Dewey-Burdock Project
License Renewal Application for SUA-1600
Fall River and Custer Counties, South Dakota
Combined Technical Report/Environmental Report

March 2024

Prepared for
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20852

Prepared by
Powertech (USA) Inc.
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Section 2.0

List of Acronyms and Abbreviations

AADT	annual average daily traffic
ACS	American Community Survey
AEA	Atomic Energy Act
AEB	aquifer exemption boundary
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ALI	annual limits of intake
AMS	air monitoring station
amsl	above mean sea level
AOR	area of review
ARR	rate of resuspension of radionuclides in surface soil
ARSD	Administrative Rules of South Dakota
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
Augustana	Archaeology Laboratory, Augustana College
AWDN	Automatic Weather Data Network
BEA	Bureau of Economic Analysis
bgs	below ground surface
BKS	BKS Environmental Associates, Inc.
BLM	U.S. Bureau of Land Management
BMP	best management practices
BNSF	Burlington Northern Santa Fe
B.P.	before present
C	Celsius
CBA	Cost Benefit Analysis
CESQG	Conditionally Exempt Small Quantity Generator
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
cm/sec	centimeters per second
COO	Chief Operating Officer
CPP	Central Processing Plant
DDE	deep-dose equivalent
DDW	Deep Disposal Well
DENR	Department of Environment and Natural Resources
DES	Draft Environmental Statement
DQO	Data Quality Objectives
DR	Damage Ratio
EC	Electrical Conductivity
EDE	effective dose equivalent
EFN	Energy Fuels Nuclear
EPA	U.S. Environmental Protection Agency
ER	Environmental Report

ERG	Environmental Restoration Group
ESP	Exchangeable Sodium Percentage
ET	evapotranspiration
EXREFA	Extended Reference Area
F	Fahrenheit
FAC	facultative
FACU	facultative upland
ft	foot/feet
ft^2/day	square feet per day
GDP	gross domestic product
gpm	gallons per minute
GPS	global positioning system
ha	hectares
HPRCC	High Plains Regional Climate Center
HEPA	high efficiency particulate air
HS&E	health, safety and environmental
HV	high volume air sampling site used synonymously with AMS
HVAC	heating, ventilating, and air conditioning
ICRP	International Commission on Radiological Protection
IDLH	immediately dangerous to life and health
IMPLAN	IMpact analysis for PLANning
IQR	interquartile range
ISL	in situ leach (In this document ISL is synonymous with ISR)
ISR	in situ recovery
IX	ion exchange
kg	kilogram
km	kilometer
km^2	square kilometer
lbs	pounds
L	liter
LAN	land application area north (Dewey)
LAS	land application south (Burdock)
LLD	lower limit of detection
LDE	lens dose equivalent
LPF	Leak Path Factor
LSA	Low Specific Activity
m	meter
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
meq	milliequivalents
mi	mile(s)
MCL	maximum contaminate level
MDA	minimum detectable activity
MDL	minimum detection limits
mg	milligram

MIG	Minnesota IMPLAN Group, Inc.
MIT	mechanical integrity test
Mph	miles per hour
mrem	millirem
MW	monitoring well
NAAQS	National Ambient Air Quality Standards
NAU	National American University
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NFF	National Flood Frequency
NFS	National Forest Service
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NVLAP	National Voluntary Laboratory Accreditation Program
NWP	Nation Wide Permit
NWS	National Weather Service
OW	open water
OWUS	other waters of the United States
PAPABJh	Palustrine Aquatic Bed Intermittently Flooded Diked
PCN	Pre-construction Notification
PEM	Palustrine Emergent
PGA	peak ground acceleration
PIC	Pressurized Ion Chamber
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
Powertech (USA)	Powertech (USA) Inc.
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
psi	pounds per square inch
psig	pounds per square inch gauge
PUB	Palustrine Unconsolidated Bottom
PUSA	Palustrine Unconsolidated Shore Temporarily Flooded
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
R2EM	Riverine Lower Perennial Emergent
R4SB7	Riverine Intermittent Steambed vegetated
RCRA	Resource Conservation and Recovery Act
RESRAD	RESidual RADioactive
RMP	risk management program
RO	reverse osmosis
RPD	relative percent difference
RSC	residual sodium carbonate

RSO	Radiation Safety Officer
RST	Radiation Safety Technician
RTV	Restoration Target Value
RWP	Radiological Work Permit
SA	specific activity
SAR	Sodium Adsorption Ratio
SCFM	standard cubic feet per minute
SD	South Dakota
SD DENR	South Dakota Department of Environment and Natural Resources
SD DOL	South Dakota Department of Labor
SD DOT	South Dakota Department of Transportation
SD DRR	South Dakota Department of Revenue and Registration
SD GFP	South Dakota Department of Game, Fish and Parks
SD GOED	South Dakota Governor's Office of Economic Development
SD NHP	South Dakota National Heritage Program
SD SMT	South Dakota School of Mines and Technology
SD SU	South Dakota State University
SDWA	Safe Drinking Water Act
SERP	Safety and Environmental Review Panel
SF	satellite facility
SIC	Standard Industrial Classification
SKM	Silver King Mines
SMA	surface mine area
SMCL	Secondary drinking water standards
SOP	Standard Operating Procedure
SPAW	Soil-Plant-Atmosphere-Water
SQRU	scenic quality rating units
SSL	soil screening level
SWI	Susquehanna Western Inc.
TDS	total dissolved solids
TEDE	total effective dose equivalent
TENORM	Technologically enhanced naturally occurring radioactive material
TLDs	thermo luminescent dosimeters
TPQ	threshold planning quantities
TR	Technical Report
TRG	target restoration goal
TSS	total suspended solids
TSX	Toronto Stock Exchange
TVA	Tennessee Valley Authority
U-nat	natural uranium
UCL	upper control limits
UIC	underground injection control
umhos/cm	micromhos per centimetre
UPL	upland
USACE	U.S. Army Corps of Engineers

USCB	United States Census Bureau
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USDW	underground source of drinking water
USFWS	United States Fish and Wildlife Services
USFS	United States Forest Services
VRM	Visual Resource Management
WDEQ	Wyoming Department of Environmental Quality
WDTI	Western Dakota Technical Institute
WIA	walk-in hunting area
WL	working level
WLM	working level months
WoUS	Waters of the United States
yr	year

Dewey-Burdock Project
Application for NRC
Uranium Recovery License
Fall River and Custer Counties
South Dakota
Technical Report

1.0 Proposed Activities

1.1 Licensing Action Requested

Powertech (USA) Inc. (Powertech (USA)) submits this combined Technical Report (TR) and Environmental Report (ER) to the United States Nuclear Regulatory Commission (NRC) in support of a license renewal application (LRA) of the Radioactive Materials License SUA-1600. The TR and ER have been combined into one document, herein referred to as the LRA, and incorporates applicable NRC guidance regulations for both the TR and ER. This LRA concerns the Dewey-Burdock Project located near Edgemont, South Dakota in Custer and Fall River Counties.

This LRA is prepared to supplement and update the information presented to the NRC in support of issuance of Source Materials License SUA-1600 in 2014. Only baseline supplemental data is provided since no activities have occurred at the Dewey-Burdock Project. The supplemental baseline data provides the necessary information to determine the environmental impacts of the Dewey-Burdock Project under SUA-1600. This LRA is submitted in accordance with the licensing requirements contained in 10 Code of Federal Regulations (CFR) Part 40 and provides the NRC staff with the necessary information to support the preparation of an Environmental Assessment (EA) as required in 10 CFR Part 51.

This LRA has been prepared using suggested guidelines and standard formats. The application is presented primarily in the NRC format found in Regulatory Guide 3.46, Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining (NRC 1982). NRC document NUREG-1569, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications* (NRC 2003) was used to ensure that all information is provided to allow NRC Staff to complete their review of this amendment application. NUREG-1748, *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs*

(August 2003) was also used to ensure information typically found in the ER was appropriately incorporated into this LRA.

1.2 Project History

Uranium was first discovered in the Edgemont District in 1952 by professors from the SDSMT. They mined about 500 pounds of ore and hauled it to Grand Junction, Colorado. The Atomic Energy Commission (AEC) announcement of a new district at Edgemont led to a boom of staking, mining, and dealing in the summer of 1952. By 1953 the AEC had built a buying station in Edgemont. In July 1956 a 250-ton per-day mill went on stream and soon expanded to a 500-ton-per-day. In 1960 a vanadium circuit was added. Production from the Edgemont District (open pits and shallow underground operations in the Fall River), some mines in the Powder River basin and several mines in the Northern Black Hills continued until 1972. Susquehanna Western Inc. (SWI) bought the Edgemont mill and took control of the mines in the Edgemont District. Until the late 1960's early 1970's they were the only company active in the Edgemont District.

In 1967, Homestake Mining Company began exploration in the Dewey area. In 1974, Wyoming Mineral Corporation (Westinghouse) acquired the Dewey properties from Homestake. In 1974, TVA bought out the mill and mines from SWI. The mill was shut down, but exploration continued. Besides WMC and TVA, other companies exploring in the district were Union Carbide, Federal Resources, and Kerr McGee. TVA acquired the Dewey Project from WMC in 1978 and continued exploration until 1986. In total, over 4000 exploration drill holes were completed on this project.

In 1981 TVA completed a mine feasibility study on the project deposits. A DES was prepared by TVA to address the potential impacts of a proposed underground mine in the PA, but the NEPA process was never completed by TVA. Due to falling uranium prices the project leases were allowed to expire. In 1994 EFN acquired the mineral interests within the PA. Their intention was to mine the uranium deposits by ISL. EFN did no additional exploration drilling on the project. In 2000 the leases were dropped.

In 2005, Powertech (USA) acquired the leases for the property, consisting of approximately 10,580 acres. Since the spring of 2007, Powertech has drilled approximately 115 exploration holes, including 20 monitoring wells on the project. Both the historic and recent drill holes have helped to generate the geologic model and delineate the extent of the mineralized sands. Refer to Figure 2.6-3 for a map showing the location of all known drill holes and Appendix 2.6-A of the approved license application, which includes a table summarizing all historical exploration drilling.

1.3 Corporate Entities

This LRA is submitted by Powertech (USA), which is the United States based wholly owned subsidiary of enCore Energy Corp., a corporation registered in British Columbia. enCore Energy Corp. shares are publicly traded on the NASDAQ Stock Exchange as EU and the Toronto Stock Exchange – Venture Exchange (TSX.V) as EU. enCore Energy Corp. owns 100 percent of the shares of Azarga Uranium Corp., formerly Powertech Uranium Corp., and owns 100 percent of the shares of Powertech (USA) Inc. The corporate office of enCore Energy Corp. is located in Corpus Christi, TX USA. Powertech (USA) Inc. is a United States based Corporation registered in the State of South Dakota.

1.4 Site Location and Description

The PA is located approximately 13 miles north-northwest of Edgemont, South Dakota and straddles the area between northern Fall River and southern Custer County line. The PA boundary encompasses approximately 10,580 acres (4,282 ha) of mostly private land on either side of S. Dewey Road (County Road 6463) and includes portions of Sections 1-5, 10-12, 14 and 15, Township 7 South, Range 1 East and Sections 20, 21, 27, 28, 29 and 30-35, Township 6 South, Range 1 East, Black Hills Meridian. Approximately 240 acres (97.1 ha) are under the control of the Bureau of Land Management (BLM) located in portions of Sections 3, 10, 11, and 12.

PA facilities will include well fields, one satellite IX process plant located within the Dewey area and one IX process plant built along with the central IX resin processing plant, which will be located at the proposed CPP and will be used to recover the final uranium product (yellowcake). Figure 1.4-1 shows the project location and license boundary.

1.5 Land Ownership

Plate 1.5-1 provides the breakdown of the mineral ownership and Plate 1.5-2 provides the breakdown of the surface use agreements of the project.

1.6 Orebody Description

The uranium deposit occurs in the Inyan Kara Group of the lower Cretaceous age. Specifically, the targeted uranium occurs in both the Fall River Formation and the Chilson Member of the Lakota Formation. The Fall River and Chilson consist of permeable sandstones deposited in a major sand channel system that makes up a groundwater aquifer. The identified uranium orebody

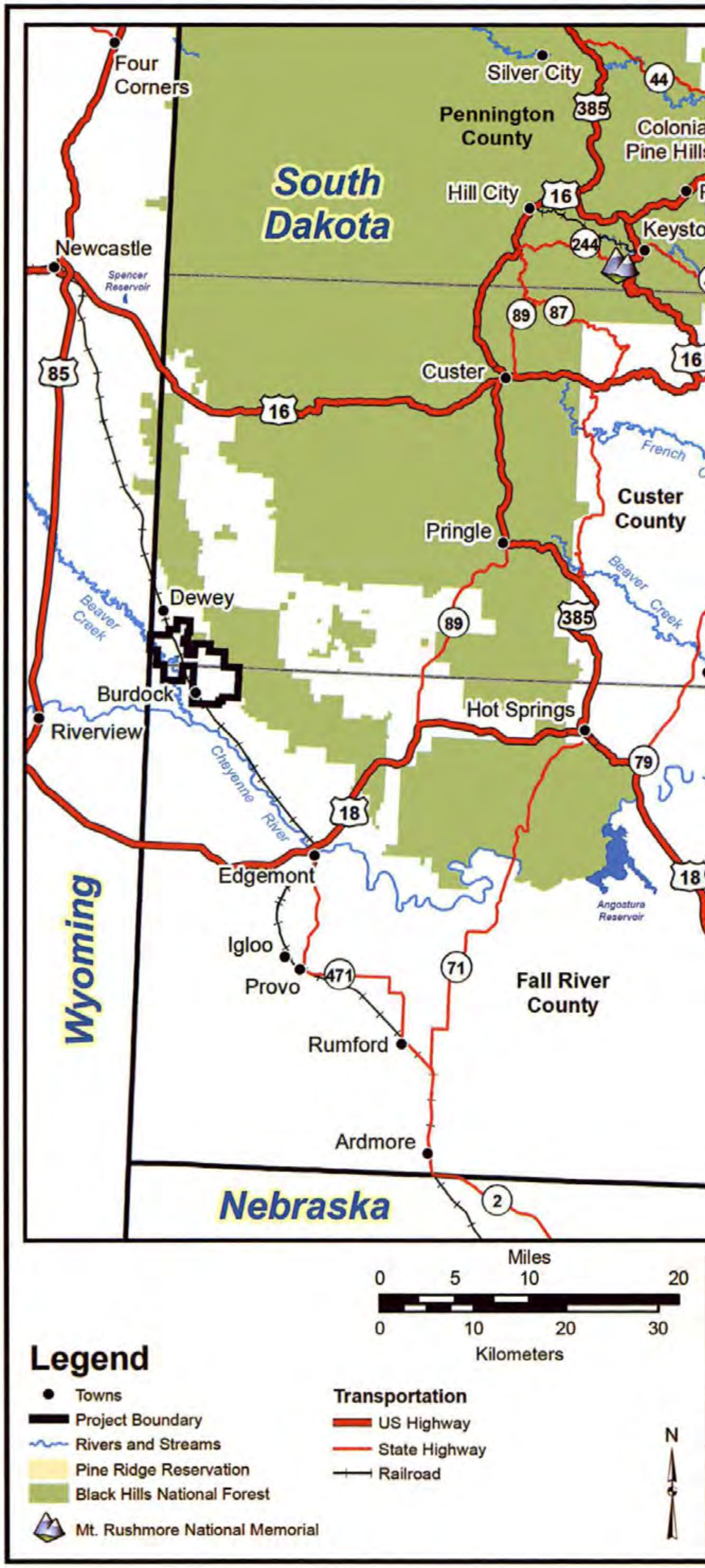

Figure 1.4-1

Project Location Map

Dewey-Burdock Project

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DATE	17-Jun-2013
FILENAME	DBProjLocMap.mxd

POWERTECH (USA) INC.

occurs in sandstones as classic roll front deposits with both oxidized and reduced zones located at both the Dewey and Burdock areas. These roll front deposits are usually "C" shaped in cross section, a few tens of feet wide and often thousands of feet long. Uranium minerals are deposited at the interface of the oxidized ground and reduced ground. As the uranium minerals precipitate, they coat the sand grains, and continual addition of uranium by oxidizing groundwater and re-solubilization followed by re-deposition at the interface has increased the uranium concentration of the identified orebody. Thickness of the orebody is generally a factor of the thickness of the sandstone host unit. Uranium mineralization has occurred in more than one horizon within the Inyan Kara Group resulting in multiple roll fronts. The estimated mineable resource (compliant with Form 43-101) within the project boundary is 7.6 million pounds of U_3O_8 with an average grade of 0.21 percent.

1.7 ISL Method and Leaching Process

The ISL process involves the oxidation and solubilization of uranium from its reduced state using leaching fluid (lixiviant). The leach fluid consists of ground water with an oxidant, such as gaseous oxygen, added to oxidize the uranium to a soluble valence and gaseous carbon dioxide to complex and solubilize the uranium ion causing it to go into solution in the leach fluid flowing through the ore zone. At the PA, Powertech (USA) will add gaseous oxygen and gaseous carbon dioxide to the recirculated native ground water from the ore zone aquifer. Once solubilized, the uranium bearing ground water will be pumped by submersible pumps via well field production wells to the surface where it is bonded by IX forces onto IX resins. After the uranium is removed, the groundwater will be recirculated and reinjected via well field injection wells. When the IX resin is loaded with uranium, the loaded resin is moved to an IX elution (stripping) column where the uranium is eluted (stripped) off the resin by a salt water solution. The resulting barren (stripped) resin is then recycled to recover more uranium. The salt water eluate solution is pumped to a precipitation process where the uranium is precipitated as a yellow solid uranium oxide. The precipitated uranium oxide is then filtered, washed, dried and packaged in sealed containers for shipment for further processing.

Typically, an ISL well field consists of a set of contiguous geometric shaped patterns of injection and production wells. Powertech (USA) generally will utilize square or rectangular patterns, and sometimes hexagons or triangles to cover the economically recoverable portions of the uranium orebody. This provides for uniform distribution of leach fluid (lixiviant) to efficiently contact the economically recoverable portions of the uranium orebody. The injection wells will be located at the corners of the geometric patterns and the production wells will be in the center of the geometric patterns. Powertech (USA) will withdraw 0.5 to 3 percent more ground water than is reinjected to maintain a flow of outside baseline quality ground water into the well field and to prevent the flow of leach fluid to the monitor well ring surrounding the orebody. The excess produced water (bleed) creates and maintains a cone of depression in the pressure surface of the aquifer so that the native ground water is continually flowing to the center of the production zone. This bleed also helps Powertech (USA) control and limit the increase in the sulfate and chloride concentration in the leach fluid. A bleed of 0.5 to 3 percent is removed from the lixiviant stream to create the hydraulic gradient that serves to contain lixiviant within the ore zone. Over-pumping the production wells maintains the cone of depression in the well fields, preventing the loss of the lixiviant outside of the intended production area and protecting ground water outside of the monitor well ring.

The lixiviant is prepared using native groundwater fortified with oxygen, and carbon dioxide. The lixiviant is pumped into the injection wells, flows between the injection and production wells through the mineralized zone by the imposed hydraulic gradient, and extracted by production wells. Production flow rates are estimated at 20-30 gallons per minute (gpm) per well.

At the surface, the pregnant lixiviant flows through IX columns, where the uranium is transferred to resin. The resin will be trucked or piped to the CPP for further refinement into final uranium product (yellowcake).

The barren lixiviant is re-fortified with oxygen and carbon dioxide and re-circulated through the orebody to leach uranium. A detailed description of the proposed ISL process can be found in Section 3.

1.8 Operating Plans, Design Throughput, and Production

Uranium ISL production facilities will be utilized at both the Dewey and Burdock sites with a CPP located at the Burdock site. The lixiviant flow rate will be limited to 4,000 gpm on an annual average basis, excluding restoration flow. Yellowcake production will be limited to 1,000,000 pounds of U_3O_8 per year.

1.9 Project Schedule

Following the issuance of an NRC source and byproduct materials license and other relevant permits it is anticipated that construction of the Burdock Well Field 1, CPP and ancillary facilities including storage ponds and deep disposal wells and/or land application pivots will commence. The construction of the Dewey Well Field 1 and ancillary facilities will follow shortly thereafter.

Alternatively, Powertech (USA) may develop either the Burdock or Dewey well fields first, followed by the well fields in the other area. Startup of the Dewey and Burdock operations will commence upon completion of construction and will continue for approximately 7 to 20 years or more during which additional well fields will be completed along the roll fronts at both Dewey and Burdock sites. It is planned that groundwater restoration can be accomplished within NRC requirements for timeliness in decommissioning (10 CFR § 40.42); however, in the event restoration cannot be accomplished within this timeframe, Powertech (USA) will seek NRC approval for an alternate schedule. The projected construction, operation, restoration and decommissioning schedule is provided in Figure 1.9-1.

Decommissioning of the well fields including well abandonment, the removal of piping, tanks, ancillary buildings and equipment, cleanup of surface soil to applicable standards and revegetation of disturbed areas will be implemented following the cessation of ISL operations at the Dewey and Burdock sites. It is likely that the CPP at the Burdock site will continue to operate for several years following the decommissioning of the well fields. The CPP may continue to process uranium-loaded resin from other ISL projects such as the nearby Powertech (USA) satellite ISL projects of Aladdin and Dewey Terrace planned in Wyoming, as well as possible tolling arrangements with other operators.

1.10 Waste Management and Disposal

Wastewater from the ISL operations will consist primarily of spent CPP elution brines, production well field bleed, and restoration flows; these wastewaters will be treated and disposed of by injection in Class V injection wells and/or by land application. Specific liquid waste sources will include:

- Wastewaters from decontamination showers, sinks, and washing machines located in the restricted area
- Production bleed
- Spent eluant brines
- Spilled process liquids
- Wastewater from groundwater restoration
- Decontamination/decommissioning solutions from surface facilities

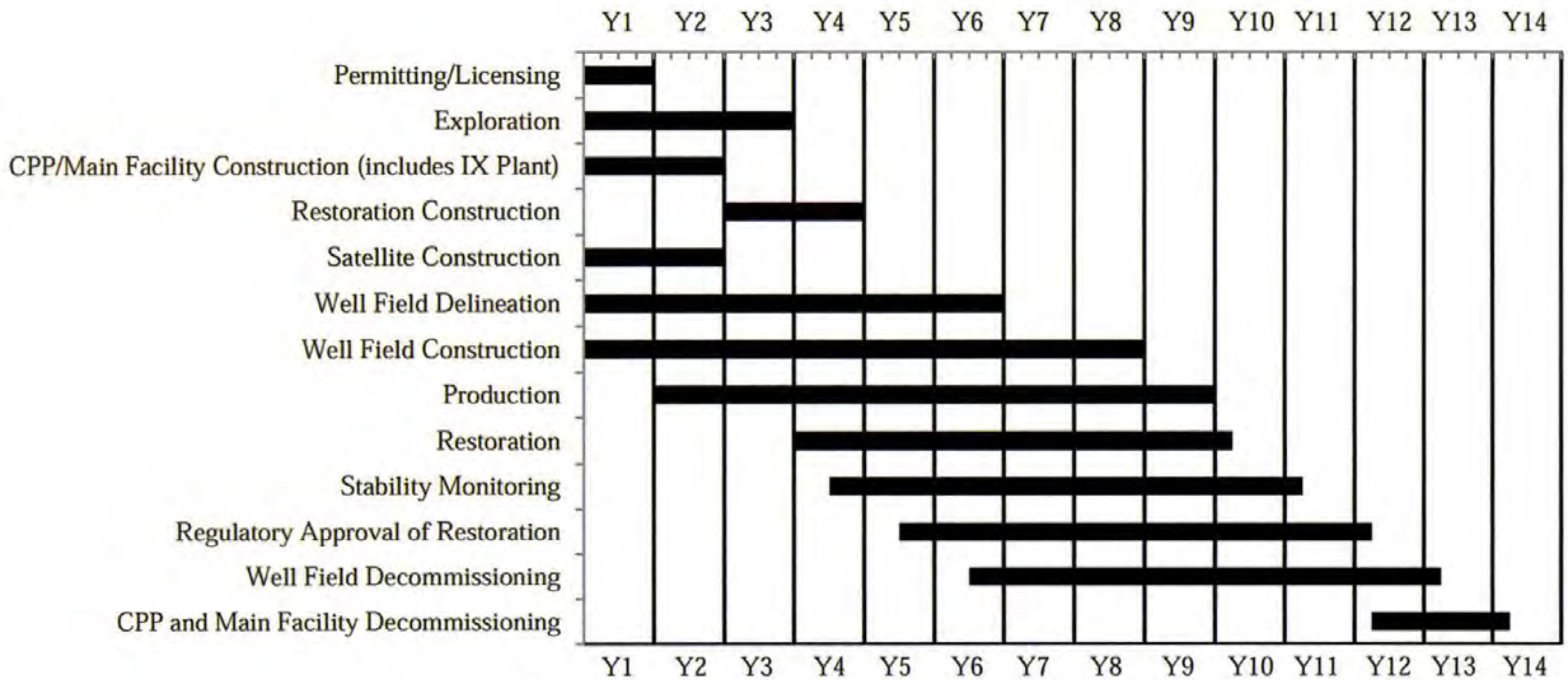


Figure 1.9-1: Projected Construction, Operation, Restoration and Decommissioning Schedule

Solid wastes such as pond sludge; soils contaminated by spills or leaks; spills of loaded or spent IX resin; filter sand or other process media; and parts, equipment, debris (e.g., pipe fittings and hardware) and personal protective equipment (PPE) that cannot be decontaminated for unrestricted release are considered Atomic Energy Act (AEA) regulated wastes and will be disposed of at an NRC or agreement state-licensed facility. Non-regulated AEA solid wastes such as office trash and spent equipment parts not associated with uranium production will be disposed at an off-site appropriately permitted Subtitle D facility. Non-regulated AEA liquid wastes such as used oil, hydraulic fluid, cleaners, solvents and degreasers will be recycled or disposed offsite at a permitted hazardous waste facility or other EPA approved disposal methods. Domestic sewage will be disposed in an on-site septic system and leachfield or other disposal methods permitted under State of South Dakota regulations.

1.11 Groundwater Restoration, Decommissioning and Site Reclamation

Groundwater restoration will be implemented as part of routine ISL operations so that restoration can be performed after a well field is depleted of uranium but concurrently with the development of subsequent well fields for uranium production. The groundwater restoration program for all well fields will be conducted pursuant to 10 CFR Part 40, Appendix A, Criterion 5. It is anticipated that a combination of phases and technologies may be utilized to restore groundwater. These restoration phases and technologies are described in detail in Section 6.

The decommissioning of well fields will commence following regulatory agency acceptance of the groundwater restoration program. The well field decommissioning will include well plugging and abandonment and the removal of well field piping, instrumentation and other support structures. At the time the CPP is decommissioned, all process equipment, buildings and ancillary equipment will be decontaminated for unrestricted release or disposed at an NRC or agreement state-licensed facility.

During site decommissioning and decontamination (D&D), areas that exceed NRC soil concentration limits will be cleaned and then surveyed for compliance with applicable standards. Surface topography and drainage patterns that have been disturbed during operations (including the surface impoundment) will be re-established and will be revegetated with native species.

1.12 Surety Arrangements

Powertech (USA) commits to supplying a financial assurance mechanism in a form and in an amount approved by NRC staff in accordance with 10 CFR Part 40, Appendix A, Criterion 9 and SUA-1600 License Condition (LC) 9.5 at least 90 days prior to the start of construction.

1.13 References

Tennessee Valley Authority, 1979, "*Draft Environmental Impact Statement - Edgemont Uranium Mine*", Tennessee Valley Authority, Chattanooga, Tennessee.

U.S. Nuclear Regulatory Commission, June 1982, *"Regulatory Guide 3.46 – Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining"*, USNRC, Office of Nuclear Regulatory Research, Washington, D.C.

U.S. Nuclear Regulatory Commission, June 2003, "*NUREG-1569 – Standard Review Plan for In Situ Leach Uranium Extraction License Applications – Final Report*", USNRC, Office of Nuclear Material Safety and Safeguards, Washington, D.C.

2.0 Site Characteristics

2.1 Site Location and Layout

The PA is located approximately 13 miles north-northwest of Edgemont, South Dakota and spans the area between northern Fall River and southern Custer Counties. The project boundary encompasses approximately 10,580 acres of mostly private land on either side of County Road 6463 and includes portions of Sections 1-5, 10-12, 14 and 15, Township 7 South, Range 1 East and Sections 20, 21, 27, 28, 29 and 30-35, Township 6 South, Range 1 East.

The site can be accessed from the northeast and the west via U.S. Highway 18 to County Road 6463. From the south, the site can be access from State Highway 471 to U.S. Highway 18 to County Road 6463. The main access road to the plant facilities and well fields is located off County Road 6463 in Section 15, T7S, R1E. This access road joins with several pre-existing roads that traverse through the Burdock Section of the project area (PA). Further to the north is the access road for the Dewey section of the PA. This road joins with several other pre-existing roads. These pre-existing roads within the Burdock and Dewey sections of the PA will be used to the extent possible to access facility structures and well fields. Secondary roads will be built from the existing roads to provide access to other facilities and well fields that are not currently reached from the pre-existing roads. Figures 3.1-1 and 3.1-2 depict the approximate primary access road, processing facility and initial well field locations in the land application and deep disposal well options, respectively.

2.2 Uses of Adjacent Lands and Waters

2.2.1 General Setting

The PA straddles the western county border between Custer and Fall River counties, South Dakota. Land within the project boundary is predominantly privately owned (97.7 percent) and the remaining 2.3 percent is managed by the Bureau of Land Management (BLM).

2.2.2 Land Use

Land use within the project boundary primarily consists of agriculture related to grazing, as well as hunting and historical mining. A 2 km review area is not available for the project site because the four counties in the study area do not utilize zoning or land use plans outside of urban areas. Approximately 390 acres of land are irrigated for hay production along Beaver Creek. The majority of agricultural production is related to grazing. Most land serves as grazing land for cattle and a small number of pigs that are consumed locally and sold as food, as well as a small number of horses. Some of the local residents also have vegetable gardens.

According to the United States Department of Agriculture's (USDA) 2017 census, Custer County generated $24,678,000 and Fall River County generated $83,837,000 from the selling of animal products. According to the National Agriculture Statistics Service, in 2023 the two counties had a combined total 80,500 head of cattle (no data was available for poultry, pig, or sheep inventories). Table 2.2-1 shows the 2023 livestock inventory for Custer and Fall River Counties.

Table 2.2-1: 2017 Livestock Inventory for Custer and Fall River Counties

Type of Livestock	Number Custer County	Number Fall River County	Percent of Total (Custer and Fall River combined)
Beef Cows	17,300	42,000	22/52%
All Cattle and Calves – excluding Beef Cows	8,200	13,000	10/16%
Sheep and Lamb	N/A	N/A	N/A
Hogs and Pigs	N/A	N/A	N/A
Total Animals	25,500	55,000	100%

Source: USDA, 2024.

Recreation lands are present in Custer, Fall River and Pennington counties within a 50-mile radius of the PA (Table 2.2-2). Major attractions include Mount Rushmore National Memorial and Wind Cave National Park which are set in the backdrop of the Black Hill National Forest. Within the PA or within the surrounding 2 km there are no recreation lands present because most of the land is private with a small portion, approximately 240 acres, managed by the BLM.

Recreational use in and around the project area is limited primarily to large game hunting. Within the project area, hunting currently is open to the public on approximately 5,700 acres. Approximately 240 acres are public lands managed by the Bureau of Land Management. In addition, the South Dakota Department of Game, Fish and Parks (SDGF&P) leases around 3,000 acres annually of privately owned land that is designated as walk-in hunting areas (WIA). The number of acres designated as WIA can change from year to year, since participants enroll their lands annually.

