downstream	
	PSC01	996764	436205	Pass Creek downstream	
	PSC02	1002722	452563	Pass Creek upstream	
	BEN01	1015872	416196	Bennet Canyon	
	UNT01	1007565	422482	Un-named Tributary	

6.1.4.1 Methods

6.1.4.1.1 Stream Sediments Sampling

At each location, four sediment sub-samples were collected with a plastic hand trowel to a depth of 5 cm each, along a transect spanning the width of the channel in areas where active sediment deposition was occurring. Prior to sampling at each site, the trowel was cleaned by rinsing with a liquid Alconox solution followed by a deionized water rinse. To represent the average radionuclide concentration across the channel, the four sub-samples were composited into a single sample. The composite sample was placed in a plastic zipper bag labeled with site ID, date, and time of collection, which was then placed into another plastic zipper bag and into a cooler with ice.

Samples were hand-delivered to ELI in Rapid City, SD along with the chain of custody forms. At the lab, samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. All samples were analyzed for natural uranium, thorium-230, radium-226, and lead-210 by wet radiochemical methods.

6.1.4.1.2 Surface Water Impoundment Sediment Sampling

Sediment sampling locations for surface water impoundments were the same as the subset of impoundments selected for water quality analysis. Impoundments were identified on aerial photographs and topographic maps and then field verified (Figure 6.1-13). A subset of 11 of the total 48 impoundments within a 2 km radius of the proposed permit boundary were chosen based on presence of water at commencement of water-quality sampling activities and their spatial distribution. The sampled impoundments include two open pit uranium mines and nine stock dams, one of which is fed by a free-flowing artesian Sundance well.

At each of the 11 sampled impoundments, a single sample was collected with a trowel to a depth of 5 cm. Prior to sampling at each site, the trowel was cleaned by rinsing with a liquid Alconox solution followed by a deionized water rinse. Samples were collected near the waters edge in a location appearing relatively undisturbed. In dry impoundments samples were collected near the upstream side of the impoundment in an area that would be submerged if water was present. The samples were placed in a plastic zipper bag labeled with site ID, date, and time of collection, then placed into another plastic zipper bag and into a cooler with ice.

Samples were hand-delivered to ELI in Rapid City, SD along with the chain of custody forms. At the lab, samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. All samples were analyzed for natural uranium, thorium-230, radium-226, and lead-210 by wet radiochemical methods.

6.1.4.2 Sediment Sampling Results

6.1.4.2.1 Stream Sediment Sample Results

Results of the stream sediment data for each stream channel sampling location and impoundment location are provided in Table 6.1-8. Beaver Creek sediment sample results from the historical TVA survey (TVA EIS, 1980) are provided in Table 6.1-9.

Figure 6.1-13: Surface Water Impoundments

Table 6.1-8: Radionuclide Concentrations in Stream Sediment Samples

		U-nat, Total	Ra-226, Total		Pb-210, Total			Th-230, Total	
		Result	Result	Precision	Result	Precision		Result	Precision
SiteID	Date	mg/kg-dry	pCi/g-dry	+/- pCi/g-dry	pCi/g-dry	+/- pCi/g-dry	Qualifier	pCi/g-dry	+/- pCi/g-dry
BEN01	6/23/2008	1.8	0.6	0.1	2.3	2.1	U	0.6	0.2
	8/21/2008	2.4	0.6	0.1	2.0	0.7		0.5	0.02
BVC01	6/17/2008	2.0	1.3	0.2	0.5	2	U	0.8	0.2
	8/21/2008	2.0	0.6	0.1	2.6	0.7		1.2	0.03
BVC04	6/17/2008	2.0	1.5	0.2	1.9	2.1	U	0.7	0.2
	8/21/2008	2.0	1.0	0.1	1.8	0.7		1.0	0.03
CHR01	6/17/2008	1.7	1.0	0.2	0.2	2	U	0.6	0.2
	8/21/2008	2.7	0.9	0.1	1.7	0.6		1.4	0.03
CHR05	6/17/2008	6.2	2.1	0.2	1.7	2	U	1.9	0.4
	8/21/2008	1.2	0.6	0.1	1.3	0.7		0.5	0.02
PSC01	6/17/2008	3.9	2.9	0.3	4.7	2.1		2.0	0.5
	8/21/2008	6.5	1.8	0.2	4.0	0.7		4.1	0.06
PSC02	6/17/2008	1.1	0.6	0.1	1.2	2	U	0.4	0.1
	8/21/2008	1.0	0.4	0.1	0.4	0.6	U	0.4	0.02
UNT01	6/23/2008	2.0	0.8	0.1	2.2	2.1	U	0.5	0.2
	8/21/2008	2.5	0.7	0.1	1.7	0.7		1.0	0.03
Sub01	6/18/2008	2.2	1.2	0.2	0.5	2	U	0.7	0.2
	8/21/2008	3.3	1.1	0.1	1.0	0.7	U	1.0	0.03
Sub02	6/18/2008	18	3.9	0.3	2.8	2.1	U	2.9	0.7
	8/21/2008	19	1.3	0.2	3.1	0.7		6.8	0.07
Sub03	6/18/2008	7.2	4.1	0.3	3.9	2.1		2.1	0.6
	8/21/2008	4.2	1.1	0.2	3.2	0.7		1.9	0.04
Sub04	6/17/2008	6.5	2.5	0.2	1.2	2	U	0.9	0.2
	8/21/2008	5.1	0.7	0.1	2.1	0.7		1.8	0.04

Table 6.1-8: Radionuclide Concentrations in Stream Sediment Samples

SiteID	Date	U-nat, Total	Ra-226, Total		Pb-210, Total			Th-230, Total	
		Result	Result	Precision	Result	Precision		Result	Precision
		mg/kg-dry	pCi/g-dry	+/- pCi/g-dry	pCi/g-dry	+/- pCi/g-dry	Qualifier	pCi/g-dry	+/- pCi/g-dry
Sub05	6/18/2008	8.5	4.2	0.3	4.2	2.1		2.4	0.5
	8/21/2008	6.0	3.0	0.2	2.8	0.7		2.3	0.04
Sub06	6/23/2008	37	8.6	0.4	9.6	2.2		7.8	1.6
	8/21/2008	32	5.2	0.3	4.0	0.7		5.9	0.07
Sub07	6/23/2008	1.7	0.7	0.1	0.6	2	U	0.5	0.2
	8/21/2008	2.2	0.4	0.1	1.9	0.7		0.9	0.03
Sub08	6/23/2008	1.2	0.6	0.1	0.6	2.1	U	0.4	0.1
	8/21/2008	1.9	0.4	0.1	1.7	0.7		0.8	0.02
Sub09	6/23/2008	2.4	1.0	0.2	1.5	2	U	0.7	0.2
	8/21/2008	2.3	0.6	0.1	1.7	0.7		0.9	0.03
Sub10	6/23/2008	1.5	0.8	0.1	1.5	2.1	U	0.7	0.3
	8/21/2008	2.1	0.6	0.1	0.9	0.7	U	0.7	0.03
Sub11	6/23/2008	2.7	0.8	0.1	2.1	2.1	U	0.5	0.2
	8/21/2008	1.8	0.6	0.1	1.5	0.7		0.8	0.03

Table 6.1-9: Historical Radionuclide Concentrations in Beaver Creek Sediment Samples (TVA EIS, 1980)

Sampling Location	Date Collected	Natural U µg/g	Ra-226 pCi/g	Pb-210 pCi/g	Th-230 pCi/g
Beaver Creek at Old Hwy 85 Bridge	7/31/1975	-	1.06 ± 0.04	-	-
	5/5/1976	2.57	1.29 ± 0.03	-	0.3 ± 0.2
	8/25/1976	1.48	1.06 ± 0.03	-	1.5 ± 0.2
	11/12/1976	1.12	0.98 ± 0.03	-	2.1 ± 0.2
	4/27/1977	1.42	1.15 ± 0.03	-	0.3 ± 0.1
	7/21/1977	3.4	0.91 ± 0.03	-	-0.05 ± 0.07
	11/15/1977	0.02	0.44 ± 0.02	3.3 ± 0.4	0.8 ± 0.2
Beaver Creek at Mouth	5/5/1976	2.65	1.25 ± 0.03	-	0.06 ± 0.2
	8/25/1976	2.23	1.71 ± 0.04	-	0.4 ± 0.1
	11/12/1976	0.86	0.84 ± 0.03	-	2.6 ± 0.3
	4/27/1977	0.87	1.31 ± 0.03	-	0.2 ± 0.1
	7/21/1977	4.1	2.45 ± 0.05	-	0.5 ± 0.2
	11/15/1977	0.72	0.83 ± 0.02	5.5 ± 0.5	0.2 ± 0.1
Beaver Creek Upstream	5/5/1976	4.37	1.03 ± 0.03	-	0.4 ± 0.3
	8/25/1976	3.01	1.23 ± 0.03	-	0.9 ± 0.2
	11/12/1976	1.5	1.01 ± 0.03	-	2.9 ± 0.3
	4/27/1977	0.89	1.34 ± 0 03	-	0.02 ± 0.07
	7/21/1977	3.7	1.41 ± 0.04	-	0.02 ± 0.08

6.1.4.3 Conclusions

The radionuclide concentrations in sediments at the project site are generally consistent with observed US soil concentrations (Myrick 1983). Exceptions are the Darrow Mine Pit (Sub 06) and the Triangle Mine Pit (Sub 02), both of which appear to contain radionuclide concentrations in sediments considerably higher than observed in soil by Myrick, 1983. The Darrow and Triangle Mine Pits are historical open pit uranium mines and elevated radionuclide concentrations in sediments would be expected.

Radionuclide concentrations in sediment at downstream locations of Pass Creek (PSC02) and the Cheyenne River (CHR05) are elevated compared to upstream locations for the same surface water bodies indicating potential impacts from mineralized areas of the on and adjacent to the site. Radionuclide concentrations in sediment at the downstream location on Beaver Creek (BVCO1) are similar to the upstream location (BVC04).

6.1.5 Ambient Gamma and Radon Monitoring

6.1.5.1 Methods

6.1.5.1.1 Ambient Gama Does Rate Monitoring

Ambient exposure rates were determined for three periods, using TLDs supplied and analyzed by Landauer, Inc. The monitoring periods were: August 18, 2007 to February 4, 2008, February 4 to May 17, 2008, and May 17 to July 17, 2008.

The TLDs were deployed at each of the eight AMS locations. Duplicates were deployed at AMS-01 and the background location (AMS-BKG).

Five of the nine TLDs deployed in the August 2007 to February 2008 period were lost, presumably by way of cattle consumption and/or disturbance.

6.1.5.1.2 Ambient Radon-222 Monitoring

Radtrak passive track etch detectors were placed at each of the eight AMS locations and an additional eight biased locations to measure radon-222 concentrations in air. For QC purposes, one duplicate detector was placed at each of two locations during each sampling event. The locations of the passive radon detectors are shown on Figure 6.1-9.

The detector measures average radon-222 concentrations in air over the measurement period. The results are reported in picocuries per liter (pCi/L).

With an overlap in time across the group of detectors, but not on an individual location basis, the four quarterly measurement periods were: August 14 to September 27, 2007; September 27, 2007 to February 1 through 12, 2008; February 1 through 12, 2008 to May 17, 2008; and May 17 to July 17, 2008.

6.1.5.2 Results

6.1.5.2.1 Ambient Gamma Dose Rate Monitoring

The ambient gamma dose rate monitoring results are listed in Table 6.1-10. The results for the TLDs reported in mrem ambient dose equivalents are as follows:

- AMS-01: 94.9 for 303 monitored days, projected to 114 mrem/year
- AMS-02: 54.0 for 61 monitored days, projected to 323 mrem/year

- AMS-03: 38.6 for 103 monitored days, projected to 137 mrem/year
- AMS-04: 152.8 for 303 monitored days, projected to 184 mrem/year
- AMS-05: 123.7 for 303 monitored days, projected to 149 mrem/year
- AMS-06: 88.0, for 164 monitored days projected to 196 mrem/year
- AMS-07: 145.3 for 303 monitored days, projected to 175 mrem/year
- AMS-BKG: 167.8 for 303 monitored days, projected to 202 mrem/year

Excluding the result at AMS-02, the range of exposure rates, 114-202 mrem/year, is similar to average worldwide exposures to natural radiation sources comprised of cosmic radiation, cosmogenic radionuclides, and external terrestrial radiation reported in the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex. The typical ranges of average worldwide exposures reported in this reference document are to 60 to160 mrem/year.

Table 6.1-10: Ambient Gamma Dose Rates

Location	Starting Date	End Date	Dose (mrem)	Projected Doses (mrem)
AMS-01	9/18/07	2/4/08	-	114
	2/4/08	5/17/08	37.2[a]	
	5/17/08	7/17/08	57.7[a]	
AMS-02	9/18/07	2/4/08	-	323
	2/4/08	5/17/08	-	
	5/17/08	7/17/08	54.0	
AMS-03	9/18/07	2/4/08	-	137
	2/4/08	5/17/08	38.6	
	5/17/08	7/17/08		
AMS-04	9/18/07	2/4/08	62.4	184
	2/4/08	5/17/08	36.1	
	5/17/08	7/17/08	54.3	
AMS-05	9/18/07	2/4/08	50.6	149
	2/4/08	5/17/08	36.7	
	5/17/08	7/17/08	36.4	
AMS-06	9/18/07	2/4/08	-	196
	2/4/08	5/17/08	36.9	
	5/17/08	7/17/08	51.1	
AMS-07	9/18/07	2/4/08	73.7	175
	2/4/08	5/17/08	35.5	
	5/17/08	7/17/08	36.1	
AMS-BKG	9/18/07	2/4/08	68.8[a]	202
	2/4/08	5/17/08	40.5[a]	
	5/17/08	7/17/08	58.5[a]	

Notes:
a. Result is average of measurement plus duplicate.

6.1.5.2.2 Ambient Radon-222 Monitoring

The ambient radon monitoring results are listed in Table 6.1-11. Period 1 ambient radon concentrations ranged from 1.0 to 9.8, averaging 2.4 pCi/L. Period 2 concentrations ranged from 0.4 to 1.8, averaging 1.2 pCi/L. Period 3 concentrations ranged from 0.4 to 3.3, averaging 1.8 pCi/L. Period 4 concentrations ranged from 0.5 to 0.8, averaging 0.5 pCi/L.

Table 6.1-11: Radon Concentrations in Air

Location	Starting Date	Ending Date	Radon-222 Conc. (µCi/ml)	Error ± (µCi/ml)	LLD (µCi/ml)	Average Rn-222 Conc. (µCi/ml)	Standard Deviation of Average (µCi/ml)	Minimum Rn-222 Conc. (µCi/ml)	Maximum Rn-222 Conc. (µCi/ml)	Percent Effluent Conc.
AMS-1	8/14/07	9/27/07	1.00E-09	-	6.82E-10	7.23E-10	2.09E-10	4.92E-10	1.00E-09	1000
	9/27/07	2/1/08	7.00E-10	-	2.00E-10					700
	2/1/08	5/17/08	7.00E-10	7.1E-11	2.83E-10					700
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
AMS-1[a]	8/14/07	9/27/07	1.00E-09	-	6.82E-10	5.73E-10	2.88E-10	4.00E-10	1.00E-09	1000
	9/27/07	2/1/08	4.00E-10	-	2.00E-10					400
	2/1/08	5/17/08	4.00E-10	5.2E-11	2.83E-10					400
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
AMS-2	8/15/07	9/27/07	2.20E-09	-	6.98E-10	1.70E-09	7.62E-10	4.92E-10	2.20E-09	2200
	9/27/07	2/1/08	1.20E-09	-	2.00E-10					1200
	2/1/08	5/17/08	7.00E-10	7.0E-11	2.83E-10					700
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
AMS-3	8/14/07	9/27/07	1.20E-09	-	6.82E-10	1.20E-09	9.30E-10	4.92E-10	2.70E-09	1200
	9/27/07	2/4/08	1.20E-09	-	2.00E-10					1200
	2/4/08	5/17/08	2.70E-09	7.9E-11	2.91E-10					2700
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
AMS-4	8/14/07	9/24/07	1.20E-09	-	7.32E-10	1.20E-09	9.98E-10	5.75E-10	2.90E-09	1200
	9/27/07	2/4/08	1.20E-09	-	2.00E-10					1200
	2/4/08	5/17/08	2.90E-09	7.8E-11	2.91E-10					2900
	5/17/08	7/17/08	5.75E-10	-	4.92E-10					575
AMS-5	8/15/07	9/27/07	2.20E-09	-	6.98E-10	1.60E-09	7.16E-10	4.92E-10	2.20E-09	2200
	9/27/07	2/1/08	1.00E-09	-	2.00E-10					1000
	2/1/08	5/17/08	1.20E-09	7.9E-11	2.83E-10					1200
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492

Table 6.1-11: Radon Concentrations in Air

Location	Starting Date	Ending Date	Radon-222 Conc. (µCi/ml)	Error ± (µCi/ml)	LLD (µCi/ml)	Average Rn-222 Conc. (µCi/ml)	Standard Deviation of Average (µCi/ml)	Minimum Rn-222 Conc. (µCi/ml)	Maximum Rn-222 Conc. (µCi/ml)	Percent Effluent Conc.
AMS-6	8/17/07	9/27/07	2.60E-09	-	7.32E-10	1.80E-09	8.40E-10	6.89E-10	2.60E-09	2600
	9/27/07	2/1/08	1.00E-09	-	2.00E-10					1000
	2/11/08	5/17/08	1.30E-09	7.6E-11	2.83E-10					1300
	5/17/08	7/17/08	6.89E-10	-	4.92E-10					689
AMS-7	8/14/07	9/27/07	1.10E-09	-	6.82E-10	1.30E-09	4.15E-10	4.92E-10	1.50E-09	1100
	9/27/07	2/1/08	1.50E-09	-	2.00E-10					1500
	2/1/08	5/17/08	1.00E-09	7.2E-11	2.83E-10					1000
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
AMS-BKG	8/14/07	9/24/07	2.00E-09	-	7.32E-10	1.80E-09	6.58E-10	4.95E-10	2.00E-09	2000
	9/27/07	2/1/08	1.60E-09	-	2.00E-10					1600
	2/1/08	5/17/08	1.70E-09	8.1E-11	2.83E-10					1700
	5/17/08	7/17/08	4.95E-10	-	4.92E-10					495
AMS-BKG[a]	8/14/07	9/27/07	2.70E-09	-	6.82E-10	2.10E-09	9.03E-10	4.92E-10	2.70E-09	2700
	9/27/07	2/1/08	1.50E-09	-	2.00E-10					1500
	2/1/08	5/17/08	1.50E-09	8.1E-11	2.83E-10					1500
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
Rn 01	8/14/07	9/23/07	2.00E-09	-	7.50E-10	1.65E-09	8.35E-10	5.00E-10	2.40E-09	2000
	9/23/07	2/11/08	1.30E-09	-	2.00E-10					1300
	2/11/08	5/17/08	2.40E-09	8.5E-11	3.13E-10					2400
	5/17/08	7/17/08	5.00E-10	-	4.76E-10					500
Rn 02	8/14/07	9/23/07	9.80E-09	-	7.50E-10	3.86E-09	5.15E-09	5.75E-10	9.80E-09	9800
	9/23/07	2/11/08	1.20E-09	-	2.00E-10					1200
	no data	-	-	-	-					-
	5/17/08	7/17/08	5.75E-10	1.5E-10	4.92E-10					575

Table 6.1-11: Radon Concentrations in Air

Location	Starting Date	Ending Date	Radon-222 Conc. (µCi/ml)	Error ± (µCi/ml)	LLD (µCi/ml)	Average Rn-222 Conc. (µCi/ml)	Standard Deviation of Average (µCi/ml)	Minimum Rn-222 Conc. (µCi/ml)	Maximum Rn-222 Conc. (µCi/ml)	Percent Effluent Conc.
Rn 03	8/14/07	9/23/07	1.20E-09	-	7.50E-10	1.05E-09	9.63E-10	4.92E-10	2.70E-09	1200
	9/23/07	2/11/08	9.00E-10	-	2.00E-10					900
	2/11/08	5/17/08	2.70E-09	8.6E-11	3.13E-10					2700
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
Rn 04	8/14/07	9/23/07	2.00E-09	-	7.50E-10	1.70E-09	6.34E-10	5.00E-10	2.00E-09	2000
	9/23/07	2/1/08	1.40E-09	-	2.00E-10					1400
	2/11/08	5/17/08	1.00E-09	7.7E-11	2.83E-10					1000
	5/17/08	7/17/08	5.00E-10	-	4.92E-10					500
Rn 05	8/14/07	9/23/07	1.50E-09	-	7.50E-10	1.30E-09	7.82E-10	8.18E-10	2.60E-09	1500
	9/23/07	2/12/08	1.10E-09	-	2.00E-10					1100
	2/11/08	5/17/08	2.60E-09	8.6E-11	3.16E-10					2600
	5/17/08	7/17/08	8.18E-10	-	4.92E-10					818
Rn 06	8/19/07	9/23/07	3.30E-09	-	8.57E-10	2.30E-09	1.35E-09	4.92E-10	3.30E-09	3300
	9/23/07	2/11/08	1.30E-09	-	2.00E-10					1300
	2/11/08	5/17/08	3.00E-09	8.5E-11	3.13E-10					3000
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492
Rn 07	8/15/07	9/23/07	3.00E-09	-	7.69E-10	2.40E-09	1.18E-09	7.21E-10	3.30E-09	3000
	9/23/07	2/12/08	1.80E-09	-	2.00E-10					1800
	2/12/08	5/17/08	3.30E-09	8.3E-11	3.16E-10					3300
	5/17/08	7/17/08	7.21E-10	-	4.92E-10					721
Rn 08	8/14/07	9/23/07	1.50E-09	-	7.50E-10	1.40E-09	4.39E-10	4.92E-10	1.50E-09	1500
	9/23/07	2/1/08	1.30E-09	-	2.00E-10					1300
	9/23/07	2/1/08	1.00E-09	7.2E-11	2.83E-10					1000
	5/17/08	7/17/08	4.92E-10	-	4.92E-10					492

Notes: [a]Duplicate track etch detector
[a]Seal potentially compromised

With the exception of one location (AMS-3), Period 1 concentrations exceeded Period 2 concentrations. On average, the radon concentrations decreased by an average of 35 percent. The range in the data sets decreased from 2.1 (Period 1) to 0.3 pCi/L (Period 2), as the largest value in Period 1, 9.8 pCi/L, decreased to 1.2 pCi/L.

Figure 6.1-14 presents the ambient radon concentrations in relation to the radium-226 concentrations predicted from the gamma-ray count rate data. One expects higher radon concentrations in the mined areas. However, there is only one case where this is true: the Q1 observation at Rn-02, located adjacent to the edge of an open pit mine, is 9.8 pCi/L. There appear to be no spatial trends in the current data set, other than the levels are within the same order of magnitude across the site, i.e., all less than 10 pCi/L and averaging 2.4, 1.2, 1.8, and 0.5 pCi/L in Periods 1 through 4, respectively.

Duplicates were collected at AMS-01 and AMS-BKG in all periods. The QC summary for the radon monitoring is as follows:

- AMS-01: In Period 1, each concentration was 1.0 pCi/L and the relative percent difference (RPD) was 0. In Periods 2 and 3, the concentrations of the sample and its duplicate were 0.7 and 0.4 pCi/L. The RPD was 55.5. In Period 4, each concentration was 0.49 pCi/L and the RPD was 0.
- AMS-BKG: In Period 1, the concentrations of the sample and its duplicate were 2.0 and 2.7 pCi/L. The RPD was 29.8. In Period 2, the concentrations of the sample and its duplicate were 1.6 and 1.5 pCi/L, with an RPD of 6.5. In Period 3, the concentrations of the sample and its duplicate were 1.7 and 1.5 pCi/L, with an RPD of 12.5. In Period 4, the concentrations of the sample and its duplicate were 0.5 and 0.49 pCi/L, with an RPD of 0.7.

There are two cases where the RPDs do not meet the project acceptance criterion of 40: AMS-01 in Period 2 and 3.

6.1.5.3 Conclusions

In terms of effluent limits, the measured values exceed the 10 CFR 20 limit of 0.1 pCi/L for radon-222 with daughters present. However, on average the measured values are within the range of reported worldwide ambient background radon concentrations, 0.027 to 2.7 pCi/L (United Nations Scientific Committee on the Effects of Atomic Radiation [UNSCEAR], 2000).

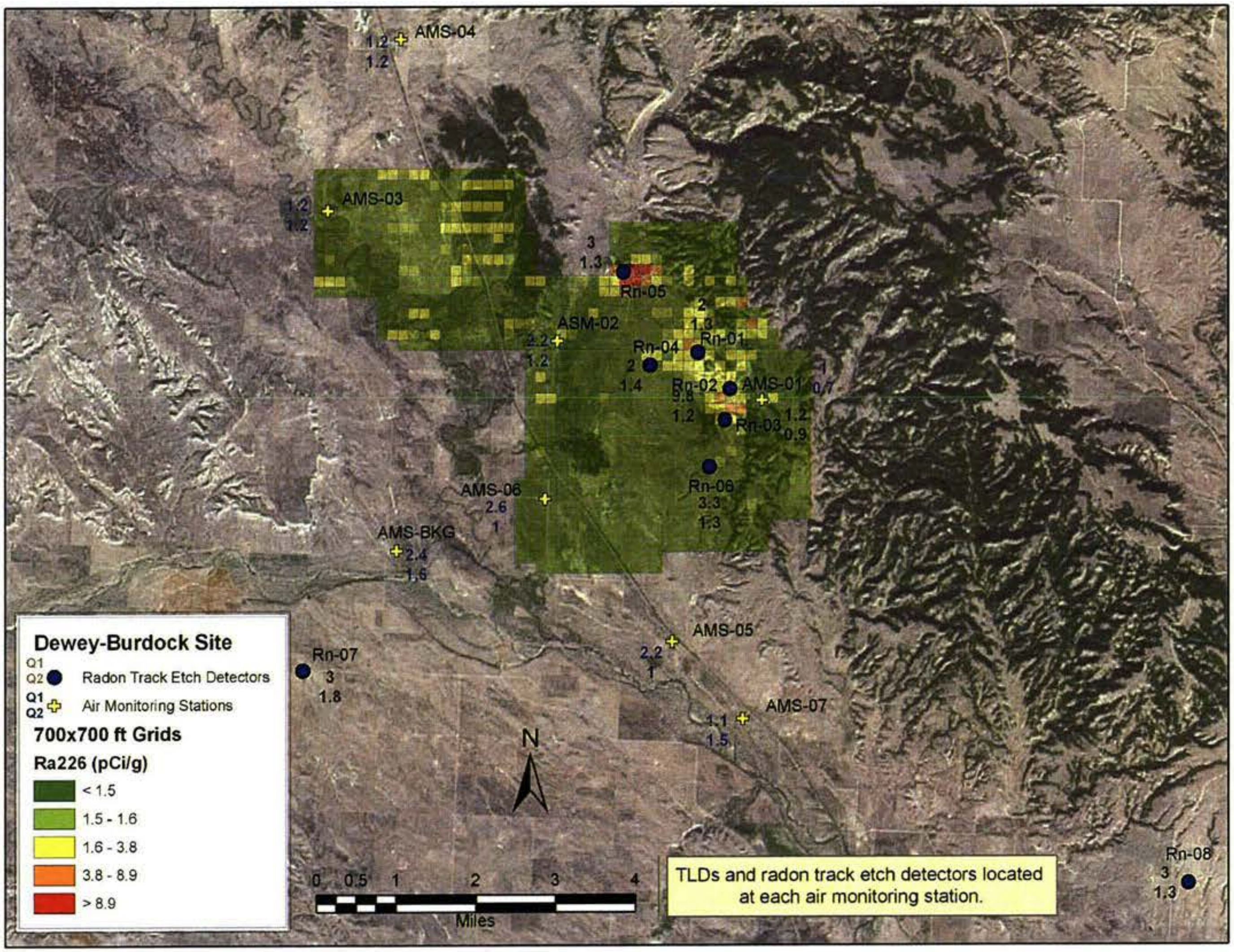

Figure 6.1-14: Radon Concentrations in Air in Relation to Predicted Radium-226 Concentrations

6.1.6 Air Particulate Monitoring

Air particulate monitoring was conducted at the project for one year. Particulates were collected using high volume air samplers.

6.1.6.1 Methods

Eight Hi-Q Model HVP-4200AFC high volume air samplers were established within and surrounding the proposed PAA. The samplers operated from August 2007 to August 2008. The locations of the air samplers are shown on Figures 6.1-9 and 6.1-14

Each high volume air sampler was equipped with an 8-in. by 10-in. 0.8 micron glass fiber filter paper. The air filters were collected approximately bi-weekly, prior to saturation, from each of the eight air samplers. Flow rate and total flow data were recorded at the same time. The samples were collected as follows:

- Period 1: August 28 to October 2, 2007
- Period 2: October 2, 2007 to January 1, 2008
- Period 3: January 4 to April 1, 2008
- Period 4: April 1 to July 9, 2008
- Period 5: July 9 to August 13, 2008

The samples were composited and digested by the external independent analytical laboratory. The samples were analyzed for radium-226, thorium-230, natural uranium, and lead-210, using the same methods as listed for the soil samples.

The laboratory data were reported in units of picocuries per filter composite (pCi/f). The data were converted to units of micocuries per milliliter (μCi/ml), as follows:

$$Concentration,\ \mu Ci/ml = \frac{Filter\ Concentration}{Total\ Flow}(1*10^{-12})$$

The units of total flow and filter concentration in the equation are cubic meters and pCi/f, respectively. The resulting concentrations for each radionuclide and high volume sampler were compared to effluent concentration limits listed in Table 2 of 10 CFR 20 Appendix B and reported in Table 6.1-12 as percentages of the respective effluent limits. The most conservative effluent limits were applied to thorium-230 ($3*10^{-12}$ μCi/ml) and lead-210 ($6*10^{-13}$ μCi/ml). The

Class D and W limits were applied to natural uranium ($3*10^{-12}$ μCi/ml) and radium-226 ($9*10^{-13}$ μCi/ml), respectively.

6.1.6.2 Air Particulate Sampling Results

In general and relative to one another (e.g., natural uranium to radium-226), the average concentrations of radionuclides were consistent at each location from period to period. The lowest average concentration was radium-226, followed by thorium-230, natural uranium, and lead-210. Average radium-226 concentrations were five orders of magnitude lower than lead-210 concentrations. The data are listed in Table 6.1-12 and summarized as averages and ranges in Table 6.1-13.

Site-wide, the data can be summarized as follows:

- Natural uranium concentrations ranged from $-3.0*10^{-17}$ to $9.1*10^{-15}$ μCi/ml and averaged $7.5*10^{-16}$ μCi/ml.
- Thorium-230 concentrations ranged from $-9.5*10^{-19}$ to $5.6*10^{-17}$ μCi/ml and averaged $1.2*10^{-17}$ μCi/ml.
- Radium-226 concentrations ranged from $-4.9*10^{-17}$ to $4.7*10^{-17}$ μCi/ml and averaged $8.9*10^{-19}$ μCi/ml.
- Lead-210 concentrations ranged from $-1.1*10^{-16}$ to $4.1*10^{-14}$ μCi/ml and averaged $1.4*10^{-14}$ μCi/ml.

There are no clear patterns in the data, in terms of radionuclide concentrations, when evaluating them spatially or temporally. Natural uranium concentrations at each location were on the order of 10^{-16} μCi/ml over the course of monitoring. Thorium-230 concentrations fluctuated between the orders of 10^{-17} and 10^{-18} μCi/ml. Radium-226 concentrations fluctuated between the orders of 10^{-17} and 10^{-19} μCi/ml. Finally, lead-210 concentrations at each location were all on the order of 10^{-14} μCi/ml over the course of monitoring.

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Table 6.1-12: Radionuclide Concentrations in Air

Location	Monitoring Period[a]	Concentration (μCi/ml)							% of Effluent Concentration				Lower Limit of Detection (μCi/ml)			
		U-nat	Th-230	Th-230 2σ Error	Ra-226	Ra-226 2σ Error	Pb-210	Pb-210 2σ Error	U-nat	Th-230	Ra-226	Pb-210	U-nat	Th-230	Ra-226	Pb-210
AMS-01	1	-1.3E-17	3.4E-18	1.0E-17	1.8E-17	1.7E-17	2.1E-14	2.4E-16	0.00%	0.00%	0.00%	3.54%	1.7E-18	1.7E-18	1.2E-17	2.1E-16
	2	2.4E-17	1.3E-17	9.8E-18	1.4E-17	9.7E-18	2.1E-14	4.9E-16	0.00%	0.00%	0.00%	3.51%	1.5E-18	1.5E-18	8.3E-18	4.2E-16
	3	3.7E-15	1.3E-17	4.2E-17	1.2E-17	5.7E-17	1.9E-14	9.8E-16	0.12%	0.00%	0.00%	3.13%	3.9E-15	2.3E-18	5.7E-17	3.7E-16
	4	0.0E+00	1.6E-18	1.1E-17	7.2E-18	9.1E-18	4.1E-14	6.9E-16	0.00%	0.00%	0.00%	6.78%	1.6E-16	1.6E-18	1.6E-18	7.9E-18
	5	-1.7E-17	6.5E-18	2.5E-17	-3.1E-17	2.7E-17	1.0E-14	6.5E-16	0.00%	0.00%	0.00%	1.74%	4.3E-18	4.3E-18	5.6E-17	6.7E-16
AMS-02	1	-2.0E-17	4.7E-18	1.1E-17	-8.6E-18	1.3E-17	8.9E-15	2.5E-16	0.00%	0.00%	0.00%	1.49%	1.6E-18	1.6E-18	1.1E-17	1.9E-16
	2	4.2E-18	0.0E+00	7.4E-18	-4.2E-18	7.4E-18	8.2E-15	4.2E-16	0.00%	0.00%	0.00%	1.37%	1.4E-18	1.4E-18	7.6E-18	3.9E-16
	3	2.9E-15	1.8E-18	2.5E-17	-2.6E-17	3.3E-17	1.2E-14	7.5E-16	0.10%	0.00%	0.00%	1.96%	3.1E-15	1.8E-18	4.1E-17	3.0E-16
	4	0.0E+00	1.6E-17	1.1E-17	-2.3E-18	7.0E-18	2.0E-14	4.7E-16	0.00%	0.00%	0.00%	3.26%	1.5E-16	1.5E-18	1.5E-18	7.6E-18
		-1.3E-17	0.0E+00	8.0E-18	-4.9E-17	2.3E-17	1.5E-14	6.5E-16	0.00%	0.00%	0.01%	2.44%	4.0E-18	4.0E-18	5.3E-17	6.2E-16
AMS-03	1	-3.0E-17	9.3E-18	1.2E-17	-1.4E-17	1.3E-17	9.2E-15	2.5E-16	0.00%	0.00%	0.00%	1.53%	1.5E-18	1.5E-18	1.2E-17	1.9E-16
	2	1.8E-17	8.9E-18	9.0E-18	9.6E-18	9.5E-18	8.0E-15	4.4E-16	0.00%	0.00%	0.00%	1.34%	1.5E-18	1.5E-18	8.9E-18	4.1E-16
	3	2.8E-15	6.9E-18	2.2E-17	-4.8E-18	3.7E-17	1.2E-14	7.5E-16	0.09%	0.00%	0.00%	1.98%	2.9E-15	1.7E-18	3.6E-17	2.8E-16
	4	0.0E+00	9.3E-18	1.0E-17	5.4E-18	8.8E-18	1.3E-14	3.9E-16	0.00%	0.00%	0.00%	2.16%	1.6E-16	1.6E-18	1.6E-18	7.8E-18
	5	-1.6E-17	1.9E-17	9.7E-18	-3.2E-18	3.1E-17	1.2E-14	6.5E-16	0.00%	0.00%	0.00%	1.99%	4.2E-18	4.2E-18	5.0E-17	6.6E-16
AMS-04	1	-2.6E-17	2.5E-18	1.1E-17	-2.8E-17	1.2E-17	8.5E-15	2.6E-16	0.00%	0.00%	0.00%	1.42%	1.7E-18	1.7E-18	9.9E-18	2.0E-16
	2	1.9E-17	6.6E-18	9.0E-18	1.2E-17	9.5E-18	1.0E-14	4.6E-16	0.00%	0.00%	0.00%	1.74%	1.5E-18	1.5E-18	8.1E-18	4.1E-16
	3	3.0E-15	-9.5E-19	3.0E-17	2.5E-17	4.7E-17	-1.1E-16	7.0E-16	0.10%	0.00%	0.00%	0.02%	3.2E-15	1.9E-18	4.4E-17	3.1E-16
	4	0.0E+00	9.4E-18	1.1E-17	2.3E-18	8.3E-18	2.2E-14	5.1E-16	0.00%	0.00%	0.00%	3.66%	1.6E-16	1.6E-18	1.6E-18	7.8E-18
	5	-1.0E-18	2.7E-17	9.7E-18	-5.2E-18	3.3E-17	1.3E-14	6.7E-16	0.00%	0.00%	0.00%	2.23%	4.2E-18	4.2E-18	5.5E-17	6.6E-16

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Table 6.1-12: Radionuclide Concentrations in Air

Location	Monitoring Period	Concentration (μCi/ml)							% of Effluent Concentration				Lower Limit of Detection (μCi/ml)			
		U-nat	Th-230	Th-230 2σ Error	Ra-226	Ra-226 2σ Error	Pb-210	Pb-210 2σ Error	U-nat	Th-230	Ra-226	Pb-210	U-nat	Th-230	Ra-226	Pb-210
AMS-05	1	1.0E-18	4.7E-18	1.1E-17	1.1E-17	1.5E-17	1.0E-14	2.3E-16	0.00%	0.00%	0.00%	1.66%	1.6E-18	1.6E-18	1.1E-17	1.9E-16
	2	2.7E-17	1.5E-17	1.0E-17	1.5E-17	9.9E-18	1.1E-14	4.8E-16	0.00%	0.00%	0.00%	1.91%	1.5E-18	1.5E-18	8.5E-18	4.3E-16
	3	2.8E-15	3.6E-17	2.3E-17	-1.3E-17	4.0E-17	1.0E-14	7.2E-16	0.09%	0.00%	0.00%	1.68%	2.9E-15	1.7E-18	4.3E-17	2.8E-16
	4	0.0E+00	2.0E-17	1.4E-17	4.7E-17	1.3E-17	2.5E-14	5.3E-16	0.00%	0.00%	0.01%	4.09%	1.5E-16	1.5E-18	1.5E-18	7.7E-18
	5	2.4E-17	5.6E-17	9.5E-18	2.2E-17	3.4E-17	1.1E-14	6.3E-16	0.00%	0.00%	0.00%	1.85%	4.1E-18	4.1E-18	4.9E-17	6.4E-16
AMS-06	1	-1.4E-17	9.4E-18	1.2E-17	0.0E+00	1.4E-17	6.0E-15	2.2E-16	0.00%	0.00%	0.00%	1.00%	1.6E-18	1.6E-18	1.1E-17	1.9E-16
	2	1.7E-17	5.5E-18	1.0E-17	-5.5E-18	8.4E-18	1.1E-14	4.9E-16	0.00%	0.00%	0.00%	1.80%	1.6E-18	1.6E-18	9.5E-18	4.4E-16
	3	2.9E-15	1.0E-17	2.4E-17	-2.0E-17	3.9E-17	1.7E-14	8.2E-16	0.10%	0.00%	0.00%	2.89%	3.1E-15	1.8E-18	4.2E-17	2.9E-16
	4	0.0E+00	1.4E-17	1.2E-17	2.3E-17	1.0E-17	2.1E-14	4.8E-16	0.00%	0.00%	0.00%	3.56%	1.5E-16	1.5E-18	1.5E-18	7.3E-18
	5	-2.6E-18	2.0E-17	9.1E-18	6.9E-18	3.3E-17	1.9E-14	6.9E-16	0.00%	0.00%	0.00%	3.25%	4.0E-18	4.0E-18	4.9E-17	6.2E-16
AMS-07	1	-1.1E-17	6.4E-18	9.1E-18	-1.3E-17	1.1E-17	7.2E-15	2.2E-16	0.00%	0.00%	0.00%	1.20%	1.4E-18	1.4E-18	9.2E-18	1.7E-16
	2	2.0E-17	7.9E-18	8.1E-18	-6.6E-19	7.5E-18	1.3E-14	4.4E-16	0.00%	0.00%	0.00%	2.13%	1.3E-18	1.3E-18	7.3E-18	3.7E-16
	3	9.1E-15	2.0E-17	2.6E-17	3.9E-18	4.2E-17	1.7E-14	7.8E-16	0.30%	0.00%	0.00%	2.85%	2.9E-15	1.7E-18	4.3E-17	2.8E-16
	4	0.0E+00	1.3E-17	1.2E-17	2.9E-17	1.0E-17	2.8E-14	5.4E-16	0.00%	0.00%	0.00%	4.66%	1.4E-16	1.4E-18	1.4E-18	7.0E-18
	5	-9.2E-19	1.7E-17	8.5E-18	1.4E-17	3.0E-17	1.3E-14	5.9E-16	0.00%	0.00%	0.00%	2.10%	3.7E-18	3.7E-18	4.6E-17	5.8E-16
AMS-BKG	1	1.6E-18	2.0E-17	1.3E-17	-5.6E-18	1.4E-17	8.3E-15	2.5E-16	0.00%	0.00%	0.00%	1.38%	1.6E-18	1.6E-18	1.2E-17	2.2E-16
	2	2.1E-17	2.0E-18	1.2E-17	3.0E-18	1.1E-17	1.8E-14	6.6E-16	0.00%	0.00%	0.00%	3.05%	2.0E-18	2.0E-18	1.2E-17	5.7E-16
	3	3.0E-15	2.8E-17	2.9E-17	-5.1E-18	4.0E-17	1.3E-14	7.7E-16	0.10%	0.00%	0.00%	2.18%	3.2E-15	1.9E-18	4.1E-17	2.5E-16
	4	0.0E+00	-7.8E-19	9.4E-18	1.2E-17	9.5E-18	2.0E-14	4.8E-16	0.00%	0.00%	0.00%	3.29%	1.6E-16	1.6E-18	1.6E-18	7.8E-18
	5	-8.1E-18	2.4E-17	9.3E-18	-1.7E-17	2.4E-17	1.2E-14	6.3E-16	0.00%	0.00%	0.00%	2.00%	4.0E-18	4.0E-18	4.0E-17	5.3E-16

Notes:

a. The laboratory reported no blank assay data for Period 5. Blank assays in the sample concentration calculation were assumed to be 50 percent of the values for blanks reported for the previous period. The assumption is based on the relative, approximate run-time of the air samplers in both periods.

NR = Not reported by the laboratory.

Table 6.1-13: Summary of Radionuclide Concentrations in Air

Location	U-nat Concentration (µCi/ml)				Th-230 Concentration (µCi/ml)				Ra-226 Concentration (µCi/ml)				Pb-210 Concentration (µCi/ml)			
	Avg	σ	Min	Max	Avg	σ	Min	Max	Avg	σ	Min	Max	Avg	σ	Min	Max
AMS-01	7.3E-16	1.6E-15	-1.7E-17	3.7E-15	7.4E-18	5.2E-18	1.6E-18	1.3E-17	4.0E-18	2.0E-17	-3.1E-17	1.8E-17	2.2E-14	2.0E-17	9.1E-18	5.7E-17
AMS-02	5.8E-16	1.3E-15	-2.0E-17	2.9E-15	4.5E-18	6.7E-18	0.0E+00	1.6E-17	-1.8E-17	2.0E-17	-4.9E-17	-2.3E-18	1.3E-14	1.1E-17	7.0E-18	3.3E-17
AMS-03	5.5E-16	1.2E-15	-3.0E-17	2.8E-15	1.1E-17	4.7E-18	6.9E-18	1.9E-17	-1.4E-18	9.2E-18	-1.4E-17	9.6E-18	1.1E-14	1.3E-17	8.8E-18	3.7E-17
AMS-04	6.0E-16	1.3E-15	-2.6E-17	3.0E-15	9.0E-18	1.1E-17	-9.5E-19	2.7E-17	1.2E-18	2.0E-17	-2.8E-17	2.5E-17	1.1E-14	1.7E-17	8.3E-18	4.7E-17
AMS-05	5.6E-16	1.2E-15	0.0E+00	2.8E-15	2.6E-17	2.0E-17	4.7E-18	5.6E-17	1.6E-17	2.2E-17	-1.3E-17	4.7E-17	1.3E-14	1.4E-17	9.9E-18	4.0E-17
AMS-06	5.8E-16	1.3E-15	-1.4E-17	2.9E-15	1.2E-17	5.4E-18	5.5E-18	2.0E-17	8.6E-19	1.6E-17	-2.0E-17	2.3E-17	1.5E-14	1.4E-17	8.4E-18	3.9E-17
AMS-07	1.8E-15	4.1E-15	-1.1E-17	9.1E-15	1.3E-17	5.7E-18	6.4E-18	2.0E-17	6.6E-18	1.6E-17	-1.3E-17	2.9E-17	1.6E-14	1.5E-17	7.5E-18	4.2E-17
AMS-BKG	5.9E-16	1.3E-15	-8.1E-18	3.0E-15	1.5E-17	1.3E-17	-7.8E-19	2.8E-17	-2.5E-18	1.1E-17	-1.7E-17	1.2E-17	1.4E-14	1.2E-17	9.5E-18	4.0E-17

In terms of comparison to 10 CFR 20 Appendix B effluent limits, the data can be summarized as follows:

- Natural uranium concentrations were 0.0 to 0.3 percent of its effluent limit.
- Thorium-230 concentrations were 0.0 percent of its effluent limit.
- Radium-226 concentrations were -0.01 to 0.01 percent of its effluent limit.
- Lead-210 concentrations were -0.02 to 6.78 percent of its effluent limit.

The LLDs, in pCi/f, reported by the laboratory for each radionuclide were converted to μCi/ml by multiplying pCi/f by $1*10^{-12}$. In no cases were the LLDs higher that their respective 10 CFR 20 effluent concentration limits. The LLDs reported in Period 2 by the laboratory for uranium exceeded the recommendation in NRC Regulatory Guide 4.14.

The LLDs for each of the radionuclides are listed in Table 6.1-12.

6.1.6.3 Conclusions

With the exception of natural uranium, the values determined above are similar to U.S. background concentrations reported in the UNSCEAR Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex B. The regional concentrations reported in this reference document are: uranium-238 ($2.4*10^{-17}$ to $1.4*10^{-16}$ μCi/ml), thorium-230 ($1.6*10^{-17}$ μCi/ml), radium-226 ($1.6*10^{-17}$ μCi/ml), and lead-210 ($2.7*10^{-15}$ to $2.7*10^{-14}$ μCi/ml).

6.1.7 Radon Flux Measurements

Radon flux rates were measured at nine locations on three occasions in the Dewey and Burdock roll front areas. The locations are shown on Figure 6.1-9. The locations coincide with the nine soil samples collected from 0-100 cm below ground surface (not in land application areas).

The first round of flux canisters was deployed on September 26, retrieved on September 27, and analyzed on September 28, 2007. The second round of flux canisters was deployed on April 20, retrieved on April 21, and analyzed on April 22, 2008. The third round of flux canisters was deployed on July 14, retrieved on July 15, and analyzed on July 16, 2008. The canisters were analyzed using EPA Test Method 115, Monitoring for Radon-222 Emissions. Results are documented in the Table 6.1-14. Sampling for the three periods yielded flux rates of 1.22, 0.74, and 1.5 picocuries per meter squared second (pCi/m^2-s), respectively. Flux rates ranged between

0.68 and 1.77 pCi/m^2-s in fall 2007, 0.28 and 1.33 pCi/m^2-s in spring 2008 and 0.48 and 2.38 pCi/m^2-s in summer 2008.

Table 6.1-14: Baseline Radon Flux Measurements

Location	Date	Flux (pCi/m^{2}s)	Std. Dev. (pCi/m^{2}s)	LLD (pCi/m^{2}s)	Average Flux @ Location (pCi/m^{2}s)
RFA-B01	September 2007	1.68	0.06	0.18	1.57
	April 2008	0.64	0.05	0.15	
	July 2008	2.38	0.06	0.15	
RFA-B02	September 2007	0.89	0.05	0.15	0.86
	April 2008	0.76	0.05	0.16	
	July 2008	0.94	0.05	0.15	
RFA-B13	September 2007	1.77	0.06	0.17	1.53
	April 2008	0.56	0.05	0.16	
	July 2008	2.27	0.06	0.15	
RFA-B15	September 2007	1.22	0.05	0.15	1.35
	April 2008	1.12	0.06	0.16	
	July 2008	1.71	0.05	0.15	
RFA-B17	September 2007	1.25	0.06	0.16	1.05
	April 2008	0.61	0.05	0.16	
	July 2008	1.30	0.05	0.15	
RFA-B21	September 2007	0.97	0.05	0.14	0.71
	April 2008	0.28	0.05	0.16	
	July 2008	0.89	0.05	0.14	
RFA-B30	September 2007	1.73	0.06	0.17	1.49
	April 2008	0.70	0.05	0.16	
	July 2008	2.03	0.05	0.15	
RFA-B36	September 2007	0.68	0.05	0.16	0.60
	April 2008	0.64	0.05	0.16	
	July 2008	0.48	0.06	0.15	
RFA-B37	September 2007	0.80	0.05	0.14	1.13
	April 2008	1.33	0.06	0.16	
	July 2008	1.27	0.05	0.14	

6.1.7.1 Conclusions

The flux rates determined at the PAA are one to two orders of magnitude below the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) requirements of 20 pCi/m^2-s specified in 10 CFR 40, Appendix A, Criterion 6. Although the latter requirement applies to

tailings and thus is not directly germane to this characterization, it is useful as a context to demonstrate the relatively low magnitude of baseline radon flux rates measured at the site.

6.1.8 Groundwater Sampling

TVA sponsored a groundwater sampling investigation within the Burdock area, in support of a Draft Environmental Statement (DES) in order to quantify groundwater quality within the Edgemont Uranium Mining Project area. The investigation was conducted over the one year period of November 1976 through November of 1977. The groundwater data represents the Fall River and Lakota Formations that form the Inyan Kara Group. In summary of the investigation a brief discussion is provided in support of current groundwater quality data:

The TVA groundwater investigation observed the water from Fall River and Lakota intermixed within some of the wells, thus representing a composite sample of the two formations. Dissolved solids averaged 1,000 mg/L and rated very hard; principle cations for both formations of the Burdock area were observed to be calcium and sodium; principle anions were sulfate and bicarbonates. Concentrations of dissolved solids, sulfates, iron and manganese exceeded the EPA secondary water quality standards. Lead exceeded the EPA standard (1,600 g/L) in one non-flowing well.