Table 2.2-2: Recreational Areas within 50 Miles of the Project

Name of Recreational Facility	Managing Agency	Distance From PA (miles)
Mount Rushmore National Memorial	U.S. Department of the Interior	44.0
Jewel Cave National Monument	U.S. Department of the Interior	23.0
Buffalo Gap National Grassland	U.S. Forest Service	3.0
Custer State Park	South Dakota Department of Game, Fish and Parks	35.0
Wind Cave National Park	U.S. Department of the Interior	29.0
Black Hills National Forest	U.S. Forest Service	0.0
Angostura State Recreation Area	South Dakota Department of Game, Fish and Parks	29.0
George S. Mickelson Trail	South Dakota Department of Game, Fish and Parks	17.0

Source: Google Earth (20 June, 2008)

The WIAs are on privately owned lands. The State WIA program compensates private landowners annually for use of the lands enrolled in the program. Landowners must renew their agreement with the State each year by May 1. Rules related to the program prohibit the firing of a firearm within 100 yards of a person or a structure. The landowner can terminate the program at any time with a written notice 30 days prior to termination and reimbursement of the annual compensation.

Prior to commencement of operations, Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable. Temporary fencing, signage, gates and other means of restricting public access will be installed in areas of active ISR operations such as well fields, processing plants and other facility areas in order to protect the public, protect workers, prevent damage to facilities, and provide security.

According to 43 CFR 3802.4, the owner of a mining claim may restrict public recreational use of/or public access across claims or portions of claims that are actively used for prospecting, mining, or processing operations in the following situations:

1) Where public recreational use of a claim would endanger or materially interfere with legitimate mining pursuits; or
2) In cases where the mining operation is hazardous and could lead to personal injury. The claimant may protect his mining equipment and operations area with appropriate signs or other lawful means.

Radiation exposure to hunters is not likely to occur, since radiation levels at ISR facilities are very low and hunters would normally be at least 100 yards from buildings such as the CPP, Satellite Facility, and header houses. Consequently, the risk to a hunter in or near the project area from radiation sources would always be less than that to a worker.

Table 2.2-3 lists the distance to the nearest resident from the center of the PA according to 22.5-degree sectors centered on the 16 cardinal compass points. Residences are depicted on Figure 5.7-11. There are five residences within the PA, including seasonal residences.

Table 2.2-3: Distance to Nearest Resident from Center of the Project

Sector	Distance from Project Center	
	Miles	Km
N	7.2	11.6
NNE	8.3	13.3
NE	6.7	10.8
ENE	13.1	21.1
E	6.8	11.0
ESE	10.7	17.3
SE	7.5	12.1
SSE	5.9	9.4
S	0.9	1.4
SSW	3.4	5.5
SW	21.0	33.7
WSW	1.7	2.7
W	20.3	32.6
WNW	6.2	10.0
NW	3.5	5.6
NNW	4.2	6.7

Data from US Census Bureau, 2000 Census.

2.2.2.1 Aesthetics

The PA is located within the Great Plains physiographic province on the edge of the Black Hills Uplift. The vegetation is a mix of short grasses and shrubs typical of semi-arid steppe land along with Ponderosa Pine forest toward the Black Hills. The color of the landscape varies from light brown and green to dark green with wildflowers in the springtime to light brown to golden during the later drier months. With the exception of historical open mine pits in the eastern portion of the PA, the visual aspect of human influence on the area is minor with most of the area used for grazing activities and associated facilities (e.g., fences and stock wells). The area's infrastructure include the Burlington Northern Santa Fe (BNSF) Railroad that runs north through Edgemont towards

Newcastle, County Road 6463 that parallels the BNSF railroad to the town of Dewey and overhead electricity lines and several gravel access roads.

2.2.2.2 Transportation and Utilities

The PA will generally be accessed north from Edgemont along County Road 6463. To the east, U.S. Highway 18 connects Edgemont with Hot Springs and to the north, State Highway 89 connects Edgemont with Custer City. Annual Average Daily Traffic (AADT) counts on U.S. Highway 18 between Edgemont and the junction with State Highway 89 is 2,000 vehicles (SDDOT 2007). The AADT count on State Highway 89 between Custer City and the junction with U.S Highway 18 is 515 vehicles (SDDOT 2007).

Records of the location of existing utilities within the PA do not exist. Powertech (USA) is in the process of ground truthing the location of any public utilities within the PA.

2.2.2.3 Fuel Cycle Facilities

The NRC provides a list of all of the source material facilities operating in the United States which include uranium mills and fuel cycle facilities. According to the NRC website there are no fuel cycle facilities within 50 miles of the PA. The closest fuel cycle facility is the AREVA NP, Inc. uranium fuel fabrication in Richland, Washington. Also in Eunice, New Mexico the Louisiana Energy Services fuel cycle facility is currently under construction (NRC, 2008).

There are no Source Material Licenses for in situ uranium projects within 50 miles of the PA. The nearest operational in situ facility is the Crow Butte ISL facility, SUA-1534, in Dawes County, near Crawford, Nebraska (NRC, 2008).

2.2.3 Uses of Adjacent Waters

2.2.3.1 Surface Water

The PA drains into the Upper Cheyenne River basin, which extends through three states – Wyoming, Nebraska, and southwestern South Dakota (HUC # 10120106, 10120107, 10120108). Within these states the Cheyenne River basin above Angostura Reservoir in South Dakota drains an area of approximately 8,996 mi^2 (Beauvais, 2000). The northern and central portions of the watershed are in the Black Hills division of the Great Plains and the southern portion is in the Pierre Hills division of the Great Plains (Kalvels, 1982 and Ensz, 1990). Land elevation ranges from about 3,160 feet (963 m) to 7,015 feet (2,138 m) above mean sea level.

The PA is drained by the Cheyenne River (Figure 2.2-1). Beaver Creek and Pass Creek pass through the project area and empty into the Cheyenne River downstream of the project boundary. Beaver Creek drains the southeastern portion of Weston County in Wyoming before entering Custer County in South Dakota and discharging to the Cheyenne River south of Burdock in Fall River County. Beaver Creek drains approximately 1670 mi^2 (1,069,000 acres); 71 percent of the watershed is in Wyoming and 29 percent is in South Dakota. The Pass Creek watershed, characterized as a sub basin of the larger Beaver Creek basin, comprises most of the east-southeast portion of the Beaver Creek basin and is almost fully contained in South Dakota. The Pass Creek watershed is 230 mi^2 and is located in Custer, Fall River, and Pennington Counties in South Dakota and a very small portion of Weston County in Wyoming. Several smaller ephemeral tributaries are also located within or adjacent to the project area. These streams, including the Cheyenne River, often experience extended periods of no flow. During periods of flow, water quality varies considerably, mostly dependent on flow regime, with relatively high amounts of sediment and low dissolved solids during high flows, and clearer waters with higher dissolved solids during low flows (Krantz, 2006).

Beaver Creek is the primary surface water resource in the PA. Pass Creek is a secondary surface water resource in the PA, although the channel is almost always dry. The remaining surface water resources in the PA are small ephemeral stream channels and small impoundments which are used by livestock when water exists. Section 2.7.3.1 presents an inventory of impoundments in and around the PA. Several small, local drainage channels pass through the Burdock portion of the project area.

The approximate elevation of the PA and the surrounding 2 km review area is 3,600 ft. The climate of the area is semi-arid with an annual precipitation of about 16.5 inches and high annual evaporation rates. Most of the precipitation accumulates during May, June, and July (48 percent of the annual). The peak discharge rates on the Cheyenne River watershed typically coincide with the late spring/early summer snowmelt, but are also influenced by summer thunderstorms.

2.2.3.1.1 Surface Water Flow

The nearest discharge gage on the Cheyenne River upstream of its confluence with Beaver Creek is USGS gage 06386500 near Spencer, WY. The nearest discharge gage downstream of the confluence of Beaver Creek and the Cheyenne River is USGS gage 06395000 at Edgemont, SD. This gage captures the contribution of flow to the Cheyenne River from Beaver Creek and Pass

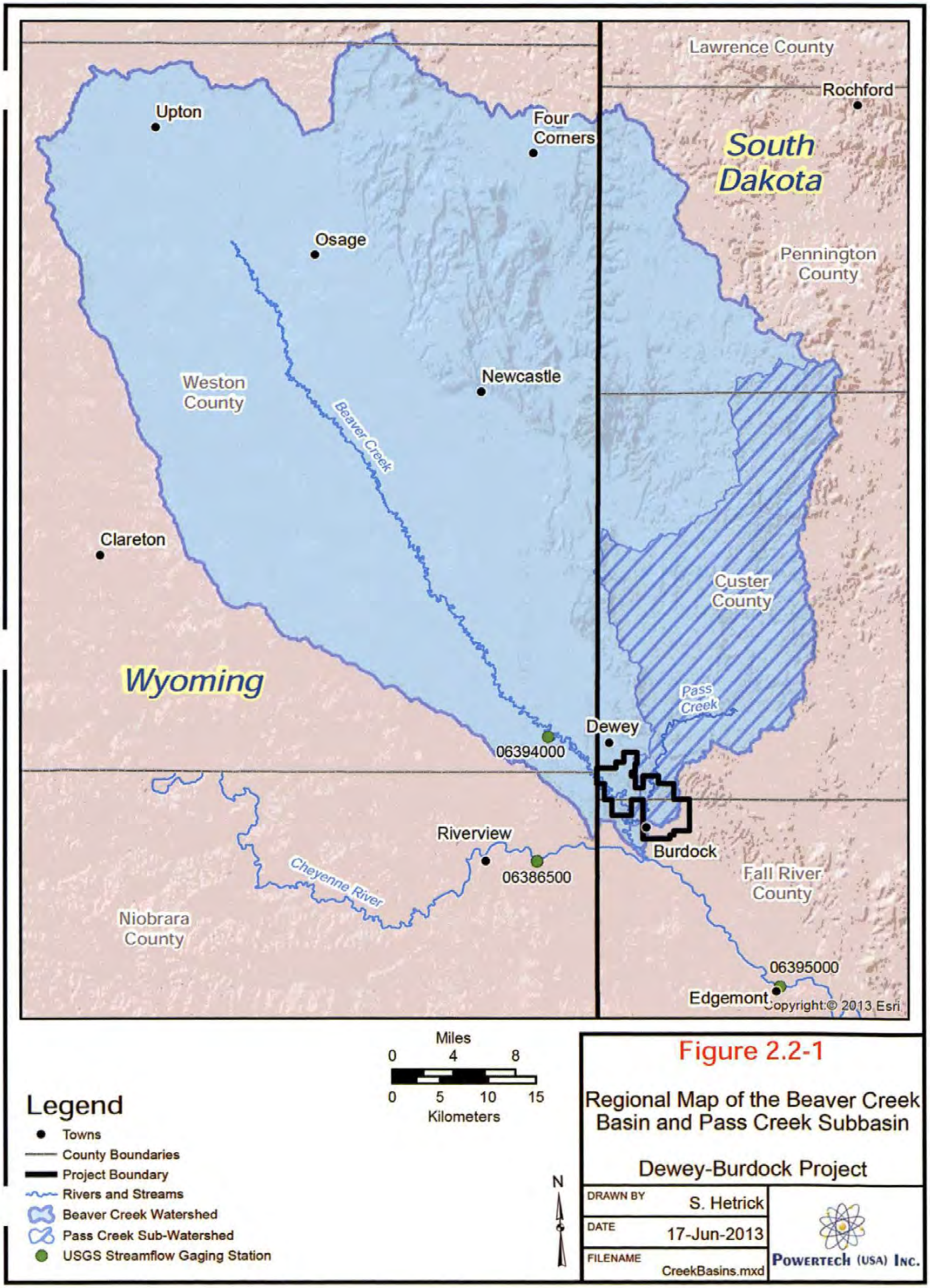


Figure 2.2-1

Regional Map of the Beaver Creek Basin and Pass Creek Subbasin

Dewey-Burdock Project

Creek between Spencer, WY and Edgemont, SD. Streamflow data from these USGS stream gages were analyzed and water quantities were described in Section 2.7 of the Technical Report.

2.2.3.1.2 Surface Water Quality

All surface waters in the State of South Dakota are classified into one or more following beneficial uses:

1. Domestic water supply waters
2. Coldwater permanent fish life propagation waters
3. Coldwater marginal fish life propagation waters
4. Warm water permanent fish life propagation waters
5. Warm water semi-permanent fish life propagation waters
6. Warm water marginal fish life propagation waters
7. Immersion recreation waters
8. Limited contact recreation waters
9. Fish and wildlife propagation, recreation, and stock watering waters
10. Irrigation waters
11. Commerce and industry waters

Cheyenne River in South Dakota upstream and downstream of the permit boundary is classified as having beneficial uses 5, 8, 9, and 10. According to the State of South Dakota 2006 303(d) list, the Cheyenne River from the Wyoming border to Beaver Creek is impaired with respect to beneficial uses fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10) due to high levels of total dissolved solids (TDS), sodium adsorption ratio (SAR), and conductivity. The rivers support status related to warm water semi-permanent fish life propagation (5) and limited contact recreation (8) is listed as "insufficient info" (SD DENR, 2006). The Cheyenne River from Beaver Creek to Angostura Reservoir is listed as supporting the beneficial use of limited contact recreation (8), but is impaired for the other three uses (5, 9, 10) due to high levels of TDS, SAR, conductivity, and total suspended solids (TSS).

Beaver Creek in South Dakota has been classified as being suitable for the same uses as the Cheyenne River except that this stream has been classified as being suitable for cold water marginal fish life propagation rather than warm water semi-permanent fish life propagation. The State of Wyoming has classified Beaver Creek in the project vicinity as presently supporting game fish or having the potential to support game fish. Beaver Creek has also been classified by Wyoming as a warm water fishery. Beaver Creek is listed as impaired from the Wyoming border to the confluence with the Cheyenne River with respect to all assigned beneficial uses due to high conductivity, TDS, TSS, fecal coliform, SAR, and temperature.

Pass Creek is classified by the State of South Dakota as having the beneficial uses of fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10). Pass Creek is listed as being in full support of assigned beneficial uses.

Powertech (USA) performed surface water quality sampling at eight stream sampling locations at the project site on a monthly basis from July 2007 through June 2008. The results of the water quality monitoring are summarized in Section 2.7 of the Technical Report.

2.2.3.2 Groundwater

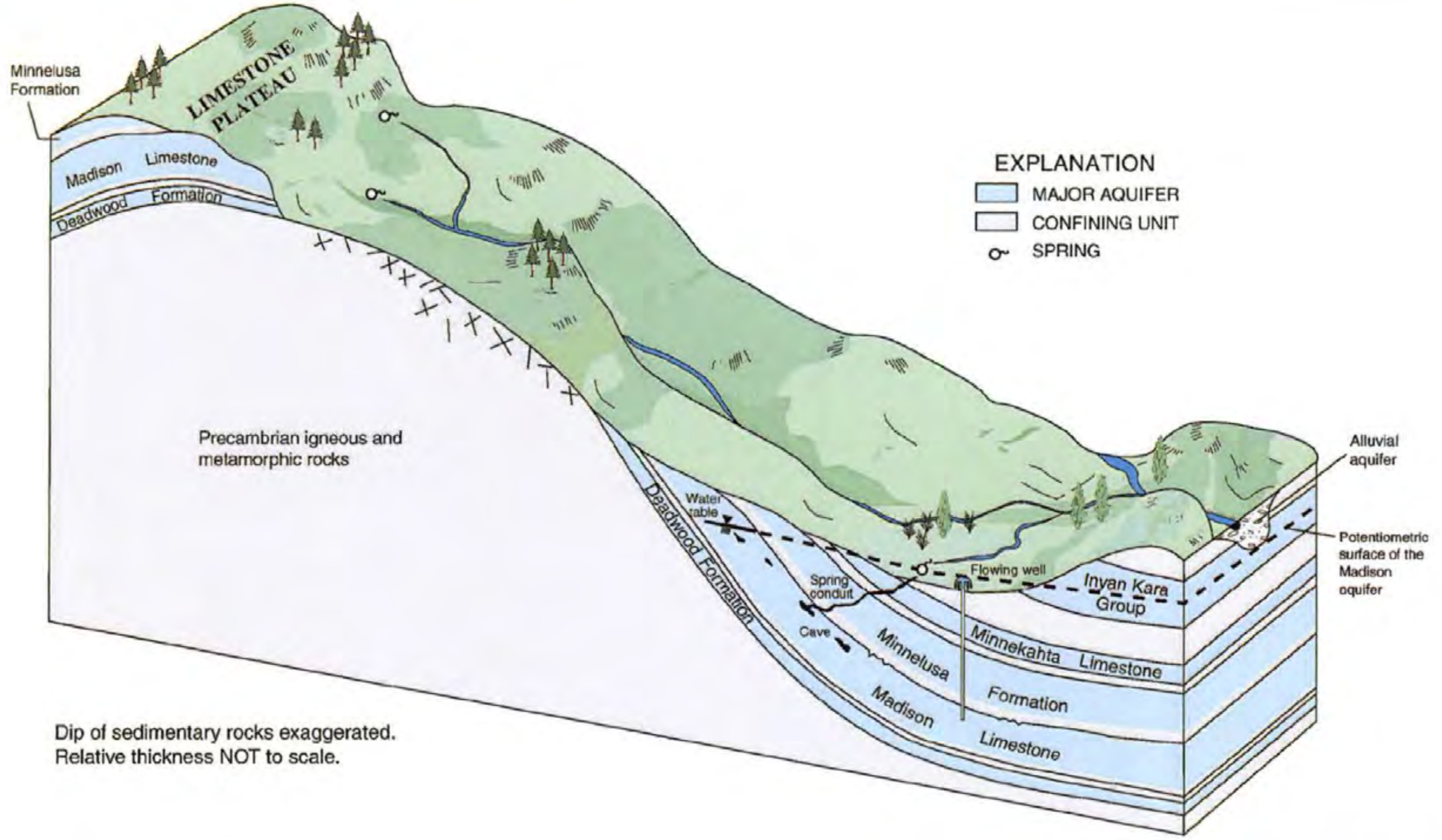
2.2.3.2.1 Regional Groundwater Hydrology

Four major aquifers are utilized as groundwater resources in the Black Hills. These main aquifers are the Inyan Kara, Minnelusa, Madison, and Deadwood. The regional groundwater hydrology is described in Section 2.7.2.1.

Figure 2.2-2 provides an overview of the hydrologic setting and general hydrogeologic flow within the Black Hills. Regionally, the general direction of groundwater flow is downdip or radially away from the central part of the Black Hills where the aquifers are recharged via infiltration from local rainfall. The aquifers transition from unconfined at the outcrop areas to confined away from the central highlands. At some distance away from the highlands the groundwater often is under sufficient pressures for artesian conditions and flowing artesian wells to exist.

The water-bearing units in the Black Hills can be divided into four main aquifers. From shallowest to deepest, these include:

- Inyan Kara Aquifer
- Minnelusa Aquifer



Source: Ground-Water Resources in the Black Hills Area, South Dakota. Water-Resources Investigations Report 03-4049, by J. M. Carter, D. G. Driscoll and J. F. Sawyer, Rapid City, South Dakota, 2003, p. 7.

Figure 2.2-2
Diagram Showing a Simplified View of the Hydrogeologic Setting of the Black Hills Area

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- Madison Aquifer
- Deadwood Aquifer

The hydraulic units of interest within the Black Hills area are shown on the stratigraphic column in Figure 2.2-3. Detailed information on the geologic units within the study area is provided in Section 2.6. The properties of major aquifer systems and geologic formations applicable to the project are discussed in greater detail in Section 2.7.

Water use estimates for different water use types for Custer and Fall River Counties are presented in Table 2.2-4.

Table 2.2-4: Estimated Water Use in Custer and Fall River Counties, South Dakota

Water Use Type	Withdraws (MGD)	
	Custer County	*Fall River County*
Public Supply	0.45	0.8
Domestic GW	0.35	0.17
Industrial GW	0	0
Industrial SW	0	0
Irrigated Acres, sprinkler	1.07	4.67
Irrigated Acres, surface flood	0.62	8.39
Irrigated Acres, total	1.69	13.06
Irrigation GW	0.05	0.08
Irrigation SW	3.56	36.12
Irrigation, total	3.61	36.2
Livestock GW	0.14	0.27
Livestock SW	0.21	0.4
Livestock total	0.35	0.67
Mining GW	N/A	N/A
Mining SW	N/A	N/A
Mining Total	N/A	N/A
Thermoelectric, total	0	0
Total GW, fresh	0.97	1.32
Total GW, saline	0	0
Total GW	0.97	1.32
Total SW, fresh	3.77	36.52
Total SW, saline	0	0
Total SW	3.77	36.52

Source: Hutson et al. 2000

Notes: GW = Groundwater
SW = Surface water
MGD = Million gallons per day

ERATHEM	SYSTEM	ABBREVIATION FOR STRATIGRAPHIC INTERVAL	STRATIGRAPHIC UNIT	THICKNESS IN FEET	DESCRIPTION
CENOZOIC	QUATERNARY & TERTIARY (?)	QTac	UNDIFFERENTIATED ALLUVIUM AND COLLUVIUM	0 - 50	Sand, gravel. boulder and clay.
		Tw	WHITE RIVER GROUP	0 - 300	Light colored clays with sandstone channel fillings and local limestone lenses.
	TERTIARY	Tui	INTRUSIVE IGNEOUS ROCKS	--	Included rhyolite, latite, trachyte and phonolite.
MESOZOIC	CRETACEOUS	Kps	PIERRE SHALE	1,200 - 2,700	Principal horizon of limestone lenses giving teepee buttes. Dark-gray shale containing scattered concretions. Widely scattered limestone masses giving small teepee buttes. Black fissile shale with concretions.
			NIOBRARA FORMATION	80 - 300 §	Impure chalk and calcareous shale.
			CARLILE SHALE — Turner Sandy Member; Wall Creek Member	350 - 750 §	Light-gray shale with numerous large concretions and sandy layers. Dark-gray shale.
			GREENHORN FORMATION	225 - 380	Impure slabby limestone. Weathers buff. Dark-gray calcareous shale with thin Oman Lake limestone at base.
			GRANEROS GROUP: BELLE FOURCHE SHALE	150 - 850	Gray shale with scattered limestone concretions. Clay spur bentonite at base.
			GRANEROS GROUP: MOWRY SHALE	125 - 230	Light-gray siliceous shale. Fish scales and thin layers of bentonite.
			GRANEROS GROUP: MUDDY SANDSTONE / NEWCASTLE SANDSTONE	0 - 150	Brown to light-yellow and white sandstone.
			GRANEROS GROUP: SKULL CREEK SHALE	150 - 270	Dark-gray to black siliceous shale.
		Kik	INYAN KARA GROUP: FALL RIVER FORMATION	10 - 200	Massive to thin-bedded, brown to reddish-brown sandstone.
			INYAN KARA GROUP: LAKOTA FORMATION — Fuson Shale; Minnewaste Limestone; Chilson Member	10 - 190 0 - 25 25 - 485	Yellow, brown and reddish brown massive to thinly bedded sandstone, pebble conglomerate, siltstone and claystone. Local fine-grained limestone and coal.
	JURASSIC	Ju	MORRISON FORMATION	0 - 220	Green to maroon shale. Thin sandstone.
			UNKPAPA SANDSTONE	0 - 225	Massive fine-grained sandstone.
			SUNDANCE FORMATION — Redwater Member; Lak Member; Hulett Member; Stockade Beaver Member; Canyon Spr Member	250 - 450	Greenish-gray shale, thin limestone lenses. Glauconitic sandstone, red sandstone near middle.
			GYPSUM SPRING FORMATION	0 - 45	Red siltstone, gypsum and limestone.
	TRIASSIC	TRPs	SPEARFISH FORMATION — Goose Egg Equivalent	375 - 800	Red silty shale, soft red sandstone and siltstone with gypsum and thin limestone layers. Gypsum locally near the base.
PALEOZOIC	PERMIAN	Pmk	MINNEKAHTA LIMESTONE	25 - 65 §	Thin to medium-bedded, fine-grained, purplish gray laminated limestone.
		Po	OPECHE SHALE	25 - 150 §	Red shale and sandstone.
	PENNSYLVANIAN	PIPm	MINNELUSA FORMATION	375 - 1,175 §	Yellow to red cross-bedded sandstone, limestone and anhydrite locally at top. Interbedded sandstone, limestone, dolomite, shale and anhydrite. Red shale with interbedded limestone and sandstone at base.
	MISSISSIPPIAN	MDme	MADISON (PAHASAPA) LIMESTONE	< 200 - 1,000 §	Massive light-colored limestone. Dolomite in part. Cavernous in upper part.
	DEVONIAN		ENGLEWOOD FORMATION	30 - 60	Pink to buff limestone. Shale locally at base.
	ORDOVIOAN	Ou	WHITEWOOD (RED RIVER) FORMATION	0 - 235 §	Buff dolomite and limestone.
			WINNIPEG FORMATION	0 - 150 §	Green shale with siltstone.
	CAMBRIAN	O€d	DEADWOOD FORMATION	0 - 500 §	Massive to thin-bedded buff to purple sandstone. Greenish glauconitic shale flaggy dolomite and flat-pebble limestone conglomerate. Sandstone with conglomerate locally at the base.
PRECAMBRIAN		p€u	UNDIFFERENTIATED IGNEOUS AND METAMORPHIC ROCKS		Schist, slate, quartzite and arkosic grit. Intruded by diorite, metamorphosed to amphibolite, and by granite and pegmatite.

Source:
Driscoll et al. (2002).

§ Modified based on drill-hole data

Figure 2.2-3

Stratigraphic Column of the Black Hills Area

Dewey-Burdock Project

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2.2.3.2.2 Study Area Groundwater Quality

At the project site, baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980). However, the guidelines were written for tailings impoundments so respective guidance has been interpreted as appropriate to ISL operations. A summary of the results and methods for the groundwater quality monitoring program, as well as the historical TVA data, is presented in Section 2.7.

2.2.3.2.3 Study Area Groundwater Use

In the PA, the Fall River Formation and Chilson Member of the Lakota Formation, the principal water-bearing formations of the Inyan Kara aquifer, are the principal sources of water. As discussed in Section 2.7.2.4, a preliminary inventory of private water-supply wells within an approximate 2 km radius of the project boundary was conducted in June 2007. Additional surveys were conducted in 2011 to evaluate the use and condition of the wells. A total of 106 wells were located (see Appendix 2.2-A of the approved license application). The wells within 2 km of the site serve as water supply for livestock (41), domestic (19), or monitoring (46). Well completion reports and other related data are found in Appendix 2.2-B of the approved license application. Stock and domestic wells within 2 km of the project area are depicted on Figure 2.2-4.

The numerical groundwater model report in Appendix 6.1-A of the approved license application provides estimates of current water usage from the Inyan Kara aquifer within the groundwater model domain.

Based on population projections, future water use in the area is expected to remain consistent with present usage.

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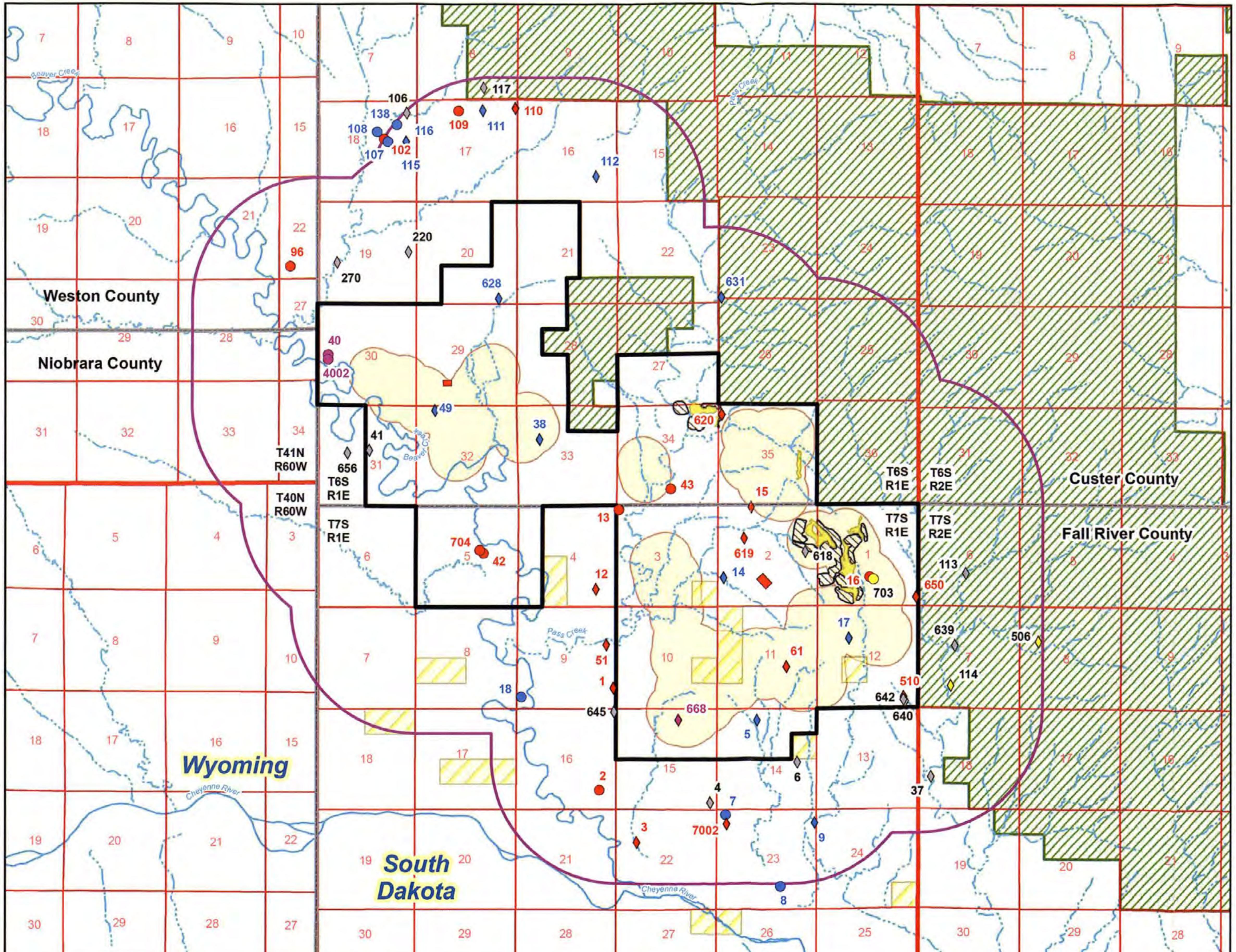

Figure 2.2-4

Domestic and Stock Wells Within 2 km of Project Area

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2.3 Population Distribution

The study area for the project socioeconomic baseline study includes population centers within an 80-km radius of the project's geographic center (latitude 43° 28' 50.071" N, longitude 103° 59' 34.559" W), considered to represent the likely maximum commuting distance for regular employees of the project (taking into account that actual road miles traveled from communities within the defined radius to the project may be in excess of the "direct line" distance).

A project's direct zone of social influence may be defined as the area within which the project's socioeconomic 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 social zone of influence adopted for the project socioeconomic baseline report primarily includes the townships, towns, and unincorporated areas within the two South Dakota counties hosting the deposits, Custer and Fall River. Approximately 1 mile (1.6 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[1] in Weston County are also included in the project's direct social zone of influence. These locations are within a 50-mile (80-km) radius of the PA's approximate center, and are thus close enough to reasonably supply workers or supplies to the project on a regular basis. No areas of appreciable population size were located within the same radius from the project in other Wyoming counties or to the south in Nebraska.

Within the direct social zone of influence, this baseline study report focuses on the Custer and Fall River counties as being the host counties for the project and thus the most likely to benefit directly from project implementation, including receipt of tax revenues. Towns within these two counties include:

- Custer County:
  - Buffalo Gap, Custer City, Fairburn, Hermosa, and Pringle
- Fall River County:
  - Edgemont, Hot Springs, and Oelrichs

[1] 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.