At the project site, baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980). Because of the significant number of groundwater wells, their geochemical similarities, and an abundance of historical water quality data, a representative subset of the wells was selected for sampling. The wells were selected based on type of use, aquifer, and location in relation to the ore bodies. The baseline study for the NRC license application consisted of 19 groundwater wells (14 existing and 5 newly drilled) making up a representative sampling group for the area (Figure 6.1-15, Table 6.1-14). The wells selected for sampling include eight domestic wells, six stock watering wells, with three of the fourteen existing wells being hydrologically upgradient of the proposed recovery areas. The total number of wells chosen for site characterization of the groundwater includes wells within the Fall River Formation (4), Lakota Formation (7), Inyan Kara Group (Fall River or Lakota) (2), Sundance Formation (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from July 2007 through June 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 12 wells were sampled monthly beginning in March 2008 and will continue to be sampled through February 2009 for a final total of all wells sampled of 31. The 12 wells required by DENR are represented in (Figure 6.1-16

and Table 6.1-16). Of the 12 wells, six wells are located in the Dewey area and six wells are located in and near the Burdock area. Of the Dewey wells, there is a set of Fall River and Lakota wells sampled, upgradient of, within the PAA, and down gradient of proposed production activities. Near the Burdock area, the same well arrangement applies with two wells upgradient of, two wells within the proposed production area, and two downgradient of the proposed production area. Data for radiological parameters available to date are presented in this section.

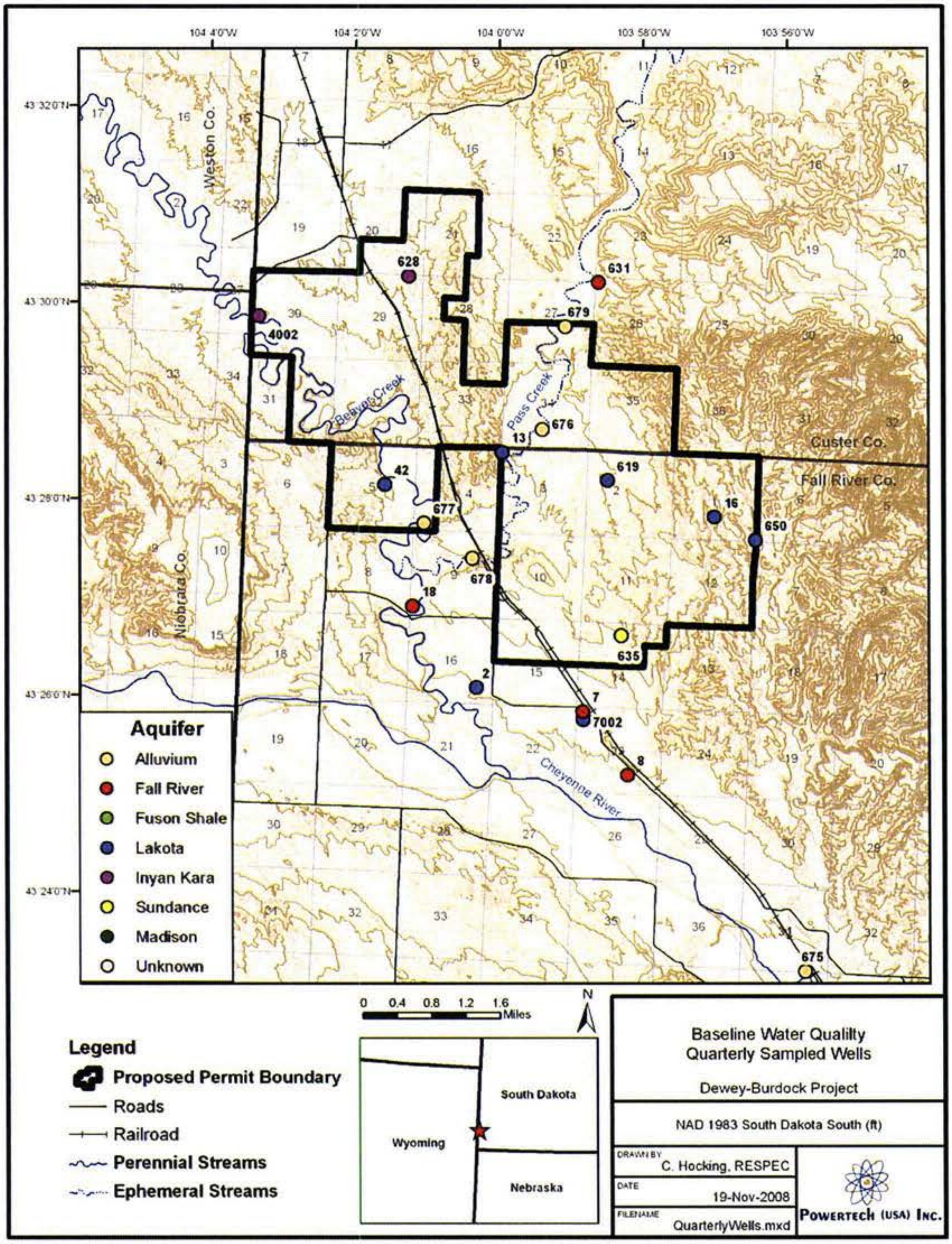

Figure 6.1-15: Baseline Groundwater Quality Quarterly Sampled Wells

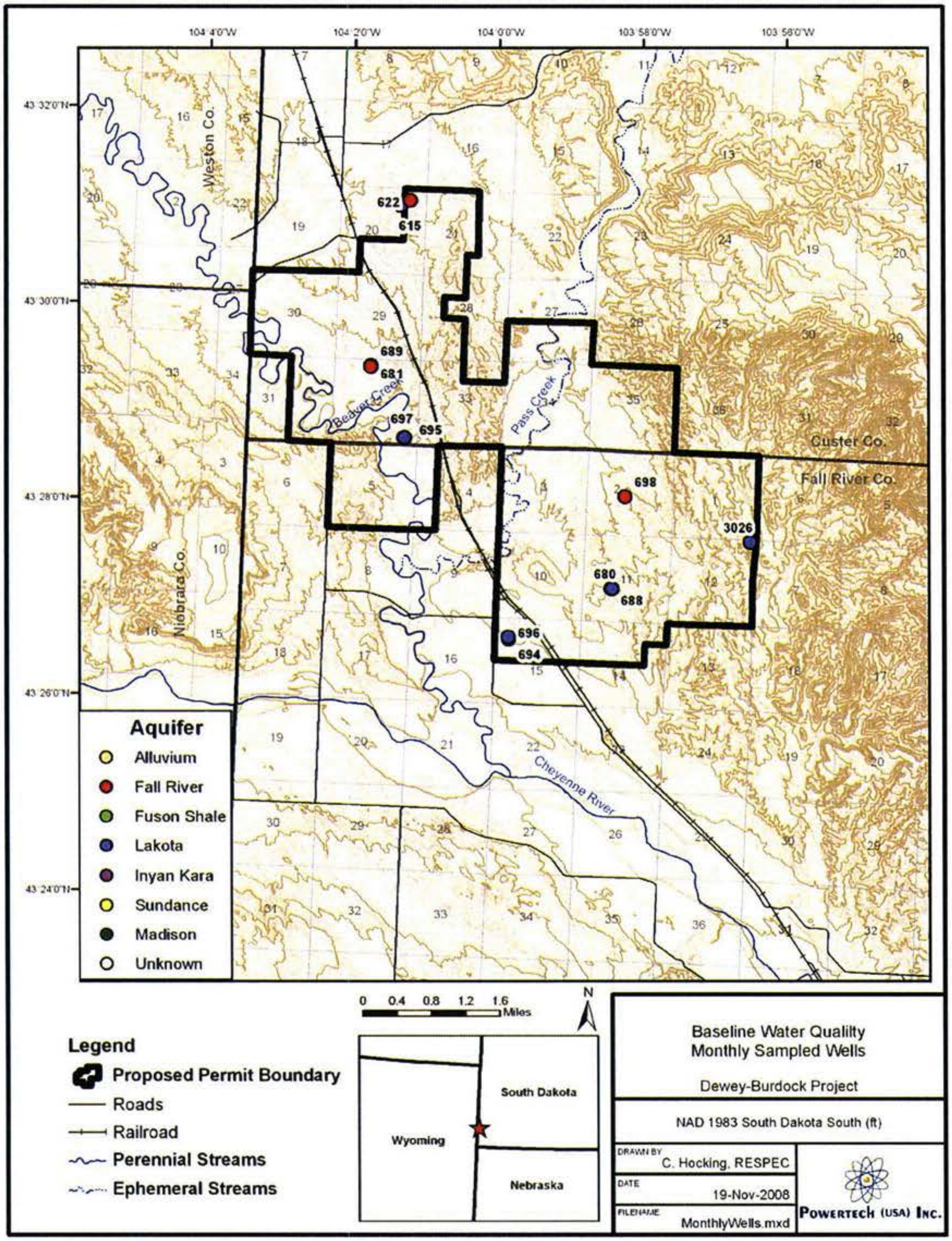

Figure 6.1-16: Baseline Groundwater Quality Monthly Sampled Wells

Table 6.1-15: Quarterly Sampled Water Quality Well Data

ID	SD State Plane 1983 East (ft)	SD State Plane 1983 North (ft)	Formation	Depth, ft	Screened Interval, ft	Description
2	995122.6	423922.6	Lakota	650	566 - 650	Peterson Domestic and Stock
7	1001702.8	422416.9	Fall River	200	unknown	Kennobie Domestic
8	1004451.2	418618.3	Fall River	240	unknown	Englebert Domestic
13	996758.9	438470.4	Lakota	625	580 - 625	C. Spencer Domestic
16	1009827.6	434446.9	Lakota	330	unknown	Daniel Domestic
18	991210.6	428960.1	Fall River	527	unknown	D. Anderson Domestic
42	989542.9	436481.4	Lakota	600	unknown	L. Putnam Domestic
619	1003106.9	437045.9	Lakota	280	unknown	Daniel West – Weather Station Stock
628	990894.7	449719.2	Inyan Kara	unknown	unknown	Abandoned Windmill Stock
631	1002575.7	449309.8	Fall River	80	30 - 80	Putnam Big Pump Stock
635	1004084.6	427130.8	Sundance	880	666 - 780	Sundance Pond Stock
650	1012180.5	433331.4	Lakota	unknown	unknown	Daniel East Stock
675	1015340.3	406352.2	Alluvium	14.4	4 - 14	Marietta Alluvial
676	999245.0	439891.6	Alluvium	22.5	12 - 22	Pass Cr. Spencer Alluvial
677	991947.3	434035.9	Alluvium	14.5	4 - 14	Putnam Alluvial
678	995023.4	431834.9	Alluvium	14.5	4 - 14	Pass Cr. Alluvial
679	1000303.0	446248.3	Alluvium	39	29 - 39	Pass Cr. Doran Alluvial
4002	981812.9	446932.2	Inyan Kara	unknown	unknown	Swimming Pool Stock
7002	1001731.5	421930.8	Lakota	500	unknown	Kennobie Stock

Table 6.1-16: Monthly Sampled Water Quality Well Data

ID	SD State Plane 1983 East (ft)	SD State Plane 1983 North (ft)	Formation	Depth, ft	Screened interval, ft	Description
615	990571.0	453708.9	Lakota	800	712 - 800	TVA No. 2
622	991174.5	454033.8	Fall River	520	503 - 580	TVA No. 8
680	1003476.6	429969.1	Lakota	436	426 - 436	Burdock Pump Test
681	988728.3	443725.3	Fall River	600	585 - 600	Dewey Pump Test
688	1003425.8	429974.4	Fall River	255	245 - 255	Burdock Pump Test West Piezo
689	988715.0	443789.2	Lakota	730	715 - 730	Dewey Pump Test North Piezo
694	997116.1	426836.1	Fall River	392	377 - 392	School House NW
695	990783.4	439312.5	Fall River	508	493 - 508	Putnam East
696	997086.2	426946.4	Lakota	587	572 - 587	School House SE
697	990748.4	439347.4	Lakota	682	667 - 682	Putnam West
698	1004307.8	435651.1	Fall River	205	180 - 205	Weather Station
3026	1012037.4	432833.2	Lakota	196	166 - 196	Daniel New Stock

6.1.8.1 Methods

Static water levels were measured at most wells prior to sample collection with regard to a reference elevation, usually a mark on the well or on a permanent structure above or near to the well. When possible, pressure of artesian wells was measured with a 15 psi or 30 psi N.I.S.T. – certified pressure gauge; the well was shut in and the pressure was allowed to stabilize before a reading was recorded. Pressure values were recorded to within at least one tenth of a psi and typically to within a hundredth of a psi. Wells with subsurface water levels were measured using an electric water level tape with measurements reported to within at least one tenth of a foot and typically to within a hundredth of a foot.

Exceptions to this were domestic wells that could not be accessed at the well head or were behind a pressure tank (wells 7, 8, 13, 16, 18, 42), free-flowing wells that could not be sealed due to leaks caused by corrosion and age (wells 2, 635, 4002), free-flowing wells that could not be sealed due to poor valve fittings or cracked valves (well 696), free-flowing wells where existed the possibility of rupturing a line when pressurized due to age (well 7002), and wells that contained pumps and pump tubing making it difficult to retrieve a water level tape (well 619).

All pumped wells, with the exception of 631, had permanent pumps installed in order to obtain samples. An existing high-capacity pump in well 631, used to pump water up a hill several hundred feet to a stock tank, was not used for sampling purposes due to logistical hurdles except for the first sample collected there on September 27, 2007. For the next three samples, a small dedicated pump was used each time the well was sampled.

Continuous free-flowing wells were sampled before pressure measurements were made and were not purged before sampling. For these wells (2, 18, 42, 635, 4002, 7002), it was assumed that free-flowing well water adequately represented formation water. After collecting a sample, a spot check with a water-quality probe was made and temperature, specific conductivity, turbidity, and pH were recorded. Pressure was then measured at the wells where it was possible within limits of feasibility.

After measuring the pressure of capped free-flowing wells (where possible), the well valve was opened and the flow rate was allowed to stabilize, then flow measurements were made using a stopwatch and a marked container (usually a 5-gallon pail, but sometimes a 1-gallon container at slower-flowing wells). Casing purge time was calculated based on water column height, casing diameter, and flow rate. Three well volumes were required to have been purged before the well water was sampled. Additionally, a water-quality sonde with a flow-through cell was connected

to the well and. water quality parameters (pH, temperature and conductivity) were periodically recorded If parameters had not stabilized after purging three volumes, wells were allowed to continue to purge until parameters had stabilized, or until the purged volume was >> three well volumes.

Pumped wells were purged of three pore volumes and once one or more of the water quality parameters stabilized (conductivity, temperature, and pH) flow from the formation was sampled.

- After measuring water level (where possible), the pump was started and flow rate was measured using stopwatch and 5-gallon marked pail.
- A water-quality probe equipped with a flow-through cell was connected to outflow.
- Wells with a high enough yield were purged for a minimum of three well volumes, and also until one or more indicator parameters had stabilized. Parameters monitored for stabilization were specific conductance, temperature, and pH. Field measurements were recorded periodically during purging of 3 volumes, and at least 3 minutes apart after purging three volumes. Table 6.1-17 gives requirements for parameter stabilization. After three well volumes had been purged and parameters stabilized, a sample was collected.
- Wells that had yields too low to be continuously pumped and purged of three well volumes were pumped dry and allowed to recover. After the well had sufficiently recovered, it was pumped and sampled. Accurate records of well purging are maintained to document the number of casing volumes purged from the well before sampling, but in all cases a minimum of one casing volume was purged before sampling.
- After calculating casing volume, alluvial wells were purged of three well volumes into a 5-gallon marked pail using either disposable bailers or a peristaltic pump. When using bailers, water quality parameters were recorded after each well volume was purged using a water-quality probe. When using the peristaltic pump, a water quality probe equipped with flow-through cell was connected to pump outflow and parameters (pH, temperature and conductivity) were recorded periodically during the purge.

Table 6.1-17: Stability Criteria for Collecting Groundwater Samples at Pumped Wells

Field Measurement	Stability Criteria[1]
pH	+/- 0.1 standard units
Temperature	+/- 0.2 C
Specific conductivity	+/- 5% (SC <= 100 µS/cm); otherwise +/- 3%

[1]Allowable variation between 5 or more sequential field-measurement values

Additional steps taken during water quality sampling include the following:

- Sampling procedures required a qualified technician (wearing gloves) to label each sample bottle with site ID, date, time of sampling, triple rinsing the bottle with sample water, then filling and capping it.
- Radon sample bottles were filled and capped immediately and with no headspace.
- Field replicate samples, consisting of a second set of samples collected at the same time following the same protocols as the sample set, were collected periodically to determine data accuracy.
- Field blanks were collected by transporting deionized water supplied by the contract laboratory to the field during regular sampling, then transferred to collection bottles in the field in order to subject the blank water to the same transportation, handling, storage, and field conditions as regular samples.
- All samples were immediately placed in coolers on ice after collection.
- Water quality sondes used to collect field parameter measurements were calibrated periodically using N.I.S.T.-traceable standards.

A groundwater quality constituent list was developed based on NUREG-1569 groundwater parameters, NRC 4.14 parameters, and added parameters from a constituent-list review with SD DENR.

6.1.8.2 Groundwater Sampling Radiological Results

Results to date for dissolved radiological groundwater parameters are shown in Table 6.1-18 and Table 6.1-19.

Table 6.1-18: Summary of Groundwater Radionuclide Concentrations From Quarterly Sampled Wells

Parameter	Aquifer	Alpha Particle-Dissolved				Uranium-Dissolved				Uranium-Total				Radium-226 -Dissolved				Radium-226-Total				Radon-222		
Units		pCi/L				mg/L				mg/L				pCi/L				pCi/L				pCi/L		
Sampling Quarter / Sample ID		3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	3rd Quarter 2007	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008	4th Quarter 2007	1st Quarter 2008	2nd Quarter 2008
Domestic Wells																								
2	Lakota	1.4	8.7	3.5	8.2	ND	ND	0.0004	ND	0.0004	NS	0.0004	ND	ND	1.3	1.1	2.1	2.2	NS	NS	NS	674	908	727
7	Fall River	4.4	7.2	15.5	3.3	ND	ND	ND	ND	NS	NS	ND	ND	0.6	1.1	0.7	0.9	ND	NS	NS	NS	206	242	451
8	Fall River	5	8.7	5.4	3.2	ND	0.0003	ND	ND	ND	NS	ND	ND	ND	NS	1.5	1.2	3.5	NS	NS	NS	123	329	514
13	Lakota	8.9	7.5	19.5	4.2	ND	ND	ND	ND	NS	NS	ND	ND	1.8	1.6	1.1	1.6	1.1	NS	NS	NS	305	258	412
16	Lakota	62.7	12.2	85.7	28.3	0.0021	0.0007	0.0007	<0.0003	NS	NS	0.0007	<0.0003	26.2	8.1	15.3	6.4	17.4	NS	NS	NS	1090	28200	3150
18	Fall River	15.7	18.9 (Rep 20.0)	31.7	27.5	0.0061	0.0066 (Rep 0.0065)	0.0066	0.0059	NS	NS	0.0062	0.0062	ND	3.2 (Rep 3.6)	3.2	2.6	4.0	NS	NS	NS	945 (Rep 944)	1220	1210
4002A	Other Inyan Kara	120 (Rep 141)	227	314	127	0.0026 (Rep 0.0026)	0.0026	0.0026	0.0023	NS	NS	0.0025	0.0025	63.6 (Rep 60.0)	54.2	57.0	52.3	62.7 (Rep 79.4)	NS	NS	NS	8010	9890	8780
7002	Lakota	45.6	39.8	91.4	29.5	0.0007	0.0006	0.0006	0.0005	NS	NS	0.0005	0.0006	8.5	8.1	8.8	8.0	6.3	NS	NS	NS	938	752	1270
Domestic/Stock Wells																								
42	Lakota	371	375	526	558	0.0150	0.0324	0.0194	0.0142	NS	NS	0.0198	0.0149	96.5	102	100	100	79.7	NS	NS	NS	132000	175000	219000
Stock Wells																								
619	Lakota	367	341	438	398	0.0020	0.0015	0.0015	0.0016	NS	NS	0.0018	0.0018	120	100	99.7	110	120	NS	NS	NS	2990	5580	5770
628	Other Inyan Kara	29.9	83.9	64.5	39	0.0017	0.0034	0.0030	0.0027	NS	NS	0.0031	0.0029	7.4	20.7	9.0	6.1	6.8	NS	NS	NS	2740	4360	5040
631	Fall River	51.0	46.5	162	60.7	0.0027	0.0029	0.0027	0.0026	0.003	NS	0.0026	0.0028	12.9	9.5	19.4	22.1	15.2	NS	NS	NS	4220	3920	4430
635	Sundance / Unkpapa	2.5	4.4	14.8	13.2	0.0020	0.0020	0.0021	0.0017	0.002	NS	0.0021	0.0017	1.6	0.8	1.3	NS	NS	NS	NS	NS	902	806	1070
650	Lakota	13.1	5.6	2.9	2.1	0.0019	ND	ND	ND	NS	NS	0.0004	ND	2.7	2.4	1.4	1.2	3.2	NS	NS	NS	134	202	254
Piezometer																								
675	Alluvial	18.8	18.3	29.3	55.2 (Rep 51.1)	0.0372	0.0307	0.0387	0.0493 (Rep 0.0485)	NS	NS	0.0387	0.0505 (Rep 0.0516)	ND	0.5	ND	0.7 (Rep 0.7)	2.3	NS	NS	NS	712	783	960 (Rep 960)
676	Alluvial	37.1	31.9	95.5	NS	0.0494	0.0548	0.0586	NS	NS	0	0.0687	NS	ND	ND	ND	NS	ND	NS	NS	NS	453	686	NS
677	Alluvial	41.0	38.7	129	43.1	0.0218	0.0443	0.0402	0.045	NS	0	0.0414	0.0471	0.9	ND	ND	0	ND	NS	NS	0	892	808	1250
678	Alluvial	23.2	18.9	41.4 (Rep 30.2)	54.7	0.0352	0.0349	0.0368	0.0355	NS	NS	0.0379	0.0387	ND	ND	ND (Rep ND)	NS	ND	NS	NS	NS	391	487 (Rep 418)	687
679	Alluvial	19.9	13.3	18.4	NS	0.0157	0.0144	0.0139	NS	NS	NS	0.0154	NS	ND	ND	0.9	NS	2.5	NS	NS	NS	819	2170	NS

Notes:

Yellow highlights designate concentrations over the EPA MCL

Blue highlights designate concentrations over the proposed EPA MCL (300 pCi/L) for radon

ND = Not detected

NS = No sample

Rep = duplicate analysis

Table 6.1-19: Summary of Groundwater Radionuclide Concentrations From Monthly Sampled Wells

Parameter	Aquifer	Alpha Particle-Dissolved				Uranium-Dissolved				Uranium-Total				Radium-226 -Dissolved				Radium-226-Total				Radon-222			
Units		pCi/L				mg/L				mg/L				pCi/L				pCi/L				pCi/L			
Sampling Quarter / Sample ID		Mar-08	Apr-08	May-08	Jun-08	Mar-08	Apr-08	May-08	Jun-08	Mar-08	Apr-08	May-08	Jun-08	Mar-08	Apr-08	May-08	Jun-08	Mar-08	Apr-08	May-08	Jun-08	Mar-08	Apr-08	May-08	Jun-08
615	Fall River	18	15.1	15.3	38.3	0.0026	0.0025	0.0024	0.0024	0.0026	0.0025	0.0025	0.0023	2.1	2	2	7.2	2.4	1.8	2.2	6.8	1370	1180	1070	1830
622	Fall River	15	22.6	32.6	36.4	<0.0003	0.0054	0.0056	0.0051	<0.0003	0.0065	0.0068	0.0059	2.3	2.7	3.2	4.1	3	3.6	4.2	3.9	501	1090	804	1950
680	Lakota	6440	4270	5500	4370	0.0569	0.0303	0.0343	0.0227	0.0541	0.0291	0.0256	0.0244	1150	1230	1340	1410	1152	1232	1353	1415	81000	151000	255000	91700
681	Fall River	2170	1400	1720	1390	0.0092	0.0098	0.0096	0.0097	0.0099	0.0102	0.0106	0.0102	414	377	415	434	418	377	417	435	254000	253000	462000	389000
688	Lakota	2.9	10.1	17.3	13.2	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.3	1.2	2.5	0.6	1.2	1.2	2.2	13.5	608	307	749	426
689	Fall River	64.3	25.5	34.9	36.5	0.0032	0.0037	0.0043	0.0034	0.0041	0.004	0.0117	0.006	7.9	4.2	5.7	5.5	9.9	4.2	6.2	5	1950	1540	1390	2520
694	Lakota	8.8	18.6	10.6	23.7	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	1.6	4	1.9	2.2	2.6	3.5	1.7	1.9	313	251	619	611
695	Lakota	NS	29.4	25.6	39.7	NS	0.0029	0.0029	0.0027	NS	0.0032	0.0029	0.0027	NS	5	3.7	5.2	NS	4.6	3.5	5.1	NS	1400	2090	2120
696	Lakota	3.9	5.2	14.3	23.9	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	1	0.5	1.8	3.3	1.6	0.3	1.7	2.9	190	185	497	517
697	Lakota	32.2	8.1	4.1	11.9	<0.0003	0.0030	<0.0003	<0.0003	<0.0003	0.0031	<0.0003	<0.0003	3.9	1.7	1.1	0.8	4.5	1.6	4.9	0.4	862	284	570	413
698	Fall River	1820	2110	1300	1790	0.109	0.11	0.102	0.104	0.123	0.119	0.118	0.113	393	370	413	429	408	376	427	441	30800	25800	24000	40700
3026	Lakota	47.6	43.8	92.4	116	0.0151	0.015	0.0281	0.0183	0.0097	0.0196	0.0322	0.0216	3.6	2.8	9.6	4.7	6.9	2.9	10.8	4.6	440	304	213	950

Notes:

Yellow highlights designate concentrations over the EPA MCL

Blue highlights designate concentrations over the proposed EPA MCL (300 pCi/L) for radon

ND = Not detected

NS = No sample

6.1.8.3 Comparison of Historical and Recent Groundwater Quality near the Project

An analysis was conducted to determine if the well chemistry data collected at the PAA by the Tennessee Valley Authority (TVA) between May 1979 and April 1984 is representative of current water quality conditions and could therefore be used to expand the current Powertech data set. Nine wells were selected for analysis based on TVA and Powertech data sets being available for each well, time period, and constituent (Figure 6.1-17). All nine wells are completed into the Inyan Kara Group, which is composed of the Lakota and Fall River formations. Five of the wells are completed into the Lakota formation, three in the Fall River formation, and one is classified as simply the Inyan Kara formation.

Powertech and TVA data comparison consisted of two phases: (1) computing basic statistics on selected data, and (2) plotting Piper diagrams. The same set of wells was used in both analyses. Table 6.1-20 lists wells, the aquifer they are completed into, and the number of sample results available for analysis from monitoring programs done by TVA and Powertech. Table 6.1-21 shows the constituents sampled for during TVA data collection and those used in the comparison analysis either with statistics or Piper diagrams. Because the Powertech program is ongoing, the sample number is the number of samples analyzed through August 2008. Data selection process, analysis details, and results from statistical analyses and Piper plots are summarized independently in the following sections.

The following procedures were followed in completing the analyses:

- The analytical data was reviewed to define the chemical constituents that were similar between the monitoring programs with a focus on bulk properties.
- The reported values of alkalinity, conductivity, pH, and total dissolved solids (TDS) were compared from nine wells that were sampled during both project periods.
- Statistics calculated included mean, minimum, and maximum.
- Comparison was made by graphical representation of the mean value of reported parameters from TVA and Powertech data.
- At well 2, mean was computed and graphed both with an outlier included and without an outlier included for Alkalinity, TDS, and conductivity.

The number of samples analyzed during the current monitoring program limited the sample size available for statistical analysis. Therefore the analyses techniques available were limited to less rigorous qualitative and quantitative techniques. Comparison statistics reported are mean,

minimum, and maximum, with relative percent difference (RPD) calculated for each statistic, where RPD is the absolute difference divided by the average (Table 6.1-22). Complete groundwater quality data results are available in Appendix 3.4-C (Powertech results) and Appendix 6.1-B (TVA results).

POWERTECH (USA) INC.

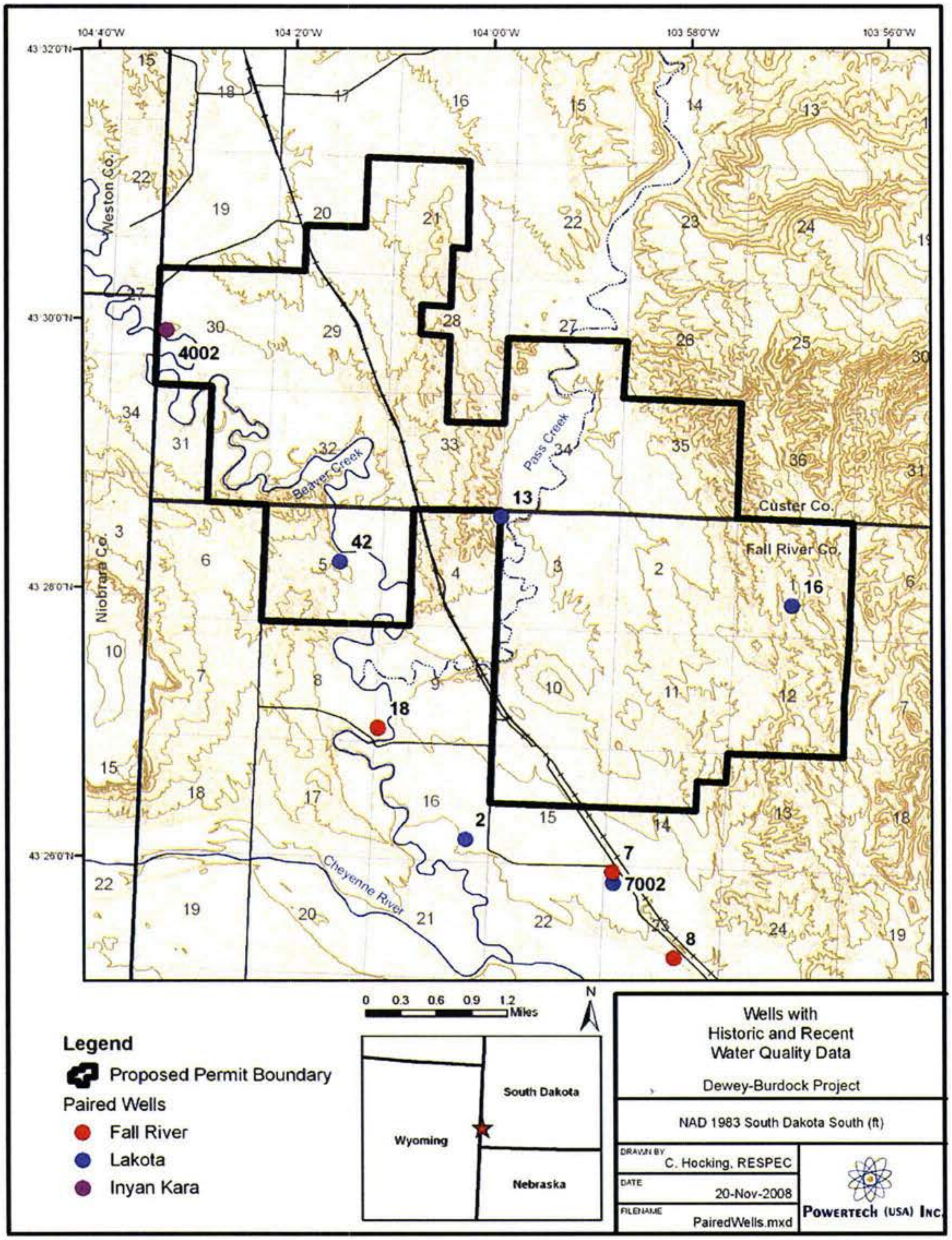

Figure 6.1-17: Wells with Historic and Recent Groundwater Quality Data

Table 6.1-20: Groundwater Quality Sampling from Previous Uranium Exploration Era as well as from Recent Exploration

Well No.	Aquifer	Number of TVA samples (1979 – 1984)	Number of Powertech samples (2006 – 2008)
2	Lakota	10	4
7	Fall River	2	5
8	Fall River	11	5
13	Lakota	11	5
16	Lakota	3	5
18	Fall River	11	6
42	Lakota	10	5
4002	Inyan Kara	5	5
7002	Lakota	11	4

Table 6.1-21: Parameters Analyzed During TVA Water Quality Monitoring

Test Analyte/Parameter	Units	Notes	Used in Historic/Recent Comparison
BULK PROPERTIES			
pH	pH Units	Field and Laboratory Program	X
Total Dissolved Solids (TDS)	mg/L		X
Total Suspended Solids (TSS)	mg/L		
Water Level	ft		
Conductivity	µmhos/cm	Field and Laboratory Program	X
Hardness			
CATIONS/ANIONS			
Calcium	mg/L		X
Alkalinity	mg/L		X
Bicarbonate (as HCO_3)	mg/L		X
Carbonate (as $CaCO_3$)	mg/L		X
Magnesium	mg/L		X
Potassium	mg/L		X
Sodium	mg/L		X
Sulfate	mg/L		X
Chloride	mg/L		X
Phosphate	mg/L		
Nitrogen	mg/L		
Cation/Anion Balance	%		
TRACE METALS			
Arsenic, As	mg/L	Dissolved	
Boron, B	mg/L	Dissolved	
Iron, Fe	mg/L	Dissolved	
Manganese, Mn	mg/L	Dissolved	
Lead, Pb	mg/L	Dissolved	
Selenium, Se	mg/L	Dissolved: Speciated	
Silcon-SiO_2	mg/L		
Uranium, U	mg/L	Total	
Vanadium, V	mg/L		
Zinc, Zn	mg/L	Dissolved	
RADIONUCLIDES			
Radium-226	pCi/L	Total	

Average alkalinity decreased slightly for all wells sampled except for No. 16 and No. 7002 which had essentially the same mean alkalinity in both time periods. The average absolute difference of the mean value of alkalinity was approximately 7 percent in the two data sets. The minimum value statistic at No. 2 showed the greatest RPD (78 percent) between TVA and

Powertech data; one sample had an alkalinity of 88 mg/L while the other three ranged from 208 mg/L to 214 mg/L. A plot comparing average alkalinity between TVA and Powertech data is given in Figure 6.1-18; this plot both includes and excludes the low value at No. 2 well in the mean calculation.

Conductivity was overall slightly greater (8 percent) than in previous sampling years. It decreased slightly in No.16 and was essentially the same in No. 13 and No. 7002. The greatest increase in conductivity was found in No.2 (from 1547 to 2285 umhos/cm); although with the exclusion of an outlier (4400 umhos/cm) the mean of Powertech samples is 1580 umhos/cm. Figure 6.1-19 is a plot of average conductivity compared between historic TVA and current Powertech data both including and excluding the outlier value at No. 2 well in the mean calculation.

Values of pH were slightly higher in Powertech samples than in TVA samples, with the exception of wells No.2 and No. 7002 (Figure 6.1-20). Mean pH values varied from 7.44 to 8.11 at wells with greater than five samples. The greatest difference in pH was at well No. 7, with mean pH of 8.5 for TVA data and mean pH of 8.11 for Powertech data.

The TDS values from the two different sampling periods were also very similar. The greatest difference was once again at well No.2 that had a mean of 1043 mg/L in the TVA era compared to 1750 mg/L in the current sampling period. One Powertech sample collected at No. 2 well had a TDS value of 3700 mg/L, while the other Powertech samples were the same at 1100 mg/L. Figure 6.1-21 gives a comparison between historic TVA and current Powertech mean TDS, showing the mean calculated both including and excluding the outlier value at well No. 2.

Table 6.1-22: Comparison of Statistics for Selected Constituents between Historic TVA Data and Current Powertech Data

		Mean			Minimum			Maximum		
	Well	Powertech	TVA	RPD	Powertech	TVA	RPD	Powertech	TVA	RPD
Alkalinity as CaCO3, mg/L	2	181	219	19%	88	200	78%	214	242	12%
	7	171	181	6%	170	171	1%	176	191	8%
	8	166	178	7%	156	166	6%	178	194	9%
	13	159	173	8%	142	160	12%	170	196	14%
	16	153	152	1%	148	144	3%	160	157	2%
	18	179	196	9%	172	180	5%	184	238	26%
	42	178	188	5%	174	179	3%	180	204	13%
	4002	140	158	12%	138	144	4%	144	202	34%
	7002	261	261	0%	250	210	17%	280	300	7%
Conductivity, uS/cm	2	2285	1547	39%	1500	1450	3%	4400	1750	86%
	7	1542	1338	14%	1440	1325	8%	1650	1350	20%
	8	1450	1385	5%	1420	1285	10%	1560	1450	7%
	13	1292	1274	1%	1140	1100	4%	1420	1400	1%
	16	1063	1162	9%	925	1150	22%	1260	1175	7%
	18	1412	1379	2%	1330	1300	2%	1470	1420	3%
	42	1408	1353	4%	1310	1200	9%	1510	1400	8%
	4002	1220	1161	5%	1130	1100	3%	1340	1195	11%
	7002	2328	2339	0%	2200	1925	13%	2480	2500	1%
pH	2	7.91	7.7	3%	7.85	7.16	9%	7.94	8.2	3%
	7	8.11	8.5	5%	8.05	8.3	3%	8.17	8.7	6%
	8	7.95	7.87	1%	7.93	7.59	4%	7.97	8.5	6%
	13	7.9	7.76	2%	7.75	7.48	4%	8.05	8.1	1%
	16	7.46	7.34	2%	7.38	7.31	1%	7.57	7.39	2%
	18	8.08	7.94	2%	8.02	7.69	4%	8.11	8.4	4%
	42	8.02	7.94	1%	7.95	7.67	4%	8.08	8.4	4%
	4002	7.83	7.75	1%	7.65	7.51	2%	8.02	8.5	6%
	7002	7.36	7.44	1%	7.22	7.14	1%	7.56	8	6%
	2	1750	1043	51%	1100	1004	9%	3600	1113	106%
	7	999	1081	8%	896	1058	17%	1050	1104	5%
	8	1000	965	4%	940	860	9%	1100	1130	3%
	13	878	886	1%	850	792	7%	890	1006	12%
	16	814	846	4%	760	796	5%	940	894	5%
	18	958	909	5%	940	520	58%	990	1118	12%
	42	950	939	1%	930	888	5%	980	1033	5%
	4002	818	773	6%	790	740	7%	850	805	5%
	7002	1875	1843	2%	1800	1690	6%	1900	1970	4%

RPD (Relative Percent Difference) = The absolute difference divided by the average.

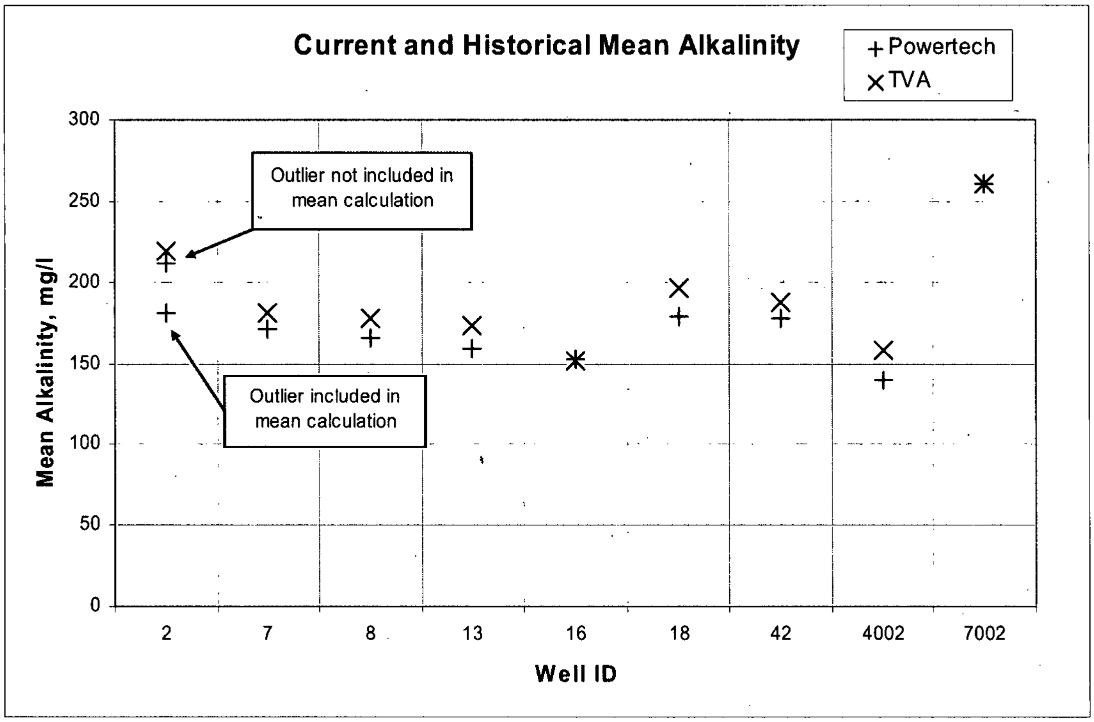

Figure 6.1-18: Mean Alkalinity Comparison between Historic TVA and Current Powertech Data

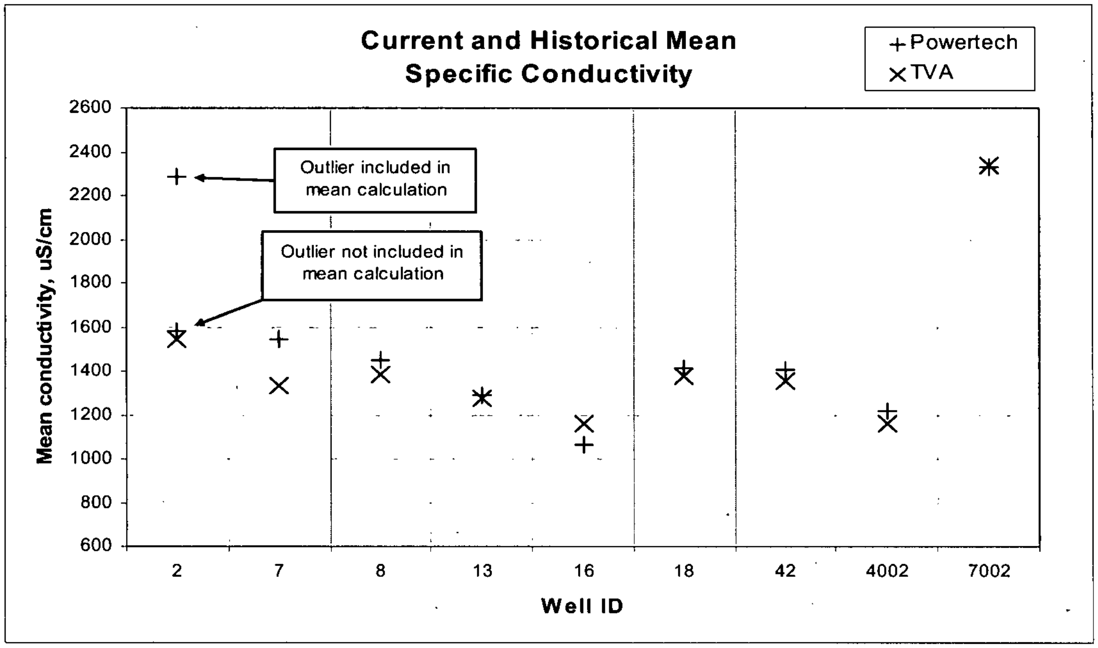

Figure 6.1-19: Mean Conductivity Comparison between Historic TVA and Current Powertech Data

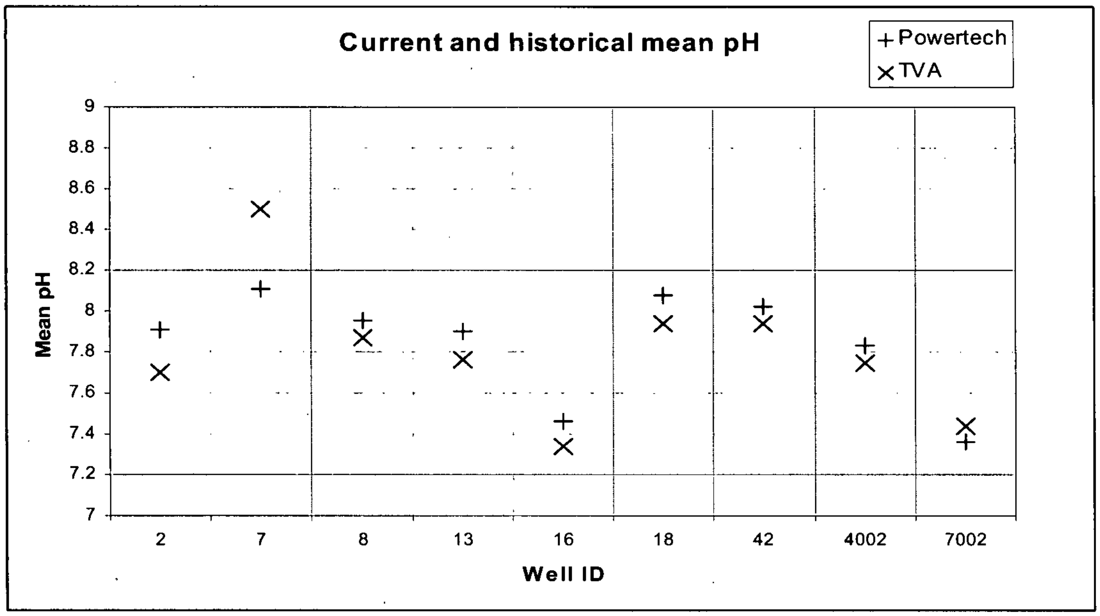

Figure 6.1-20: Mean pH Comparison between Historic TVA and Current Powertech Data

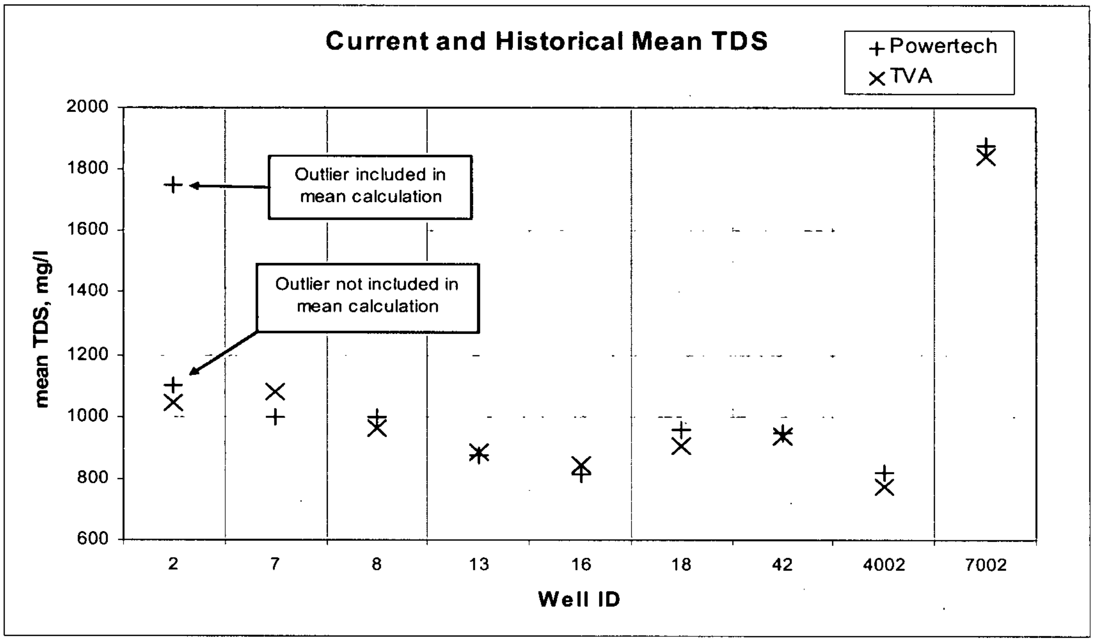

Figure 6.1-21: Mean TDS Comparison between Historic TVA and Current Powertech Data

Piper diagrams were constructed for this group of wells with both historic and recent samples to determine if the general water quality type has changed over the course of the last 30 years (Figures 6.1-22 through 6.1-26). Piper diagrams are a useful tool to evaluate overall water quality as they provide a visual representation of the proportional concentrations of major ions. These figures consist of two trilinear diagrams (one for each cations and anions) and a comprehensive quadrilateral diagram. The trilinear diagrams illustrate the relative concentrations of cations (left diagram) and anions (right diagram) in each sample plotted as percent of total in milliequivalents per liter (meq/l). Cations included on the diagram include sodium (Na+) plus potassium (K+), calcium (Ca++), and magnesium (Mg++). Anions plotted include bicarbonate (HCO3-) plus carbonate (CO3--), sulfate (SO4--), and chloride (Cl-). Each sample is represented by a point in each trilinear diagram. The quadrilateral field at the top of the Piper diagram is designed to show both anion and cation groups and is used to assign a general water type.

Inspection of the resulting Piper diagrams reveals that water quality within both the Fall River and Lakota formations display a similar distribution. For both formations, sulfate is by far the dominant anion accounting for 70 to 80 percent meq/l (Figure 6.1-22). Relative abundance of calcium and magnesium are fairly even though most samples have a slightly higher percentage of

calcium. Most samples contain between 55 and 85 percent meq/l sodium although water from the Lakota has a greater fluctuation with a group of samples having only 20 to 30 percent meq/l of sodium. Figures 6.1-23 and 6.1-24 display the water major ion concentrations sorted by aquifer and historical and recent data sets. In general, both the historic and recent data sets display the same trends and range in water type grading between a calcium-magnesium sulfate to sodium sulfate type.

Figures 6.1-25 and 6.1-26 display the proportional concentrations of major ions symbolized by well. These diagrams illustrate that samples for a particular well form a cluster, and hence it can be said that water quality has not greatly varied by sampling event. It is also apparent that the water type is variable from well to well. The geographical location and distance from the outcrop are therefore believed to be the main influences on water type, although well depth and screened interval may also have an effect. Wells that are located on or near the Inyan Kara outcrop (well 16 for example) yield a more calcium-magnesium sulfate type water, whereas wells further downgradient evolve to a sodium sulfate type water. This finding is consistent with that of Gott et al. (1974), who believed the difference in water type distribution resulted from recharge to the Inyan Kara from upward leaking Minnelusa aquifer water. It can be concluded that relative ion concentration of Inyan Kara formation water is similar today to what it was during TVA sampling in the PAA.

Although a rigorous statistical analysis was not performed due to the small sample size of the Powertech and TVA well chemistry data, the general water quality parameters in the aquifers has shown good consistency over time. Therefore, the Powertech data set can be supplemented with the previously collected TVA data to expand the knowledge of baseline water quality conditions and the time period of data collection from one to almost 30 years. Future monitoring is anticipated to demonstrate the continuing stability of water chemistry.