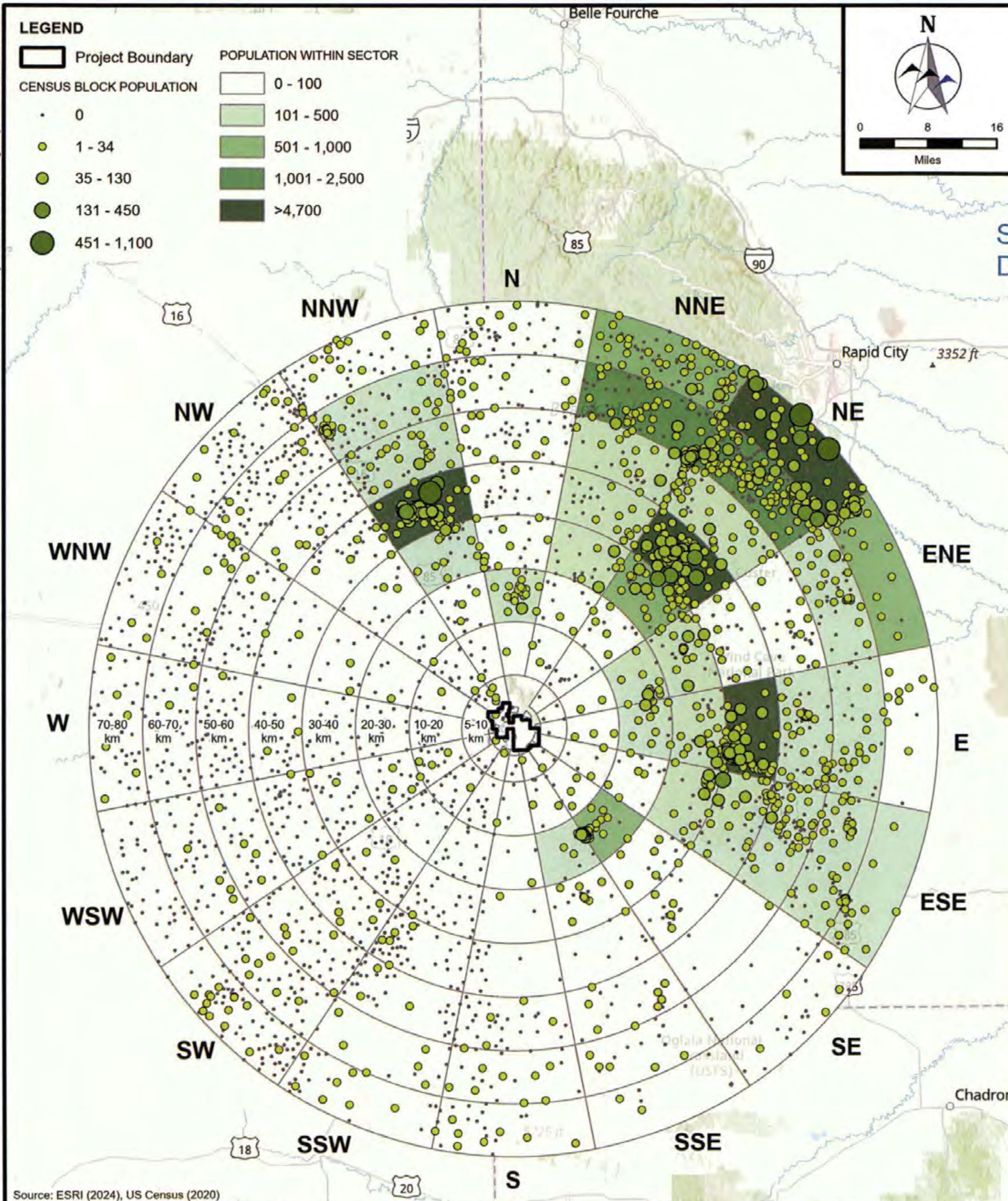
Rapid City, South Dakota, the closest urban area to the project, is approximately 100 miles (161 km) via road northeast of the PA, in Pennington County, and may serve as a regional logistics hub and source of workers and supplies for the project as well. Because of its greater distance from the project, Rapid City is considered to be part of the project's indirect social zone of influence. Two other towns in Pennington County also fall within the project's indirect social zone of influence, Hill City and Keystone.

2.3.1 Population

The majority of population and demographic information contained in this baseline report was obtained from the 2020 Decennial Census and 2020 American Community Survey 5-Year Estimate. 2020 data was used to provide the most comprehensive and comparable dataset. Other sources of demographic information include the U.S. Bureau of Labor Statistics, the South Dakota Department of Labor and Regulation, Labor Market Information Center, and South Dakota Department of Revenue.

NUREG-1569 obliges consideration of population data within a 50-mile (80-km) radius from the project's approximate center; the data is shown in Figure 2.3-1.

In general, detailed information on population distribution and demographics is only provided for the towns within the project's direct social zone of influence, as defined in the preceding section, with emphasis on the two South Dakota counties in which the project is located, Custer and Fall River. For some datasets (such as population), estimations based on data trends are cited to provide more updated information; these estimations are acknowledged as projections rather than defined data where used. Population by sector and cumulative population by sector based on Figure 2.3-1 are presented in Table 2.3-1.



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APPROVED BY: BJS
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POPULATION SECTOR-BLOCK ANALYSIS

FIGURE 2.3-1

Table 2.3-1: Population within a Given Distance from Project Center

	Distance from Project Center, km							
Sector	**0 - 10**	**10 - 20**	**20 - 30**	**30 - 40**	**40 - 50**	**50 - 60**	**60 - 70**	**70 - 80**
N	-	26	204	62	16	39	56	73
Cumulative	-	*26*	*230*	*292*	*308*	*347*	*403*	*476*
NNE	-	8	8	115	104	322	1,298	556
Cumulative	-	*8*	*16*	*131*	*235*	*557*	*1,855*	*2,411*
NE	-	-	47	694	3,752	233	1,724	3,703
Cumulative	-	-	*47*	*741*	*4,493*	*4,726*	*6,450*	*10,153*
ENE	-	27	185	307	43	43	320	754
Cumulative	-	*27*	*212*	*519*	*562*	*605*	*925*	*1,679*
E	-	42	142	391	4,092	313	101	38
Cumulative	-	*42*	*184*	*575*	*4,667*	*4,980*	*5,081*	*5,119*
ESE	-	9	20	226	406	297	186	124
Cumulative	-	*9*	*29*	*255*	*661*	*958*	*1,144*	*1,268*
SE	4	8	690	29	31	2	-	19
Cumulative	*4*	*12*	*702*	*731*	*762*	*764*	*764*	*783*
SSE	6	9	149	49	2	29	10	11
Cumulative	*6*	*15*	*164*	*213*	*215*	*244*	*254*	*265*
S	-	3	2	5	-	25	45	41
Cumulative	-	*3*	*5*	*10*	*10*	*35*	*80*	*121*
SSW	9	-	-	3	14	18	20	43
Cumulative	*9*	*9*	*9*	*12*	*26*	*44*	*64*	*107*
SW	-	2	-	11	17	32	25	62
Cumulative	-	*2*	*2*	*13*	*30*	*62*	*87*	*149*
WSW	5	8	10	7	12	28	15	-
Cumulative	*5*	*13*	*23*	*30*	*42*	*70*	*85*	*85*
W	-	-	-	-	14	1	10	12
Cumulative	-	-	-	-	*14*	*15*	*25*	*37*
WNW	-	5	2	7	7	13	54	23
Cumulative	-	*5*	*7*	*14*	*21*	*34*	*88*	*111*
NW	16	8	6	5	24	19	35	66
Cumulative	*16*	*24*	*30*	*35*	*59*	*78*	*113*	*179*
NNW	4	10	22	216	4,323	199	224	90
Cumulative	*4*	*14*	*36*	*252*	*4,575*	*4,774*	*4,998*	*5,088*
All Sectors	**44**	**165**	**1,487**	**2,127**	**12,857**	**1,613**	**4,123**	**5,615**

US Census Bureau, 2020 Decennial Census.

The distance to the nearest resident within each sector is presented in Table 2.3-2.

Table 2.3-2: Distance to Nearest Residents from Center of the Project Area

Sector	Distance from Project Center	
	Miles	Km
N	7.2	11.6
NNE	8.3	13.3
NE	6.7	10.8
ENE	13.1	21.1
E	6.8	11.0
ESE	10.7	17.3
SE	7.5	12.1
SSE	5.9	9.4
S	0.9	1.4
SSW	3.4	5.5
SW	21.0	33.7
WSW	1.7	2.7
W	20.3	32.6
WNW	6.2	10.0
NW	3.5	5.6
NNW	4.2	6.7

2.3.2 Demography

Demographic data for Custer and Fall River county populations collected for this baseline study includes information regarding population breakdown by sex, age, race, and household size, and is summarized and compared to similar data for the State of South Dakota in Table 2.3-3.

Review of the tabulated data indicates that the populations of Custer and Fall River counties are older than the state average, with older median ages, lower percentages of households with children, and higher percentages of households with persons 65 years of age or older. Additionally, family and household sizes for both counties were slightly smaller than the State averages.

In 2020, female-headed households with no spouse present accounted for 4.7 percent and 13.8 percent of the total households in Custer and Fall River counties, respectively, varying from the State average of 9.0 percent.

Racial data for the two counties show that the local population is predominantly white, with American Indian/Alaskan Native the predominant minority group. At 7.5 percent, the percentage of American Indians in Fall River County is higher that of Custer County, but still below the State average of 8.5 percent.

Table 2.3-3: Area Demographic Data, South Dakota

Data Type	Custer County	Fall River County	South Dakota
Male / female ratio, %	50.4 / 49.6	51.8 / 48.2	50.4 / 49.6
Median age, years	55.9	54.4	37.2
Average household size, people	2.18	2.05	2.43
Average family size, people	2.52	2.63	3.04
Households with individuals under 18 years, %	20	15.1	29.7
Households with individuals 65 years and over, %	48	41.2	29.1
Female householder with no spouse present, %	4.7	13.8	9.0
Above, with own children under 18 years, %	3.3	3.9	5.6
Race, %			
White	92.8	86.2	83.6
Black or African American	0.3	0.0	2.1
American Indian and Alaskan Native	4.4	7.5	8.5
Asian	0.3	1.2	1.4
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.1
Some Other Race	0.2	0.0	0.8
Two or More	2.0	5.1	3.4
Hispanic / Latino (of any race)	3.8	2.1	4.1

US Census Bureau, American Community Survey 5-Year Estimates, 2020

For comparative purposes, similar data was tabulated for the two Wyoming counties bordering the project, Niobrara and Weston, as shown in Table 2.3-4 below, compared against the state-wide data for Wyoming. As with the South Dakota counties hosting the project, the populations of Niobrara and Weston counties are older than the State average, with smaller household and family sizes, and higher percentage of senior citizens. PA

2.3.2.1 Population Projections

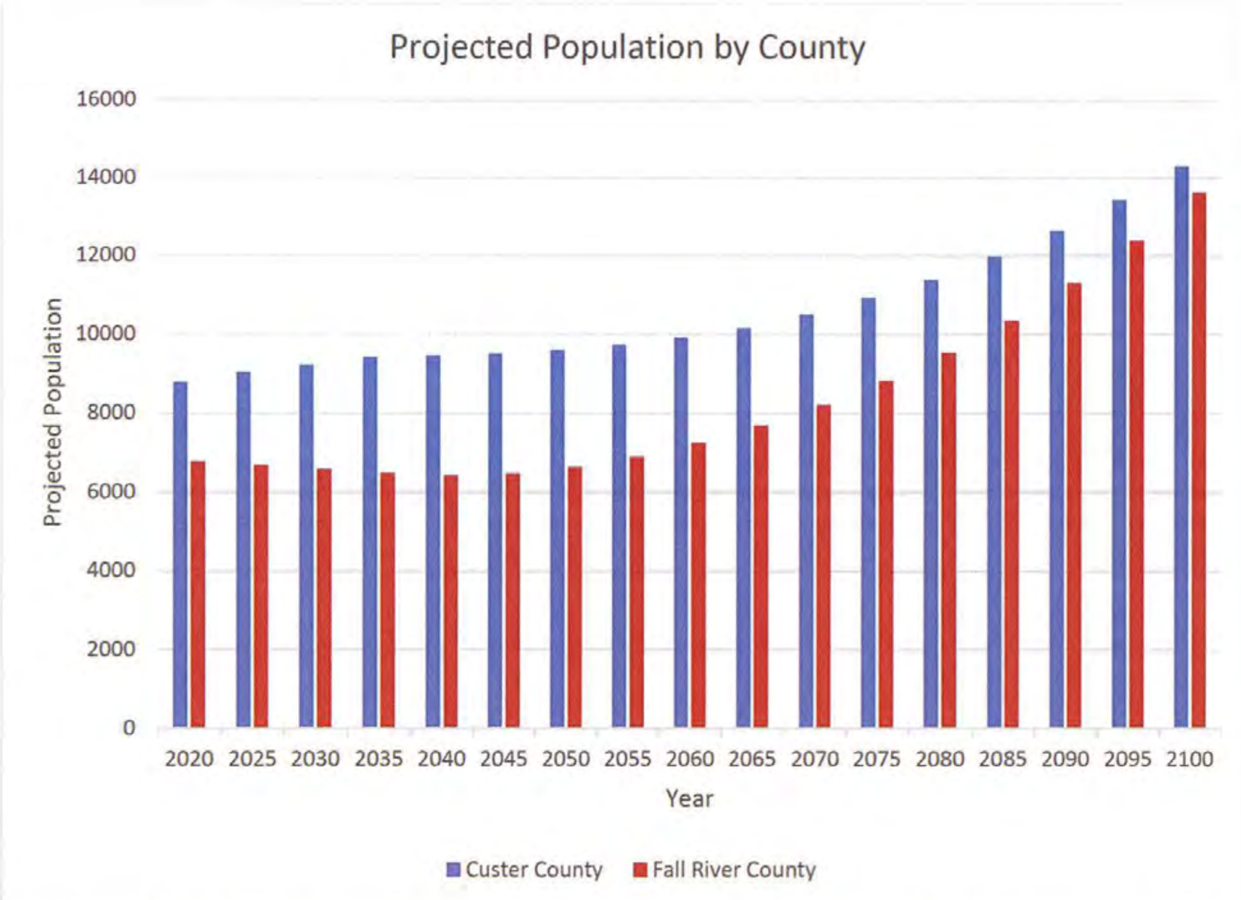
Population projections for Custer and Fall River counties are shown in Figure 2.3-2. The population of Fall River County is expected to decline approximately 2% over the next 30 years, and the population of Custer county is projected to increase approximately 9% during the same period.

A breakdown of population per town within each county is shown in Table 2.3-5. Custer City and Hot Springs, the county seats of Custer and Fall River counties, respectively, are also the largest towns in each county.

Table 2.3-4: Area Demographic Data, Wyoming

Data Type	Niobrara County	Weston County	Wyoming
Male / female ratio, %	42.0 / 58.0	52.7 / 47.3	51.0 / 49.0
Median age, years	40.4	42.4	38.0
Average household size, people	2.34	2.29	2.43
Average family size, people	2.92	2.67	3.00
Households with individuals under 18 years, %	32.6	22.8	29.2
Households with individuals 65 years and over, %	35.6	33.8	29.2
Female householder with no spouse present, %	5.6	7.5	7.9
Above, with own children under 18 years, %	4.0	2.5	5.1
Race, %			
White	92.9	92.5	90.3
Black or African American	0.2	0.6	0.9
American Indian and Alaskan Native	2.4	0.6	2.3
Asian	0.0	1.6	0.8
Native Hawaiian and Other Pacific Islander	1.5	1.7	0.1
Some Other Race	0.2	0.1	1.7
Two or More	2.3	2.9	3.9
Hispanic / Latino (of any race)	6.3	1.9	10.1

US Census Bureau, American Community Survey 5-Year Estimates, 2020



Source: NASA Socioeconomic Data and Applications Center, 2021. SSP2 (Middle of the Road) estimate.

Figure 2.3-2: Population by County

2020 population densities for both Custer and Fall River counties were quite low, at approximately four to six people per mi^2 (two people/ km^2). In comparison, the state average population density estimate for 2020 was approximately 11 people per mi^2 (four people/km^2).

Population data for some other areas of interest to the project are shown in Table 2.3-6, and include population statistics for two towns in Pennington County (which includes Rapid City) – Hill City and Keystone, and two locations in Weston County, Wyoming – Newcastle and Osage, all considered close enough to the project to be within in its direct social zone of influence.

Table 2.3-5: Population Change, Custer and Fall River Counties, 2000 – 2020

County / Town	Population	
	2000 Census	2020 Census
Custer		
Buffalo Gap	164	131
Custer City	1860	1919
Fairburn	80	60
Hermosa	315	382
Pringle	125	109
Fall River		
Edgemont	867	725
Hot Springs	4129	3395
Oelrichs	145	117

US Census Bureau, 2000 and 2020 Decennial Census

Table 2.3-6: Population Data for Other Areas of Interest, 2000-2020

County, State / Town	Population		
	2000 Census	2020 Census	*% Change*
Pennington Co, SD			
Hill City	780	872	***+11.2***
Keystone	311	240	***-22.8***
Weston Co, WY			
Newcastle	3065	5492	***+79.2***
Osage	215	151	***-29.8***

US Census Bureau, 2000 and 2020 Decennial Census

2.3.2.2 Schools

Public schools (kindergarten through 12th grade) in South Dakota are generally organized at the county or sub-county level by school district. The five public school districts in and around the PA and their attendant schools and age levels are:

- **Custer School District:**
  - Custer Elementary, Pre-Kindergarten (PK) - 5th

- Custer Middle, $6^{th} – 8^{th}$
- Custer High, $9^{th} – 12^{th}$
- Hermosa Elementary, PK – 8th
- Fairburn Elementary, Kindergarten (K) – 8^{th}
- Spring Creek Elementary, K – 8^{th}

- **Elk Mountain School District:**
  - Elk Mountain Elementary, K – 6^{th}
- **Hot Springs School District:**
  - Hot Springs Elementary, PK - 5^{th}
  - Hot Springs Middle, 6^{th} - 8^{th}
  - Hot Springs High, $9^{th} – 12^{th}$
- **Edgemont School District:**
  - Edgemont Elementary, K – 6^{th}
  - Edgemont Junior High, $7^{th} – 8^{th}$
  - Edgemont High, $9^{th} – 12^{th}$
- **Oelrichs School District:**
  - Oelrichs Elementary, K – 6^{th}
  - Oelrichs Junior High, $7^{th} – 8^{th}$
  - Oelrichs High, $9^{th} – 12^{th}$

There are no private or charter primary or secondary schools in Custer County. Bethesda Lutheran School in Hot Springs is the only private school in Fall River County, and serves grades PK – 5^{th}.

The closest post-secondary schools to the project are in Rapid City, approximately 100 miles via northeast via road, and include the Western Dakota Technical Institute (WDTI), the South Dakota School of Mines and Technology (SDSMT), and the Rapid City Campus of the National American University (NAU).

2.3.3 Local Socioeconomic Baseline Conditions

2.3.3.1 Labor Force

The SD DOL defines "labor force" as all civilians not in institutions, 16 years of age and older, and who are employed or unemployed and actively seeking employment. SD DOL develops its labor force estimates in cooperation with the US Bureau of Labor Statistics. "Labor supply" is defined by the SD DOL as the number of persons who would be available to staff a new or expanding business in the area of interest, and includes people who are currently employed but are seeking to change jobs and people who are unemployed but actively seeking jobs, and also considers workers who would commute into the area to work. Labor supply statistics are shown in Table 2.3-7.

Table 2.3-7: Area Labor Statistics, 2020

	Custer County	Fall River County	South Dakota
Labor force, persons	4,048	3,013	464,511
Employed, persons	3,824	2,850	44,901
Unemployed, persons	224	163	19,610
Unemployment rate, annual %	5.5%	5.4%	4.2%

US Bureau of Labor Statistics 2024

Annual unemployment rates in both Custer and Fall River counties were higher than the State-wide rate.

2.3.3.2 Employment

Employment data from 2020 for major sectors of employment including private sector enterprises and local, state, and federal government for Custer and Fall River counties are shown in Table 2.3-8. "Covered workers" are defined by the SD DOL as workers at firms for whom unemployment insurance is provided. Workers excluded from the "covered" category include the self-employed, unpaid family workers, elected government officials, railroad employees, election officials, work-study students, some religious and non-profit organization employees, smaller business employees, and part-time or seasonal workers.

Government (local, state, or federal) was the largest employment sector for both Custer and Fall River counties. Major private enterprise sectors of employment for both counties were leisure/hospitality, education and health services, and trade/transportation/utilities.

Table 2.3-8: Covered Worker Employment by Sector, 2020

Employment Sector	Custer County, % Employed	Fall River County, % Employed	South Dakota, % Employed
Construction	7.3	3.7	5.9
Education and Health Services	10.5	15.7	16.5
Financial Activities	3.3	2.1	6.7
Information	1.0	1.1	1.2
Leisure and Hospitality	23.7	11.7	9.8
Manufacturing	0.7	0.5	10.3
Natural Resources and Mining	1.9	2.9	1.7
Other Services	3.9	2.3	2.7
Professional and Business Services	7.4	4.2	7.9
Trade, Transportation and Utilities	16.3	12.2	19.9
% Total, Private Ownership	***76.1***	***56.5***	***82.6***
Local Government	12.8	15.6	11.2
State Government	4.3	7.4	3.4
Federal Government	6.8	20.4	2.8
% Total, Government	***23.9***	***43.5***	***17.4***
Total Covered Workers:	**2229**	**2392**	**417112**

South Dakota Department of Labor and Regulation, Labor Market Information Center, 2024.

2.3.3.3 Income Levels

Median and per capita income levels are shown in Table 2.3-9. All data is presented as reported, in 2020 dollars, and has not been adjusted for inflation.

Median and per capita incomes for Custer County were higher than the state average, and lower than the state average for Fall River County.

Table 2.3-9: Income Levels

Location	Median Household Income	Median Family Income	Per Capita Income in the Past 12 Months
Custer County	*$64,556*	*$79,409*	*$35,677*
Buffalo Gap	$28,750	$60,694	$24,468
Custer City	$57,300	$70,200	$30,651
Hermosa	$67,545	$69,152	$30,376
Fall River County	*$51,383*	*$67,222*	*$29,139*
Edgemont	$23,750	$42,083	$18,917
Hot Springs	$45,428	$73,650	$28,694
Oelrichs	$55,536	$57,917	$26,146
South Dakota	***$59,896***	***$77,042***	***$31,415***

US Census Bureau American Community Survey 5-Year Estimate, 2020

2.3.3.4 Tax Base

South Dakota does not impose a state income tax on its citizens or businesses, and abolished its estate tax in 2001. The majority of State revenue is generated from the 4 percent State-wide sales and use (services) tax, with other sales and use taxes levied by many municipalities, typically an additional 1–2 percent. The South Dakota Department of Revenue and Registration (SD DRR) is the entity responsible for collection and regulation of various taxes at the State level, including:

- Non-income business taxes – including sales and use, contractor's excise, and municipal (city) and special jurisdiction (tribal) taxes;
- Special taxes – including tobacco excise, bank franchise, ore and energy mineral severance, gaming excise, coin-operated laundromat licensing, and various alcohol taxes; and
- Motor vehicles taxes – including titles, licensing, motor fuel, and dealer licensing.

Towns with a municipal sales and use tax may also impose a gross receipts tax on various sales, including lodging, restaurants, alcoholic beverage sales, and admissions to places of amusement and cultural and sports events. SD DRR is responsible for collection of municipal taxes. Only towns imposing a municipal sales and use tax in the PA are listed in Table 2.3-10 below.

Table 2.3-10: Municipal Tax Rates - 2024

Location	Municipal Sales Tax Rate	Gross Receipts Tax Rate
Custer County		
Custer City	2%	1%
Hermosa	2%	1%
Pringle	2%	none
Fall River County		
Edgemont	2%	1%
Hot Springs	2%	1%
South Dakota Department of Revenue, 2024.		

Local governments are solely responsible for collection of property taxes, which are the primary source of funding for school systems, counties, municipalities, and other local government units.

Property tax categories include agricultural land, owner-occupied property, and other valuations (such as residential property not occupied by the owner, commercial property, and utility property). Each county is responsible for administering and collecting its own property tax system and monies, which are the primary source of funding for school systems and local government entities. In calendar year 2021, South Dakota property owners paid over $1.49 billion in taxes to fund local governments and provide K-12 education for the state's children. Of the $1.49 billion approximately 41 percent came from owner occupied property, approximately 33 percent came from other property, and approximately 25 percent came from agricultural property.

2.3.3.5 Housing

Housing data was obtained from the USCB, which compiles various housing statistics from the most recent census on a state-wide or county-wide basis. Data used for this baseline study included information about the number and type of housing units, homeownership rates, and median home values. USCB also updates certain municipal data on an annual basis via the American Community Survey (ACS), including building permits issued and number of housing units present, so that this data reflects more current trends and can be used in economic forecasting. Housing data for Newcastle and Osage in Weston County, Wyoming are also provided as these locations could also serve as potential host communities for Project employees.

2.3.3.6 Dwelling Types

Census 2020 data was collected for various types of housing units, including single-family detached and attached homes, multi-unit dwellings (apartments), mobile homes, and rooms or groups of rooms designed as separate living quarters with direct occupant access. Census 2020 data is subdivided by single unit (detached and attached), specific housing unit type, the USCB does provide the information on housing units in multi-unit structures as a percentage of total housing units. Table 2.3-11 summarizes the Census 2020 housing data for the PA, including units for rent and seasonal/recreational/occasional use unit vacancy rates. Custer and Fall River counties have high seasonal unit vacancy rates, indicative of their proximity to the many recreational and scenic areas in the Black Hills.

2.3.4 Environmental Justice

PAUS Bureau of Land Management Socioeconomic Profiles were obtained for Custer and Fall River counties. These profiles compare county and state-wide data to determine if there are a disproportionate percentage of minorities or low-income populations that might be affected by the ISL Project relative to the State.

As shown in Table 2.3-12, minorities make up 11.1 and 15.9 percent of the total population for Custer and Fall River Counties, respectively, which is less than the state average of 19.4 percent. No concentration of minorities was identified to reside near the PA, which is located in a rural area, while most of the minority population lives in urban centers such as Custer City (Census Tract 9952) or Hot Springs (Census Tract 9942).

The percent of individuals below the poverty level was 8.3 percent in Custer County and 19.3 percent in Fall River County. Compared to the state-wide average of 12.3 percent, Fall River's poverty rate is only higher, while Custer County is below the state-wide average; therefore, there is not a disproportionate concentration of low-income populations and no concentration of minorities was identified within the study area compared to the State as a whole. The percent of low income individuals was 24.4 percent in Custer County and 35.6 percent in Fall River County. Compared to the state-wide average of 28.4 percent, Fall River's poverty rate is higher, while Custer County is 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.

Table 2.3-11: Housing Unit Statistics - 2020

Housing Unit Type	Custer County, SD		Fall River County, SD		Niobrara County, WY		Weston County, WY	
	Units	% of Total	Units	% of Total	Units	% of Total	Units	% of Total
Total housing units	5294	100%	4227	100%	1306	100%	3571	100%
Owner-occupied	3249	61.4%	2337	55.3%	681	52.1%	2419	67.7%
Renter-occupied	644	12.2%	801	18.9%	219	16.8%	463	13.0%
Single family homes	3956	74.7%	2842	67.2%	1047	80.2%	2496	69.9%
Multi-unit housing	347	6.6%	726	17.1%	67	5.1%	308	8.6%
Mobile homes	968	18.3%	659	15.6%	192	14.7%	759	21.3%
Other (boat, RV, van, etc.)	23	0.4%	0	0%	0	0%	8	0.2%
Vacant units	1401	26.5%	1089	25.8%	406	31.1%	689	19.3%
Units for rent	199	3.8%	87	2.1%	38	2.9%	121	3.4%
Seasonal / recreational / occasional use vacancy	640	12.1%	484	11.5%	49	3.8%	58	1.6%
Units lacking complete plumbing	28	0.7%	35	1.1%	11	1.2%	8	0.3%
Units lacking complete kitchen facilities	46	1.2%	42	1.3%	11	1.2%	32	1.1%
No telephone service	72	1.8%	60	1.9%	13	1.4%	54	1.9%

Data from US Census Bureau, American Community Survey 5-Year Estimate, 2020

Table 2.3-12: Race and Poverty Characteristics for Areas Surrounding the Dewey-Burdock Project

	Custer County	Fall River County	State of South Dakota
White, non-Hispanic Population	90.8	85.3	82.2
Total Racial Minority Population	11.1	15.9	19.4
Hispanic or Latino Population	4.3	4.0	4.4
American Indian Population	2.1	7.9	8.0
Percent of Individuals Below Poverty Level	8.3	19.3	12.3
Percent of Low Income Individuals	24.4	35.6	28.4

BLM Socioeconomic Profile, 2024 (2022 data)

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 project is not expected to generate any adverse environmental impacts to the area's natural resources, there will not be any disproportionate environmental consequences to minority groups or low income populations.

2.3.5 References

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United States Bureau of Labor Statistics, 2024, Current Population Survey, https://www.bls.gov/data/, retrieved February 2024.

2.4 Historic, Scenic and Cultural Resources

As described in SUA-1600 LC 9.8, a Programmatic Agreement was executed on April 7, 2014 (Adams Accession No. ML14066A344) to protect cultural resources within the PA.

2.4.1 Historic Archeological, and Cultural Resources

A Level III Cultural Resources Evaluation was conducted for the PA. 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 (Appendix 2.4-A of the approved license application).

Augustana documented 161 previously unrecorded archaeological sites and revisited 29 previously recorded sites within the PA 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 five percent of total sites recorded, while multi-component sites (pre-historic/historic) comprise the remaining eight 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 PA in relation to the Black Hills proper. The disparity existing between the number of historic and prehistoric sites observed in the PA 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 one 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 permit area is not unique, in regards to the number of documented sites, and is typical of the periphery of the Black Hills.

The high density of sites observed in the PA, specifically those of prehistoric affiliation, is both consistent with previous findings in the immediate vicinity [Winham et al., 2001] and strongly indicative of the intense degree to which this landscape was being exploited during prehistoric times. Data indicate a slight rise in the number of sites observed from earlier periods into the Middle Plains Archaic, and then a major increase into the Late Plains Archaic/Plains Woodland period before an equally significant drop-off into Late Prehistoric times. In general, this trend is largely consistent with the majority of available paleodemographic data from the region [Rom et al., 1996]. Despite the high density of sites within the permit area, there is a lack of evidence indicative of extended or long-term settlement localities in the region. Though the reason behind this phenomenon remains unclear, the bulk of preliminary data from the current investigation appear to mirror this trend.

The landscape comprising the PA is erosional in nature, leading to many sites being heavily deflated. The extent of the erosion processes is evidenced by the large number of sites recommended by Augustana as not eligible for listing on the National Register of Historic Places because of their location on deflated landforms. This equates to approximately half of the total number of identified sites in the PA. Notable exceptions to these deflated localities include the valleys and terraces along Beaver and Pass Creeks, as well as many places within and adjacent to, some of the more heavily wooded areas.

Nearly 200 hearths were identified within 24 separate site areas during Augustana's investigation. These features varied considerably from one another in both size and form (and likely function in many cases) and ranged from fully intact to completely eroded. Previous research in the nearby area has demonstrated a similar pervasiveness of such features in the archaeological record [Buechler, 1999; Lippincott, 1983; Reher, 1981; Sundstrom, 1999; Winham et al., 2001], and specifically in relation to Plains Archaic-period site assemblages [Rom et al., 1996].

Radiocarbon data obtained from a number of these hearths produced dates ranging from approximately 3,150–1,175 before present (B.P.) (UGa-4080 and UGa-4081), with the majority of these samples dating to Middle and Late Plains Archaic times [Reher, 1981].

Protection by way of avoidance of archaeological sites was maintained during the exploration phase of the project, and site avoidance is the continued goal during development and operations. Where required, sites in the area of production activity will be flagged and/or fenced and personnel will be made aware of their presence. In the event that a new site is discovered, the site will be protected and the state archaeologist will be notified. Powertech (USA) has been working closely with the state of South Dakota's Archaeological Research Center, and will continue to do so throughout the life of this project. A Memorandum of Agreement has been executed between Powertech (USA) and the State Archaeologist (Appendix 2.4-B of the approved license application).

2.4.2 Visual and Scenic Resources

Visual and scenic resources consist of the visible natural (e.g., landforms and vegetation) and cultural components (e.g., roads and buildings) of the environment. Important visual resources can be landscapes that have unusual or intrinsic value, or areas with human or cultural influences that are valued for their visual or scenic setting. The BLM's Visual Resource Management (VRM) is an attempt to assess and classify landscapes in order to properly manage their visual and scenic resources (BLM, 1984).

2.4.2.1 Visual Resource Management Classes

In order to determine the VRM class of the landscape within the PA and the surrounding 2 km area were rated in accordance with the U.S. BLM Manual 8400 – Visual Resource Management. The visual resource inventory classes are used to develop visual resource management classes. The following VRM classes are objectives that quantify the acceptable levels of disturbance for each class.

- Class I Objectives – To preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
- Class II Objectives – To retain the existing character of the landscape. This level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract attention of the casual observer. Any changes must repeat

the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

- Class III Objectives – To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.com.

- Class IV Objectives – To provide management activities which require major modifications of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer's attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

According to the scenic quality inventory conducted in June 2008, which rated scenic quality, sensitivity level, and distance zones, the area was classified a VRM Class IV. The objective of this class is to provide management for activities that might require major modifications of the existing character of the landscape. The level of change permitted for this class can be high. Table 2.4-1, provided by the BLM, was used to determine the visual resource inventory class.

Table 2.4-1: BLM Visual Resource Inventory Classes

		Visual Sensitivity Levels						
		High			**Medium**			**Low**
Special Area		I	I	I	I	I	I	I
Scenic Quality	A	II	II	II	II	II	II	II
	B	II	III	III* IV*	III	IV	IV	IV
	C		IV	IV	IV	IV	IV	IV
		f/m	b	s/s	f/m	b	s/s	s/s
		Distance Zones						

* If adjacent area is Class III or lower, assign Class III, if higher assign Class IV
f/m = foreground –middleground,
b = background,
ss – seldom seen

2.4.2.2 Visual Resource Management Rating

In order to determine the scenic quality rating of the PA and the surrounding 2 km area, a visual resource inventory was conducted in accordance with the BLM Handbook H-8410-1, Visual Resource Inventory (BLM, 1986). A visual resource inventory was conducted for each Scenic

Quality Rating Units (SQRU) – areas that demonstrated similar physiographic characteristics – in the area.

Scenic Quality – Scenic quality is a measure of the visual appeal of a tract of land. In the visual resource inventory process, public lands are given an A, B, or C rating based on the apparent scenic quality, which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. These key factors are rated according to form, line, color, texture, scale and space on a comparative scale from zero to five taking into consideration similar features within the same physiographic province. The results of the inventory and the associated rating for each key factor are summarized in Table 2.4-2 and Table 2.4-3.

Table 2.4-2: Scenic Quality Inventory and Evaluation of the SQRU 001

Key Factor	Rating Criteria	Score
Landform	Flat to rolling plains with weathered plateaus in the background	3
Vegetation	Vegetation is dominated by several variety of grasses and shrubs with some wildflowers and cottonwood trees	3
Water	Water is present but not visible from the road and view points	0
Color	Soil is light brown to brown and vegetation is tan to light green and dark green	3
Adjacent Scenery	The area borders the forested Black Hills uplift	1
Scarcity	Landscape is common for the region	1
Cultural modifications	Existing modifications consist of a dirt road and railway and grazing activities	0
	Total Score	11

Table 2.4-3: Scenic Quality Inventory and Evaluation of the SQRU 002

Key Factor	Rating Criteria	Score
Landform	Flat to rolling plains with hills covered by evergreen forests	3
Vegetation	Vegetation is dominated by several variety of grasses and shrubs with some wildflowers and cottonwood trees and evergreen forest	3
Water	Water is present but not visible from the road and view points	0
Color	Soil is light brown to brown and vegetation is tan to light green and dark green	3
Adjacent Scenery	The area borders the forested Black Hills uplift	1
Scarcity	Landscape of the Black Hills Uplift is uncommon with the physiographic province of the Great Plains	3
Cultural modifications	Existing modifications consist of a dirt road and railway and grazing activities	0
	Total Score	13

Sensitivity Level – Sensitivity levels are a measure of the public's concern for scenic quality. Public lands are assigned high, medium, or low sensitivity levels by considering the following factors: type of users, amount of use, public interest, adjacent land use, and special areas.

Distance Zones – Distance zones categorize areas according to their visibility from travel routes or observation points. The three categories are foreground-middleground, background and seldom seen.

- Foreground-Middleground Zone – The area that can be seen from each travel route from a distance of 3 to 5 miles where management activities might be viewed in detail. The outer boundary of this distance zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape.
- Background – The area that can be seen from each travel route up to a distance of 15 miles and that extend beyond the foreground-middleground zone.
- Seldom Seen – The areas that are not visible within the foreground-middleground and background zones or areas beyond the background zones.

According to NUREG-1569, if the visual resource evaluation rating is 19 or less, no special management is required (NRC, 2003). Based on the visual resource inventory conducted in June 2008, the total score of the two Scenic Quality Rating Units within the PA 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 project will be required.

2.4.3 References

United States Department of Interior (USDOI), Bureau of Land Management (BLM), "*Manual 8400 – Visual Resource Management 1984*", [Web Page] <http://www.blm.gov/nstc/VRM/8400.html> Accessed June 9, 2008.

United States Department of Interior (USDOI), Bureau of Land Management (BLM), "*Manual H-8410-1 - Visual Resource Inventory 1986*", [Web Page] <http://www.blm.gov/nstc/VRM/8410.html> Accessed June 9, 2008.

U.S. Nuclear Regulatory Commission, NUREG-1569, "*Standard Review Plan for In-Situ Leach Uranium Extraction License Application*", 2003.

2.5 Meteorology

2.5.1 Introduction

The project is located in an area in southwestern South Dakota that can be characterized as a semiarid or steppe climate. It lies adjacent to the southwestern extension of the Black Hills. The area experiences abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. There are also large diurnal and annual variations in temperature.

Precipitation in the PA is generally light or mild. Migratory storm systems that originate in the Pacific Ocean release a majority of their moisture over the Rocky or Cascade Mountains. Major precipitation events can occur when these systems regain moisture already present in the area or moisture adverted from the Gulf of Mexico. Localized summer convective storms, caused by the Black Hills, can produce heavy precipitation events.

To complete the site-specific analysis, a weather station was installed in coordination with the South Dakota State Climatology office at approximately the center of the PA, in accordance with NUREG-1569, in July 2007. This site collects temperature, humidity, solar radiation, wind speed/direction, barometric pressure, and precipitation at 1-minute, 5-minute, and hourly time steps. The site-specific analysis presented herein was conducted over one year from July 18, 2007 to July 17, 2008.

Along with the site weather station, data compiled from several sites surrounding the project area (listed in Table 2.5-1 and shown in Figure 2.5-12) were obtained from the High Plains Regional Climate Center (HPRCC), South Dakota State University (SDSU), and the Wyoming Refining Company (WRC) compliance site at Newcastle, Wyoming. These data were used to represent the long-term meteorological conditions of the project region. These sites were used to characterize regional trends of temperature, snowfall and precipitation along with growing, heating, and cooling degree days. The site that best represents the long-term precipitation and temperature of the project area is the Edgemont site, which is the closest in proximity and elevation to the project area. The Newcastle WRC site was the only site with adequate representative data to characterize wind speed/direction.

Data were analyzed at each site by time of day, month, and season of the year. The seasons for this analysis are defined as: winter (December, January, February), spring (March, April, May), summer (June, July, August), and fall (September, October, November).

Table 2.5-1: Meteorological Stations Included in Climatology Analysis

Name	Data Source	X (°W)	Y (°N)	Z (ft)	Years of Operation
Redbird	NCDC[(a)]	104.17	43.15	3,890	1948–2006
Oral	SDSU[(b)]	103.16	43.24	2,960	1971–2007
Oelrichs	NCDC	103.14	43.11	3,340	1948–2007
Newcastle	NCDC	104.14	43.51	4,380	1918–2006
Edgemont	NCDC	103.49	43.18	3,440	1948–2007
Custer	NCDC	103.36	43.46	5,330	1926–2007
Ardmore	NCDC	103.39	43.04	3,550	1948–2007
Angostura	NCDC	103.26	43.22	3,140	1948–2007
Jewel Cave	SDSU	103.49	43.43	5,298	2004–2008
Newcastle WRC	IML[(c)]	104.21	43.85	4,333	2002-2011

Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008; IML, 2011

(a) National Climatic Data Center.

(b) South Dakota State University Climate Web site.

(c) IML, compliance monitoring results.

2.5.2 Regional Overview

To determine whether the period of data collection (July 18, 2007 to July 17, 2008) was representative of long-term meteorological conditions, weather data from the Newcastle WRC meteorological station for the same period was compared to data collected at the Newcastle WRC site over the long term (2002 through 2010).

IML Air Science (IML) in Sheridan, Wyoming, operates a meteorological station in Newcastle, Wyoming, which generated more than nine years (2002 through May 2011 at the time of this writing) of hourly meteorological data. The Newcastle WRC site is approximately 30 miles north-northwest of the Dewey-Burdock project area and provides a better comparison to the project area than the Chadron NWS site, which is the nearest NWS station to the project area, in terms of elevation, surrounding topography and proximity to the southwestern flank of the Black Hills.

The Newcastle WRC site is used to supplement the ambient air quality compliance demonstration. The station meets the requirements of Ambient Air Monitoring Guidelines for the Prevention of

Significant Deterioration (EPA, 1987). Table 2.5-1a identifies the instruments and associated specifications at this station.

The specifications in Table 2.5-1a meet or exceed the requirements set forth in Regulatory Guide 3.63, Section C3. All instruments are audited for accuracy on a semiannual basis. Representative audit reports, spanning the baseline monitoring period for the Dewey-Burdock Project, are attached as Appendix 2.5-A of the approved license application. Data recovery for all parameters at the Newcastle WRC site exceeded 96% for both long-term (2002 through 2010) and concurrent-year (7/18/2007 to 7/17/2008) periods. The parameters analyzed were temperature, wind speed, wind direction (sigma theta), and relative humidity.

Table 2.5-1b summarizes the one-year and nine-year averages for the Newcastle WRC site alongside the one-year average at the Dewey-Burdock project area. This table shows that average wind speeds and fluctuations in wind direction (sigma theta) at the Newcastle WRC site were comparable for the two periods of record. Wind speeds averaged slightly higher at the Dewey-Burdock project area, with temperatures slightly lower and relative humidity slightly higher (a consequence of the lower temperatures). The similarities drawn between the two sites are not intended to imply equivalence. Rather, they are meant to suggest that the prominent meteorological forces affecting regional weather patterns exert themselves at both sites. If this case can be made, then year-to-year variations at one site may imply parallel, temporal variations at the other site. A comprehensive discussion of wind patterns at the Newcastle WRC site is presented in Section 2.5.2.4 and Appendix 2.5-A of the approved license application.

Table 2.5-1a: Newcastle WRC MET Station Equipment List

Parameter	Instrument	Range	Accuracy	Threshold	Instrument Height
Wind Speed	RM Young 05305 Wind Monitor AQ	0 to 112 mph	±0.4 mph or 1% of reading	0.9 mph	10 meters
Wind Direction	RM Young 05305 Wind Monitor AQ	0 to 360°	±3°	1.0 mph	10 meters
Temperature	Fenwal Electronics 107 Temperature Probe	-25° to 50° C	±0.2° C @ 0 - 60° C, ±0.4° C @ -35° C	--	2 meters
Precipitation	Met One Tipping Bucket	0 to 12 inches	±0.5% @ 0.5 in/hr rate	0.01 inch	1 meter
Barometric Pressure	Campbell Scientific - 105	600 – 1060 millibar	±0.5 mb @ 20° C	--	2 meters
Relative Humidity	CS 500-L Temp/RH probe	0 – 100% -40° to 60°C	±3% RH 10% to 90%	--	2 meters
Data Logger	CS CR510	--	--	--	--

Source: IML, 2011

Table 2.5-1b: Regional (Newcastle WRC) vs. On-Site Meteorology

Parameter	Newcastle WRC 9-Year Average	Newcastle WRC 1-Year Average	Dewey-Burdock 1-Year Average
Wind Speed (mph)	6.8	7.0	8.7
Sigma Theta (°)	19.3	19.6	18.7
Temperature (°F)	47.0	51.9	45.5
Relative Humidity (%)	58.1	55.3	60.9

The average daily temperature over the baseline monitoring year at the Newcastle WRC site was 51.9°F, which is slightly warmer than the 9-year average (historical) daily temperature of 47.2°F. Figure 2.5-1 compares monthly temperature statistics for the two periods. It can be seen that both the average and extreme monthly temperatures for the baseline year are within a few degrees of the longer-term averages. The 9-year graph also includes 30-year average temperatures for Newcastle, obtained from the Western Regional Climate Center, demonstrating the 9-year average temperatures at the Newcastle WRC site to be nearly identical to the 30-year average temperatures at the NWS Coop Site #486660 in Newcastle.

The average daily wind speed at Newcastle WRC site over the baseline monitoring year was 7.0 miles per hour (mph), very close to the 9-year historical average of 6.8 mph. Figure 2.5-2 compares the monthly average and maximum wind speeds for the short and long-term periods.

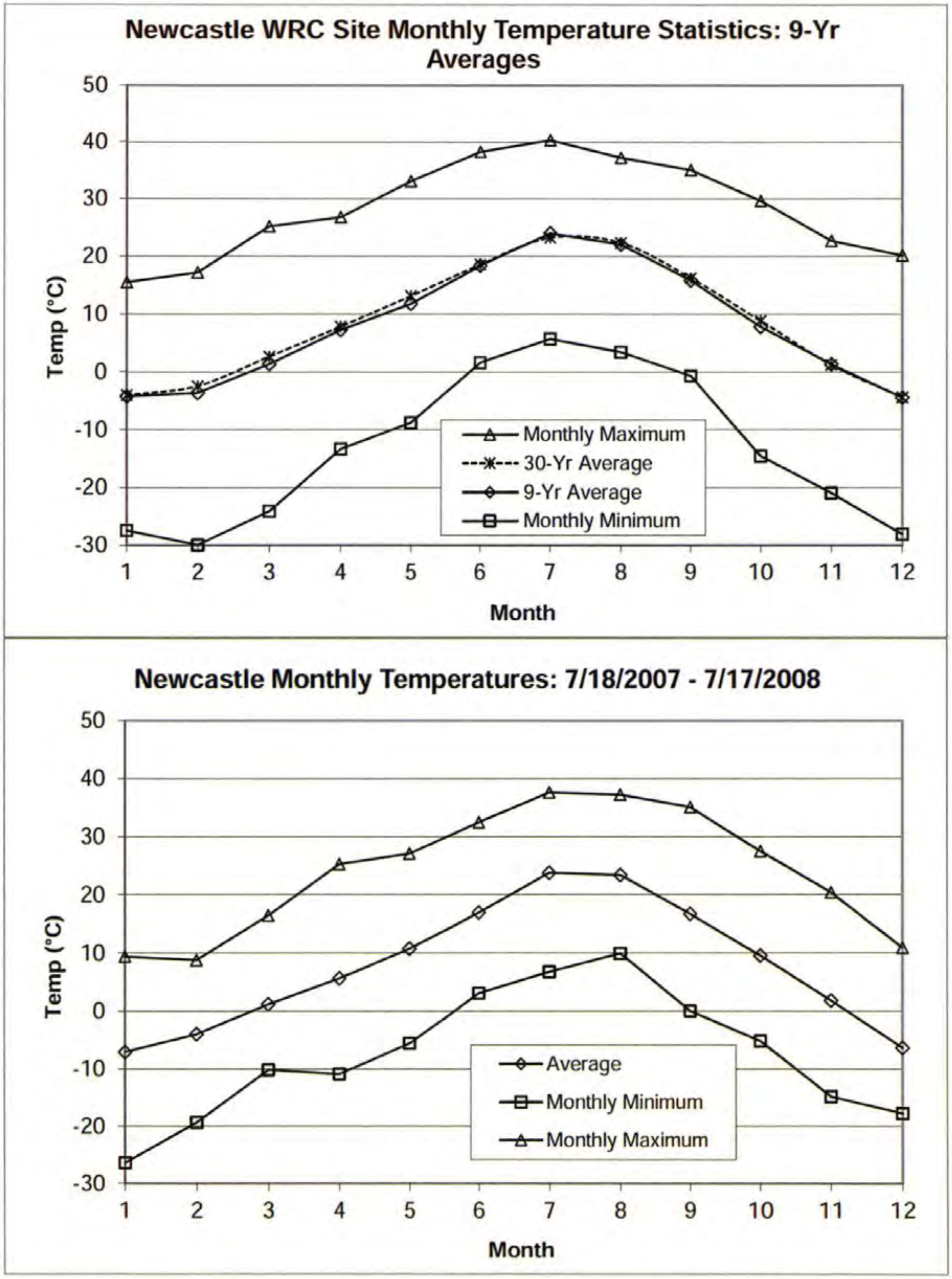
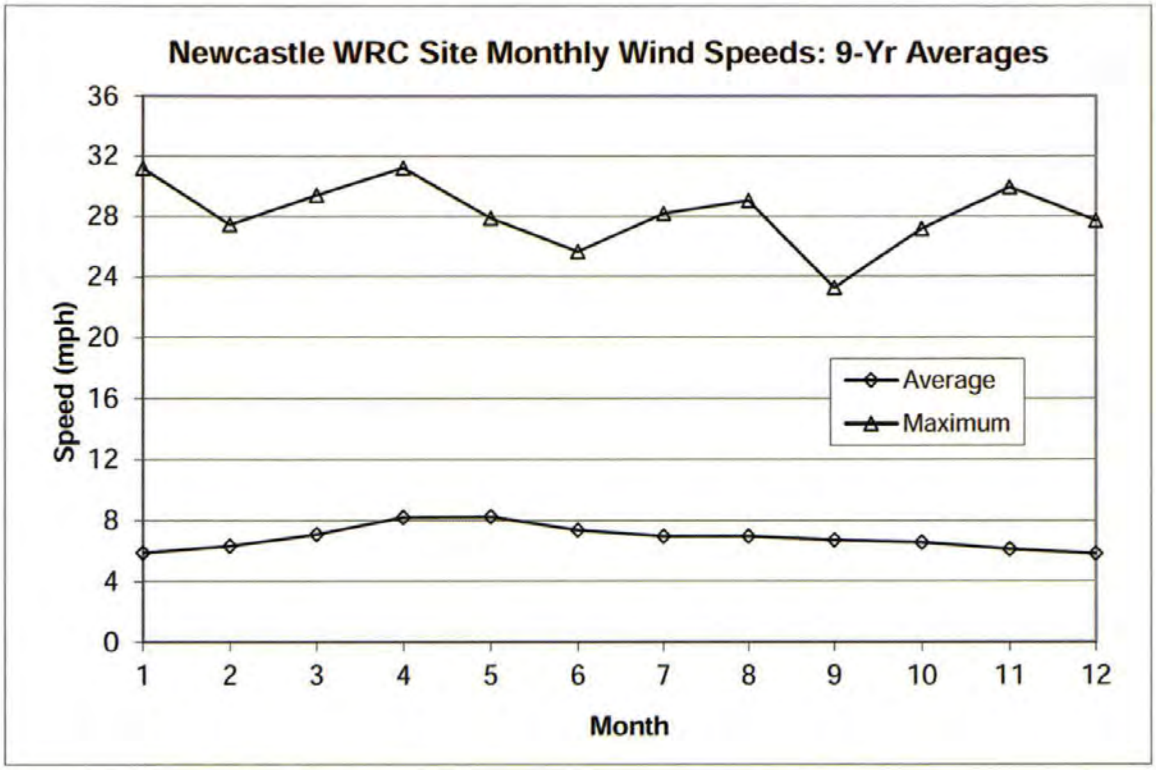


Figure 2.5-1: 1-yr and 9-yr Temperatures at the Newcastle WRC Site



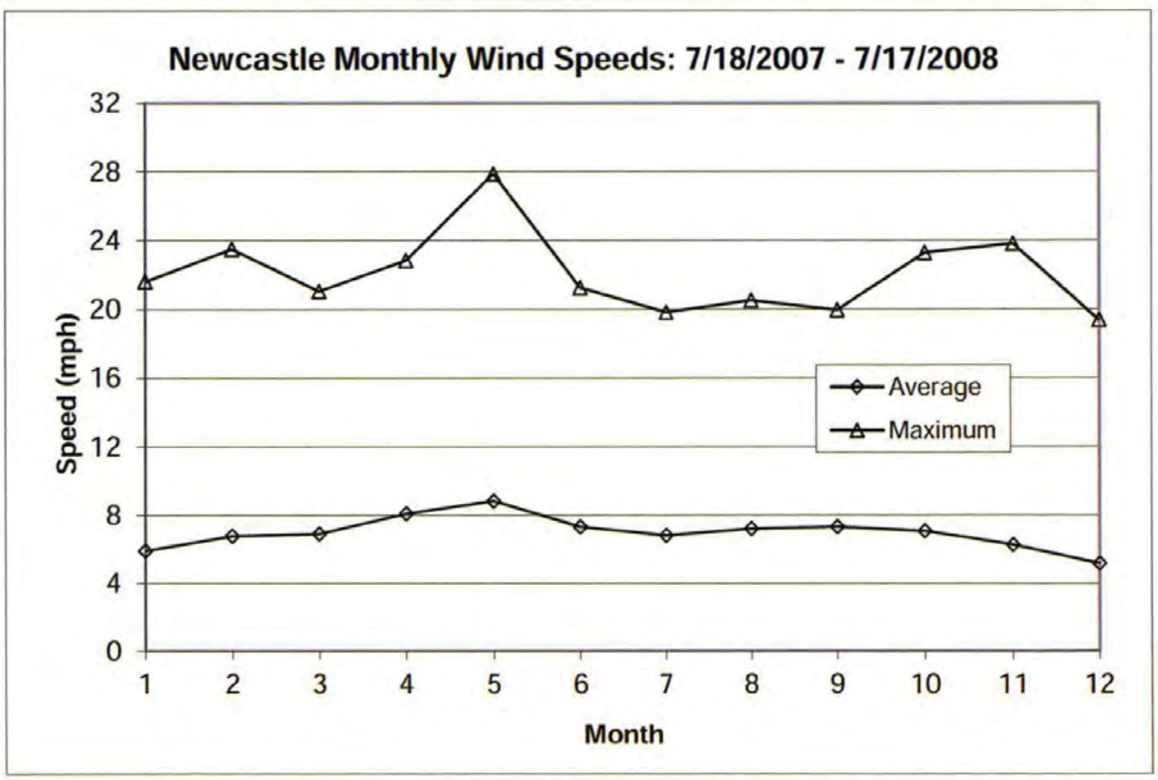
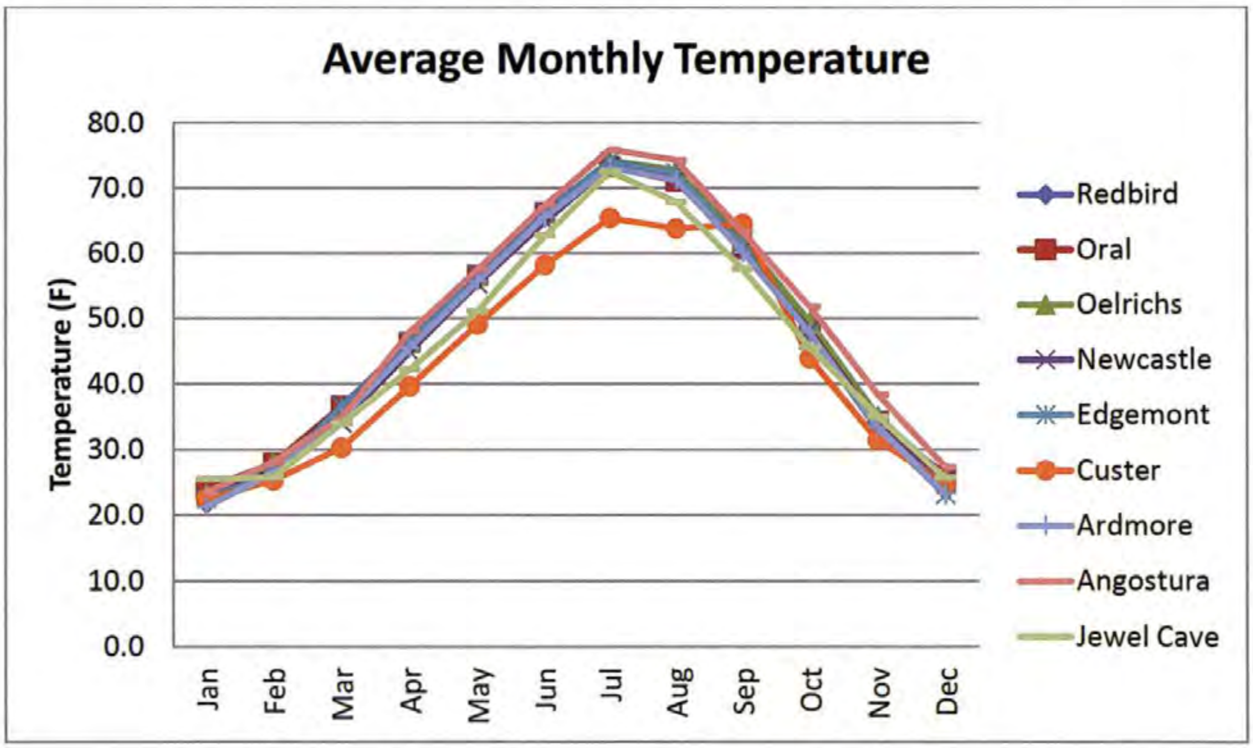


Figure 2.5-2: **1-yr and 9-yr Wind Speeds at the Newcastle WRC Site**

During the baseline monitoring year, Newcastle received 17.3 inches of precipitation, about 15% above the 100-year average annual precipitation of 15.1 inches (Western Regional Climate Center, Coop Site #486660).

2.5.2.1 Temperature

Long-term temperature statistics were also obtained from regional NWS sites. The annual average temperature in this region is 46.7°F. Figure 2.5-3 and Table 2.5-2 display the monthly, annual, and seasonal average temperatures. This region has some of its warmest days in the summer months with the hottest month being July (average temperature of 72.8°F). The coldest month of the year is January, with an average temperature of 23.0°F. The differences seen between sites can be attributed to elevation. Custer and Jewel Cave have the lowest average temperature primarily because these sites are nearly 1,000 feet higher in elevation than all other sites.



Source: High Plains Regional Climate Center, 2008, South Dakota State University, 2008

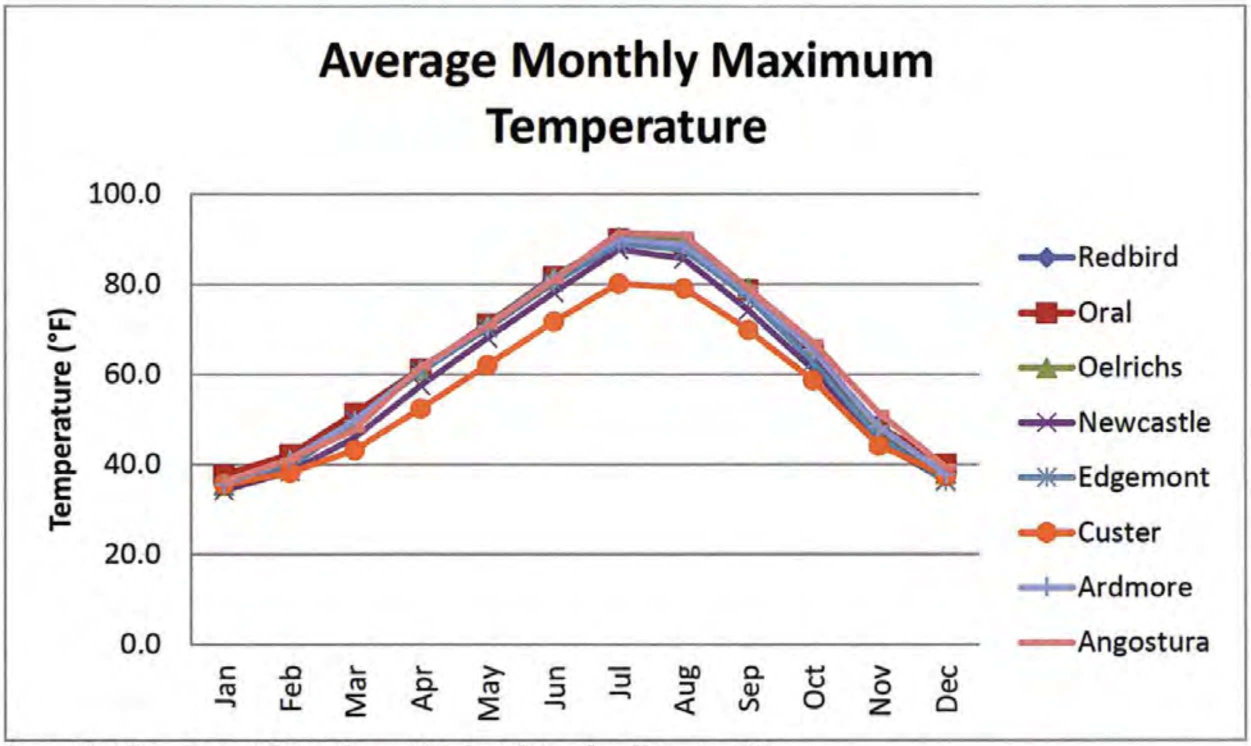
Figure 2.5-3: Average Monthly Temperatures for Regional Sites

Table 2.5-2: Average Monthly, Annual, and Seasonal Temperatures for Regional Sites

Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Winter	Spring	Summer	Fall
Redbird	21.8	27.3	35.1	45.8	55.8	65.5	73.3	71.4	60.4	47.9	33.1	23.8	46.8	24.3	45.6	70.1	47.2
Oral	24.1	27.9	36.6	46.3	56.6	66.2	73.2	71.1	60.7	48.3	34.3	26.1	47.6	26.1	46.5	70.2	47.8
Oelrichs	23.2	28.0	35.4	46.3	56.5	66.3	74.2	72.8	62.1	49.5	35.0	25.7	47.9	25.7	46.1	71.1	48.9
Newcastle	22.8	26.7	34.1	44.9	55.3	64.9	73.3	71.3	60.5	48.2	33.9	25.4	46.8	25.0	44.7	69.8	47.5
Edgemont	22.5	26.3	36.6	46.5	56.8	66.4	74.1	72.3	61.4	47.7	32.9	23.1	47.2	24.0	46.6	70.9	47.3
Custer	22.5	25.3	30.3	39.6	49.1	58.2	65.4	63.8	64.5	43.9	31.4	24.8	42.4	24.2	39.7	62.5	43.3
Ardmore	21.3	26.5	34.8	45.5	55.7	65.6	73.1	71.2	60.2	47.8	33.4	23.3	46.5	23.7	45.3	70.0	47.1
Angostura	23.5	28.1	34.9	47.9	57.5	67.4	75.9	74.3	63.3	51.8	38.4	27.3	49.2	26.3	46.8	72.5	51.2
Jewel Cave	25.5	25.8	34.0	42.2	51.1	62.7	72.5	67.9	57.6	45.6	35.0	25.7	45.5	25.7	42.4	67.7	46.1
Regional Average	23.0	26.9	34.6	45.0	54.9	64.8	72.8	70.7	61.2	47.9	34.2	25.0	46.7	25.0	44.9	69.4	47.4

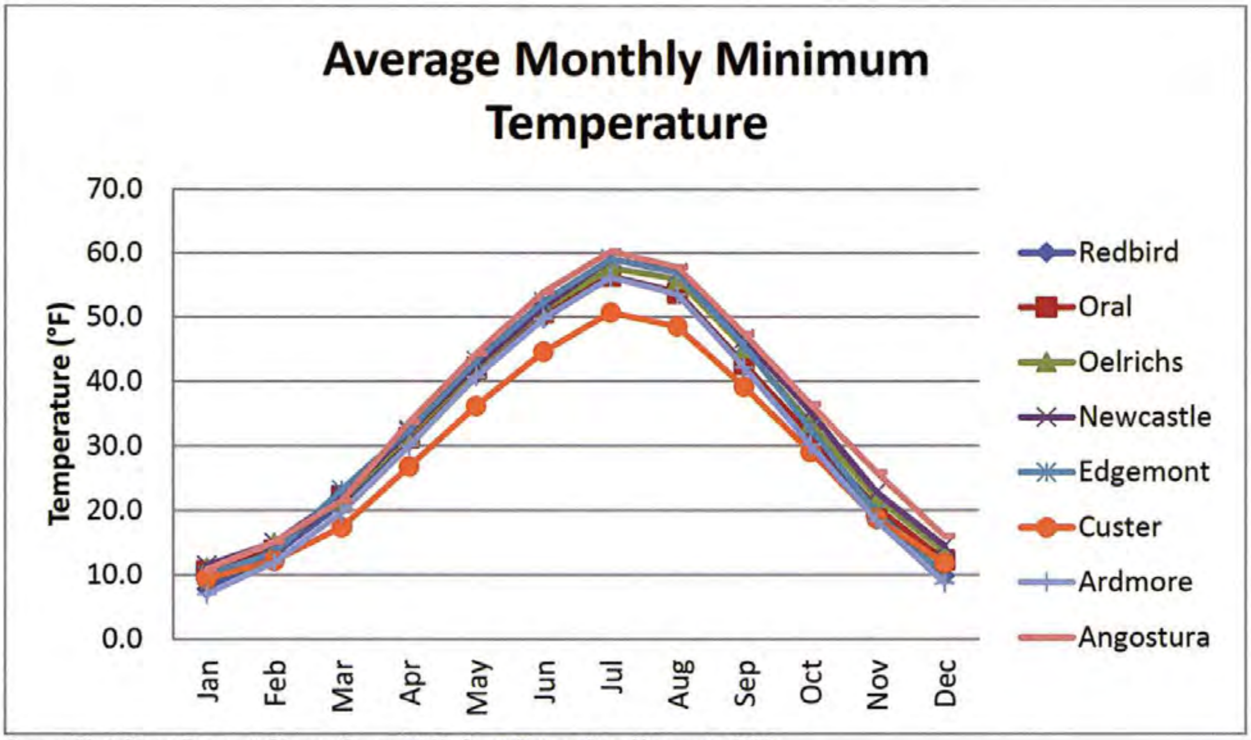
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figures 2.5-4 and 2.5-5 show the average maximum and minimum temperatures in the region. The average monthly maximum temperature is 60.7°F, while the average monthly minimum temperature is 32.7°F, as shown in Tables 2.5-3 and 2.5-4. The highest average monthly maximum temperatures in the region usually fall during the month of July (88.3°F). The lowest average monthly minimum temperatures can be found in January with a regional average of 10.4°F.