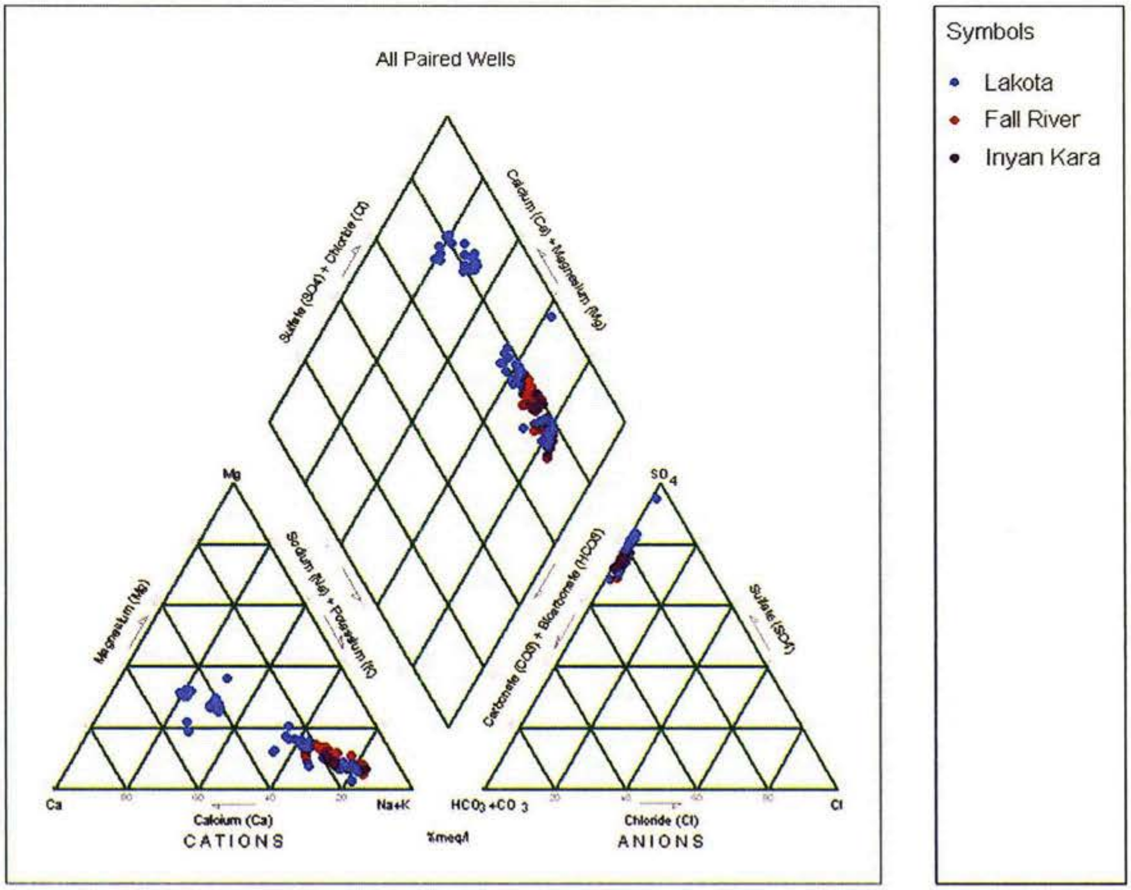

Figure 6.1-22: Piper Diagram of Well Data Grouped by Formation for Wells Sampled by TVA and Powertech

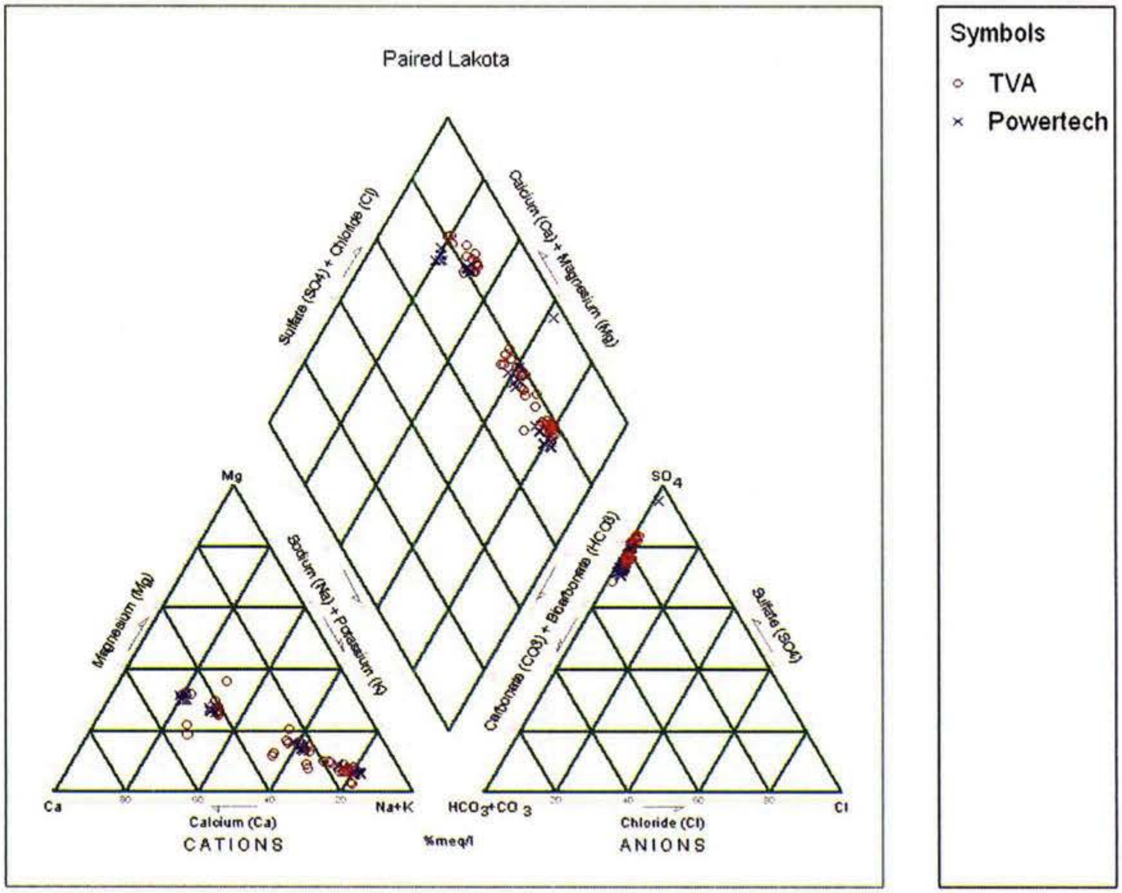

Figure 6.1-23: Piper Diagram of Sample Results from Lakota Wells Grouped by Vintage

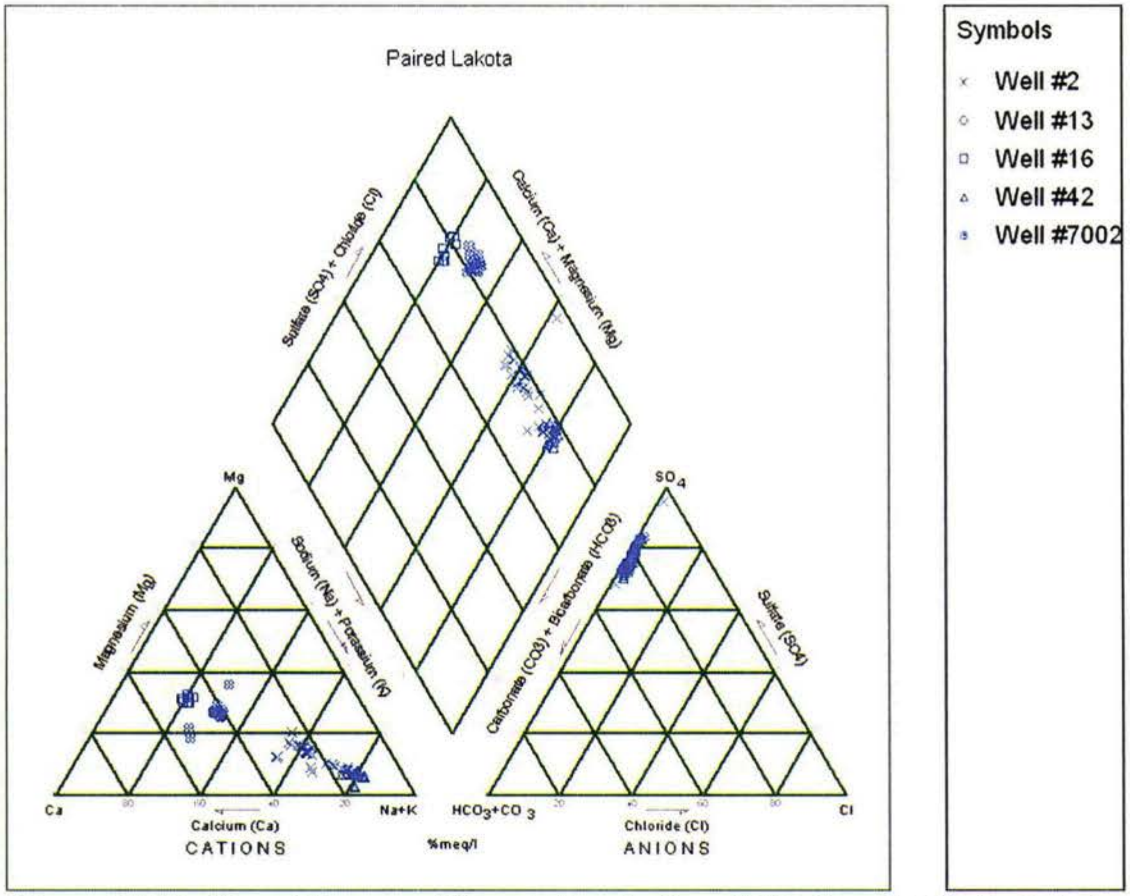

Figure 6.1-24: Piper Diagram of Sample Results from Wells Sampled in the Lakota Formation by TVA and Powertech Grouped by Well

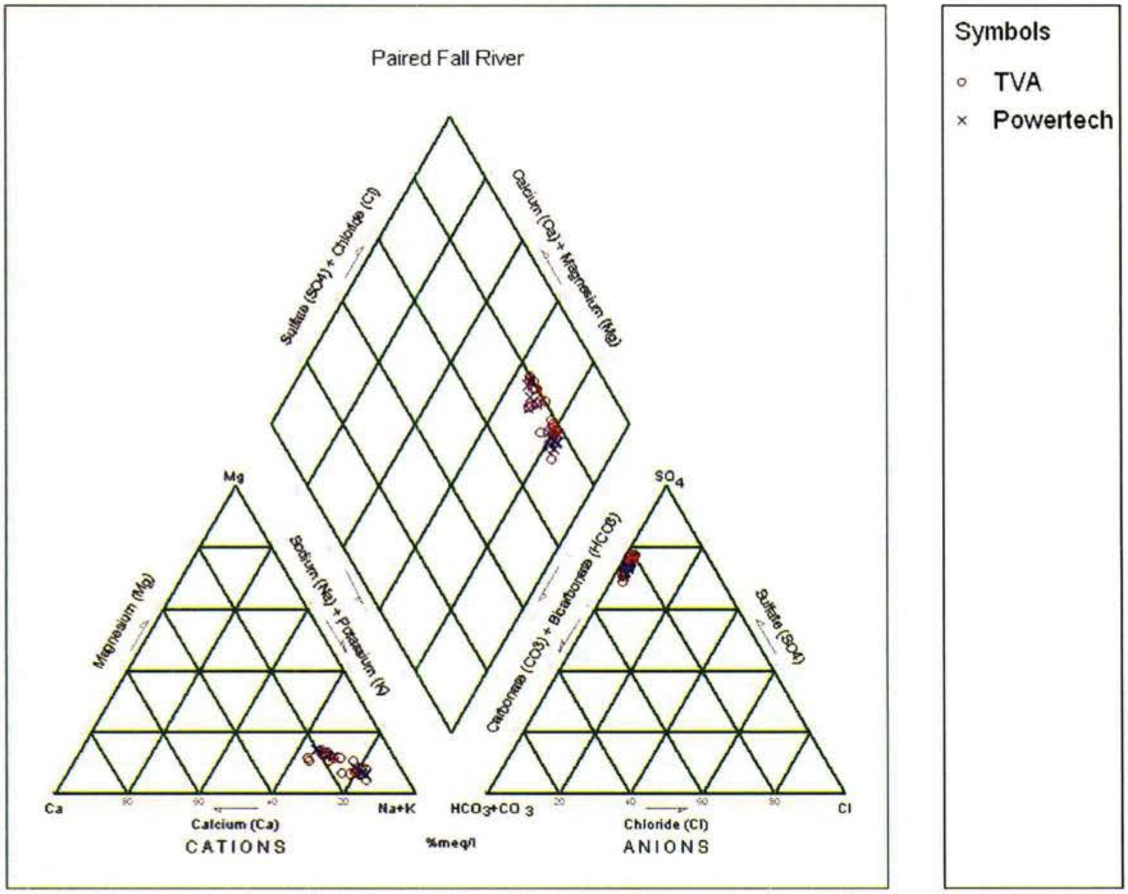

Figure 6.1-25: Piper Diagram of Sample Results from Fall River Wells Grouped by Vintage

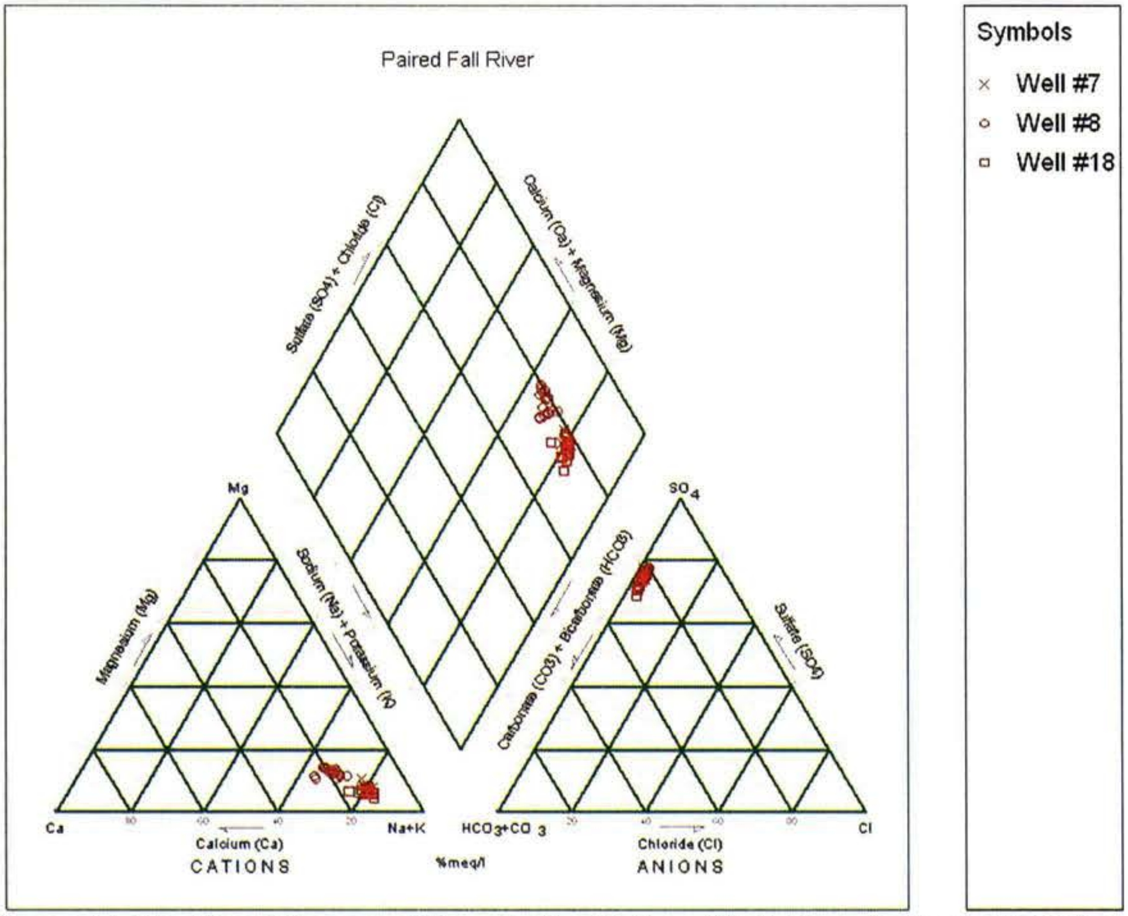

Figure 6.1-26: Piper Diagram of Sample Results from Wells Sampled in the Fall River Formation by TVA and Powertech Grouped by Well

6.1.8.4 Conclusions

The radiological baseline sampling results indicate that the groundwater contained within the ore zones of the Inyan Kara Group has concentrations of radionuclides that greatly exceed EPA MCL concentrations at levels and, therefore, are not acceptable for human consumption. The aquifer does not presently, and will not in the future, serve as a source of drinking water.

6.1.9 Surface Water Sampling

Working within the practices of good stewardship and in conjunction with federal and state agencies (NRC Guide 4.14 (RG 4.14), NUREG-1569, and South Dakota mining rules ARSD 74:29), the perennial and ephemeral streams and impoundments in the PAA were sampled

upstream and downstream of the PAA. Figure 6.1-27 and Figure 6.1-28 show the locations of the stream and impoundment sampling sites.

TVA conducted a surface water sampling investigation in support of a DES in order to quantify surface water quality within the Edgemont Uranium Mining Project area. The investigation was conducted between December 1974 and September 1977. The surface water data was supplemented by incorporation of USGS and the State of South Dakota surface water quality data into the draft assessment. In summary of the assessment a brief discussion is provided in support of current surface water quality data:

The Cheyenne River and Beaver Creek water bodies exhibited concentrations elevated above state standards in regards to mean dissolved solids; the total alkalinity and hardness averages for both the Cheyenne River and Beaver Creek represented levels that characterize both water as very hard and exceeded the mean dissolved solids concentrations in the Cheyenne for criteria set for livestock watering. Cheyenne averaged 156 mg/L for total alkalinity and 1,390 mg/L for hardness. Beaver Creek averages for total alkalinity and hardness were observed at 148 mg/L and 1,425 mg/L respectively. Dissolved solids for Cheyenne and Beaver creek averaged 3,513 mg/L and 2,960 mg/L respectively. Chemical water quality concentrations for both water bodies that were observed above the EPA Primary drinking water standards with regard to barium and arsenic; EPA secondary drinking water standards (proposed at the time of the investigation) were exceeded in both bodies of water with regards to concentrations of chlorides, iron (exceeded South Dakota water quality standard), manganese, and sulfates; cadmium was above the standard in Beaver Creek. Both water bodies were deemed unsuitable for continuous irrigation use on all soils by 1972 National Academy of Science / National Academy of Engineering (NAS/NAE) Water Quality Criteria (Tennessee Valley Authority, 1979).

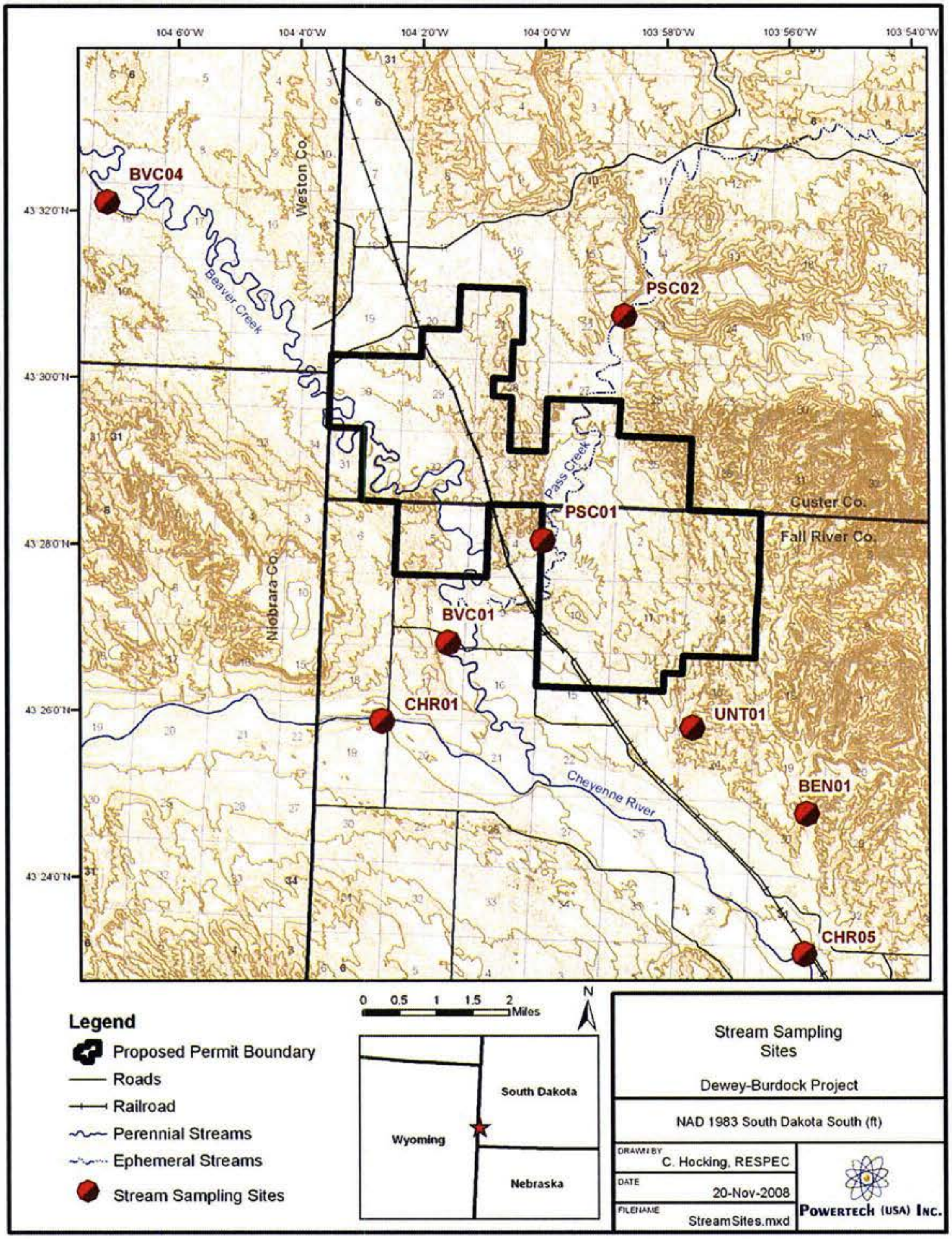

Figure 6.1-27: Stream Water Quality Sampling Sites

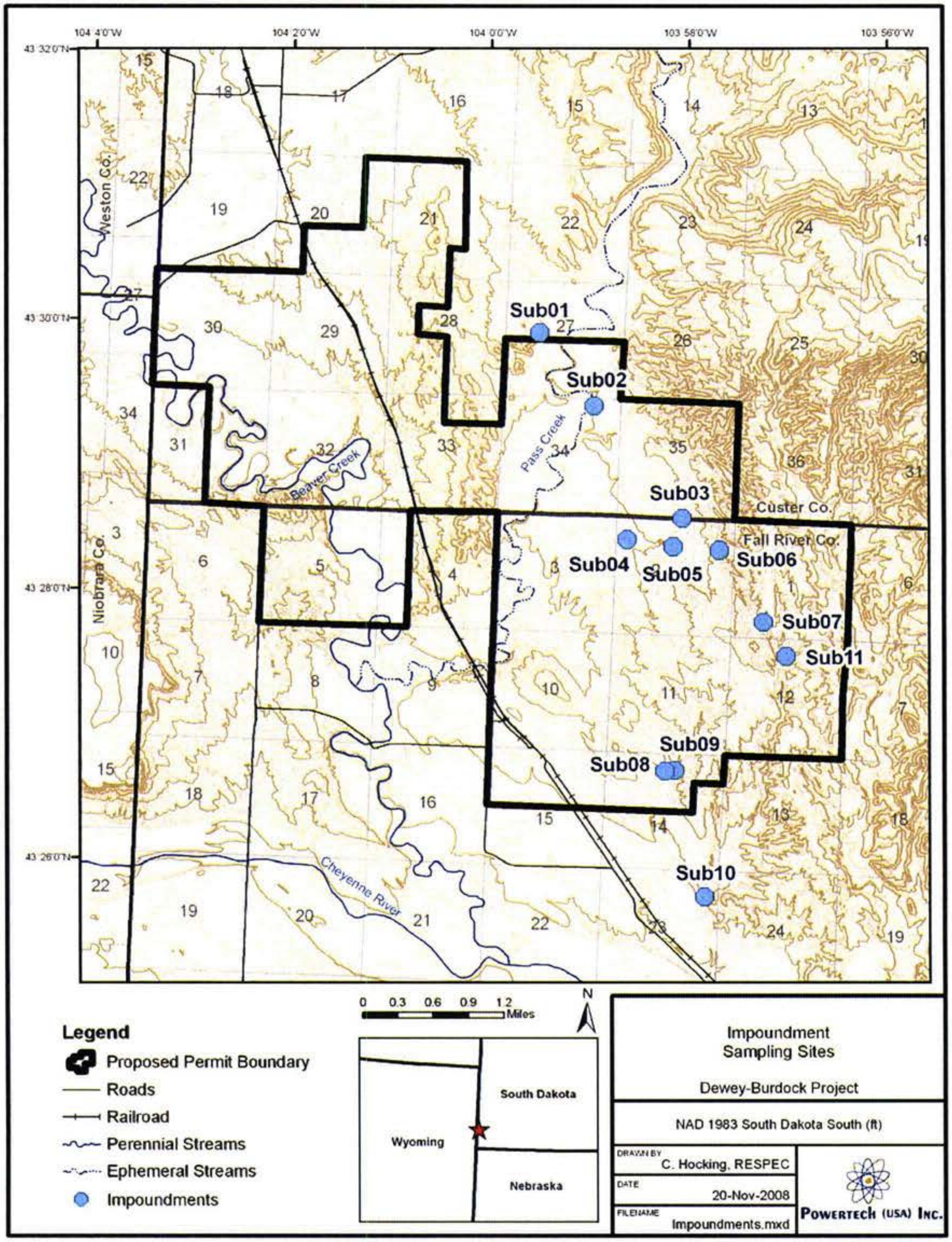

Figure 6.1-28: Impoundment Water Quality Sampling Sites

Surface water sampling locations were chosen with consideration given to site specificity based on NRC Guide 4.14 (RG 4.14) and the South Dakota mining rules ARSD 74:29, which require background radiological data to be collected for surface waters.

The following stream sampling sites were established in support of the site characterization activities:

- Two sites on Beaver Creek (BVC01 and BVC04).
- Two on Pass Creek (PSC01 and PSC02).
- Two on the Cheyenne River (CHR01 and CHR05).
- One on smaller watershed in Bennett Canyon (BEN01).
- One on an unnamed tributary within the permit boundary (UNT01).

Surface water impoundments included stock dams and mine pits. Surface water impoundments were originally identified on topographic maps and aerial photographs. Subsequently ground truthing was completed in July 2007 to fully identify and gather impoundment-location data. A total of 11 (of 48 impoundments identified, verified, photographed, and described) were sampled and are summarized in Table 6.1-23.

Because of the number of impoundments, their relatively small drainage basin, and the tendency of many to be dry after substantial rainfall, sampling a representative subset of the water impoundments was proposed. Impoundments were selected based on the presence of water, drainage area, and specific locations relative to proposed operations. Eleven surface water impoundments were selected to construct a representative sampling group for the PAA. Abandoned and reclaimed mine pits were selected due to the ubiquitous nature of plumes that often accompany mine pits. This information in characterizing the specific site is considered important in understanding the groundwater quality that may be affected via the mine pits near potential areas of operations.

Table 6.1-23: Impoundment Water Quality Sampling Locations

	Site ID	SD State Plane 1983		Type / Name	Groundwater Influence
		East (ft)	North (ft)		
Subimpoundments	Sub01	998654	446816	stock pond	
	Sub02	1001071	443526	Triangle Mine Pit	x
	Sub03	1005005	438448	mine dam	
	Sub04	1002542	437518	stock pond	
	Sub05	1004591	437191	mine dam	
	Sub06	1006665	437019	Reclaimed Darrow Mine pit - Northwest	
	Sub07	1009312	434360	stock dam	
	Sub08	1004195	427057	stock pond	x
	Sub09	1004640	427089	stock pond	
	Sub10	1005961	421367	stock pond	
	Sub11	1009659	432225	stock pond	

Number of surface water samples analyzed ranged from 57 to 81 depending upon availability of water during each sampling event. A complete summary of results for the major constituents of concern in surface water is described in Appendix 6.1-C, along with surface water analytes, number of samples, methods and Practical Quantitation Limits (PQL).

6.1.9.1 Methods

A surface water quality sample constituent list (Appendix 6.1-C) was developed based on NUREG-1569 groundwater parameters (less radon), NRC 4.14 parameters, and added parameters from a constituent-list review with South Dakota DENR. The following methodology was applied to the collection of surface water samples:

- Field methods for sampling surface waters followed South Dakota Department of Environment and Natural Resources *Standard Operating Procedures for Field Samplers, Volume I* (SD DENR, 2003).
  - Field methods required a qualified technician (wearing gloves) to measure and record field water quality parameters dissolved oxygen, turbidity, pH, specific conductivity, and temperature with a water-quality probe.
  - Sample bottles and preservative were supplied by EPA-certified Energy Laboratories in Rapid City and rinsed three times with sample water before sample collection and labeled with site ID, date, and time. Bacteriological sample bottles were not rinsed prior to filling.

  - Samples were field-preserved (where required) and immediately placed on ice then delivered within 24 hours to Energy Laboratories in Rapid City along with proper chain-of-custody forms.
  - A replicate and a blank sample were collected for every 10 water quality samples collected.
- Sites on Beaver Creek and Pass Creek were visited monthly and sampled when water was present.
- Although it does not pass through the permit boundary, the Cheyenne River was also sampled monthly upstream and downstream of confluences with streams passing through the permit boundary.

Due to the sporadic and sometimes sudden nature of flow events concerning the tributaries and remoteness of the locations, passive samplers ("single-stage samplers") designed to collect samples during ephemeral-flow events were installed and used in Pass Creek (PSC01 and PSC02), Bennett Canyon (BEN01), and Unnamed Tributary (UNT01).

6.1.9.2 Surface Water Sampling Results

Results and statistical summaries for field water quality parameters collected at the Beaver Creek (BVC) and Cheyenne River (CHR) sites are shown on Tables 6.1-22, 6.1-23, 6.1-24, and 6.1-25. Months without data indicate either a completely frozen stream or absence of water. Tables 6.1-28 and 6.1-29 summarize the analytical results for total dissolved solids (TDS), total sulfate, and total chloride, and for radionuclides, respectively.

Analysis of field parameters shows some exceedances of South Dakota state standards at Beaver Creek while other parameters fall into compliance range. pH was higher than 8.8 in 15 percent (3 of 20) measurements, but was not found to be lower than the 6.5 standard for coldwater marginal fish life. Dissolved oxygen measurements were in full compliance, with an average value of 10.8 mg/L (n=21) and a minimum of 6.54 mg/L. Nineteen percent (4 of 21) of temperature measurements were greater than the 75 °F standard for coldwater marginal fish life, with a maximum measured temperature of 82.5 °F. Krantz (2006) modeled temperatures in Beaver Creek and reports from a temperature-sensitivity analysis that air temperature is the primary controlling factor for stream temperatures in Beaver Creek. Specific conductivity values exceeded the fish, wildlife, and stock daily-maximum standard of 7,000 umhos/cm in 14 percent (3 of 21) of measurements and exceeded the irrigation daily maximum standard of 4,375 umhos/cm in 48 percent (10 of 21) of measurements. This is in line with the TVA DES results summarized in the beginning of this section.

Analysis of Cheyenne River field parameters also showed some exceedances of state standards. Specific conductivity values exceeded the fish, wildlife, and stock daily-maximum standard of 7,000 umhos/cm in 5 percent (1 of 20) of measurements and exceeded the irrigation daily-maximum standard of 4,375 umhos/cm in 40 percent (8 of 20) of measurements. Dissolved oxygen values were below the state standard for warm-water semi-permanent fish life of 5 mg/L in 6 percent (1 of 18) of samples. Water temperature measurements (n=20) and pH measurements (n=20) were all found to be in compliance.

Table 6.1-24: Field data and statistics for BVC01

BVC01					
Date	**Temp, F**	**pH**	**Dissolved Oxygen, mg/L**	**Specific Conductivity, uS/cm**	**Turbidity, NTU**
8/20/2007	81.6	8.91	12.29	1777	21.0
9/26/2007	62.1	8.87	10.95	1339	1.7
10/17/2007	53.9	8.58	11.13	5726	2.5
11/19/2007	38.4	8.20	12.20	7678	6.4
12/11/2007	31.9	7.94	11.21	4134	6.4
1/11/2008	31.9		10.07	2812	8.6
3/9/2008	32.3	8.24	13.57	1718	308
4/14/2008	60.9	8.15	9.20	5109	11.8
5/26/2008	55.1	7.95	6.86	860	1790
6/17/2008	74.9	8.13	10.39	5650	53
N	10	9	10	10	10
Mean	52.3	8.33	10.79	3680	221
Median	54.5	8.20	11.04	3473	10.2
Std Dev	18.2	0.37	1.85	2308	559
Min	31.9	7.94	6.86	860	1.7
Max	81.6	8.91	13.57	7678	1790

Table 6.1-25: Field Data and Statistics for BVC04

BVC04					
Date	Temp, F	pH	Dissolved Oxygen, mg/L	Specific Conductivity, uS/cm	Turbidity, NTU
8/20/2007	81.0	8.82	12.31	1450	79.5
9/28/2007	51.4	7.60	6.85	4712	
10/17/2007	50.1	8.46	10.45	7157	12.6
11/19/2007	41.2	8.18	12.39	5416	9.3
12/11/2007	31.9	7.86	11.01	4055	2.9
1/11/2008	31.8	7.74	11.37	3022	16.8
3/9/2008	31.9	8.12	13.74	2015	226
4/14/2008	62.5	8.27	12.21	7186	14.3
5/26/2008	55.5	8.09	6.54	733	1730
6/17/2008	77.3	7.52	9.55	4915	33.8
7/8/2008	82.5	8.38	12.80	6217	
N	11	11	11	11	9
Mean	54.3	8.09	10.84	4262	236
Median	51.4	8.12	11.37	4712	16.8
Std Dev	19.5	0.39	2.35	2229	565
Min	31.8	7.52	6.54	733	2.9
Max	82.5	8.82	13.74	7186	1730

Table 6.1-26: Field Data and Statistics for CHR01

CHR01					
Date	Temp, F	pH	Dissolved Oxygen, mg/L	Specific Conductivity, uS/cm	Turbidity, NTU
9/5/2007	79.4	8.44	13.08	4085	19.0
9/26/2007	60.8	8.02	10.48	3895	1.0
10/17/2007	55.6	8.02	5.17	6929	9.9
11/19/2007	42.2	7.47	3.74	7847	5.8
3/9/2008	45.1	8.11	12.84	3990	7.4
4/16/2008	58.9	8.32	8.13	6180	1.5
5/26/2008	56.0	8.17	7.77	350	1798
6/17/2008	80.6	8.27	7.85	2897	73.4
N	8	8	8	8	8
Mean	59.8	8.10	8.63	4522	240
Median	57.5	8.14	7.99	4038	8.7
Std Dev	14.0	0.29	3.35	2406	630
Min	42.2	7.47	3.74	350	1.0
Max	80.6	8.44	13.08	7847	1798

Table 6.1-27: Field Data and Statistics for CHR05

CHR05					
Date	**Temp, F**	**pH**	**Dissolved Oxygen, mg/L**	**Specific Conductivity, uS/cm**	**Turbidity, NTU**
9/5/2007	78.1	8.16	12.20	4570	1.0
9/26/2007	65.9	8.01		4002	2.0
10/17/2007	58.0	8.12	10.08	6986	8.3
11/19/2007	43.2	8.16	11.03	6384	13.3
12/11/2007	31.9	7.95	11.14	3888	3.8
1/11/2008	31.8	7.65	9.22	3058	2.0
2/12/2008	32.4	7.42		3353	12.3
3/9/2008	32.0	8.24	12.92	1118	177
4/14/2008	53.8	8.10	9.92	4905	12.5
4/15/2008	59.7	8.15	8.85	4970	36.0
5/26/2008	55.9	8.19	7.69	510	1790
6/17/2008	74.1	8.24	7.63	3721	59.3
N	12	12	10	12	12
Mean	51.4	8.03	10.07	3955	176
Median	54.9	8.14	10.00	3945	12.4
Std Dev	16.9	0.25	1.78	1872	511
Min	31.8	7.42	7.63	510	1.0
Max	78.1	8.24	12.92	6986	1790

Since the beginning of July 2007, surface water samples have been collected and submitted to Energy Laboratories Inc. for analysis. Table 6.1-28 summarizes the analytical results for total dissolved solids (TDS), total sulfate, and total chloride. Sample results were compared to Secondary drinking water standards (SMCLs) set by the EPA that designate constituents that alter the color, taste, and odor of water. These constituents are not considered health risks but may deter human consumption when concentrations are above the SMCL. These constituents, along with the number of samples that exceed these guidelines, are also presented in following table and discussed below.

Almost all of the samples exceeded the recommended concentration of 500 mg/L for TDS. Values of TDS ranged from 219 to 7040 mg/L with the highest values obtained from the Cheyenne River site (CHR-01). A number of samples also exceeded the SMCL for sulfate; 41 of 43 samples exceeded the SMCL for sulfate of 250 mg/L. 36 of these samples were over double the limit (over 500 mg/L). To date, more than half (23 of 43) samples have exceeded the SMCL of 250 mg/L for chloride (Table 6.1-28).

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Table 6.1-28: Summary of Key Surface Water Concentrations

Parameter	Total Dissolved Solids @ 180 - mg/L				Sulfate - Total mg/L				Chloride - Total mg/L			
Sample ID	BVC-01	BVC-04	CHR-01	CHR-05	BVC-01	BVC-04	CHR-01	CHR-05	BVC-01	BVC-04	CHR-01	CHR-05
Sample Date: 7/1/2007	967	1770	5590	3710	463	859	3550	2030	101	251	125	386
8/20/2007	1120	945	NS	NS	511	436	NS	NS	158	118	NS	NS
9/5/2007	1090	5640	3160[a] (Rep 3230) - 5970[b]	3730[a] - 5720[b]	568	2520	2010a (Rep - 2060) - 3970[b]	2160[a] - 4160[b]	141	1310	74[a] (Rep 74) - 138[b]	344[a] - 221[b]
10/17/2007	4520	5700	6370	6450	2180	2670	4060	4060	852	1540	166	269
11/19/2007	5860	4110	7040	4900	2540	1920	4520	2340	1370	1040	176	912
12/11/2007	3110 (Rep 3210)	3140	NS	3100	1430 (Rep 1510)	1450	NS	1570	581 (Rep 610)	601	NS	509
1/11/2008	2610	2650	NS	2920	1470	1450	NS	1610	208	255	NS	258
2/12/2008	NS	NS	NS	2950	NS	NS	NS	1730	NS	NS	NS	250
3/9/2008	4070	1680 (Rep 1730)	1280	1160	2490	681 (Rep 736)	572	463	113	339 (Rep 364)	249	232
4/14/2008	3840	5340	5720	3540 (Rep 3860)	1570	1860	3690	1540 (Rep 1710)	973	1730	156	780 (Rep 861)
5/26/2008	609	516	219	365	317	286	86	180	62	9	2	17
6/17/2008	3830	3090	2060	2560	1410	1090	1090	1180	970	739	78	337
Average	2875	3144	4157	3425	1359	1384	2616	1919	503	721	129	375
Minimum	609	516	219	365	317	286	86	180	62	9	2	17
Maximum	5860	5700	7040	6450	2540	2670	4520	4060	1370	1730	249	912

Notes:

[a] Sampled 9/5/2007

[b] Sampled 9/26/2007

Green highlights designate concentrations over the EPA "Secondary" guideline value above which use of water may give rise to complaints by consumers

NS = No sample

Rep = duplicate analysis

Table 6.1-29 summarizes the analytical results for radionuclides. Sample results were compared to EPA National Primary Drinking Water Standards and are discussed below.

Several groundwater samples collected exceed the National Primary Drinking Water Standards. Constituents with samples exceeding the standards include gross alpha particles, uranium, and radium-226. Complete surface water quality data results are available in Appendix 6.1-D.

Most of the samples (26 of 43) exceeded the MCL for gross alpha particles of 15 picocuries per liter (pCi/L), with the exceedances occurring in samples from both Beaver Creek and Cheyenne River sites. The range of gross alpha particles sampled was 2.3 to 65.8 pCi/L. Uranium concentrations ranged from 0.0017 to 0.0368 mg/L for dissolved and 0.003 to 0.0378 for total uranium with 9 of 102 (dissolved and total) samples exceeding the MCL of 0.03 mg/L. Radium 226 (dissolved) and Radium (total) concentrations exceeding the MCL of 5.0 pCi/L are presented in Table 6.1-29. For drinking water standards, Pb-210 is currently not regulated by the EPA, though in 1999 a standard of 1 pCi/L was proposed (EPA, 2000).

Table 6.1-29: Summary of Surface Water Radionuclide Concentrations

Parameter	Alpha Particle-Dissolved pCi/L				Uranium-Dissolved mg/L				Uranium-Total mg/L			
Sample ID / Sample Date	BVC-01	BVC-04	CHR-01	CHR-05	BVC-01	BVC-04	CHR-01	CHR-05	BVC-01	BVC-04	CHR-01	CHR-05
Jul-2007	5.9	11.4	16.9	16.7	NS	NS	NS	NS	0.00	0.01	0.02	0.01
Aug-2007	7.1	7.0	NS	NS	NS	NS	NS	NS	0.00	0.00	NS	NS
Sep-2007	6.6	2.3	15.9[a] (Rep 16.7) - 33.8[b]	9.7[a] - 25.6[b]	0.0075	0.0140	0.0149	0.0346	0.01	0.01	0.0142[a] (Rep 0.0142) - 0.015[b]	0.0136[a] - 0.0348[b]
Oct-2007	12.0	26.6	34.2	23.2	0.0097	0.0230	0.0308	0.0368	0.01	0.02	0.03	0.04
Nov-2007	65.8	34.7	27.0	16.8	0.0182	0.0189	0.0310	0.0151	0.02	0.02	0.03	0.01
Dec-2007	27.9 (Rep 25.8)	17.1	NS	24.9	0.0124 (Rep 0.0129)	0.0114	NS	0.0125	0.0142 (Rep 0.0151)	0.01	NS	0.02
Jan-2008	12.6	13.9	NS	19.3	0.0134	0.0141	NS	0.0150	0.01	0.01	NS	0.02
Feb-2008	NS	NS	NS	15.7	NS	NS	NS	0.0143	NS	NS	NS	0.01
Mar-2008	17.4	6.7 (Rep 8.8)	5.1	4.0	0.0269	0.0056 (Rep 0.0055)	0.0034	0.0039	0.03	0.0061 (Rep 0.0062)	0.00	0.00
Apr-2008	15.1	23.4	5.7	19.8 (Rep 19.9)	0.0125	0.0165	0.0324	0.0134 (Rep 0.0135)	0.01	0.02	0.04	0.0141 (Rep 0.014)
May-2008	18.2	12.5	29.1	29.8	0.0020	0.0017	0.0024	0.0028	0.01	0.01	0.01	0.01
Jun-2008	8.9	3.9	35.3	29.9	0.0092	0.0078	0.0177	0.0139	0.01	0.01	0.02	0.02
Average	18.0	14.5	22.6	19.6	0.0124	0.0126	0.0189	0.0028	0.01	0.01	0.02	0.02
Minimum	5.9	2.3	5.1	4.0	0.0020	0.0017	0.0024	0.0028	0.00	0.00	0.00	0.00
Maximum	65.8	34.7	35.3	29.9	0.0269	0.0230	0.0324	0.0368	0.03	0.02	0.04	0.04

Parameter	Radium-226 -Dissolved pCi/L				Radium-226-Total pCi/L				Lead-210 -Dissolved pCi/L			
Sample ID / Sample Date	BVC-01	BVC-04	CHR-01	CHR-05	BVC-01	BVC-04	CHR-01	CHR-05	BVC-01	BVC-04	CHR-01	CHR-05
Jul-2007	NS	NS	NS	NS	0.10	0.10	0.10	0.10	NS	NS	NS	NS
Aug-2007	NS	NS	NS	NS	0.10	0.70	NS	NS	NS	NS	NS	NS
Sep-2007	0.10	0.10	0.10	0.10	0.10	0.70	0.1[a] (Rep 0.1) - 0.1[b]	0.1[a] - 0.1[b]	0.5000	0.0005	0.5000	0.5000
Oct-2007	0.30	0.50	0.50	0.10	NS	NS	NS	NS	0.5000	0.0005	3.2000	6.6000
Nov-2007	n/s	n/s	NS	NS	0.10	0.80	0.60	0.10	4.6000	0.0005	0.5000	0.5000
Dec-2007	0.1 (Rep 0.1)	0.10	NS	0.10	0.4 (Rep 0.1)	0.30	NS	0.10	11 (Rep 0.5)	0.0005	NS	5.9000
Jan-2008	0.10	0.10	NS	0.10	0.10	0.10	NS	0.10	0.5000	0.0005	NS	0.5000
Feb-2008	NS	NS	NS	0.10	NS	NS	NS	0.10	NS	NS	NS	NS
Mar-2008	-0.02	0.08 (Rep 0.06)	0.20	0.07	-0.70	0.1 (Rep -0.2)	1.50	1.80	NS	0.0005 (Rep 0.0005)	NS	NS
Apr-2008	0.10	0.10	0.30	0.1 (Rep 0.1)	0.10	0.30	0.10	0.4 (Rep 0.5)	NS	0.0005	NS	NS
May-2008	2.00	-0.06	0.06	1.40	5.10	2.20	4.10	5.10	-1.0000	0.0005	0.5000	0.7000
Jun-2008	-0.02	0.10	0.20	0.20	-0.95	-0.53	-0.72	-0.48	NS	0.0005	NS	NS
Average	0.33	0.13	0.23	0.25	0.45	0.48	0.74	0.68	2.6833	0.0005	1.1750	2.4500
Minimum	-0.02	-0.06	0.06	0.07	-0.95	-0.53	-0.72	-0.48	-1.0000	0.0005	0.5000	0.5000
Maximum	2.00	0.50	0.50	1.40	5.10	2.20	4.10	5.10	4.6000	0.0005	3.2000	6.6000

Notes:
[a] Sampled 9/5/2007
[b] Sampled 9/26/2007

Yellow highlights designate concentrations over the EPA MCL
Blue highlights designates one of the two sample concentrations exceeded the EPA MCL

NS = No sample
Rep = duplicate analysis

Statistics for all surface water constituents detected at or above PQL are provided in Appendix 6.1-E. The minimum and maximum results for all sampled constituents detected at or above the PQL are listed in Appendix 6.1-F. A comparison between water quality constituents in impoundments and streams that were detected at or above the PQL is presented in Appendix 6.1-G. Constituents in italics are those in which the absolute difference in percent detections between streams and impoundments was 30 percent or greater. Fecal coliform, alkalinity, bicarbonate, and dissolved and total boron were detected primarily in streams, while ammonia, dissolved aluminum, dissolved iron, dissolved nickel, dissolved and total zinc, and dissolved and total radium 226 were primarily detected in subimpoundments. Tabular results for all samples are listed in Appendix 6.1-D.

6.1.9.3 Conclusions

Radiological data for surface water in the PAA has been collected and analyzed according to NRC Regulatory Guide 4.14. When water was present, streams were sampled monthly and impoundments were sampled quarterly.

Powertech has initiated, planned and implemented the surface water quality site characterization study with the intentions of good stewardship, following industry standards, and in conjunction with federal and state regulations and with full consideration of federal and state guidance. Results from the surface water characterization study correspond well with the study conducted by TVA in 1979. The surface water bodies that transverse the Proposed Action site had in the past been deemed unsuitable for irrigation due to the high concentrations of salts as classified by the NAS/NAE. Based on current characterization of the surface water bodies within the proposed site of operation, the data seem to represent very little variance from the previous TVA study conducted in 1979

6.1.10 Vegetation Sampling

Three rounds of vegetation sampling were conducted on the project. One vegetation sample was collected in August, 2007; and April and July, 2008 at each AMS, the locations of which are shown on Figure 6.1-9.

6.1.10.1 Methods

The samples were collected using grass clippers and placed in large plastic lawn bags, labeled appropriately, and stored in a laboratory supplied cooler until transferred to the laboratory. All types of vegetation present (typically short grasses and clover plants) at each location were

sampled and composited into a single sample. The analytes and corresponding analytical methods were the same as those used for soil. Polonium-210, determined using a laboratory-specific digestion and alpha spectrometry method, was added to the analytical suite (Energy Laboratories, 2008).

6.1.10.2 Vegetation Sampling Results

Table 6.1-30 presents the results of the vegetation sampling. There appear to be no temporal or spatial trends in the data. The following list is a summary of the averages for the set of samples:

- Radium-226 concentrations ranged from 0.02 to 0.09 pCi/g, averaging 0.05 pCi/g.
- Natural uranium concentrations ranged from 0.01 to 0.04 pCi/g, averaging 0.02 pCi/g.
- Thorium-230 concentrations ranged from 0.01 to 0.03 pCi/g, averaging 0.02 pCi/g.
- Lead-210 concentrations ranged from 0.6 to 1.7 pCi/g, averaging 1.2 pCi/g.
- Polonium-210 concentrations ranged from 0.08 to 0.23 pCi/g, averaging 0.15 pCi/g.

Analytical errors associated with the reported concentrations results are high, relative to the reported means.

Table 6.1-30: Baseline Radionuclide Concentrations in Vegetation

Location	Date Collected		8/14/2007	4/20/08	7/15/08	Average (µCi/kg)
AMS-01	U-nat (µCi/kg)	Concentration	1.4E-05	2.8E-02D	9.4E-06	1.4E-05
		Error ± 2σ	-	-	-	
		LLD	1.7E-06	2.4E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	5.5E-05	3.3E-05	8.1E-05	5.6E-05
		Error ± 2σ	3.2E-05	5.5E-06	1.2E-05	
		LLD	1.7E-06	3.7E-06	7.4E-06	
	Th-230 (µCi/kg)	Concentration	<1.7E-06	1.2E-05	1.2E-05	8.6E-06
		Error ± 2σ	<1.7E-06	5.2E-06	8.4E-06	
		LLD	1.7E-06	2.0E-07	8.4E-07	
	Pb-210 (µCi/kg)	Concentration	1.8E-03	2.9E-03	3.3E-04	1.7E-03
		Error ± 2σ	5.4E-04	1.1E-04	1.3E-04	
		LLD	8.6E-06	1.0E-06	2.1E-04	
	Po-210 (µCi/kg)	Concentration	1.3E-04	4.7E-04	1.7E-05	2.1E-04
		Error ± 2σ	9.8E-05	7.2E-05	1.5E-05	
		LLD	8.6E-06	1.0E-06	1.0E-06	
AMS-02	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	1.0E-05	2.7E-02D	3.2E-06	6.6E-06
		Error ± 2σ	-	-	-	
		LLD	5.5E-07	2.0E-07	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.2E-05	3.0E-05	9.3E-06	2.0E-05
		Error ± 2σ	1.1E-05	4.5E-06	3.6E-06	
		LLD	5.5E-07	2.8E-06	4.0E-06	
	Th-230 (µCi/kg)	Concentration	4.7E-06	1.4E-05	-9.5E-07U	5.9E-06
		Error ± 2σ	6.0E-06	4.9E-06	5.0E-06	
		LLD	5.5E-07	2.0E-07	4.7E-07	
	Pb-210 (µCi/kg)	Concentration	3.3E-04	1.3E-03	1.5E-04	5.9E-04
		Error ± 2σ	1.5E-04	6.9E-05	7.3E-05	
		LLD	2.7E-06	1.0E-06	1.2E-04	
	Po-210 (µCi/kg)	Concentration	1.8E-05	2.0E-04	9.1E-06U	7.6E-05
		Error ± 2σ	2.0E-05	4.2E-05	8.5E-06	
		LLD	2.7E-06	1.0E-06	1.0E-06	

Table 6.1-30: Baseline Radionuclide Concentrations in Vegetation (cont.)