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-4: Average Monthly Maximum Temperatures for Regional Sites



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-5: Average Monthly Minimum Temperatures for Regional Sites

Table 2.5-3: Average Monthly, Annual, and Seasonal Maximum Temperatures for Regional Sites

Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Winter	Spring	Summer	Fall
Redbird	35.8	41.3	49.3	60.7	70.6	81.1	90.2	88.9	78.2	65.0	47.4	37.9	62.2	38.3	60.2	86.7	63.5
Oral	37.7	42.2	51.4	61.2	71.2	81.8	90.1	88.5	78.8	65.0	48.3	40.1	63.0	40.0	61.3	86.8	64.0
Oelrichs	35.3	40.8	49.0	60.9	71.0	81.5	90.6	89.7	79.3	65.5	48.0	37.8	62.5	38.0	60.3	87.3	64.2
Newcastle	34.2	38.4	46.0	57.5	68.1	78.2	87.7	85.7	74.3	61.1	45.0	36.3	59.4	36.3	57.2	83.9	60.1
Edgemont	35.2	39.3	49.9	60.6	70.3	80.4	89.0	87.7	77.1	62.8	45.9	36.2	61.2	36.9	60.3	85.7	61.9
Custer	35.5	38.2	43.2	52.4	62.1	71.8	80.2	79.1	69.9	58.7	44.2	37.5	56.1	37.1	52.5	77.0	57.6
Ardmore	35.6	41.2	49.7	61.2	70.8	81.4	90.1	88.9	78.2	65.4	48.4	37.8	62.4	38.2	60.5	86.8	64.0
Angostura	36.2	41.2	47.7	61.6	70.8	80.9	91.4	91.0	79.1	67.2	51.4	39.4	63.2	38.9	60.0	87.8	65.9
Jewel Cave	35.4	36.2	44.3	53.3	62.4	74.6	85.1	80.0	69.2	56.8	45.9	35.4	56.5	35.6	53.3	79.9	57.3
Regional Average	35.7	39.9	47.8	58.8	68.6	79.1	88.3	86.6	76.0	63.1	47.2	37.6	60.7	37.7	58.4	84.7	62.1

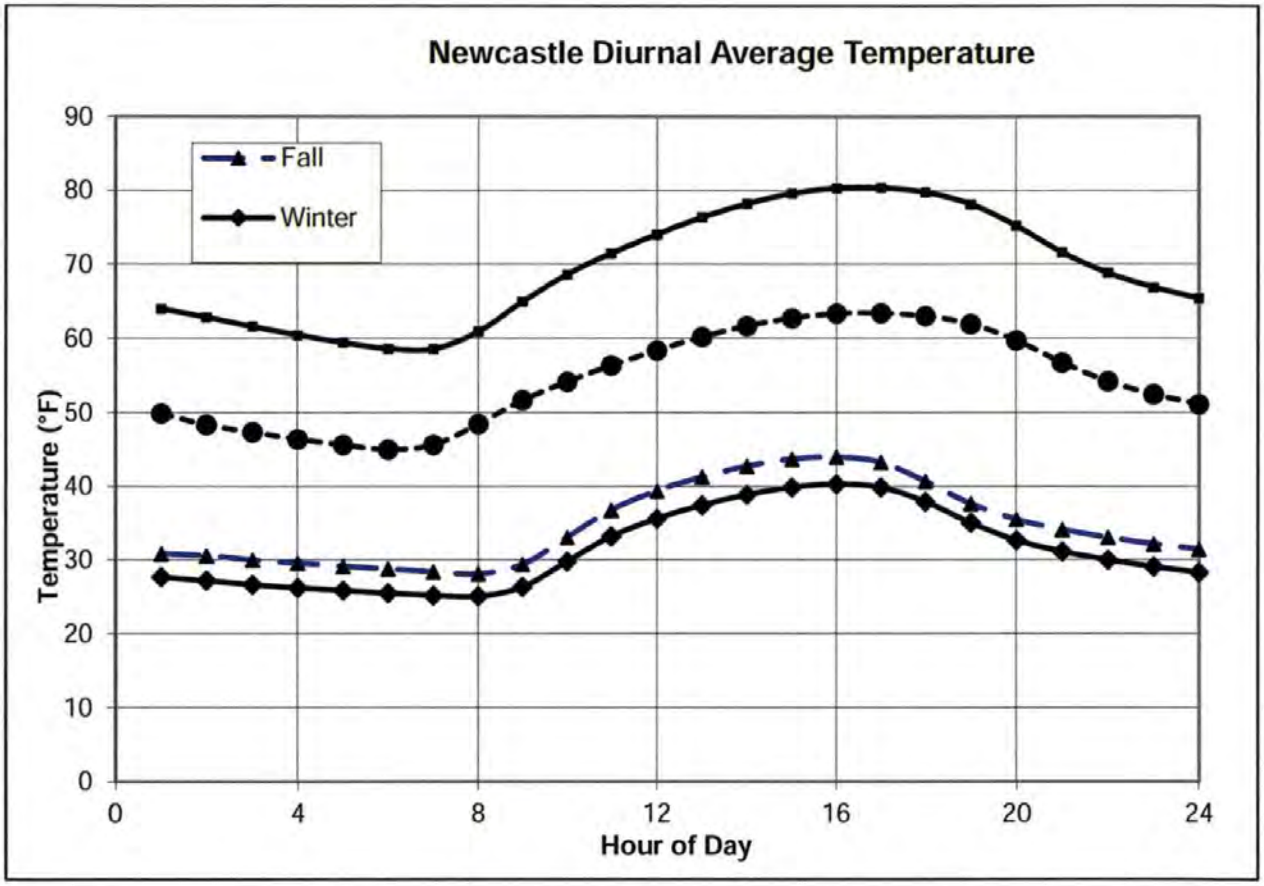
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Table 2.5-4: Average Monthly, Annual, and Seasonal Minimum Temperatures for Regional Sites

Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Winter	Spring	Summer	Fall
Redbird	7.8	13.2	21.0	30.8	41.1	49.9	56.3	53.9	42.6	30.9	18.8	9.8	31.4	10.3	31.0	53.4	30.8
Oral	10.6	13.8	22.2	31.3	41.9	50.7	56.4	53.7	42.7	31.6	20.4	12.3	32.3	12.2	31.8	53.6	31.6
Oelrichs	11.1	15.0	21.7	31.7	42.0	51.2	57.7	55.9	45.2	33.6	21.9	13.6	33.4	13.3	31.8	54.9	33.6
Newcastle	11.5	15.0	22.2	32.2	42.4	51.5	59.1	57.0	46.6	35.3	22.8	14.5	34.2	13.6	32.3	55.9	34.9
Edgemont	10.0	13.4	23.2	32.5	43.2	52.4	59.1	56.9	45.6	32.7	19.7	9.9	33.2	11.1	33.0	56.1	32.7
Custer	9.4	12.2	17.4	26.8	36.2	44.6	50.7	48.5	39.2	29.1	18.7	11.8	28.7	11.1	26.8	47.9	29.0
Ardmore	7.0	11.9	19.7	30.0	40.7	49.7	56.2	53.5	42.2	30.2	18.4	8.7	30.7	9.2	30.2	53.1	30.2
Angostura	10.8	15.1	21.5	33.7	44.3	53.9	60.3	57.8	47.4	36.5	25.9	16.0	35.3	14.0	33.2	57.3	36.6
Jewel Cave	15.4	15.7	24.5	31.1	40.0	51.0	59.7	56.3	45.9	35.1	24.8	16.6	34.7	15.9	31.9	55.7	35.3
Regional Average	10.4	13.9	21.5	31.1	41.3	50.5	57.3	54.8	44.2	32.8	21.3	12.6	32.7	12.3	31.3	54.2	32.7

Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-6 displays diurnal temperature variations by season for the Newcastle WRC site from 2002 through 2010. The figure shows large variations in average diurnal temperatures, especially during the summer months.

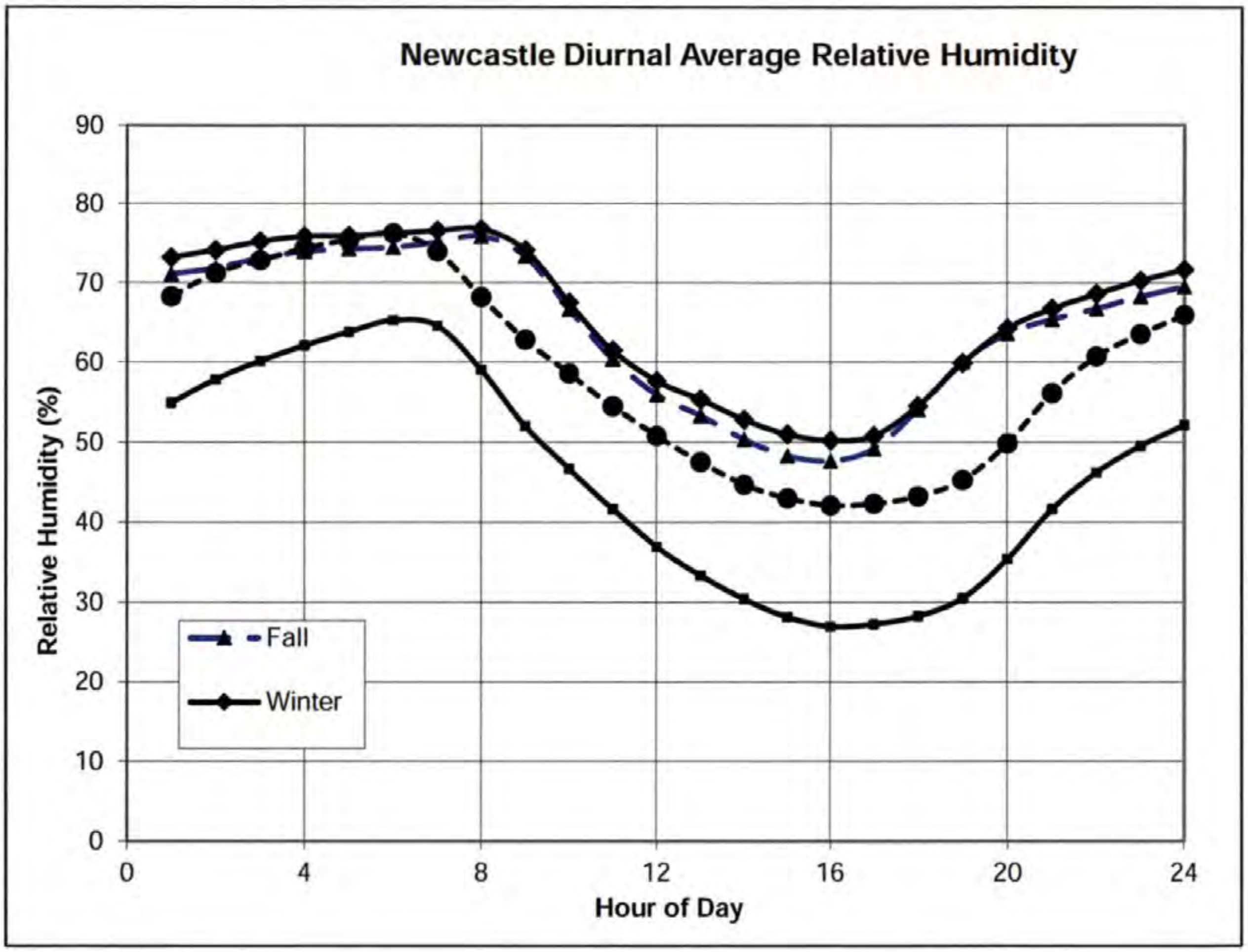


Source: IML, 2011

Figure 2.5-6: Newcastle WRC Site Seasonal Diurnal Temperature Variations

2.5.2.2 Relative Humidity

Relative humidity measures the ratio of moisture in the air to saturated moisture content at a certain temperature. This parameter was recorded for the Newcastle WRC site. Figure 2.5-7 displays the relationship of relative humidity to the season and time of day for this site. The figure shows that the summer has the lowest relative humidity, averaging 45.5 percent, while winter has the highest relative humidity, averaging 67.7 percent. Both seasonal and diurnal variations in relative humidity are largely attributed to air temperature. Since cooler air will hold less moisture, relative humidity tends to be higher during the winter and at night.



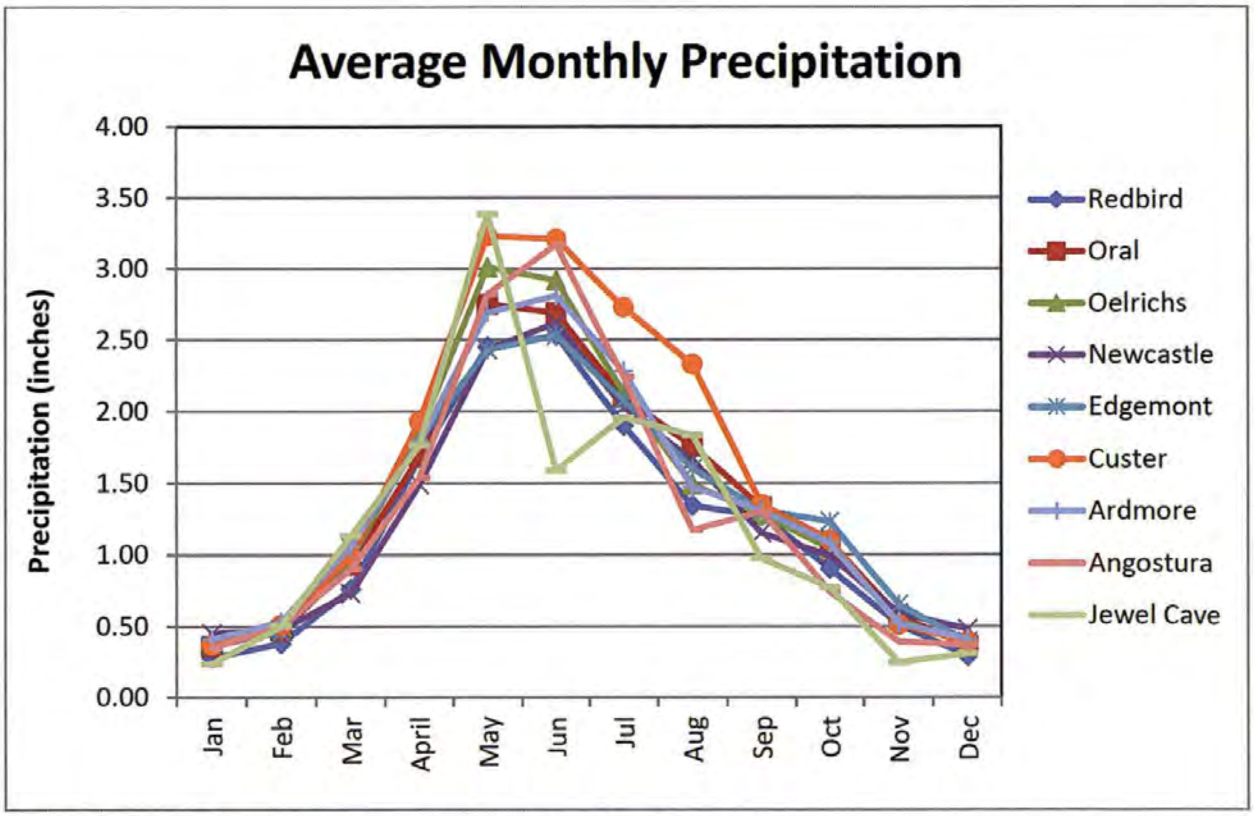
Source: IML, 2011

Figure 2.5-7: Newcastle WRC Site Seasonal Diurnal Relative Humidity Variations

2.5.2.3 Precipitation

Figure 2.5-10 and Table 2.5-5 show average monthly and seasonal precipitation amounts for all of the regional NWS sites. This area can be very dry at times with a regional annual average precipitation of 16.5 inches. Most of the precipitation accumulates during May, June, and July (48 percent of the annual). Typically, May is the wettest month of the year for this region with an average total of 2.8 inches. Winter receives roughly 8 percent of the total annual precipitation. January is the driest month of the year with an average accumulation of 0.36 inch of precipitation.

Figure 2.5-10a shows average monthly precipitation at the Newcastle NWS Coop site for the past 30 years. For comparison, Figure 2.5-10b shows monthly precipitation totals for the baseline monitoring year. It can be seen that unusually high precipitation was measured in the months of May and July of 2008.



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

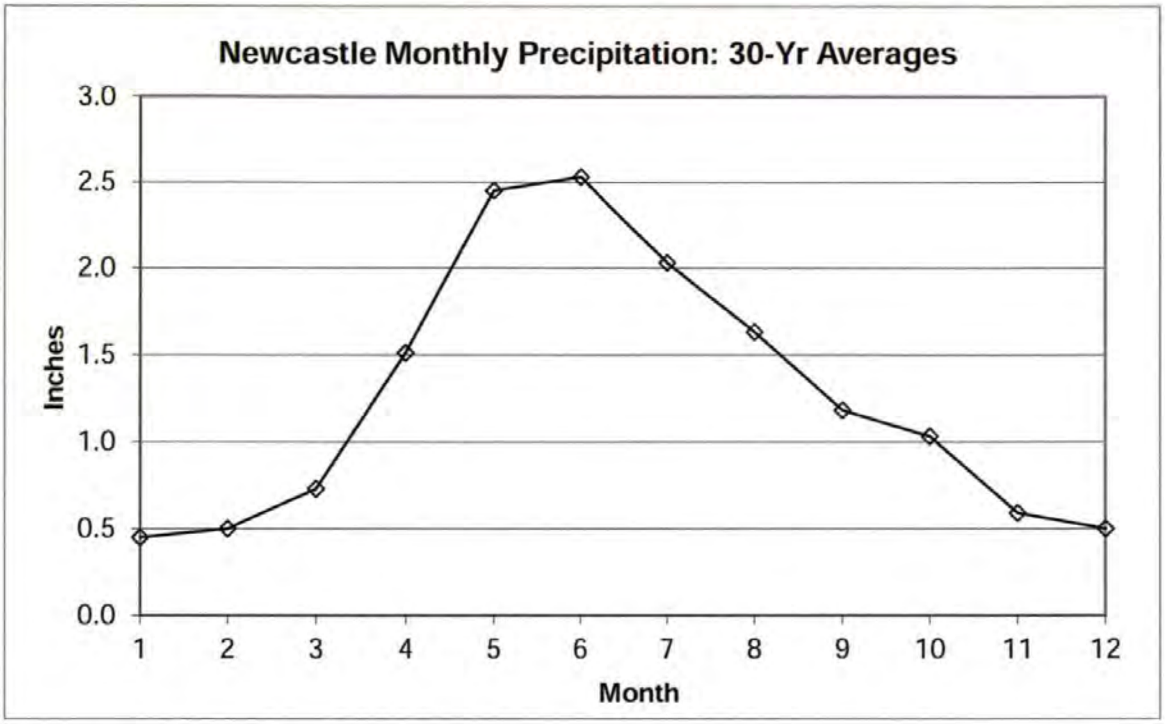
Figure 2.5-10: Average Monthly Precipitation for Regional Sites

Table 2.5-5: Average Seasonal and Annual Precipitation for Regional Sites

Name	Annual	Winter	Spring	Summer	Fall
Redbird	14.29	0.95	4.89	5.77	2.68
Oral	16.10	1.19	5.37	6.54	3.00
Oelrichs	16.50	1.28	5.83	6.54	2.85
Newcastle	15.11	1.41	4.65	6.32	2.73
Edgemont	15.87	1.22	5.26	6.20	3.19
Custer	18.66	1.27	6.15	8.28	2.96
Ardmore	16.35	1.34	5.54	6.56	2.91
Angostura	15.51	1.22	5.26	6.59	2.44
Jewel Cave	20.00	6.30	6.30	5.40	2.00
Region Average	16.49	1.80	5.47	6.47	2.75

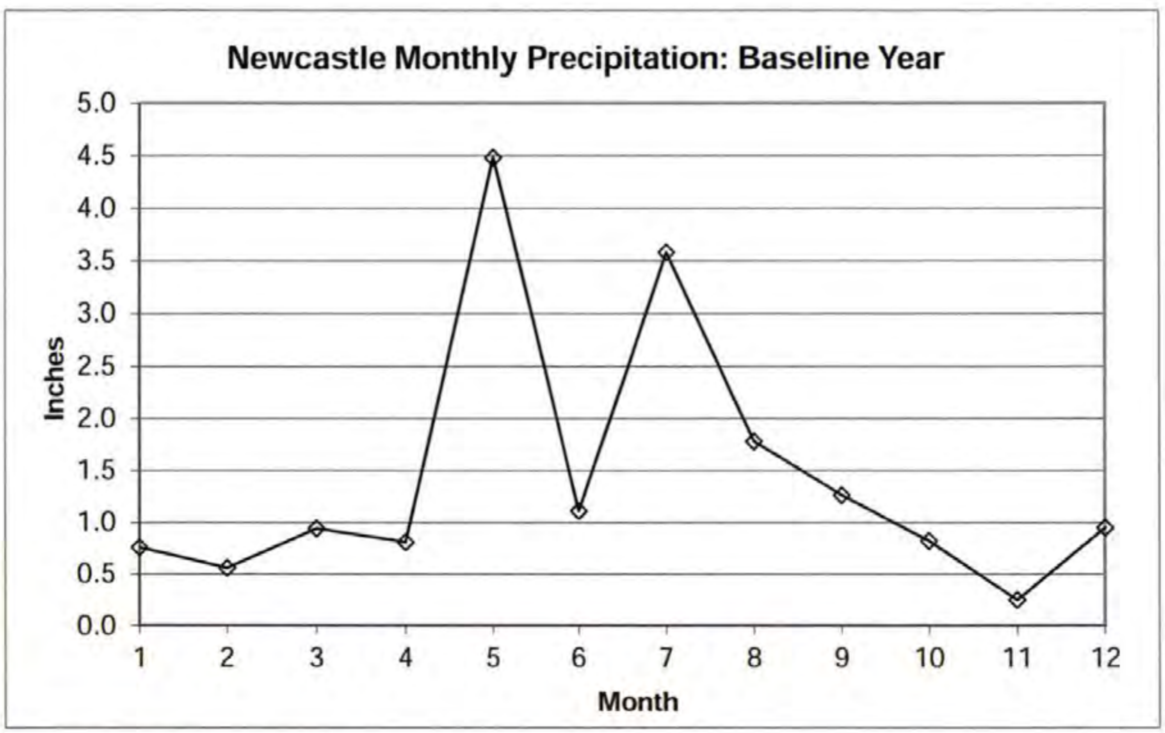
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

This region receives an average of 38 inches of snowfall each year. As shown in Figure 2.5-11, most snowfall accumulates during the month of March with a regional average of 8.5 inches. Custer receives the most annual snowfall (48 inches). This can be attributed to the higher elevation and the influence of the surrounding Black Hills (Figure 2.5-12).



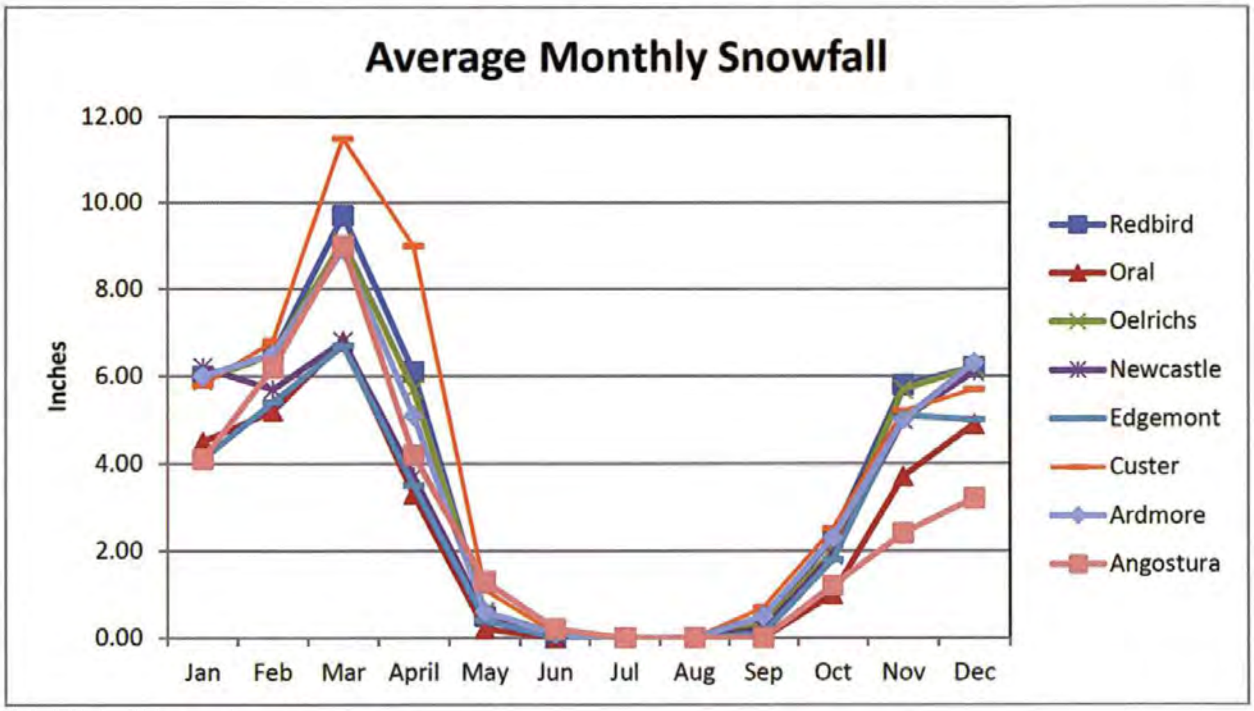
Source: Western Regional Climate Center, 2011

Figure 2.5-10a: Average Monthly Precipitation for Newcastle



Source: Western Regional Climate Center, 2011

Figure 2.5-10b: Baseline Year Monthly Precipitation for Newcastle



Source: South Dakota State University, 2008

Figure 2.5-11: Average Monthly Snowfall at Regional Sites

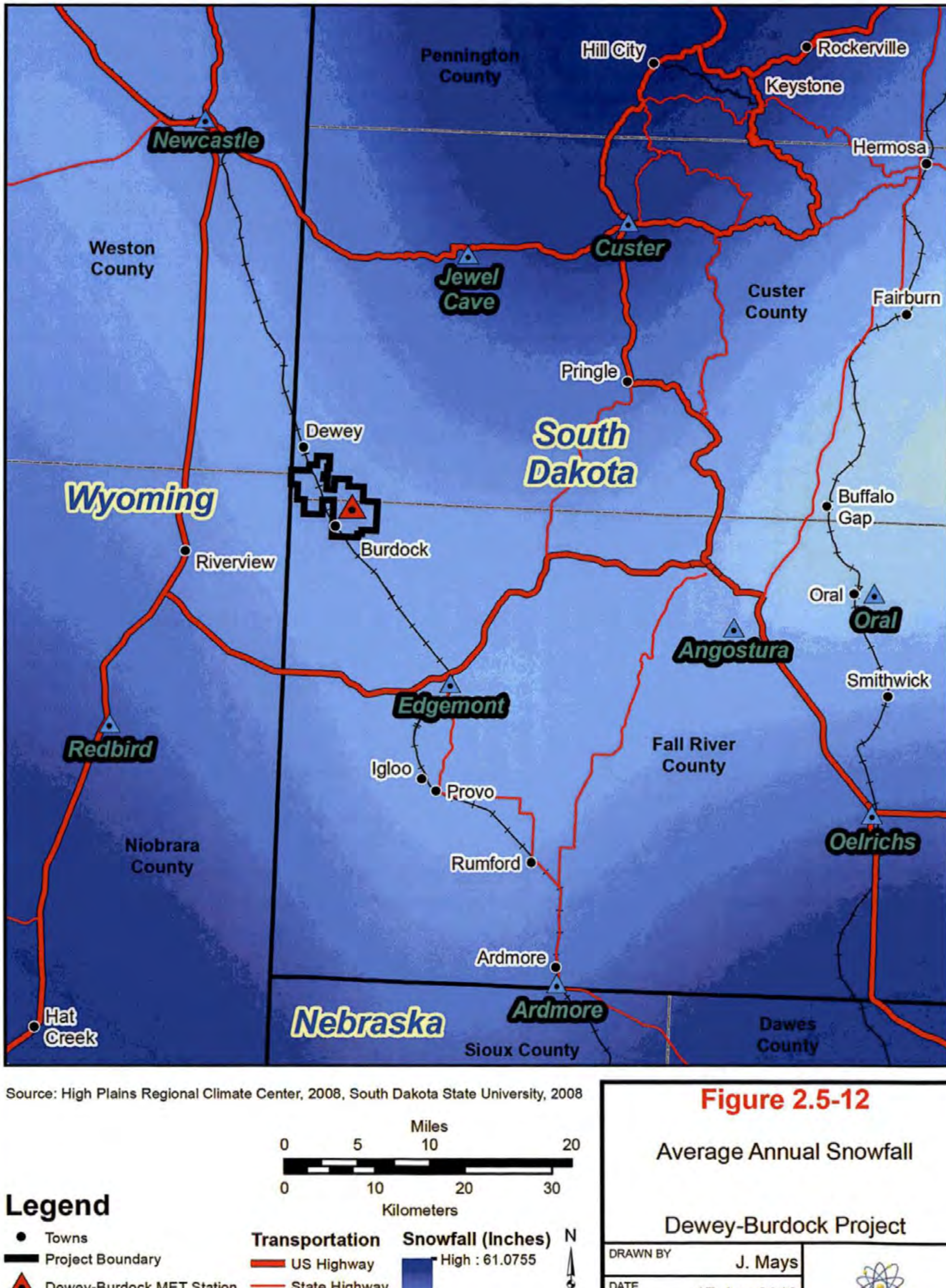


Figure 2.5-12

Average Annual Snowfall

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	AnnualSnowfall.mxd

POWERTECH (USA) INC.