Location	Date Collected		8/14/2007	4/20/08	7/14/08	Average (µCi/kg)
AMS-03	U-nat (µCi/kg)	Concentration	9.8E-06	1.5E-01D	7.7E-06	9.8E-06
		Error ± 2σ	-	-	-	
		LLD	6.4E-07	2.4E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	7.4E-05	1.1E-04	7.5E-06	9.2E-05
		Error ± 2σ	2.2E-05	9.7E-06	4.9E-06	
		LLD	6.4E-07	3.7E-06	6.6E-06	
	Th-230 (µCi/kg)	Concentration	2.6E-06	4.1E-05	1.0E-05	2.2E-05
		Error ± 2σ	4.4E-06	1.1E-05	6.6E-06	
		LLD	6.4E-07	2.0E-07	7.7E-07	
	Pb-210 (µCi/kg)	Concentration	9.1E-04	1.4E-03	3.3E-04	8.8E-04
		Error ± 2σ	2.2E-04	8.2E-05	1.2E-04	
		LLD	3.2E-06	1.0E-06	1.9E-04	
	Po-210 (µCi/kg)	Concentration	7.8E-05	2.3E-04	9.6E-06U	1.5E-04
		Error ± 2σ	4.4E-05	4.4E-05	1.1E-05	
		LLD	3.2E-06	1.0E-06	1.0E-06	
AMS-04	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	9.3E-06	2.1E-02D	8.4E-06	9.3E-06
		Error ± 2σ	-	-	-	
		LLD	8.1E-07	1.9E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.3E-05	3.1E-05	9.3E-06	
		Error ± 2σ	1.4E-05	4.6E-06	5.2E-06	2.7E-05
		LLD	8.0E-07	2.8E-06	6.7E-06	
	Th-230 (µCi/kg)	Concentration	3.6E-06	8.3E-06	-2.7E-06U	6.0E-06
		Error ± 2σ	5.6E-06	4.2E-06	4.2E-06	
		LLD	8.0E-07	2.0E-07	7.7E-07	
	Pb-210 (µCi/kg)	Concentration	1.5E-03	1.2E-03	2.1E-04	1.4E-03
		Error ± 2σ	3.0E-04	6.6E-05	1.2E-04	
		LLD	4.0E-06	1.0E-06	1.9E-04	
	Po-210 (µCi/kg)	Concentration	9.8E-05	1.7E-04	9.0E-06U	
		Error ± 2σ	6.4E-05	3.9E-05	9.6E-06	1.3E-04
		LLD	4.0E-06	1.0E-06	1.0E-06	

Table 6.1-30: Baseline Radionuclide Concentrations in Vegetation (cont.)

Location	Date Collected		8/14/2007	4/20/08	7/14/08	Average (µCi/kg)
AMS-05	U-nat (µCi/kg)	Concentration	3.7E-05	2.3E-01D	1.4E-05	3.7E-05
		Error ± 2σ	-	-		
		LLD	1.3E-06	1.3E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.4E-05	7.9E-05	5.9E-06U	5.2E-05
		Error ± 2σ	1.8E-05	5.7E-06	5.3E-06	
		LLD	1.3E-06	1.8E-06	7.7E-06	
	Th-230 (µCi/kg)	Concentration	1.5E-05	4.8E-05	-8.8E-07U	3.2E-05
		Error ± 2σ	1.7E-05	8.1E-06	5.7E-06	
		LLD	1.3E-06	2.0E-07	8.8E-07	
	Pb-210 (µCi/kg)	Concentration	1.7E-03	3.3E-04	3.4E-04	1.0E-03
		Error ± 2σ	4.2E-04	3.0E-05	1.4E-04	
		LLD	6.5E-06	1.0E-06	2.2E-04	
	Po-210 (µCi/kg)	Concentration	6.6E-05	1.6E-04	2.1E-05	1.1E-04
		Error ± 2σ	6.0E-05	3.1E-05	1.6E-05	
		LLD	6.5E-06	1.0E-06	1.0E-06	
AMS-06	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	3.8E-05	1.3E-01D	2.2E-05	3.8E-05
		Error ± 2σ	-	-		
		LLD	8.3E-07	3.2E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	3.2E-05	9.2E-05	1.8E-05	6.2E-05
		Error ± 2σ	1.6E-05	9.9E-06	5.0E-06	
		LLD	8.2E-07	4.6E-06	5.0E-06	
	Th-230 (µCi/kg)	Concentration	1.9E-05	3.9E-05	2.1E-05	2.9E-05
		Error ± 2σ	1.3E-05	1.1E-05	7.4E-06	
		LLD	8.2E-07	2.0E-07	5.7E-07	
	Pb-210 (µCi/kg)	Concentration	1.0E-03	1.8E-03	1.4E-04U	1.4E-03
		Error ± 2σ	2.6E-04	1.1E-04	8.7E-05	
		LLD	4.1E-06	1.0E-06	1.4E-04	
	Po-210 (µCi/kg)	Concentration	6.0E-05	4.0E-04	5.7E-06U	2.3E-04
		Error ± 2σ	4.4E-05	7.7E-05	5.7E-06	
		LLD	4.1E-06	1.0E-06	1.0E-06	

Table 6.1-30: Baseline Radionuclide Concentrations in Vegetation (concl.)

Location	Date Collected		8/14/2007	4/20/08	7/14/08	Average (µCi/kg)
AMS-07	U-nat (µCi/kg)	Concentration	1.8E-05	1.4E-01 D	2.7E-05	1.8E-05
		Error ± 2σ	-	-		
		LLD	9.7E-07	21E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	2.7E-05	7.6E-05	2.4E-05	5.2E-05
		Error ± 2σ	1.6E-05	7.2E-06	7.5E-06	
		LLD	9.7E-07	3.0E-06	7.7E-06	
	Th-230 (µCi/kg)	Concentration	1.6E-05	4.0E-05	2.0E-05	2.8E-05
		Error ± 2σ	1.8E-05	1.2E-05	8.6E-06	
		LLD	9.7E-07	2.0E-07	8.6E-07	
	Pb-210 (µCi/kg)	Concentration	2.1E-03	6.2E-04	-3.2E-05U	1.4E-03
		Error ± 2σ	3.6E-04	5.3E-05	1.3E-04	
		LLD	4.8E-06	1.0E-06	2.1E-04	
	Po-210 (µCi/kg)	Concentration	1.5E-04	2.3E-04	2.0E-05	1.9E-04
		Error ± 2σ	8.2E-05	4.7E-05	1.3E-05	
		LLD	4.8E-06	1.0E-06	1.0E-06	
AMS-BKG	Date Collected		8/14/2007	4/20/08	7/14/08	
	U-nat (µCi/kg)	Concentration	4.0E-05	9.0E-02D	1.0E-05	2.5E-05
		Error ± 2σ	-	-	-	
		LLD	9.7E-07	3.8E-06	2.0E-07	
	Ra-226 (µCi/kg)	Concentration	4.1E-05	8.3E-05	1.3E-05	6.2E-05
		Error ± 2σ	2.0E-05	1.1E-05	4.6E-06	
		LLD	9.7E-07	6.4E-06	5.1E-06	
	Th-230 (µCi/kg)	Concentration	1.0E-05	3.5E-05	7.3E-06	2.3E-05
		Error ± 2σ	1.3E-05	1.2E-05	4.2E-06	
		LLD	9.7E-07	2.0E-07	5.6E-07	
	Pb-210 (µCi/kg)	Concentration	6.9E-04	1.4E-03	1.3E-04U	1.0E-03
		Error ± 2σ	2.8E-04	1.0E-04	8.6E-05	
		LLD	4.8E-06	1.0E-06		
	Po-210 (µCi/kg)	Concentration	2.5E-05	2.2E-04	9.3E-06	1.2E-04
		Error ± 2σ	3.2E-05	5.1E-05	8.8E-06	
		LLD	4.8E-06	1.0E-06	1.0E-06	

Notes:
D = Lower limit of detection increased due to sample matrix interference. Average concentrations do not include "D" qualified results.

6.1.10.3 Conclusions

Other than the observation that radionuclide concentrations in the vegetation samples are one to two orders of magnitude lower than those in the corresponding shallow (0-5 cm) soil samples, there are no apparent relationships between the media. Radium-226, natural uranium, and thorium-230 concentrations were highest in offsite soil sample AMS-BKG, located 1.9 miles west of the site near the existing offsite topsoil pile. Only the concentration of natural uranium was highest at this location in vegetation and soil. The concentration of radium-226 in soil at this location was in the middle of its range. Lead-210 had the greatest activity levels of the five radionuclides analyzed. Pb-210 concentrations are 1-2 orders of magnitude higher than other radionuclides evaluated as shown in Table 6.1-18. These results are likely due to a higher relative abundance of Pb-210 in air particulates from radon decay products. This latter observation is supported by the air particulate data presented in Section 6.1.6. .

6.1.11 Food Sampling

To determine baseline radionuclide concentrations in local food, Powertech collected three tissue samples, one liver (DBAT 03) and two meat samples (DBAT 01 DBAT 02), from a locally grazing cow on June 25, 2008. The results are listed in Table 6.1-31. Errors are reported as $\pm 2\sigma$.

Table 6.1-31: Baseline Radionuclide Concentrations in Local Food

Sample ID	Radionuclide	Parameter	Result
DBAT-01	**U-nat (µCi/kg)**	**Concentration**	ND
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	3.0E-06
		Error ± 2σ	2.0E-06
		LLD	3.0E-06
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	2.0E-05
		LLD	8.0E-06
	Pb-210 (µCi/kg)	Concentration	-7.0E-06
		Error ± 2σ	4.0E-05
		LLD	7.0E-06
	Po-210 (µCi/kg)	Concentration	8.0E-06
		Error ± 2σ	1.0E-04
		LLD	8.0E-06
DBAT-02	**U-nat (µCi/kg)**	Concentration	ND
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	6.0E-05
		Error ± 2σ	3.0E-05
		LLD	4.0E-05
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.4E-03
		LLD	1.0E-04
	Pb-210 (µCi/kg)	Concentration	2.0E-04
		Error ± 2σ	7.0E-04
		LLD	1.2E-03
	Po-210 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.2E-03
		LLD	1.0E-04
DBAT-03	**U-nat (µCi/kg)**	Concentration	ND
		Error ± 2σ	-
		LLD	7.0E-06
	Ra-226 (µCi/kg)	Concentration	3.0E-06
		Error ± 2σ	1.0E-06
		LLD	2.0E-06
	Th-230 (µCi/kg)	Concentration	0.0
		Error ± 2σ	1.0E-04
		LLD	6.0E-06
	Pb-210 (µCi/kg)	Concentration	-7.0E-06
		Error ± 2σ	4.0E-05
		LLD	6.0E-05
	Po-210 (µCi/kg)	Concentration	2.0E-05
		Error ± 2σ	2.0E-04
		LLD	6.0E-06

There are several cases where reported concentrations are at or below LLDs that, in turn, exceed the LLDs recommended in RG 4.14. This is evident for all reported concentrations of natural uranium, radium-226 and polonium-210 in Sample DBAT-01, and lead-210 in all three samples.

6.2 Physiochemical Groundwater Monitoring

6.2.1 Program Description

During the Proposed Action, an extensive groundwater sampling program specific to each well field will be conducted prior to, during, and following ISL operations to identify any potential impacts to water resources of the area. The groundwater monitoring program is designed to 1) establish baseline water quality prior to mining, 2) detect excursions of lixiviant either horizontally or vertically outside the of the target mineralization zone, 3) demonstrate compliance with groundwater quality standards, and 4) determine when the mined Sandstone aquifer has been adequately restored following ISL operations. Objectives 1 (partially) and 4 will be accomplished using injection and recovery wells. Objectives 1 (partially), 2, and 3 will be accomplished using two types of dedicated monitoring wells consisting of perimeter, and internal monitoring wells.

6.2.2 Groundwater Monitoring

The groundwater monitoring program includes the production zone monitor ring and overlying and underlying monitor wells, which are designed to detect and recover a potential excursion of lixiviant outside the production zone.

6.2.2.1 Well Field Baseline Sampling

Powertech will establish the baseline groundwater quality before beginning operations in a well field. Production and monitoring zone wells will be sampled at least four times over a sufficiently spaced interval to indicate seasonal variability. Wells will be selected based on a density of one well per 4.0 acres of mine unit, all wells in the monitoring ring, and wells in aquifers above and below the confining layers of the production zone. Wells will be sampled periodically for parameters as shown in Table 6.2-1.

Based on statistical analysis of the data following ASTM Standard D 6312 (ASTM, 2001) to determine the baseline range of statistical variability of an indicator constituent, target restoration goals (TRG) will be established, which will be used to assess the effectiveness of groundwater restoration activities. Powertech will consult with DENR concerning the specific groundwater suite of constituents prior to well field baseline evaluation.

Table 6.2-1: Baseline Water Quality Parameters and Indictors for Groundwater

Test Analyte/Parameter	Units	Method
BULK PROPERTIES		
pH	pH Units	A4500-H B
Total Dissolved Solids (TDS)	mg/L	A1030 E[1], A2540 C
Conductivity	µmhos/cm	A2510B
CATIONS/ANIONS		
Chloride	mg/L	E300.0
Sulfate	mg/L	E300.0
Total Alkalinity (as $CaCO_3$)	mg/L	A2320 B
TRACE METALS		
Arsenic, As	mg/L	E200.8
Iron, Fe	mg/L	E200.7
Lead, Pb	mg/L	E200.8
Manganese, Mn	mg/L	E200.8
Strontium	mg/L	E200.8
Uranium, U	mg/L	E200.8
Vanadium	mg/L	E200.7, E200.8
RADIONUCLIDES		
Gross Alpha=Alpha Particles	pCi/L	E900.0
Gross Beta=Beta Particles and Photons	mRem/Year	E900.0
Radium-226	pCi/L	E903.0
Radon-222	pCi/L	D5072-92

Notes: All metals analyses are for dissolved metals
Table adapted from USNRC (2008) Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities-Draft Report for Comment. NUREG-1910. July 2008.

6.2.2.2 Monitor Well Baseline Water Quality

Production zone monitoring wells are installed around the periphery of each production area to monitor for any fluids that might escape the hydraulic controls (Hunkin, G. G., 1977 and Dickinson, K. A., and J. S. Duval, 1977) with a screened interval open to the sand unit containing the production zone. This monitoring "ring" design serves two purposes: 1) to monitor any horizontal migration of fluid from within the sand unit or aquifer where production is occurring, 2) to determine baseline water quality data and characterize the area outside the production pattern area. Upper Control Limits (UCL) are determined for these wells from the baseline water quality data. Production zone monitor wells will be located no more than 400 feet from the production area, and will be spaced no more than 400 feet between productions zone monitoring wells. Production zone monitoring wells are installed before the start of production

activities in order that required baseline sampling and hydrologic tests (as required) can be conducted.

Non-production monitoring wells consist of two types of monitor wells termed "overlying" and "underlying". The screened intervals of overlying wells are located in the sand unit or aquifer immediately above the ore-bearing stratum. The overlying non-production monitoring wells are designed to provide monitoring of any upward movement of production fluids that may occur from the production zone and to guard against potential leakage from production and injection well casing into any overlying aquifer. The overlying wells are used to obtain baseline water quality data and are used in the development of UCLs for the overlying zones that will be used to determine if vertical migration of production fluids is occurring. The screened zone for the overlying wells is determined from electric logs by qualified geologists or hydrogeologists. The first layer of overlying non-production zone monitoring wells will be evenly distributed through the production area with a minimum of one well for every four acres of production area. Should additional aquifers exist above the first monitoring layer; additional overlying monitors will be located in these aquifers with a minimum of one well positioned for every eight acres of production area.

A single layer of underlying monitor wells will be completed in the first sand unit or aquifer underlying the ore-bearing stratum similarly based on the local lithology. The underlying monitor wells are used to obtain baseline water quality data and are used in the development of UCLs for the underlying aquifer that will be used to determine if vertical migration of production fluids downward is occurring. The screened zone for the underlying monitor wells is determined from electric logs by qualified geologists or hydrogeologists. Underlying non-production monitoring wells will be evenly distributed through the production area with a minimum of one well for every four acres of production area. Underlying wells likely will not be installed below the Lakota formation, primarily due to the presence of the approximately 100' thick and relatively impermeable Morrison formation immediately below Lakota formation.

6.2.2.3 Well Field Hydrologic Data Package

In accordance with NRC Performance Based Licensing requirements, the Well Field Hydrologic Data Package is reviewed by a Safety and Environmental Review Panel (SERP) to ensure that the results of the hydrologic testing and the planned uranium activities are consistent with technical requirements and do not conflict with any requirement stated in NRC regulations or in the NRC license. A written SERP evaluation will evaluate safety and environmental concerns

and demonstrate compliance with applicable NRC license requirements as discussed in Section 5 of the Technical Report. The written SERP evaluation will be maintained at the site.

The Well Field Hydrologic Data Package contains the following:

- A description of the proposed mine unit (location, extent, etc.)
- A map(s) showing the proposed production patterns and locations of all monitor wells.
- Geologic cross-sections and cross-section location maps
- Isopach maps of the production zone, the overlying confining unit, and the underlying confining unit.
- Discussion of how the hydrologic test was performed, including well completion reports
- Discussion of the results and conclusions of the hydrologic test including pumping test raw data, drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps and when appropriate, directional transmissivity data and graphs
- Sufficient information to show that wells in the monitoring well ring are in adequate communication with the production patterns
- Baseline water quality information including proposed UCLs for monitoring wells and average production zone/restoration target values
- Any other information pertinent to the area tested will be included and discussed

6.2.2.4 Operational Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, UCLs are set for chemical constituents that would be indicative of a migration of lixiviant from the well field. These monitoring wells will be routinely sampled to check fluid levels and changes in water quality notably for early detection indicated by changes to the UCLs. The UCLs are calculated as 20 percent above the maximum baseline standards for each parameter. The constituents chosen for indicators of lixiviant migration and for which UCLs will be set are total dissolved solids, chloride, sulfate, and uranium. Chloride was selected because it is easily measured due to the efficiency of solubility during the mining process. Sulfate and uranium were selected because their concentrations significantly increase during the ISL process.

The monitoring wells are sampled semi-monthly at approximately two week intervals (at least 10 days apart) and the samples are analyzed for and compared against the excursion parameter UCL values. The water level in each monitor well will be measured and recorded prior to each sampling event. Water level and analytical monitoring data for the UCL parameters are reported to the EPA and SD DENR on a quarterly basis and will be retained on site for NRC review.

6.2.2.4.1 Excursion Verification and Corrective Action

If the concentration of two or of the three excursion indicators exceeds the UCL concentrations, during a sampling event, a subsequent sample will be taken within 24 hours and analyzed for the excursion indicators. If the confirmatory sample results are not complete within 30 days then for reporting purposes (described below) the excursion is considered confirmed. If the second sample does not confirm an excursion a third sample will be taken within 48 hours. If two or more excursion indicators of either the second or third sample results exceed the UCL concentrations for the excursion indicators, the well in question will be placed on excursion status and corrective action will be taken. The first sample will be considered an error if neither the second or third sample confirm the first sample results.

In the event of an excursion Powertech will notify the NRC within 24 hours by telephone or email, and in writing with 30 days, and begin corrective actions: increasing sampling frequency to weekly, increase the pumping rates of production wells in the area of the excursion to increase the net bleed, pump individual wells to enhance recovery of mining solutions, and prepare an excursion report for NRC. If these actions are not effective at retrieving the excursion within 60 days, Powertech will suspend injecting lixiviant into the production zone adjacent to the excursion until the excursion is retrieved and the UCL parameters are not exceeded.

Due to the naturally occurring structure of the geochemical sink that has created the uranium deposits and the site specific hydrogeology, vertical excursions are not a primary concern. The confining layers above and below the ore-bearing formations, Skull Creek Shale and Morrison Formation, respectively will prevent lixiviant from vertically migrating into overlying or underlying aquifers.

The Skull Creek Shale has a thickness of approximately 200 feet and is the upper confining unit for the Project. Core samples were collected from the lower Skull Creek shale; analyses of these core samples demonstrate that the Skull Creek clays have extremely low vertical permeabilities, in the range of 6.8×10^{-9} cm/sec (0.007 millidarcies).

The Morrison is a shale layer approximately 100 feet thick, which serves as an underlying confining unit between the Inyan Kara and the Sundance aquifers. Analyses of core samples demonstrate that the Morrison clays have extremely low vertical permeabilities, ranging from 4.2 x 10^{-8} cm/sec to 3.9 x 10^{-9} cm/sec (0.043 millidarcies to 0.004 millidarcies).

6.3 Ecological Monitoring

Annual wildlife monitoring surveys will follow the same regimen as other ISL operations in the region to maximize comparisons among survey results and impact assessments. At a minimum, those surveys typically include the following, as modified for site-specific habitats:

1. Early spring surveys for, and monitoring of, grouse leks, new and/or occupied raptor territories and/or nests, T&E species (federal and state), and species tracked by SDNHP, as directed, on and within 1.0 mile of the PAA

2. Late spring and summer surveys for raptor production at occupied nests, and opportunistic observations of all wildlife species, including T&E species) and other species of management concern

3. Other surveys as required by regulating agencies

Two examples of the latter efforts would target bald eagles and aquatic resources. Annual monitoring of nesting and wintering bald eagles would generate valuable information that could be used to further reduce potential impacts and to help develop mitigation measures that would benefit this species while allowing ISL mining to proceed or continue. Since there is no "significant pathway to man indentified in this individual licensing case" with regards to aquatic species, sampling is not anticipated

Because the PAA does not include any critical big game habitats, and is covered by SDGFP big game surveys, that agency did not require such efforts for these baseline wildlife surveys; consequently, no long-term monitoring requirements are anticipated. A similar approach has been applied to other baseline projects (uranium, coal, bentonite, gold) in South Dakota and Wyoming, and is the current policy for annual monitoring at surface mines in the two-state region.

All aspects of a regular and/or periodic monitoring program would be developed according to current agency protocols and guidelines. Those considerations would apply to field surveys and

equipment; data collection, analysis, reporting, and storage procedures; agency consultations and collaborations; permitting requirements; and any other relevant components.

6.4 Quality Assurance Program

Powertech will establish a quality assurance program at the facility consistent with the recommendations contained in NRC Regulatory Guide 4.15 "*Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) -- Effluent Streams and the Environment*" (RG 4.15). The purpose of the program is to ensure that all radiological and nonradiological measurements that support the radiological monitoring program are reasonably valid and of a defined quality. These programs are needed (1) to identify deficiencies in the sampling and measurement processes and report them to those responsible for these operations so that licensees may take corrective action and (2) to obtain some measure of confidence in the results of the monitoring programs to assure the regulatory agencies and the public that the results are valid.

The quality assurance program will contain the following RG 4.15 elements:

- The organizational structure, responsibilities, and qualifications of both the management and the operational personnel
- Specification and qualifications of personnel
- The SOPs used in the monitoring programs
- The records of samples, from collection to shipping to analysis
- The records of quality control of the sample analyses, including results of quality control blanks, duplicates, and cross-checks performed by other laboratories
- The calibration and operation of equipment used in obtaining samples, measuring radiation, etc.
- Data verification and validation procedures
- The data and calculations used to determine concentrations of radioactive materials, radiation doses due to occupational exposure, etc.

Quality assurance procedures, as described in RG 4.14, Sections 3, will be defined for the following programs:

- External Monitoring Program

- Airborne Radiation Monitoring Program
- Contamination Control Program
- Airborne Effluent and Environmental Monitoring Program
- Management Control Program

Additionally, quality assurance recommendations contained in RG 4.14 and RG 8.22 will be incorporated in the environmental monitoring and bioassay programs, respectively. In general, the quality control requirements for a specific activity will be incorporated into the SOP for that activity.

The quality assurance program will be audited periodically. The audits will be conducted by individuals qualified in radiochemistry and monitoring techniques. However, the auditors will not have direct responsibilities in the areas being audited. An example of an appropriate auditor is a consultant or a qualified member of the SERP. The results of the audits will be documented and made available to members of management with authority to enact any changes needed (i.e. RSO, Facility Manager, etc.).

Regulatory requirements followed with regard to design, implementation, and analysis for all of the preoperational environmental monitoring documented within this environmental report included 10 CFR Part 20, Part 40 and 40 CFR Part 190. Regulatory Guide 4.14, even though not intended for ISL purposes remains the leading guidance for environmental monitoring for the uranium mining industry. Discussions with NRC staff combined with the guidance in RG 4.14 were closely followed in order to meet design, sampling, and analytical recommendations of the NRC to facilitate the determination for licensing requirements during the review process.

7.0 Cost-Benefit Analysis

7.1 Introduction

This section has been prepared to meet the requirements established under NUREG-1569, and includes a description of the economic benefits of the proposed project. For the most part, benefit and cost estimates have been quantified; however, some potential environmental impacts cannot be reliably quantified and the benefit and cost estimates have been analyzed using qualitative or non-monetary terms.

The following economic analyses were created using IMPLAN (IMpact analysis for PLANning), an industry standard software used to measure the potential impacts due to a change in economic activity on a regional or local economy. IMPLAN was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency (FEMA) to estimate the economic effects of proposed resource outputs on local communities. Since 1988, the Minnesota IMPLAN Group, Inc. (MIG) has managed IMPLAN for public users.

The results of the cost-benefit analysis (CBA) presented in this section establish that the project is cost-effective and will provide a positive economic benefit to the 50 km radius impact area and the State of South Dakota.

7.2 Alternatives and Assumptions

CBA is a standard analytical tool used to determine whether the present cost of a project will result in sufficient benefits to justify investment in a capital intensive project (Zerbe and Bellas 2006). To adequately evaluate the economic impacts of any project, the CBA needs to define the alternatives being considered and the underlying assumptions including qualities of goods, labor costs, market conditions and discount rates used to compute net present value as well as establish the scope of potential impacts and non-monetary impacts.

7.2.1 Identification of Alternatives

This CBA evaluates the benefits and costs of the project resulting from its future operation in Custer and Fall River counties, South Dakota. The analysis also includes a comparison of the proposed project to the no action alternative.

7.2.1.1 No Action Alternative

Under this alternative, the project would not be constructed as planned. There would be no impacts to the existing environment including land and water resources at the proposed site in Fall River and Custer Counties. In addition, there would be no change to the existing underlying socioeconomic and demographic trends within the impact analysis area as positive economic benefits to local communities and the State of South Dakota would not be realized.

7.2.1.2 Proposed Action

The proposed action includes the construction and operation of a uranium ISL facility. The ISL facility will utilize gaseous oxygen and carbon dioxide that are injected into the ore-body within the Inyan Kara Formation to recover the uranium which is then pumped to the surface where it is extracted and processed into the final (yellowcake) product. This proposed action involves limited surface disturbance, negligible radiological impacts with insignificant changes in the overall groundwater quality at the project site.

7.2.2 Key Assumptions

Key assumptions involved in the cost and benefits of the project include: (1) the operating life of the project; (2) the discount rate; (3) the scope of the potential impacts; and (4) non-monetary impacts. These assumptions are described in more detail below.

7.2.2.1 Operating Life of the Project

The project is considered as a single unit of analysis including the well fields, SF, CPP and other ancillary facilities. For this analysis, the total operating/production life of the project is assumed to be 7 years. There are three phases of operation which will be analyzed as separate units with distinct costs and benefits associated with each:

- Two years of site development and facility construction
- Seven years of well fields and central plant operations – includes continued well field construction and initiation of restoration
- Seven years of the site reclamation groundwater restoration and decommissioning of well fields and ancillary facilities

7.2.2.2 Discount Rate

A cost-benefit analysis attempts to compare all applicable cost and benefits to the present value. Determining the net-present value (NPV) is calculated using a discount rate that allows for the comparison of the present value of future expenditures and allows all relevant future cost and benefits to be compared in present-value terms. A discount rate of 7.0 percent has been used for this present-value calculation as referenced in Circular A-94 from the United States Office of Management and Budget (OMB 1992). Circular A-94 was revised in 1992 based on extensive review and public comment and currently reflects the best available guidance on standardized measures of costs and benefits. This rate approximates the marginal pre-tax rate of return on an average investment in the private sector in recent years.

7.2.2.3 Scope of Impact

An important step in any CBA is establishing a viable scope of impact and establishing who will be affected by the project (Zerbe and Bellas 2006). This analysis has been limited to the project's direct zone of influence that is defined as the area within which the project's impacts and benefits are reasonably anticipated to be concentrated, including the population areas most likely to contribute to the project's local workforce and to provide ongoing sources of supplies and commodities during construction and operations.

The direct zone of influence required under NUREG-1569 for the project cost-benefit analysis includes a radius of 80 km (50 miles) from the center of the project area and includes the townships, towns, and unincorporated areas within the two South Dakota counties surrounding the project, Custer and Fall River. Approximately 1.5 miles (2.4 km) of the project's western border follows the Wyoming/South Dakota state line south of Dewey, South Dakota. Therefore, the Wyoming locations of Newcastle and Osage[2] in Weston County are also included in the project's direct zone of influence, but because the project is located entirely within Custer and Fall River counties this CBA evaluates the project's economic impact only within these two counties and the South Dakota taxes that will be levied. These locations are considered close enough to reasonably supply workers or supplies to the project on a regular basis. No areas of appreciable population size were located within this radius (80 km) from the project in other Wyoming counties or to the south in Nebraska.

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[2] Osage is not an incorporated town but is defined as a "CDP" or census-designated place by the USCB in partnership with State agencies. CDPs are areas of significant population outside of any incorporated municipality and that are locally identified by a name.

Rapid City, South Dakota, the closest urban area to the project is located approximately 100 miles (161 km) via highways northeast of the project area, in Pennington County. Rapid City may serve as a regional logistics hub and source of workers and supplies for the project as well. Because of its greater distance from the project, Rapid City is considered to be part of the project's indirect zone of influence. Two other communities in Pennington County also fall within the project's indirect zone of influence, Hill City and Keystone.

7.2.2.4 Non-monetary Impacts

A conventional CBA uses monetary values to compare goods and services derived from a project or program. The value of goods and services represent their relative importance. If the project's total value of the benefits is greater than the total value of the costs, then it is beneficial. While many inputs in the project CBA are goods and services that are traded in markets at established and well-known prices such as, skilled labor, construction material, and gasoline, other inputs are not directly traded and are more difficult to value (Zerbe and Bellas 2006). These inputs such as, changes to land or water resources, or aesthetic impacts have been assigned a qualitative value based on the best available information.

7.3 Economic Benefits of Project Construction and Operation

This section evaluates the potential economic impacts of construction and operation-related activities over the life of the project. Economic benefits created from the project include the number of jobs created and local and state tax revenues generated and other activities that have the potential to favorably affect the local economy.

This analysis uses IMPLAN as previously described to calculate the potential economic impacts to Custer and Fall River Counties. IMPLAN can tailor the input-output models according to specific regional or community data and the program can analyze the impacts from more than 500 different types of industries for counties throughout the United States. In order to analyze the impacts of the project on the local economies affected, the project's industry classification has been identified as mining and construction. The model also requires labor and capital expenditures as inputs in order to evaluate the potential economic impacts of the project. The outputs calculated are the potential direct, indirect and induced employment impacts and tax revenues generated.

The surrounding counties of Custer and Fall River, South Dakota were analyzed using the two industry sectors most closely associated with the stages of development to of the proposed

project: construction (IMPLAN code 41) and support activities for production (IMPLAN code 29). IMPLAN does not have a specific uranium production sector associated with Custer and Fall River counties, so all tax revenue estimates are considered as an approximation given that ad valorem and severance taxes will likely differ for different production sectors.

7.3.1 IMPLAN Input Data

For this analysis the initiation of the construction stage of the project assumes a start date of 2009 continuing through 2010. Table 7.3-1 shows the input data for construction, operation and reclamation expenditures over the life of the project. The total estimated number of construction workers directly involved in construction is 86. The total non-payroll capital construction expenditures are estimated at $45.8 million per year and $21.2 million per year for operation expenditures and $2.0 million per year for reclamation expenditures.

Upon completion of the well fields and central processing plant the operation will employ approximately 84 full-time employees over the following 7 year period and approximately 18 employees during the final 7 years of restoration and reclamation. It is likely that many of these employees will come from Custer and Fall River counties.

Table 7.3-1: Input Data for the Project

Activities	IMPLAN Code	Per Year		
		2009-2010	**2011-2017**	**2018-2024**
Construction Expenditures				
Non-payroll	41	$45.8 M	N/A	N/A
Payroll	41	86 Workers $3.5 M	N/A	N/A
Operation Expenditures				
Non-payroll	29	N/A	$21.2 M	$ 2.0 M
Payroll	29	N/A	84 Workers $5.6 M	18 Workers $1.0 M

7.3.2 Employment Benefits

Using the Input Data from Table 7.3-1, IMPLAN can generate the potential employment-related effects of the project. IMPLAN defines employment as total wage and salary employees, including self-employed jobs that are related to the proposed project. It also includes both full-time and part-time workers and is measured in annual average jobs.

Table 7.3-2 shows the potential direct, indirect and induced effects on Custer and Fall River Counties' employment. The direct employment effects refer to the employment directly generated by the project. For the initial construction phase in years 2009 to 2010, the model estimated the potential for an additional 171 non-payroll (indirect and induced) workers that could be hired in Custer and Fall River Counties based on the 86 payroll workers engaged directly in construction activities and the $45.8 million in non-payroll capital expenditures incurred by the project per year.

Table 7.3-2: Employment Effects of the Project in Custer and Fall River Counties

Years	Employment			
	Direct	Indirect	Induced	Total
2009-2010	86	45	126	257
2011-2017	84	36	35	155
2018-2024	18	3	3	24

Potential indirect effects, which pertain to the interaction of local industries (direct effects) purchasing from local industries could include increased labor demands, goods and services required to support project (e.g. retail and restaurant staff). In addition, new workers living within Custer and Fall River Counties would spend their income locally, which would induce additional income and employment. The sum of potential direct, indirect and induced effects represents the total potential employment impacts of the project.

These results indicate that the project has the potential to create a total of 257 (including 86 Powertech (USA) employees) jobs during the construction stage and a total of 155 (including 84 Powertech (USA) employees) jobs during the operation stage and 23 (including 18 Powertech (USA) employees) jobs during the reclamation stage of the project. The economic impacts of the project will not limited to Custer and Fall River Counties, but will likely benefit the surrounding Counties of Weston, Niobrara, and Pennington because of increased commerce and capital exchange within the region.

7.3.3 State and Local Tax Revenue Benefits

In addition to the employment benefits of the project, IMPLAN can calculate the expected State and Local taxes generated over the life of the project. In order to remain consistent with the scope of impact, Federal taxes are not included in this analysis. The results presented in Table 7.3-3 are standardized to 2008 dollar equivalents using the OMB recommended real discount rate of 7.0 percent.

Potential state and local tax revenue associated with the proposed project are presented in Table 7.3-3. Only indirect business taxes, which include excise taxes, property taxes, fees, licenses, and sales taxes that stem directly from the construction and operation of the project and paid by Powertech (USA) are presented instead of the tax revenue generated from employee or employer social insurance taxes, which represent only a transfer of wealth rather than a net economic gain when compared to the no action alternative.

As shown in Table 7.3-3, the results from the IMPLAN analysis indicate that the construction, operation and reclamation stages of the project are expected to generate a net present value of approximately $13.54 million in total business tax revenue over the life of the project. The total enterprise (corporate) tax was not analyzed because South Dakota does not levy a Corporate Income tax.

Table 7.3-3: IMPLAN Projections of State and Local Tax Revenue

	Construction 2 years	**Operation 7 years**	**Reclamation 7 years**	**Total**
Indirect Business Tax Revenue	**Net Present Value ($)***			
Motor Vehicle License (per annum)	$10,800	$6,107	$552	
Other Taxes (per annum)	$51,351	$29,037	$2,627	
Property Tax[1] (per annum)	$334,485	$334,485	$334,485	
State/Local Non Taxes (per annum)	$28,602	$16,173	$1,463	
Sales Tax[2] (per annum)	$1,374,000	$636,000	$60,000	
Total Indirect Business Taxes per Year	$1,799,238	$1,021,802	$399,127	
Total Indirect Business Taxes	$3,598,476	$7,152,614	$2,793,889	**$13,544,979**

*2008 Dollar Equivalents

[1]Property Tax was calculated using the value generated by the IMPLAN model for construction, $334,485.

[2]Sales Tax was calculated by applying 3 percent to the total non-payroll expenditures

In addition to the business tax revenues, the State of South Dakota, Special Tax Division of the Department of Revenue and Regulation levies a uranium severance tax of 4.5 percent as well as 0.24 percent conservation tax on the taxable value of any energy mineral produced from the Proposed Actions (South Dakota Department of Revenue and Regulations – Special Tax Division 2008). Current resource estimates for the proposed project are 7.6 million pounds (43-101 compliant). A total reserve estimate has not been included because it is still incomplete. Assuming that the identified 7.6 million pounds were sold at current market prices of approximately $60 per pound, the severance tax would yield approximately $20,520,000 in net economic benefits over the life of the operation, 50 percent of which would be collected by the

counties, and an additional $1,094,400 for the conservation tax. The total taxes generated over the lifetime of the project, including indirect business taxes, are estimated to be approximately $35.1 million.

7.3.4 State and Local Value Added Benefits

IMPLAN was used to calculate the value added benefits to Custer and Fall River Counties. Value added is a measure of wealth created by an economy, in other words, as an industry buys goods and services and remanufactures those goods to create a product of greater value, this increase in value represents the value added. The IMPLAN model calculates the value added based on four components, employee compensation, proprietor income, other property income and indirect business tax. Employee compensation is wage and salary payments as well as benefits. Proprietary income consists of payments received by self-employed individuals as income. Other property type income consists of payments from interest, rents, royalties, dividends, and profits. Indirect business taxes consist primarily of excise and sales taxes paid by individuals to businesses. As shown in Table 7.3-4, the results from the IMPLAN analysis indicate that the construction, operation and reclamation stages of the project are expected to generate approximately $186.7 million in value added benefits over the life of the project.

Table 7.3-4: Value Added Benefits

	Construction 2 years	Operation 7 years	Reclamation 7 years	
South Dakota/Fall River & Custer Counties				**Total**
Value Added (per annum)	$39,091,679	$14,135,859	$1,366,119	
Total	$78,183,358	$98,951,013	$9,562,833	$186,697,204

7.3.5 Benefits of Environmental Research and Monitoring

Due to the remoteness and low population of the project area, the ongoing environmental baseline studies and monitoring have greatly increased the information available on area's natural resources. Required operational monitoring as presented in Section 5.0 will continue to provide beneficial scientific data about the area.

7.4 External Costs of Project Construction and Operation

This section of the analysis evaluates the external costs of the project. Both short-term and long-term external costs are also identified and described for people living in the surrounding communities not directly involved in the project.

7.4.1 Short Term External Costs

7.4.1.1 Potential Housing Shortages

Because of the project's close proximity to the more populated communities of Custer City and Hot Springs, South Dakota and Newcastle, Wyoming with a combined population greater than 9,000 people, it can be assumed that much of the workforce would come from these localities. The remaining workforce would likely relocate from the surrounding area (e.g., South Dakota, Nebraska and Wyoming). The IMPLAN model results show that during the two year constructional stage 2010-2012, the project has the potential to sustain the creation of 257 new jobs for two years. During the following 7 year operation stage the project has the potential to sustain the creation 155 jobs for seven years, and 24 jobs over the final seven years.

In the unlikely event that the entire direct payroll and non-payroll workforce relocated to Custer and Fall River counties, the population increase for the three stages of operations would be 619, 374 and 58, based on the average family size in South Dakota of 2.41 as of 2006. This increase in population would account for an increase of 6.9 percent (total population 15248) in the total population of Custer and Fall River counties. This is a very conservative estimate because it is likely that a large percentage of the workforce for operation and reclamation will be sourced from the existing workforce, thereby reducing the total population increase substantially. The impacts associated with an increase in population are expected to be dispersed because of the remoteness of the project site and the phased nature of construction, operation and reclamation. While this is a moderate increase in the overall percentage of the local population, this influx of immigration could be partially mitigated by implementing a preferential hiring scheme and using regional educational/training institutions to help train workers and to ensure that as many of the local residents are hired as possible.

7.4.1.2 Potential Impacts on Schools and Other Public Services

There are several schools located within Custer and Fall River Counties. The Custer School District includes: Custer Elementary, Hermosa Elementary, Fairburn Elementary, Spring Creek Elementary, Custer Middle, and Custer High School. Total enrollment for the Custer School

District is 991 students with a student to teacher ratio of 12.1 to 1. The Hot Springs School District includes: Hot Springs Elementary, Hot Springs Middle and Hot Springs High School. Total enrollment for the Hot Springs School District is 873 students with a student to teacher ratio of 12.9 to 1. The Edgemont School District includes: Edgemont Elementary, Edgemont Junior High and Edgemont High School with a total enrollment of 138 students and a student to teacher ratio of 8.8 to 1.

Families moving into the aforementioned school districts near the project site as a result of the project are not expected to strain the current school system because they are presently under-capacity as shown by the combined student teacher ratio for the three school districts of 12.1:1 as compared to the State wide student teacher ratio of 13.4:1 and the national average of 15.7:1.

The costs associated with increased demand of public facilities and services are expected to be minimal. The need for additional water supply and waste disposal facilities are expected to be minimal based on adequate existing capacity. Existing emergency response and medical treatment facilities are capable of responding to any possible incident at the project site; therefore the basic services required to support the project already exist. Since much of the workforce will be local and the aforementioned services should be capable of handling the increase in demand from immigration related to the project, there are no significant changes or stresses anticipated for other public services, such as police, health care, or utilities.

7.4.1.3 Potential Impacts on Noise and Congestion

There are only a few residences in the vicinity of the proposed project. Most of the land in the surrounding 2.0 mile radius of the project is devoted to rangeland. Other land uses include grazing, crop land, hunting and wildlife habitat. As a result of the low population density of the area surrounding the project site, the anticipated limited use of large machinery and vehicles and the infrequent movement of transport vehicles to and from the project site, no significant noise or congestion impacts are anticipated within the surrounding 2.0-mile area during operations. There will be some increased traffic, noise and dust on the county road between the site and Edgemont during construction activities. However, these impacts will be of short duration.

7.4.2 Long Term External Costs

7.4.2.1 Potential Impairment of Recreational and Aesthetic Values

While several opportunities for recreational activities exist in the Custer and Fall River counties surrounding the project and within the project's surrounding 2.0-mile area, the current

recreational use is limited to deer, elk, and antelope hunting. During operations, hunting will be restricted within the permit boundary for safety reasons. However, this activity will not be permanent as hunting will return following reclamation of the site.

Within a 50-mile radius of the project, recreational areas include Buffalo Gap National Grassland, the George S. Mickelson Trail, the Black Hills National Forest, Jewel Cave National Monument, Angostura State Recreation Area, Custer State Park, Mount Rushmore National Memorial and Wind Cave National Park.

While the project is geographically located within 50 miles of several federal and state recreational areas, it will have only a minor affect on the regional recreational and aesthetic values because of its remote location and its limited access to large or highly traveled state roads or federal highways that service these recreational areas. Also, the project will not impair the existing aesthetic values of the area due to limited surface land disturbance and the construction of minimal structures that will not be visible from any major highway or scenic vantage point in the area.

7.4.2.2 Potential Land Disturbance

The land that encompasses the project area has been historically used for cattle grazing and open-pit uranium mining operations. Therefore, the project site has been previously disturbed and impacted from agricultural and mining activities.

The ISL (well field) method of uranium production minimizes land surface disturbance in comparison to conventional surface or underground mining and milling methods that cover large areas and generate waste rock and mill tailings. In addition, the land surface disturbance associated with constructing ISL well fields and access roads will only be short-term as concurrent reclamation with native vegetation will occur throughout the life of the project. Short-term surface disturbance impacts will result from the construction and operation of the SF, CPP, surface impoundments and irrigated land until final reclamation and closure of these facilities is completed.

A Level III cultural resources evaluation and report have been prepared (Appendix 4.10-A) that includes a survey of archaeological sites within the PAA. Sites that may require additional data evaluation or recovery will be avoided as well field development progresses. More detail is provided in Section 4.10 on cultural resources within the PAA.

7.4.3 Potential Groundwater Impacts

Operational controls during production and groundwater restoration will assure that leach solutions are contained and will not impact nearby USDWs. The use of groundwater supply for operations will be a temporary commitment of water resources and Powertech (USA) expects that the proposed groundwater restoration techniques will be successful at returning the mining zones at the project site consistent with baseline and NRC criterion 5(b)(5). Also the slow rate of groundwater flow and natural geochemical conditions of the aquifer (i.e., reductive conditions) that originally formed the ore body will continue to oxidize and precipitate recovery zone constituents, which will help protect USDWs and allow the aquifers impacted to return to their pre-production class of use. Potential impacts to groundwater resources are discussed in detail in Section 4.6.2.

7.4.3.1 Potential Habitat Disturbance

The project area has historically been used for cattle rangeland and has been the site of mining and exploration projects since the 1950's. There are no anticipated adverse impacts or irreversible loss of surface vegetation or wildlife habitat relative to existing conditions as a result of project operations. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for its pre-ISL uranium recovery uses. Potential environmental impacts to vegetation and wildlife are discussed in detail in Section 4.7.

7.4.4 Potential Radiological Impacts

The potential radiological impacts due to the project during operation are small (4.14.2). The decommissioning of the project site and disposal of radioactive material will satisfy all applicable NRC requirements and/or license conditions and will be transported off site to an NRC approved 11e.(2) disposal facility. The radiological effects including estimated exposures from the water and air pathways are discussed in detail in Section 4.14.2.

7.5 Cost-Benefit Summary

The most significant benefits of the project are its potential to sustain the creation of 257 new jobs during construction, 155 jobs during operation, and 24 jobs during reclamation, all of which include the direct, indirect and induced effects on the local economies. In addition, an estimated $91.6 million during construction will be spent on non-payroll expenditures, $148.4 million during operation and 14.0 million during reclamation; and approximately $35.1 million in state

and local tax revenue and $186.7 million in value added benefits are expected to be generated over the life of the project (Table 7.5-1) as a result of the project.

Table 7.5-1 summarizes the associated short-term and long-term cost of the proposed project. Impacts to the regional housing market should be minimal because of the large percentage of local workers, impacts to schools and public facilities should be negligible because of their present ability to absorb any associated regional influx, and the impact of noise and additional traffic presents little or no change compared to the no action alternative. Due to the remote location of the project site and minimal surface disturbance, impacts to recreational activities and aesthetic values within the area should be negligible.

This CBA indicates that the construction and operation costs including capital costs of this project will result in positive economic benefits to the local and regional economy by the creation of hundreds of jobs and millions of dollars in tax revenue over the life of the project. The development the ISR project should present Custer and Fall River counties with net positive gain when compared to the no action alternative.

Table 7.5-1: Summary of Benefits and Costs for the Project

Benefits	Costs
Value Added $186,697,204 **Tax Revenue** $35.1 million **Potential to create temporary and permanent jobs** 257 jobs over two years during construction 155 jobs over seven years during operation 24 jobs over seven years during reclamation **Increased knowledge of the local environment and natural resources**	**Housing Impacts** Little or no change **Schools and Public Facilities** Negligible **Noise and Congestion** None **Impairment of Recreation and Aesthetic Values** Negligible **Land Disturbance** Minor **Groundwater Impacts** Controlled through mitigation **Radiological Impacts** Controlled through mitigation

8.0 Summary of Environmental Consequences

8.1 Summary of Environmental Consequences

This section summarizes the environmental consequences of the Proposed Action. The following impacts are a product of the project and cannot be avoided. Applicable mitigation measures have been summarized that moderate the negative consequences of these impacts.

Table 8.1-1 summarizes the environmental impacts associated with the Proposed Action from construction through reclamation. Each impact is quantified, where possible, and the mitigation measures that will be taken to decrease the effects of each impact are summarized. All the impacts can be considered short- to medium-term, lasting months to several years. No significant long-term impacts have been identified that would extend beyond the length of the Proposed Action.

Table 8.1-1: Summary of Environmental Consequences

Impacts	Estimated Impacts	Mitigation Measures
Production		
Production of U3O8 (lbs/yr)	1,000,000	None
Use of Natural Resources		
Temporary Land Surface Impacts (acres)	Minimal temporary impacts to the well field areas 108 (without land application) to 463 (with maximum amount of land application) acres per year over the life of the project; significant temporary disturbance confined to a small portion of the project Site	Topsoil will be salvaged until the disturbed areas can be revegetated per SD DENR regulations to return land surface to pre-operational conditions.
Temporary Land Use Impacts	Temporary loss of agricultural production (grazing livestock) and wildlife habitat within the project area for the duration of the project	Reclamation activities including topsoil salvaging and revegetation of land surface will be used to return land use to pre-operational use.
Groundwater consumption (net gpm)	320	None
Groundwater quality impacts	Slight alteration of ore zone groundwater	Restoration measures include groundwater sweeps and groundwater treatment to return the groundwater quality to pre-operational conditions.
Visual and scenic impacts	Moderate and temporary impact; Well fields and Plants would negatively affect the aesthetics	Building materials and paint will be selected that complement the natural environment, topography will be taken into consideration in order to conceal wellheads, plant facilities, and roads.
Emissions		
Dust emissions (tons/yr.)	10	Enforcement of speed limits and the application of water on unpaved roads
Radon emissions (curies/yr.)	924	None
Radiological Impacts		
Additional maximum predicted dose (mrem/yr.)	12.5 (mrem/yr.)	None
Fractional increase to background continental dose (percent)	0.000000075	None

Table 8.1-1: Summary of Environmental Consequences (concl.)

Impacts	Estimated Impacts	Mitigation Measures
Socioeconomic Impacts		
Direct Employment		
Construction	86	None
Full Operations	84	None
Restoration	18	None
Construction Capital Expenditures ($/yr.)	45,800,000	None
Operations Capital Expenditures ($/yr.)	21,200,000	None
Restoration Capital Expenditures ($/yr.)	2,000,000	None
Non-payroll workers (Construction 2009-2010)	171	None
Non-payroll workers (Operations 2011-2017)	71	None
Non-payroll workers (Restoration 2018-2024)	6	None
Value Add Benefit	$186,697,204	None
Indirect Business Tax revenues	$13,544,000	None
Total Severance Tax revenues	$20,520,000	None
Waste Management Impacts		
Waste Water (gpm)	320 (process and bleed water at each site)	Land Application
Solid waste produced (yd^3/yr.)	100-300	Disposal at a licensed facility
11e.(2) byproduct waste produced (yd^3/yr.)	186,600	Disposal at a licensed facility, decontamination and contamination control.

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9.3.1 Reference for Land Use

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The 19 Drawings specifically referenced in the Table of Contents have been processed into ADAMS.

These drawings can be accessed within the ADAMS package or by performing a search on the Document/Report Number.

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