2.5.2.4 Wind Patterns

As described in Section 2.5.2, Powertech determined that the Newcastle WRC site is more representative of the project area than the Chadron NWS site. Although the Chadron NWS site represents the closest NWS station with hourly wind data, it was eliminated from consideration since it is more than 60 miles from the project area and the wind patterns are substantially different (refer to Figure 2.5-20), which shows comparative wind roses for the Newcastle, Dewey-Burdock, and Chadron weather stations. Instead, the Newcastle WRC site was chosen due to its proximity (approximately 30 miles away) and similar elevation, surrounding topography and proximity to the southwestern flank of the Black Hills. The meteorological instruments at the Newcastle WRC site meet or exceed both NWS and NRC standards (refer to Table 2.5-1a).

For demonstrating that baseline monitoring is representative of long-term conditions, particular emphasis is placed on wind speed, wind direction and atmospheric stability, as these parameters impact MILDOS-AREA modeling as well as air quality monitoring locations. While the Newcastle WRC site is not strictly representative of the Dewey-Burdock project area, it is sufficiently close in distance and geography to infer the regional relationship between the baseline monitoring period (7/18/2007 to 7/17/2008) and long-term conditions. The following describes how the baseline monitoring period is representative of long-term meteorological conditions in the region.

Figure 2.5-13 shows wind roses at the Newcastle WRC site for the nine full years of monitoring and for the one year corresponding to the Dewey-Burdock baseline monitoring period. Figure 2.5-14 presents a graphical comparison of short and long-term wind direction distributions. Both figures demonstrate qualitatively that the period from 7/18/2007 to 7/17/2008 is representative of the longer term.

The long-term representativeness can be demonstrated quantitatively by isolating wind speed and wind direction variables to correlate short-term and long-term frequency distributions. IML has developed a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from one year of monitoring at a particular location represent the long-term distributions at that same location (Appendix 2.5-E of the approved license application).

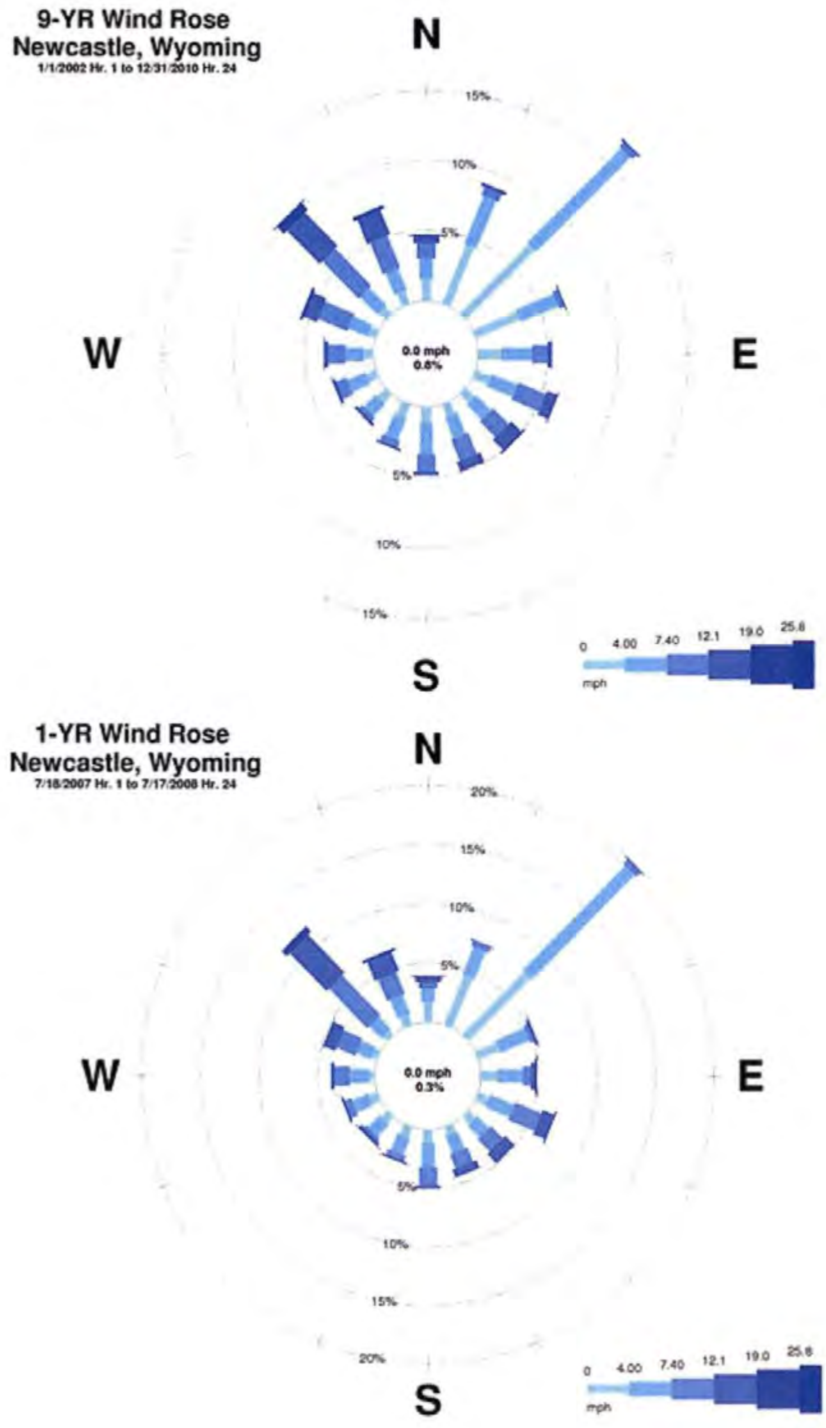


Figure 2.5-13: Newcastle WRC Site 9-Year and 1-Year Wind Roses

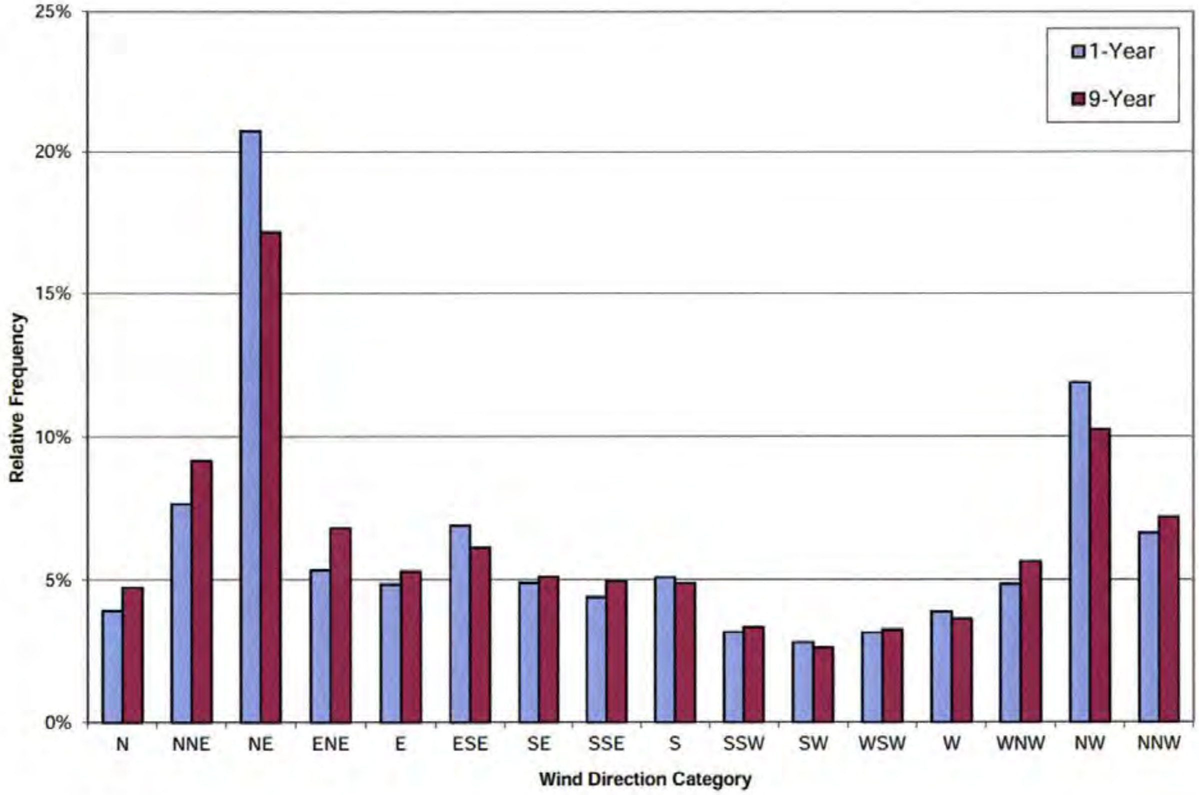
For the joint frequency wind distribution used in the MILDOS-AREA model, wind speeds are divided into six classifications ranging from mild (0 – 3 mph) to strong (> 24 mph). Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in Figure 2.5-14.

The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the 16 directions can be calculated to produce a wind direction frequency distribution. For each parameter, the one-year and nine-year distributions can then be compared. Linear regression analysis provides a useful tool to assess the degree of correlation between short and long-term distributions.

Figure 2.5-15 presents the correlation for the wind speed distributions at the Newcastle WRC site. Each point represents one of the six wind speed classes. The x-coordinate corresponds to the percent of the one-year period during which the wind speed fell in a given class, while the y-coordinate corresponds to the percent of the nine-year period during which the wind speed fell in that same class.

The regression line (red) in Figure 2.5-15 represents the least-squares fit to the six data points. The corresponding R^2 value of 0.994 implies very strong linear correlation. The linear slope of 0.98 further implies that short and long-term wind speed frequencies are substantially equivalent.

A similar analysis can be performed for wind direction frequencies. Figure 2.5-16 presents this correlation at the Newcastle WRC site. Each point represents one of the 16 wind direction categories. The x-coordinate corresponds to the percent of the one-year period during which the wind blew from a given direction, while the y-coordinate corresponds to the percent of the nine-year period during which the wind blew from that same direction.



Source: IML, 2011

Figure 2.5-14: Newcastle WRC Site Short vs. Long-Term Wind Direction Distribution

The regression line (red) in Figure 2.5-16 represents the least-squares fit to the 16 data points. The corresponding R^2 value of 0.954 implies very strong linear correlation. The linear slope of 0.78 further implies that short and long-term wind direction frequencies are similar.

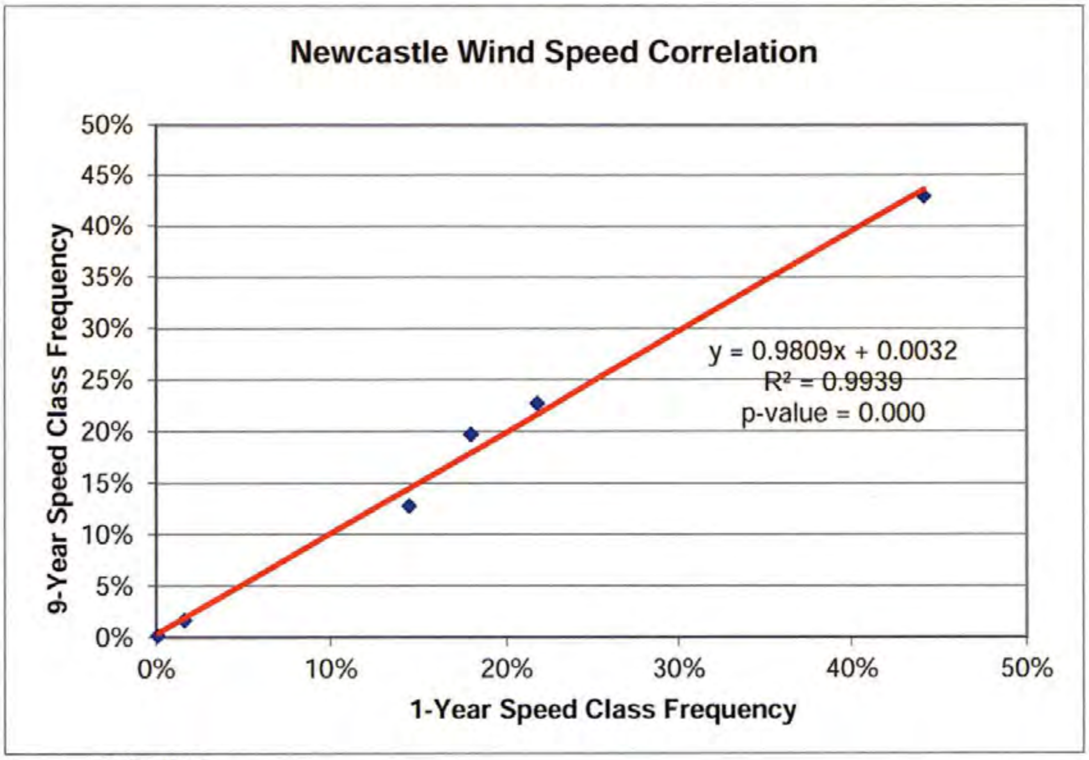
Figures 2.5-15 through 2.5-16 offer conclusive evidence that the 2007-2008 baseline monitoring year adequately represents the last nine years at the Newcastle WRC site. Since the one-year wind data serve as reliable predictors of the long-term wind conditions at the Newcastle WRC site, and since the Dewey-Burdock project area experiences similar regional weather patterns, it is concluded that the one-year baseline monitoring represents long-term meteorological conditions at the Dewey-Burdock project area.

This same methodology can be used to determine whether or not the Newcastle WRC site weather data are strictly representative of the Dewey-Burdock project area. Figure 2.5-17 compares the wind direction distributions for the baseline monitoring year at the two sites.

With an R^2 of 0.052, Figure 2.5-17 indicates little or no correlation of wind direction frequencies between the two sites. This result is heavily influenced by what appears to be an outlier. The NE sector constitutes 3.5% of the winds at Dewey-Burdock and 20.7% of the winds at the Newcastle WRC site. This difference may stem from local topographic effects. The Newcastle WRC site is situated in a "bowl" at the base of the Black Hills, and is subject to mild convection winds that tend to blow down the mountain from evening to early morning hours. This common phenomenon is related to differential air temperatures that cycle diurnally, with the cooler mountain air sinking to the adjoining valleys at night. Figure 2.5-18 shows the long-term wind rose for the Newcastle WRC site for daytime hours only (9:00 a.m. to 5:00 p.m.). During these hours the NE component is substantially diminished relative to Figure 2.5-13, presumably due to the absence of down-slope convection breezes. It is reasonable to assume that the Dewey-Burdock project area, situated several miles farther from the mountains than Newcastle, would not experience the same degree of diurnal convection breezes.

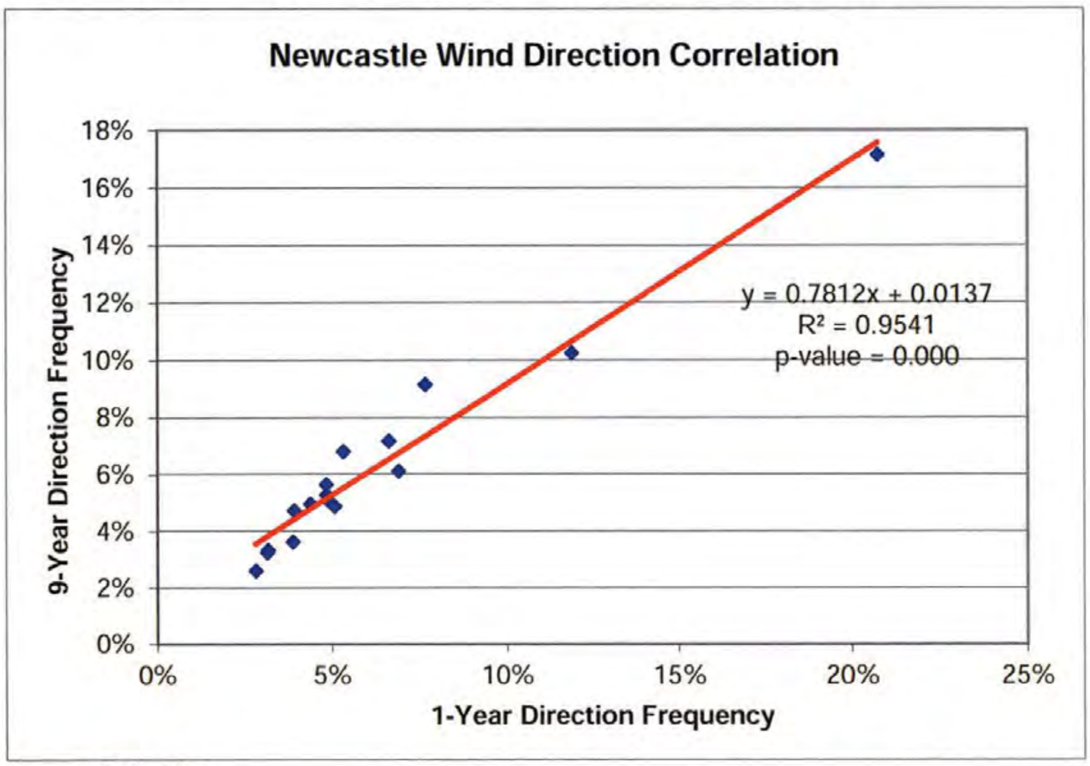
If the NE component is removed from each frequency distribution, a mild correlation between the two sites emerges. Figure 2.5-19 presents the same regression analysis as Figure 2.5-17, except with the NE outlier removed. While the much higher R^2 value of 0.60 still suggests no more than a weak correlation, it supports the premise that both sites are influenced by similar regional weather patterns. Appendix 2.5-E of the approved license application presents the results of another study showing that in northeastern Wyoming, spatial variations in wind patterns (attributable to local topography) far exceed temporal variations (attributable to synoptic weather systems from year to year). Hence, the conclusion that using the baseline year to represent long-term conditions is valid at either the Newcastle or the Dewey-Burdock project area, but not between the two sites.

Figure 2.5-20 compares the baseline year wind roses from Newcastle, Dewey-Burdock, and Chadron. With the exception of the NE component discussed above, the Newcastle wind rose resembles that of Dewey-Burdock. On the other hand, the Chadron wind rose reflects an entirely different wind regime. The meteorological differences between Chadron and these other two sites may be attributed to the much greater distance from Chadron to the Black Hills, its lower elevation (3,280 ft), and the increased influence of Great Plains weather patterns.



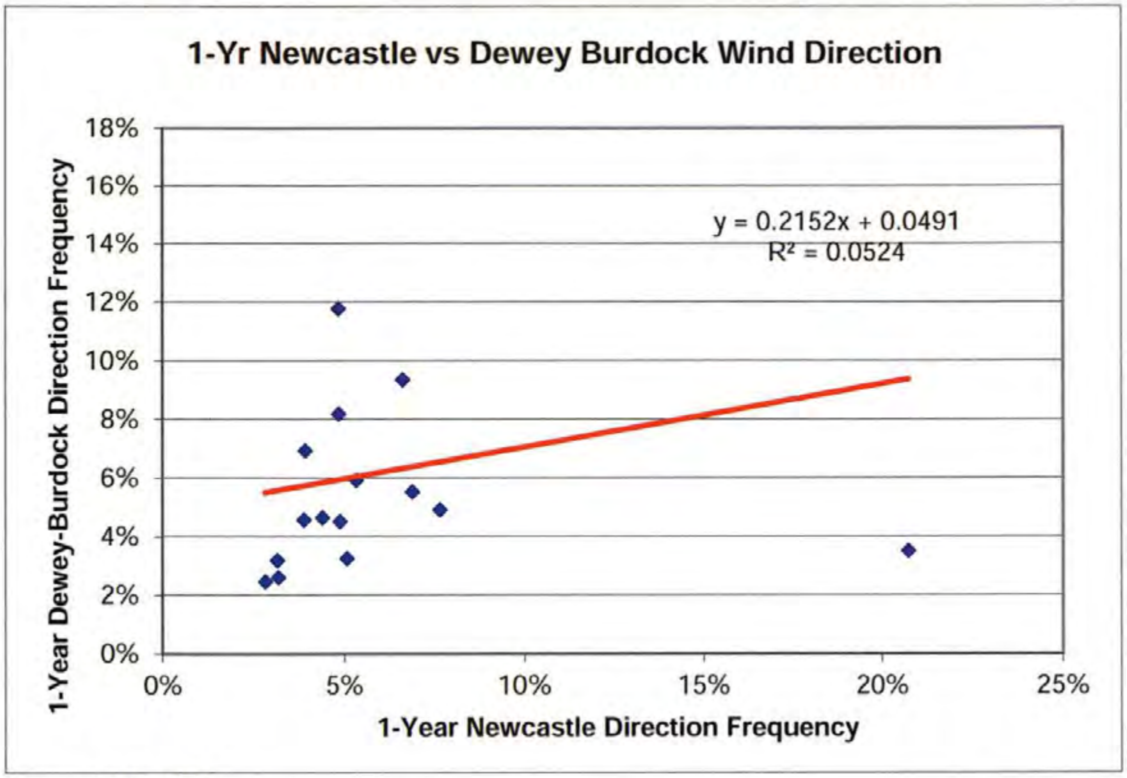
Source: IML, 2011

Figure 2.5-15: Newcastle WRC Site Wind Speed Correlation



Source: IML, 2011

Figure 2.5-16: Newcastle WRC Site Wind Direction Correlation



Source: IML, 2011

Figure 2.5-17: 1-Year Newcastle vs. Dewey-Burdock Wind Direction

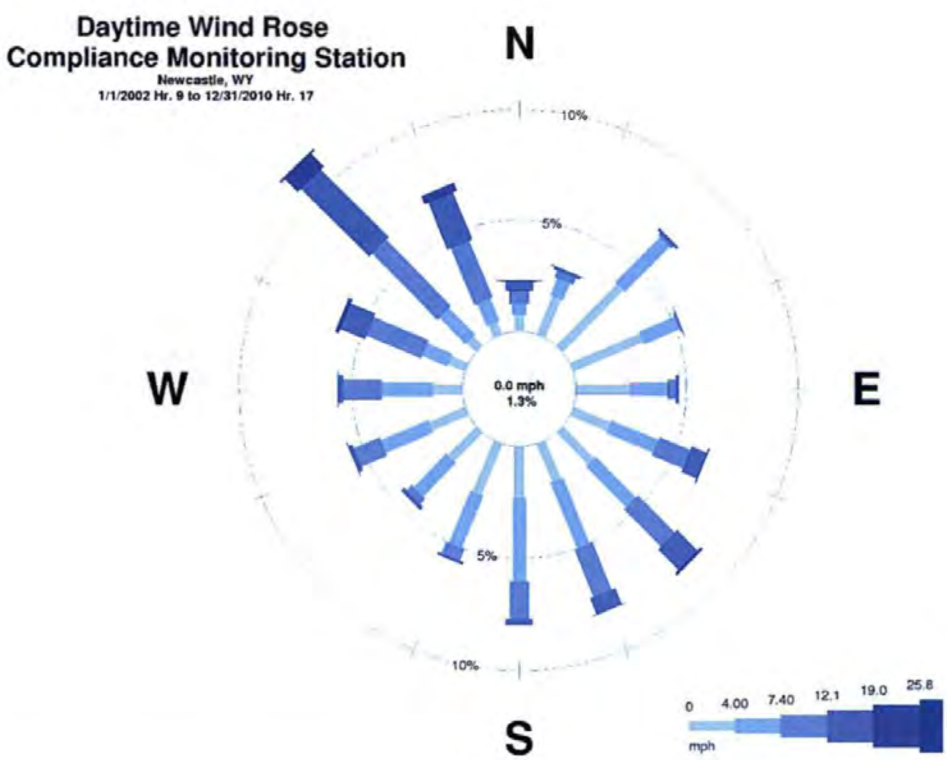
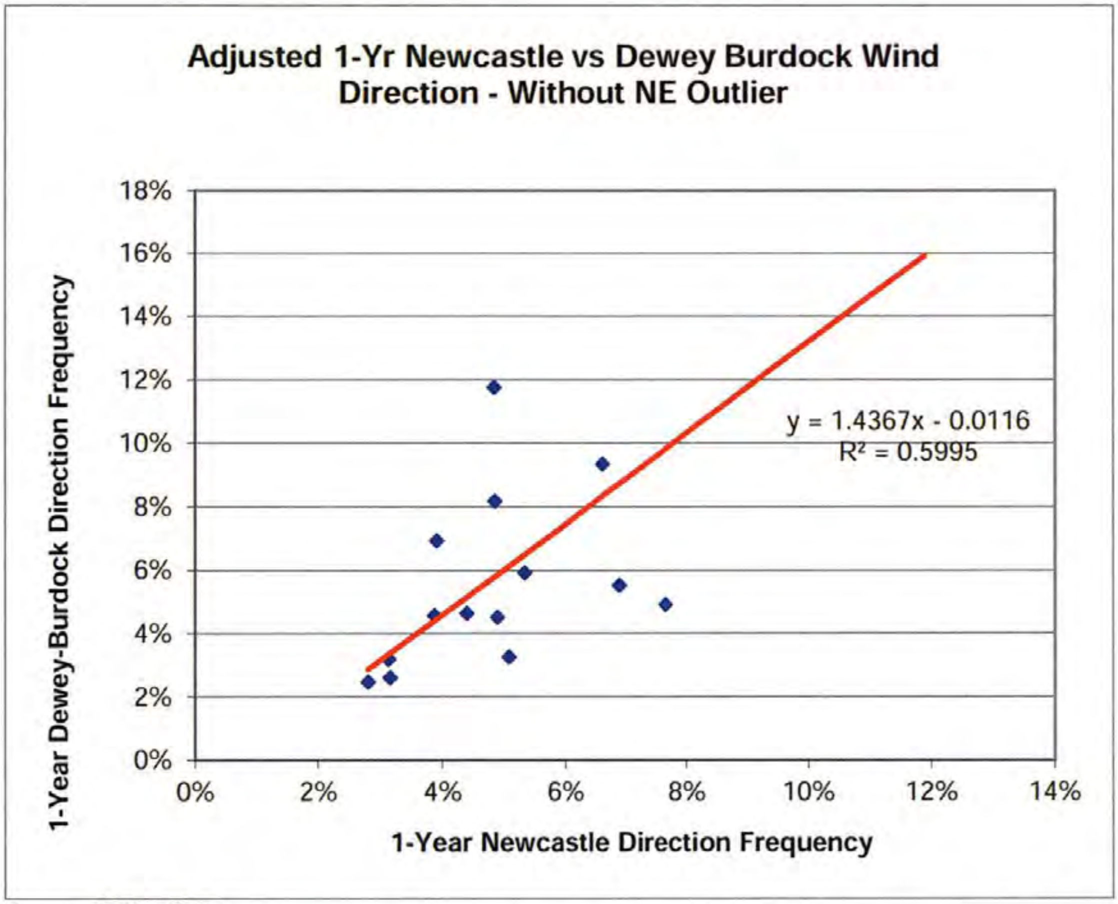


Figure 2.5-18: Daytime Wind Rose at the Newcastle WRC Site



Source: IML, 2011

Figure 2.5-19: Adjusted 1-Year Newcastle WRC Site vs. Dewey-Burdock Wind Direction – Without NE Outlier

2.5.2.5 Cooling, Heating and Growing Degree Days

The graphs shown in Figures 2.5-21, 2.5-22, and 2.5-23 summarize the growing degree, cooling degree, and heating degree days for the nine meteorological sites in the area. The data show a similar pattern for all three parameters throughout the sites with the exception of the Jewel Cave and Custer sites, which is likely caused by the higher relative elevation of these two sites.

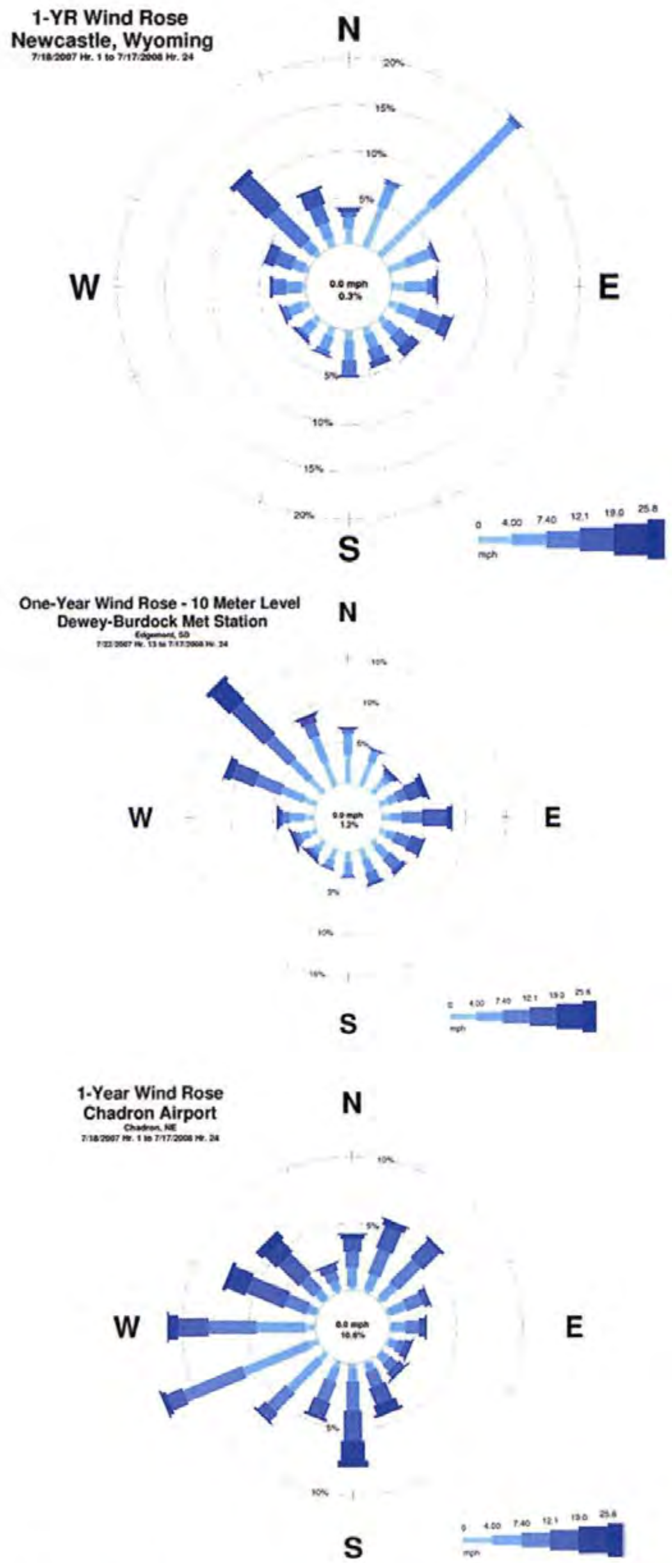
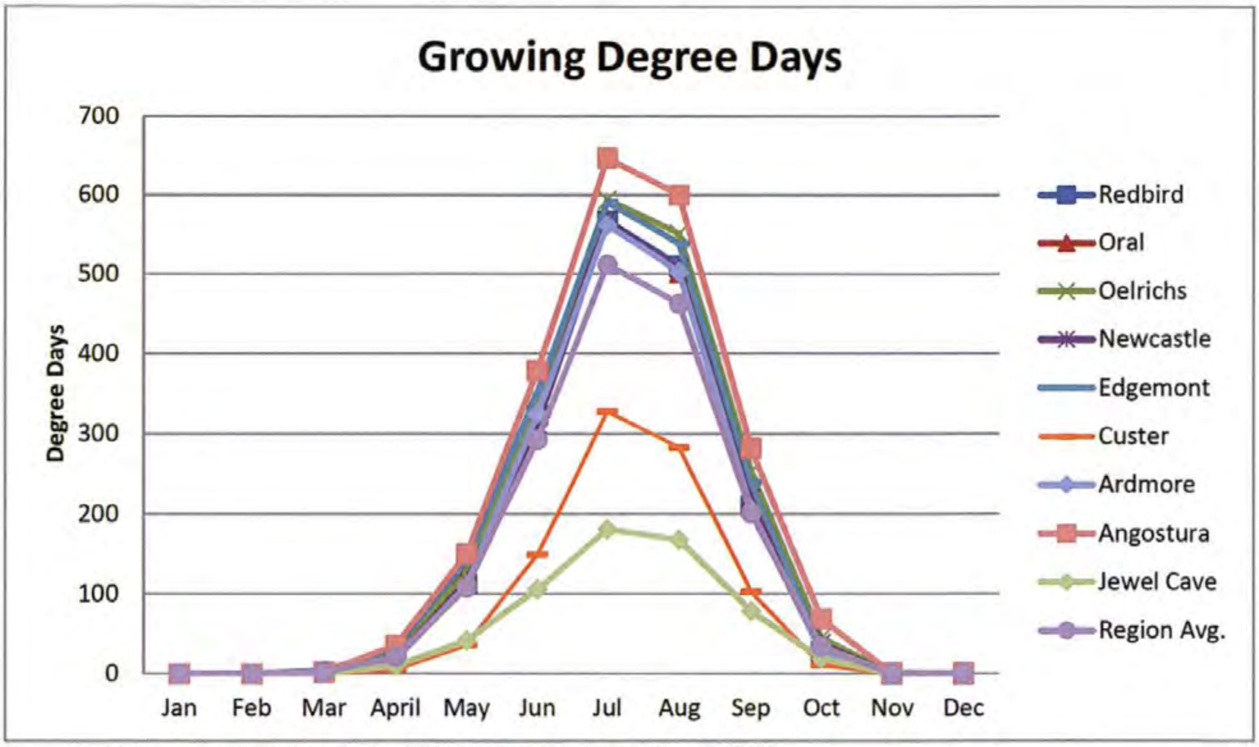
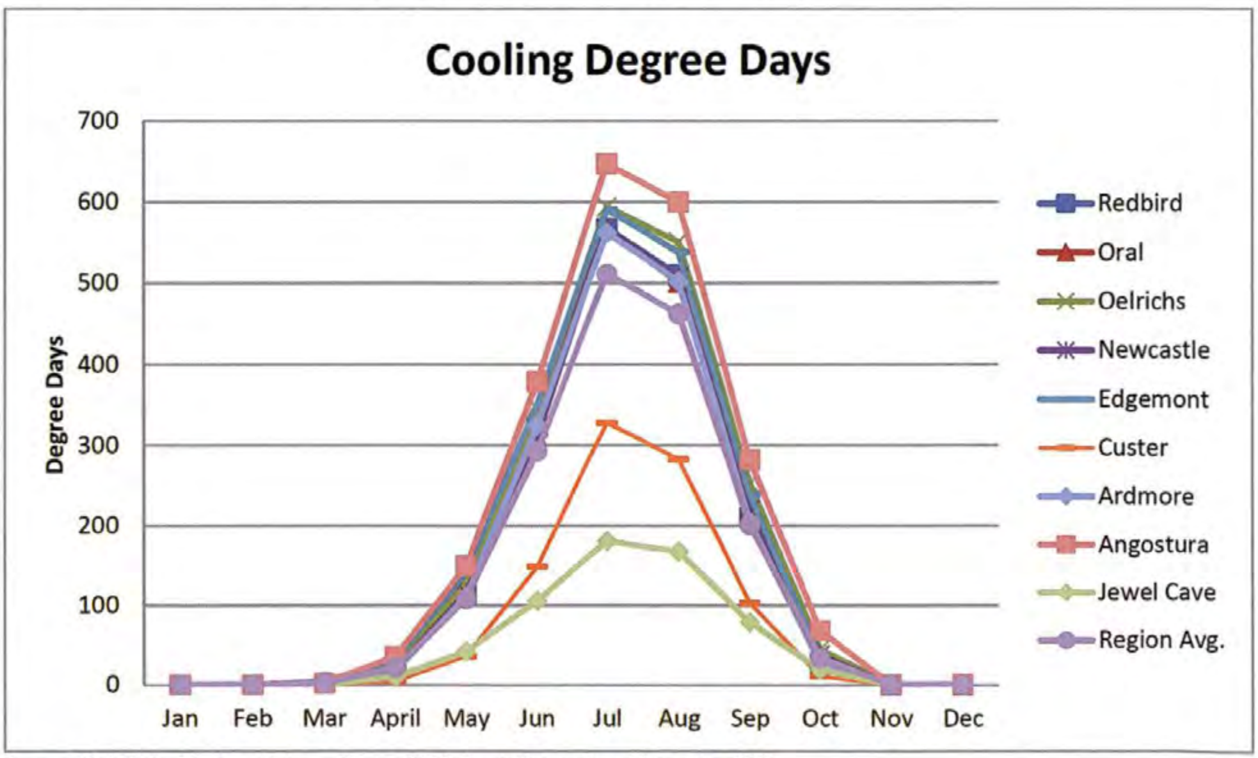


Figure 2.5-20: Comparative 1-Year Wind Roses



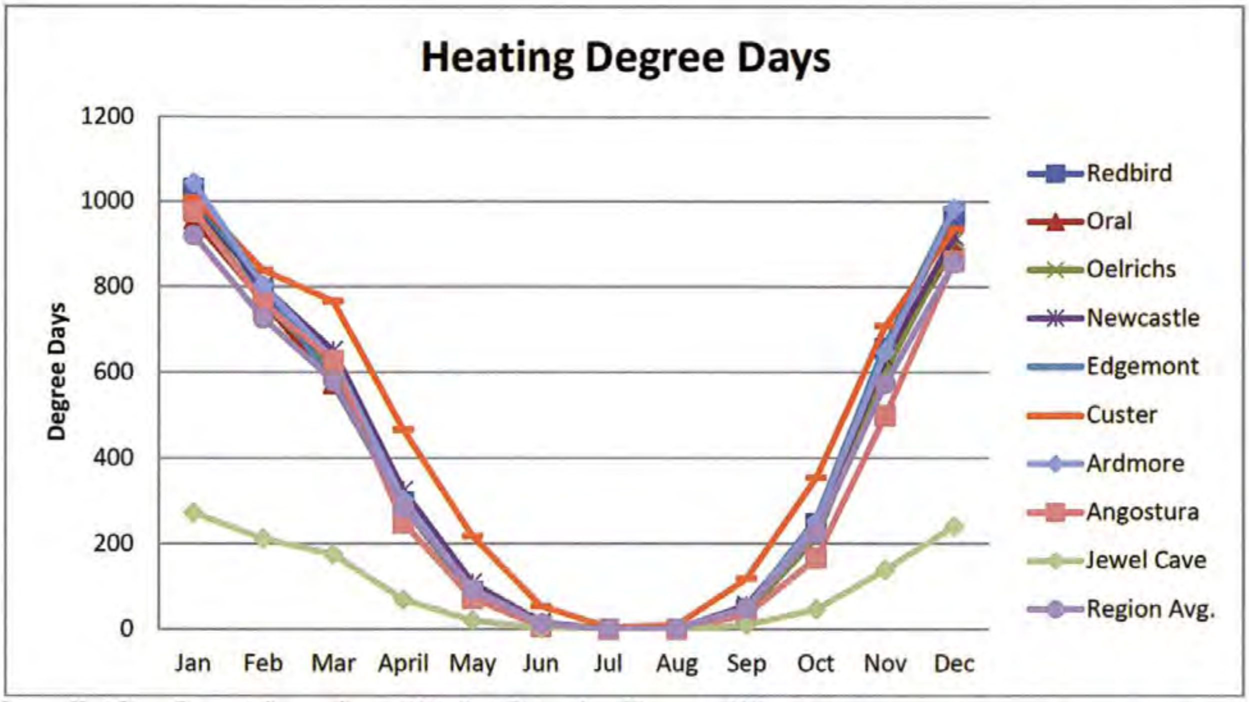
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-21: Growing Degree Days for Regional Sites



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-22: Cooling Degree Days for Regional Sites



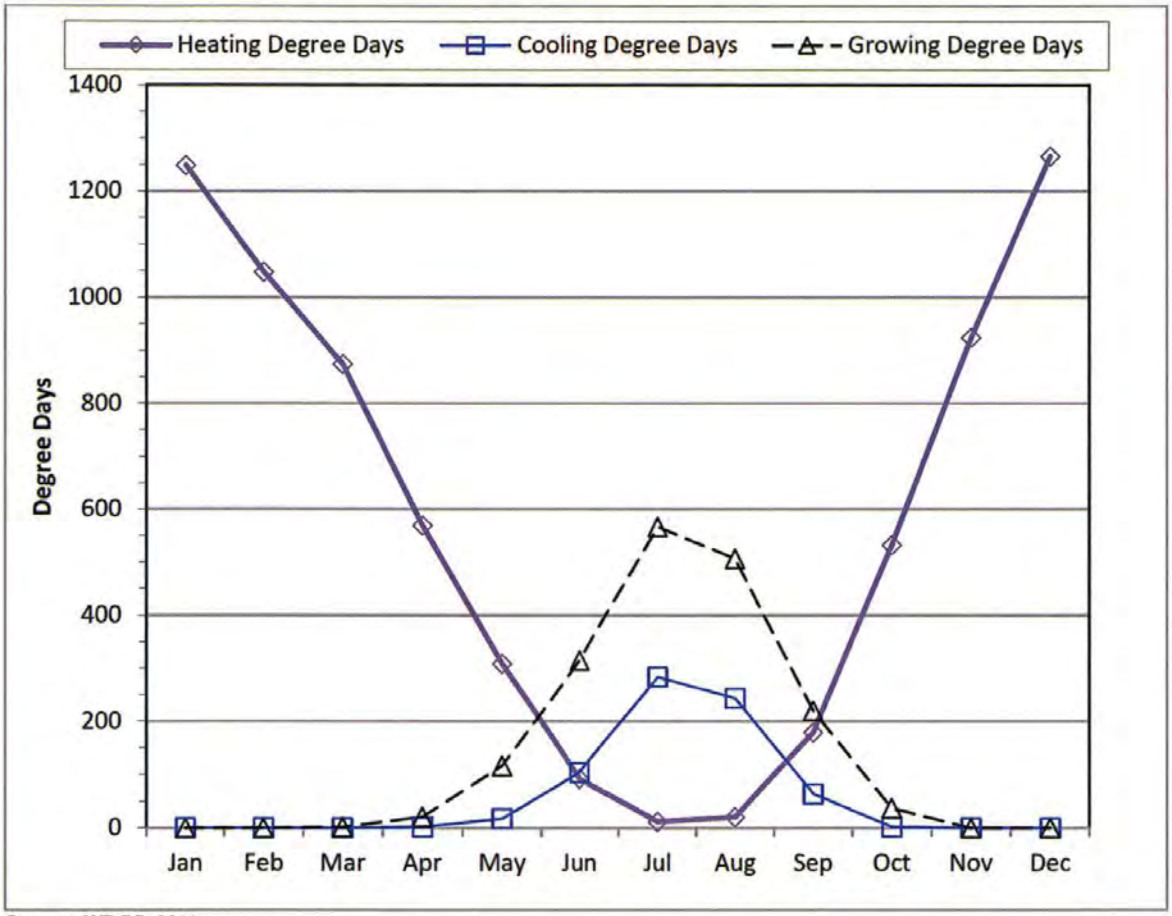
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-23: Heating Degree Days for Regional Sites

Figure 2.5-24 presents these three measures for Newcastle on the same graph. All degree days calculations used a base temperature of 55°F. Heating and cooling degree days are included to show deviation of the average daily temperature from the chosen base temperature. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The number of growing degree days and cooling degree days is computed in the opposite fashion where the base temperature is subtracted from the average of the high and low temperature for the day. Negative values are disregarded for both calculations.

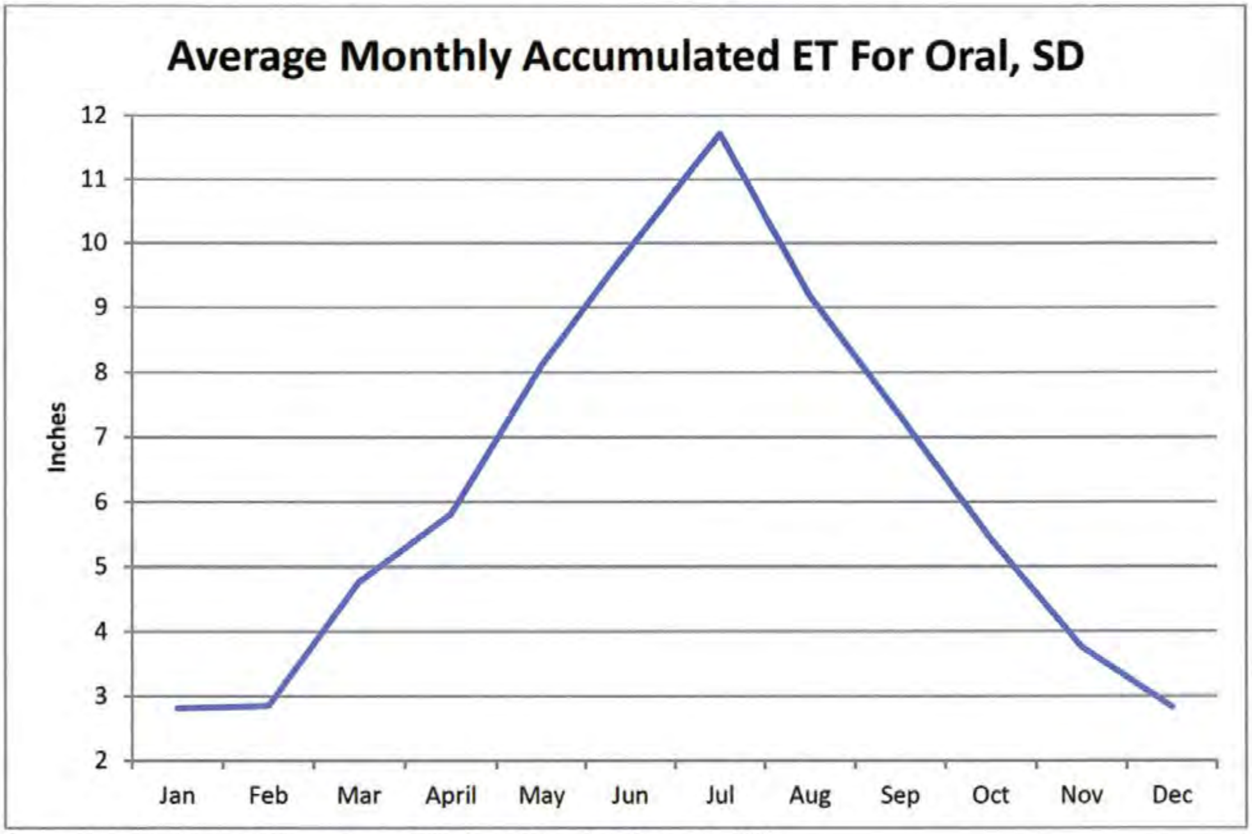
2.5.2.6 Evapotranspiration

The American Society of Civil Engineers (ASCE) Standardized Reference Evapotranspiration Equation was used to calculate daily evapotranspiration (ET) using a tall reference crop coefficient. The weather parameters needed to calculate ET using this method are daily maximum and minimum temperature, maximum and minimum relative humidity, total solar radiation, and average wind speed. The Oral site was the only one in the region with all these weather parameters being sampled, and was, therefore, the site used for this analysis. The data were available from May 8, 2003, to July 20, 2008. Figure 2.5-25 displays a graph of the average accumulated ET for each month. Most ET occurs during the summer months of June, July, and August with an average monthly accumulation of 10.3 inches. During the winter months, low ET (2.8 inches) occurs because of low temperatures and low solar radiation.



Source: WRCC, 2011

Figure 2.5-24: Degree Days for Newcastle

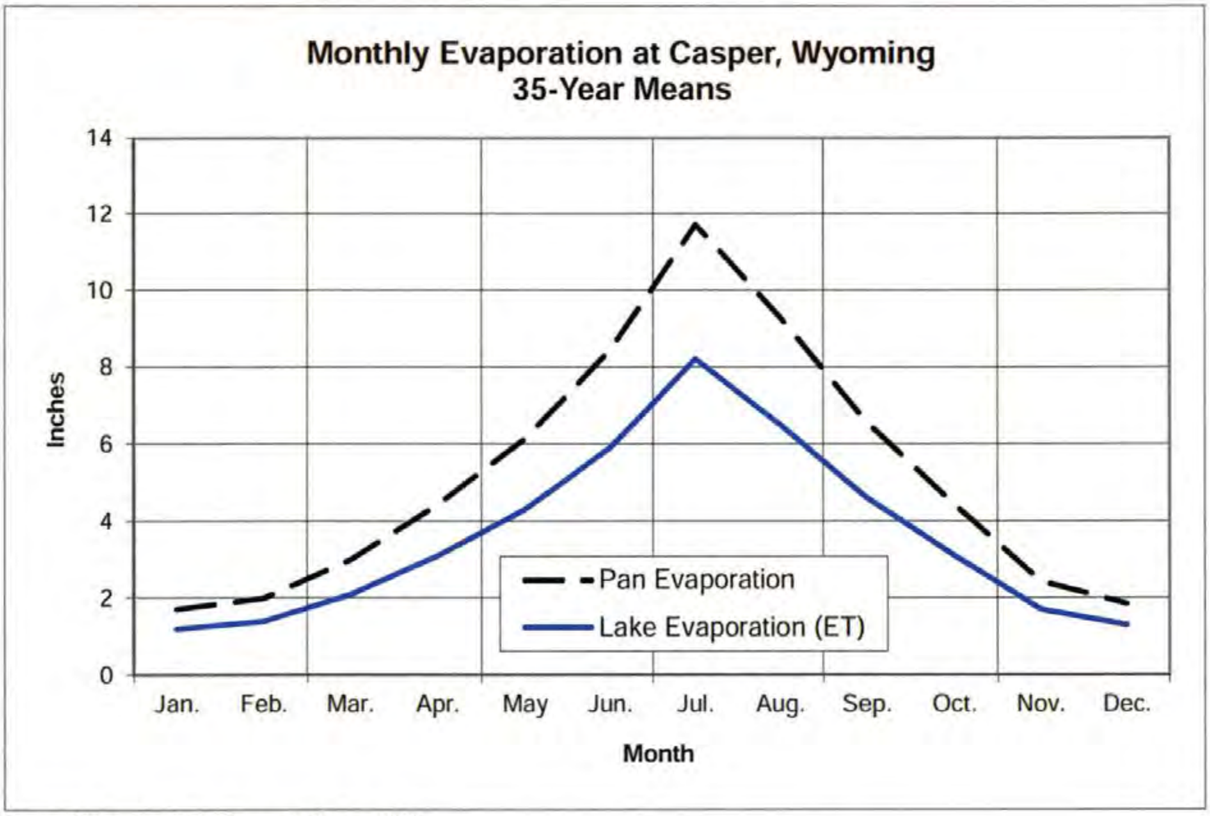


Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-25: Average Monthly Accumulated Evapotranspiration for Oral, South Dakota

No ET data were available for the Newcastle site. The nearest relevant evaporation data in Wyoming were obtained from the Wyoming Water Research Center (WWRC) for Casper, Wyoming. Casper experiences solar radiation values similar to Newcastle. Higher winds and lower rainfall at Casper suggest that ET should be higher than at Newcastle.

The lake evaporation rates in Figure 2.5-26 are computed from pan evaporation measurements by applying a 0.70 multiplier which is typical practice in this region. The WWRC source document states that "the potential evapotranspiration estimates are sometimes considered to be equivalent to lake evaporation." Therefore, the lake evaporation provides a surrogate measure of ET in Casper.



Source: Wyoming Water Research Center, 1985

Figure 2.5-26: Average Monthly Evaporation for Casper, Wyoming

It will be noted by comparing Figures 2.5-25 and 2.5-26 that projected ET values are significantly higher at Oral, South Dakota than at Casper, Wyoming. This could be attributed to the use of a tall reference crop coefficient at the Oral, South Dakota site. Regardless, the Newcastle site is expected to more closely resemble Casper, Wyoming.

2.5.3 Site Specific Analysis

The site-specific analysis was completed using data collected from a weather station installed in approximately the center of the permit boundary. The station is located on a site that is representative of the area within the boundary. Twelve months of data from July 18, 2007 to July 17, 2008 are used for this analysis.

This site was configured and installed by the South Dakota Office of Climatology at South Dakota State University. Parameters monitored include wind speed/direction at both 3- and 10-meter heights (9.8 and 32.8 feet), ambient temperature, relative humidity and solar radiation. Section 2.5.3.2 provides a discussion on how the data were used to determine atmospheric stability classes and resulting joint frequency distributions, thus meeting the goals of Regulatory Guide 3.63. The hourly average wind speed and wind direction reported at the site represent averages of twelve 5-minute data points for each hour. Table 2.5-6 lists the model number and specifications of the sensors that were installed. All results of the statistical analysis, completed using Minitab software version 14.0 for the parameters analyzed, are included in Appendix 2.5-B of the approved license application.

Table 2.5-6: Specifications for Weather Instruments Installed to Perform Site-Specific Analysis

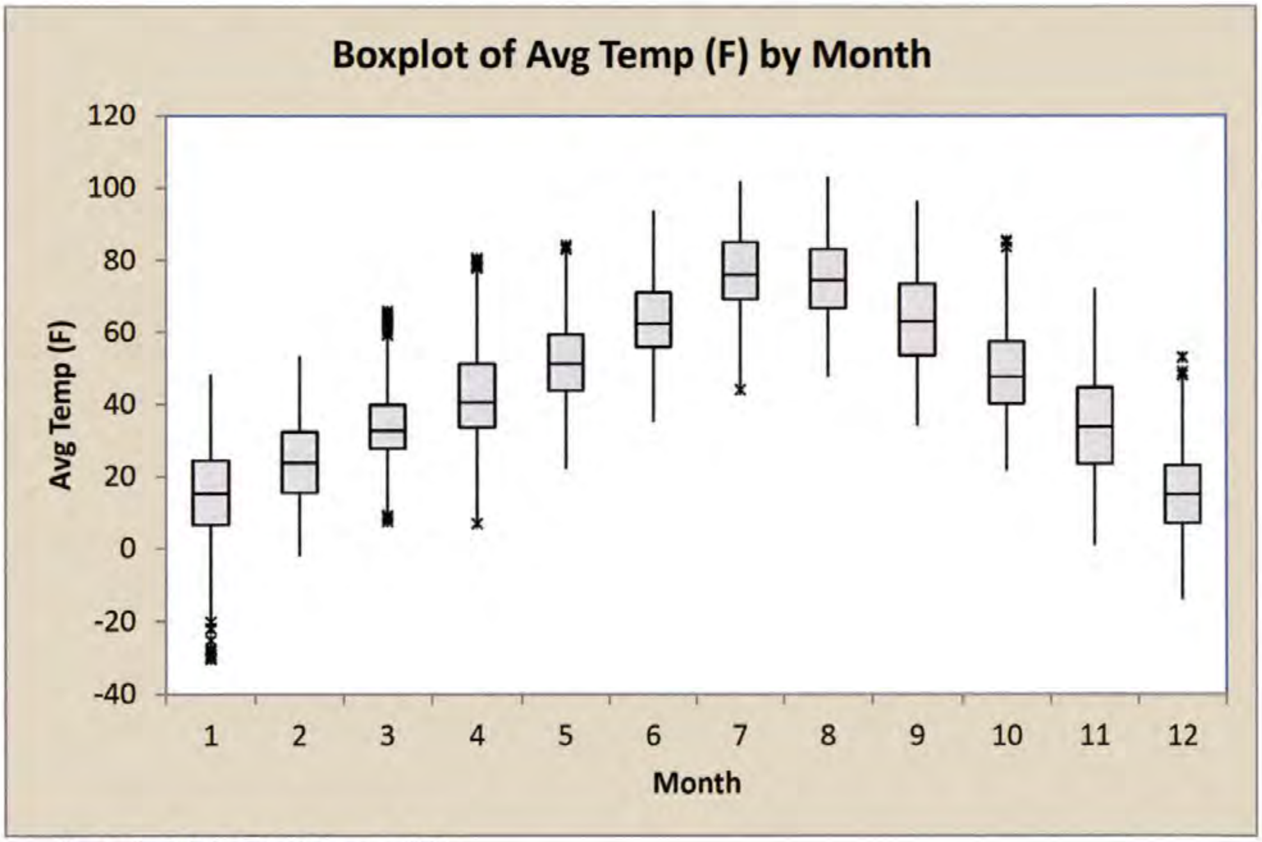
Instrument	Model	Manufacturer	Accuracy/ Threshold	Operating Temperature	Required Standard
Precipitation	VR6101	Vaisala	0.01 inch/0.01 inch	-40°C to 60°C	0.1 inch
Wind Direction	024A	Met-One	±5 degrees/1 mph	-50°C to 70°C	±5 degrees
Wind Speed	014A	Met-One	0.25 mph/1 mph	-50°C to 70°C	1.0 mph (0.5 m/s)
Temperature and RH	HMP45C	Vaisala	Temp: ±2% for 10-90% RH: ±3% of 90-100% RH	-40°C to 60°C	Consistent with current state of the art
Solar Radiation	LI200X	Lt-Cor	Absolute error in natural daylight is ±5% max; ±3% typical	-40°C to 65°C	Consistent with current state of the art

All instruments were factory-calibrated prior to installation. Both the Met-One wind speed sensor and the Met-One wind direction sensor have an operating threshold of 1.0 mph (0.45 m/sec). No instrument audits or re-calibrations were performed at the Dewey-Burdock weather station during the baseline monitoring year. Data quality control during the baseline monitoring period was conducted by comparing hourly averages to nearby stations. In a letter from the State Climatologist, Dr. Todey, to Powertech (USA), included in Appendix 2.5-F of the approved license application, it was reported that no data quality issues were detected that would have required a special site visit.

During the baseline year, wind data recovery was 87% at the 10-meter level and 99.7% at the 3-meter level. Temperature data recovery was 97.5%, relative humidity data recovery was 100%, and solar radiation data recovery was 99.8%.

2.5.3.1 Temperature

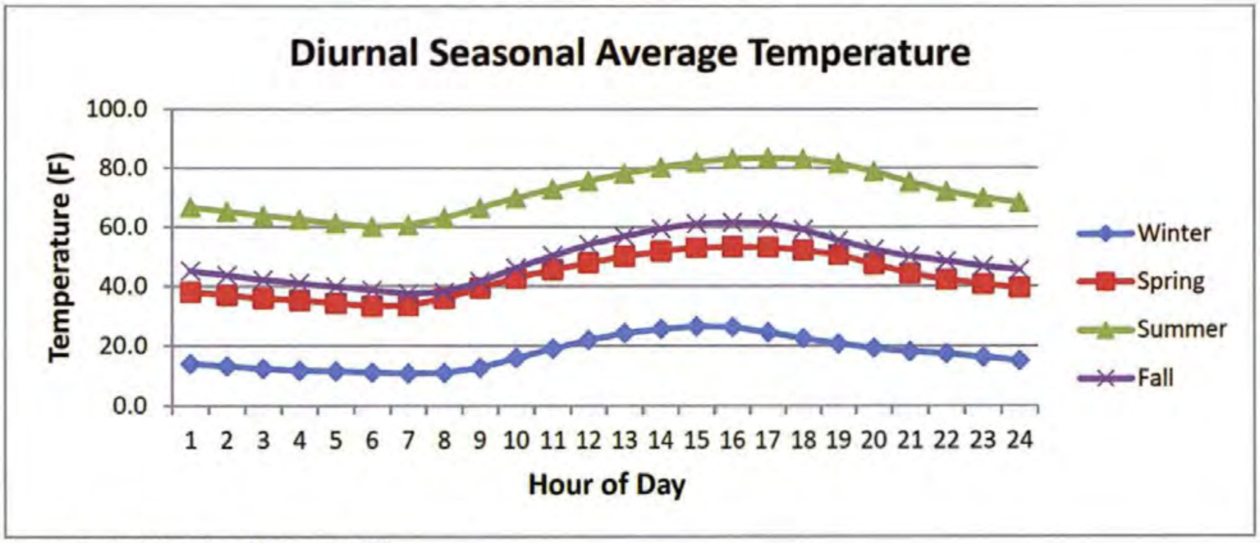
The average hourly temperature over the year for the site was 45.5°F. A maximum temperature of 104°F was reached on both July 21, 2007 and August 13, 2007, while the minimum temperature for the period of record was –28°F on January 22, 2008. A boxplot of the average temperature by month is shown in Figure 2.5-27. July was the warmest month with a median temperature of 76°F with a first quartile of 69°F and a third quartile value of 85°F. Conversely, December and January were the coolest months with a median temperature of 15°F.



Source: South Dakota State University, 2008

Figure 2.5-27: Average Temperature (Degrees Fahrenheit) by Month from the Project Meteorological Site

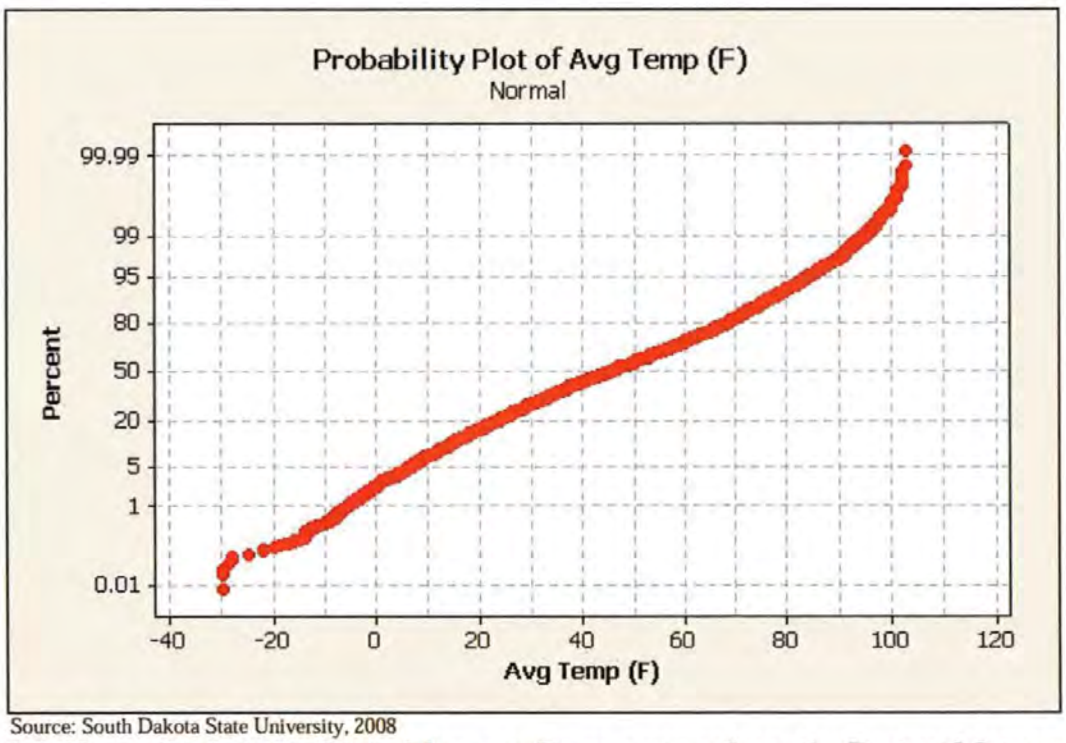
There were large variations in seasonal and diurnal temperature (Figure 2.5-28). In the summer season, average temperatures were as low as 60°F at 6 a.m. to 83.6°F at 5 p.m. In the winter season, temperatures varied from an average of 11°F between 7 a.m. and 8 a.m. and rose to nearly 27°F at 4 p.m. The diurnal variations are the result of the lack of relative humidity in the atmosphere at the site, which causes the earth's surface to rapidly absorb and release the energy supplied by the sun.



Source: South Dakota State University, 2008

Figure 2.5-28: Diurnal Average Temperature for the Project Meteorological Site by Season

Figure 2.5-29 shows a probability plot of average hourly temperature for the year. Temperatures above or below 46°F were expected at the site 50 percent of the time, and temperatures dipped below the freezing mark (32°F) 31 percent of the time.



Source: South Dakota State University, 2008

Figure 2.5-29: Probability Plot of Average Temperature from the Project Meteorological Site

2.5.3.2 Wind Patterns

Wind speed and direction were measured in the field using Met-One 014A and 024A model sensors. Wind data analysis outputs are included in Appendix 2.5-C of the approved license application. The average wind speed over the period of record was approximately 9 mph, while calm winds occurred only 1.2 percent of the time.

As shown in Table 2.5-7, over a third of the winds (34 percent) come from the north-northwest, northwest and west-northwest. Approximately 24 percent of all winds were less than 3.5 mph. Northwesterly, west-northwesterly and north-northwesterly winds were prevalent in the winter months. Easterly, east-northeasterly and east-southeasterly winds were prevalent in summer months. Figures 2.5-30 and 2.5-31 show the quarterly wind roses for the Dewey-Burdock project area at the 10-meter height. The period from January through March was used for the 1st Quarter, April through June for 2nd Quarter, July through September for 3rd Quarter and October through December for 4th Quarter. The 3rd Quarter wind rose reflects hourly data from both 2007 and 2008. Figure 2.5-32 shows the annual wind rose for the project area, with northwesterly and west-northwesterly winds dominating. Figure 2.5-33 shows that December had the least amount of wind with an average wind speed of 5 mph. In contrast, May was the windiest month with an average wind speed of 12 mph.

Joint wind data recovery at the Dewey-Burdock 10-meter height was approximately 87% for the baseline monitoring year, compared to the Regulatory Guide 3.63 recommendation of 75% for joint data recovery. Most of the invalid records occurred in the six weeks after the station began operating (late July and August 2007). Data recovery at the 3-meter height was over 99% for the year. To verify that the missing data at 10 meters did not significantly skew the wind analysis, an annual and a summer wind rose were generated for the 3-meter level. Figure 2.5-34 compares the annual wind roses at 3 and 10 meters, while Figure 2.5-35 compares the summer wind roses. For each period, the wind directions are distributed similarly at both heights. The principal differences can be explained by the normal increase in wind speeds with height, and by the greater frequency of winds from the regionally dominant (northwesterly) direction at 10 meters.

The joint frequency distribution provides more detail on wind speed distribution by wind direction and atmospheric stability class. Appendix 2.5-C of the approved license application presents the stability classes and joint frequently distribution for the Dewey-Burdock project area and describes the methodology used for calculations.

Table 2.5-7: Normalized Frequency Distribution of Wind at the Project Meteorological Site

Frequency Distribution (Normalized)							
Wind Direction	**Wind Speed Classification (mph)**						
	1–3	**4–7**	**8–12**	**13–18**	**19–24**	**≥ 24**	**Total**
N	0.030713	0.024749	0.002587	0.001125	0.000337	0.000000	**0.059511**
NNE	0.027653	0.012374	0.001575	0.000450	0.000000	0.000112	**0.042165**
NE	0.016474	0.007087	0.004050	0.002025	0.000112	0.000337	**0.030086**
ENE	0.009649	0.011924	0.013612	0.011812	0.002025	0.001800	**0.050822**
E	0.009178	0.016424	0.028573	0.014174	0.001350	0.000562	**0.070262**
ESE	0.007531	0.014399	0.016312	0.008437	0.000787	0.000000	**0.047466**
SE	0.006825	0.015862	0.013837	0.002025	0.000225	0.000000	**0.038773**
SSE	0.011885	0.018224	0.008212	0.001237	0.000337	0.000000	**0.039896**
S	0.012120	0.013724	0.002025	0.000112	0.000000	0.000000	**0.027982**
SSW	0.012356	0.007087	0.002587	0.000337	0.000000	0.000000	**0.022368**
SW	0.008472	0.006750	0.002925	0.002137	0.000787	0.000112	**0.021184**
WSW	0.009414	0.010124	0.003600	0.002812	0.000900	0.000562	**0.027413**
W	0.009884	0.018449	0.006075	0.003262	0.001462	0.000112	**0.039245**
WNW	0.015650	0.031498	0.030486	0.018899	0.004162	0.000337	**0.101033**
NW	0.021299	0.035323	0.042298	0.042185	0.016762	0.002700	**0.160566**
NNW	0.028594	0.032623	0.012262	0.004837	0.001575	0.000337	**0.080229**
Subtotal	**0.237699**	**0.276621**	**0.191014**	**0.115868**	**0.030823**	**0.006975**	**0.859000**
Calms							**0.012200**
Missing/Incomplete							**0.128800**
Total							**1.000000**

Source: South Dakota State University, 2008

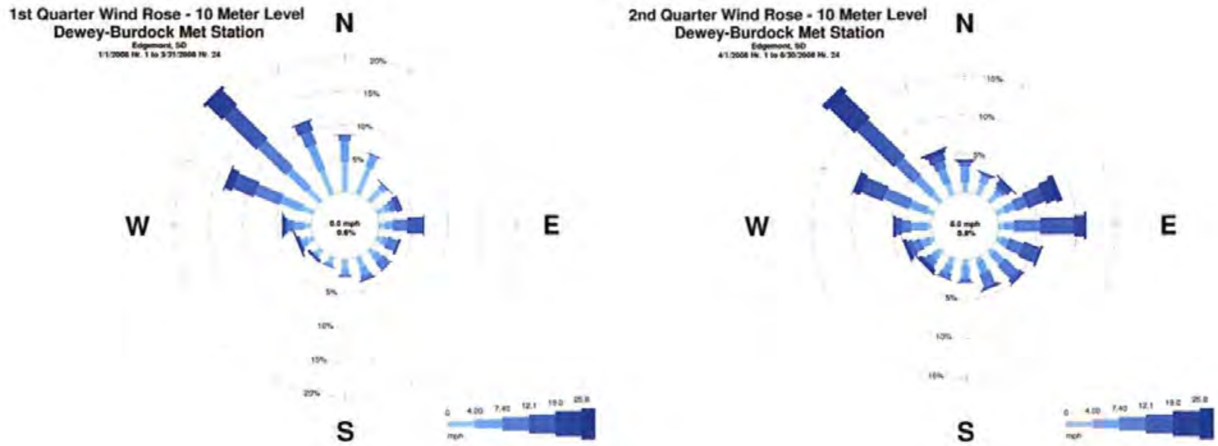


Figure 2.5-30: First and Second Quarter Wind Roses

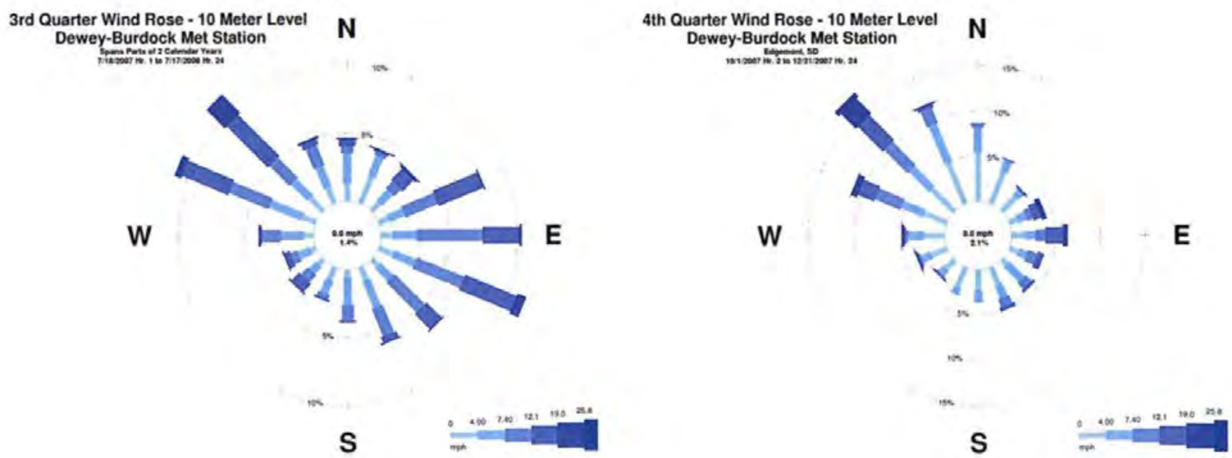


Figure 2.5-31: Third and Fourth Quarter Wind Roses

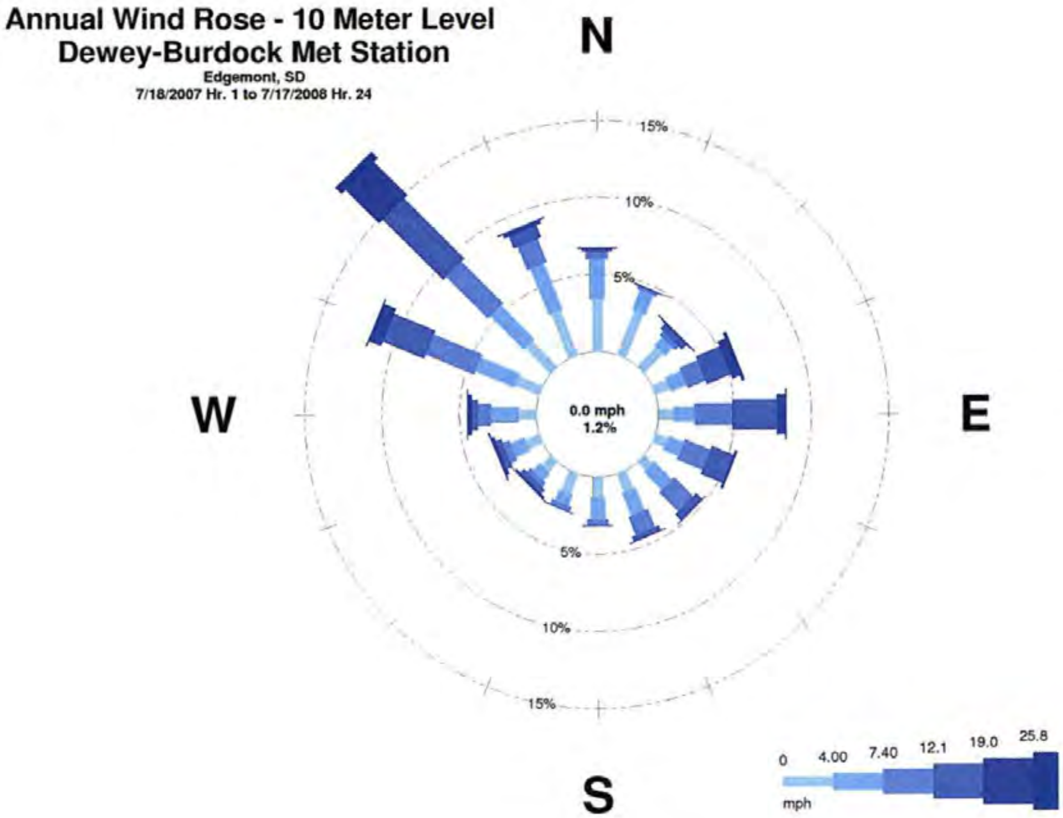


Figure 2.5-32: Annual Wind Rose

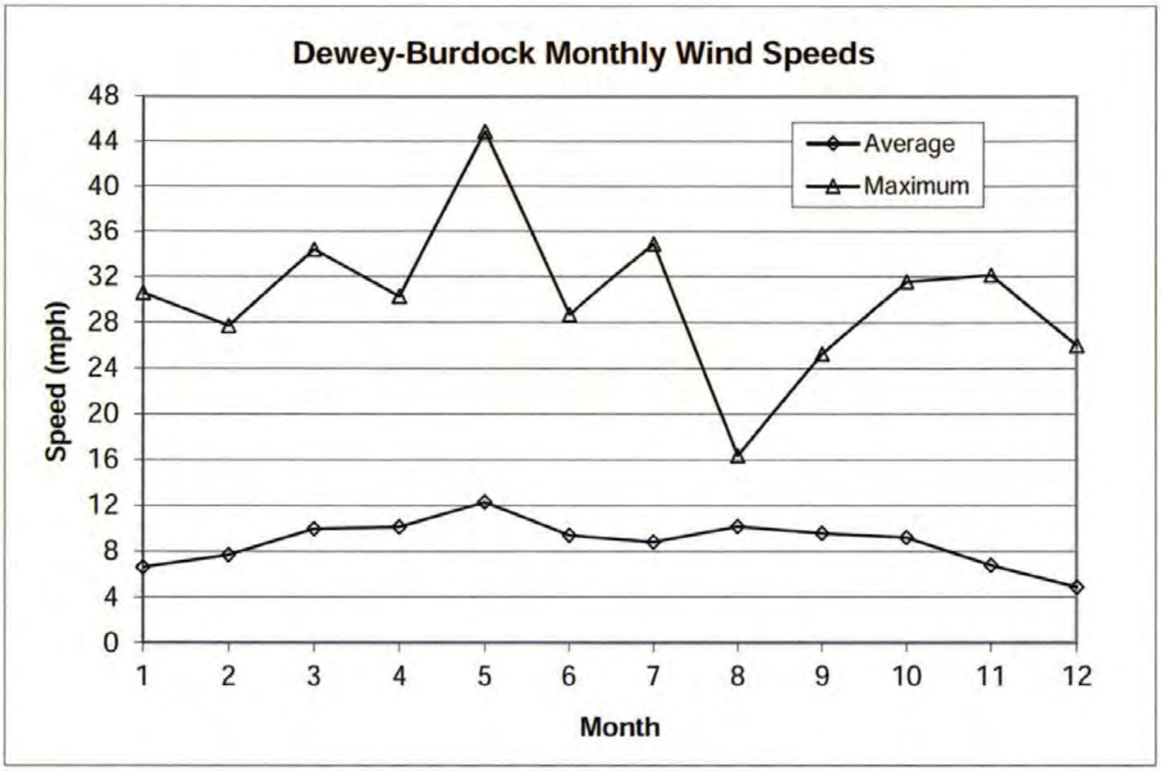


Figure 2.5-33: Dewey-Burdock Monthly Wind Speeds

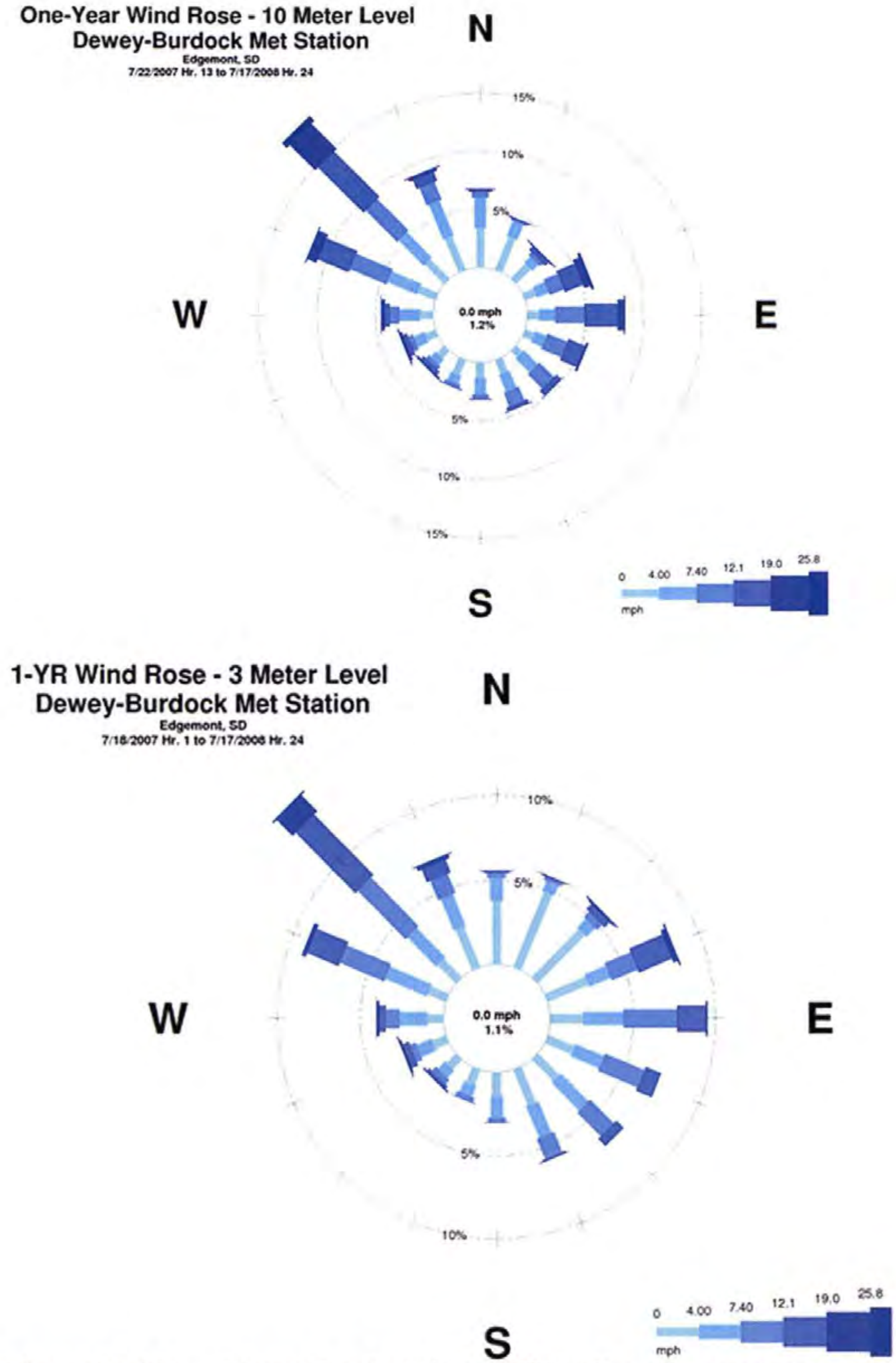
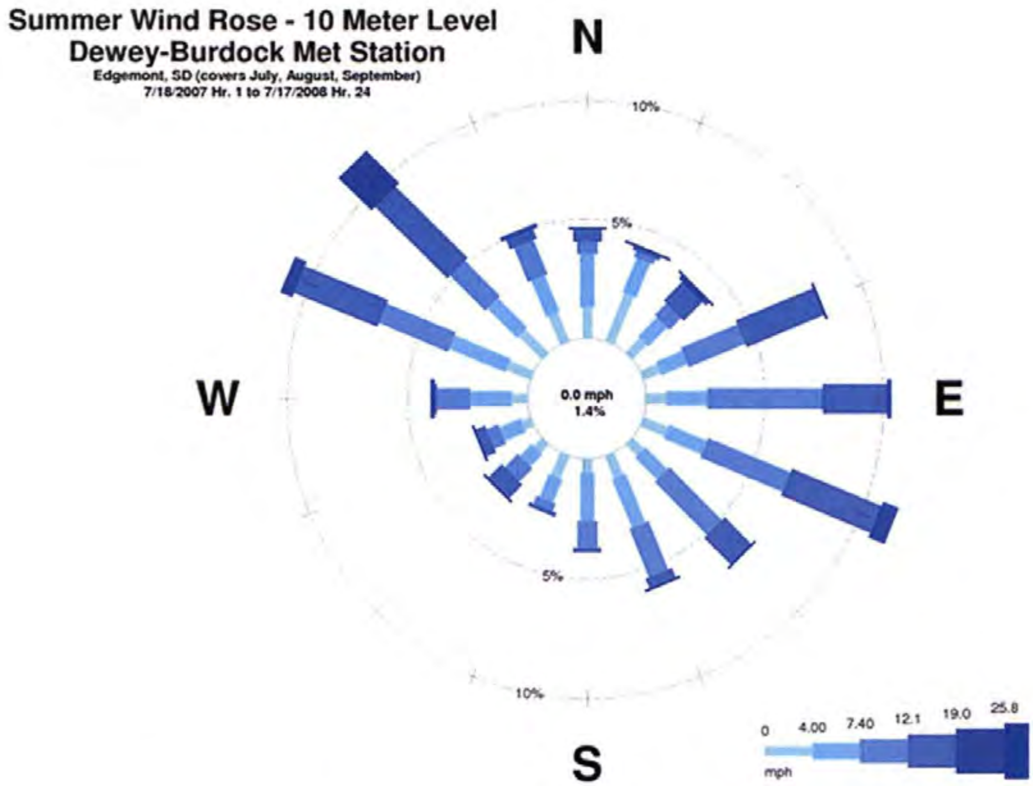


Figure 2.5-34: Dewey-Burdock Annual Wind Rose Comparison: 10m vs. 3m



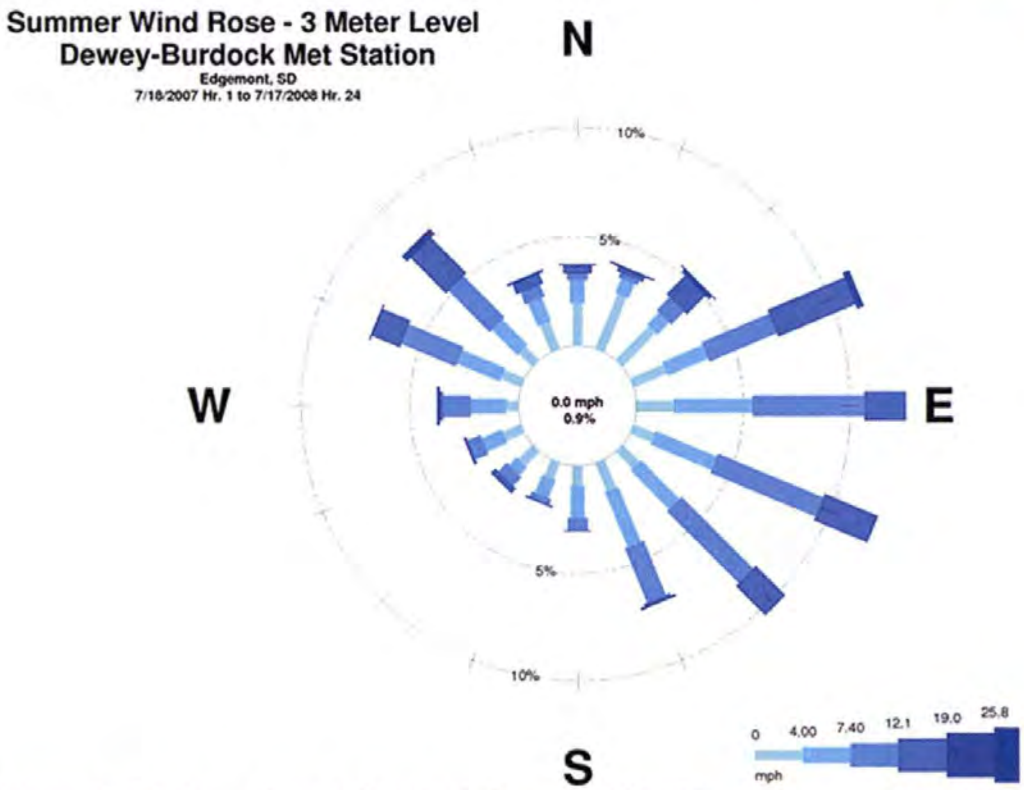
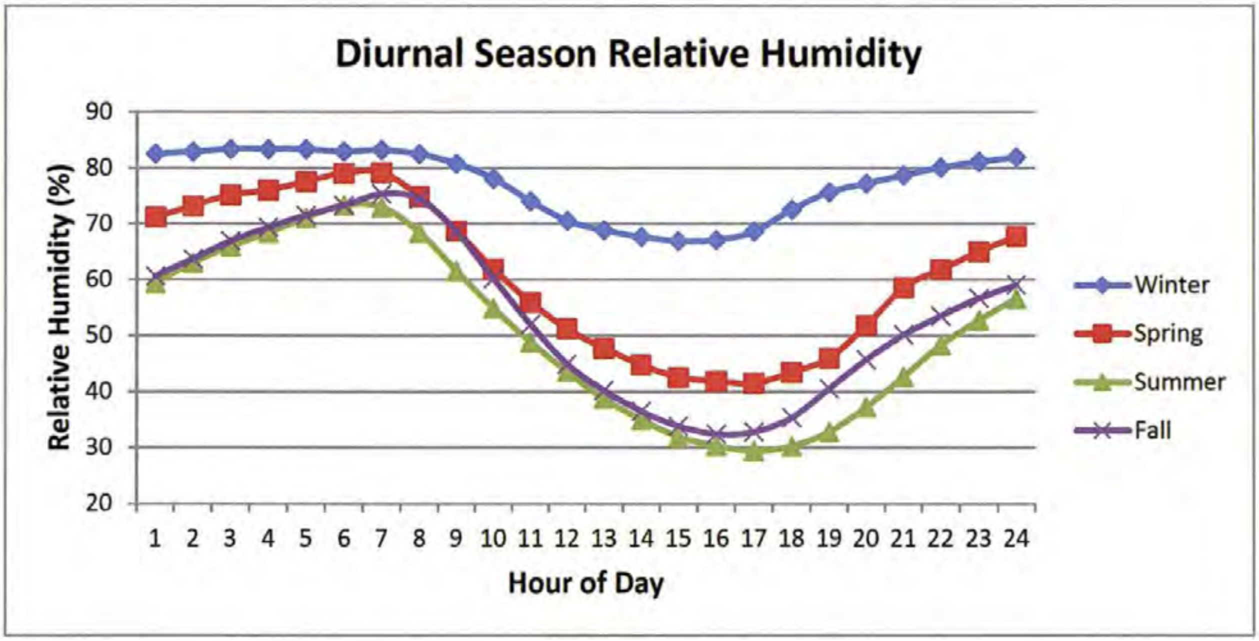


Figure 2.5-35: Dewey-Burdock Summer Wind Rose Comparison: 10m vs. 3m

2.5.3.3 *Relative Humidity*

As mentioned in previous sections, the relative humidity at the site is low. Mean values range from a low of 51 percent in the summer months compared to a high of 77 percent in the winter months. Relative humidity values varied greatly throughout the day, especially in the summer and spring months. On average, during the spring, summer, and fall months, relative humidity reached its maximum from 5 a.m. to 7 a.m. and then declined steadily until 4 p.m. to 5 p.m. when it began its evening ascent (Figure 2.5-36). During the winter months, the diurnal relative humidity range was much less because of less intense and shorter duration solar radiation.

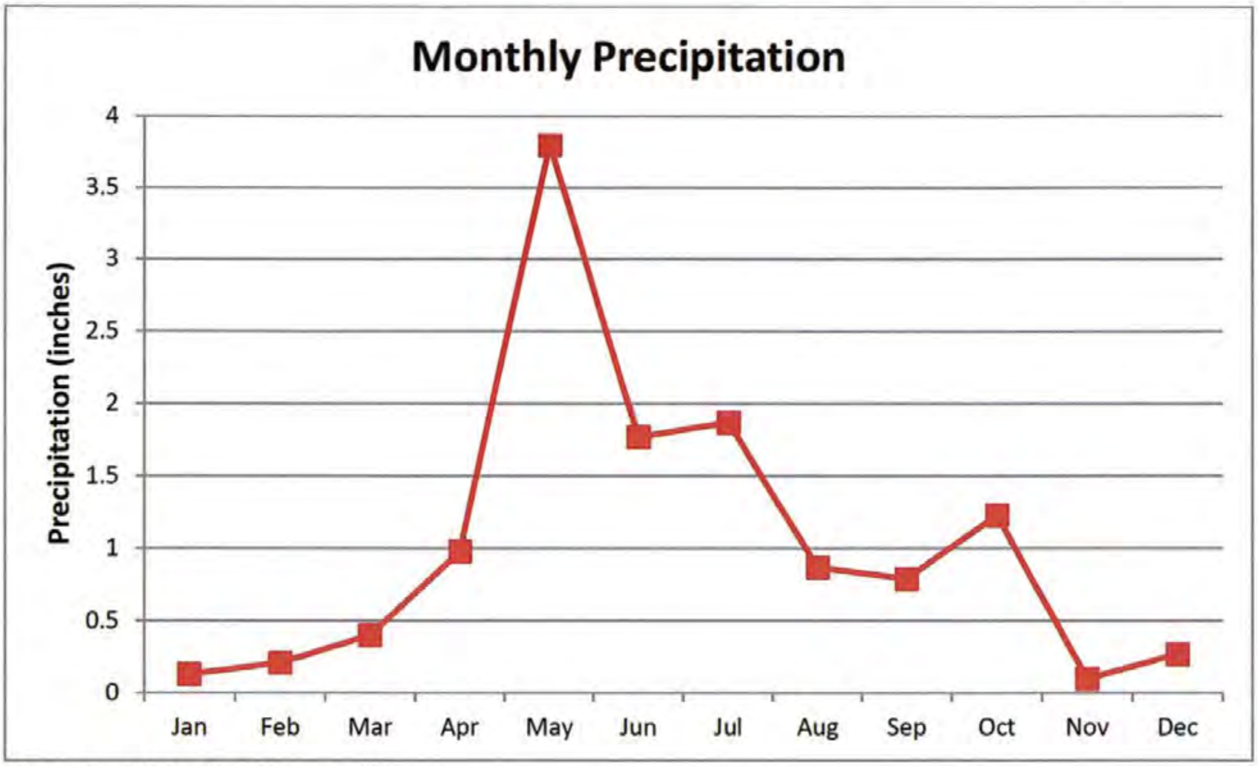


Source: South Dakota State University, 2008

Figure 2.5-36: Diurnal Relative Humidity by Season from Project Meteorological Site

2.5.3.4 *Precipitation*

Data for this site were collected using a Vaisala VRG 101 all-weather precipitation gauge. The region received 12.42 inches of precipitation during the year of monitoring. Figure 2.5-37 displays the precipitation totals by month. The largest monthly precipitation total occurred in May (3.8 inches) and the least occurred in November (0.10 inches). The greatest daily precipitation total (1.29 inches) occurred on May 23, 2008. Also on May 23, 2008, the area received 0.71 inch of precipitation between the hours of 8 p.m. and 9 p.m., which was the most intense event of the sampled year.

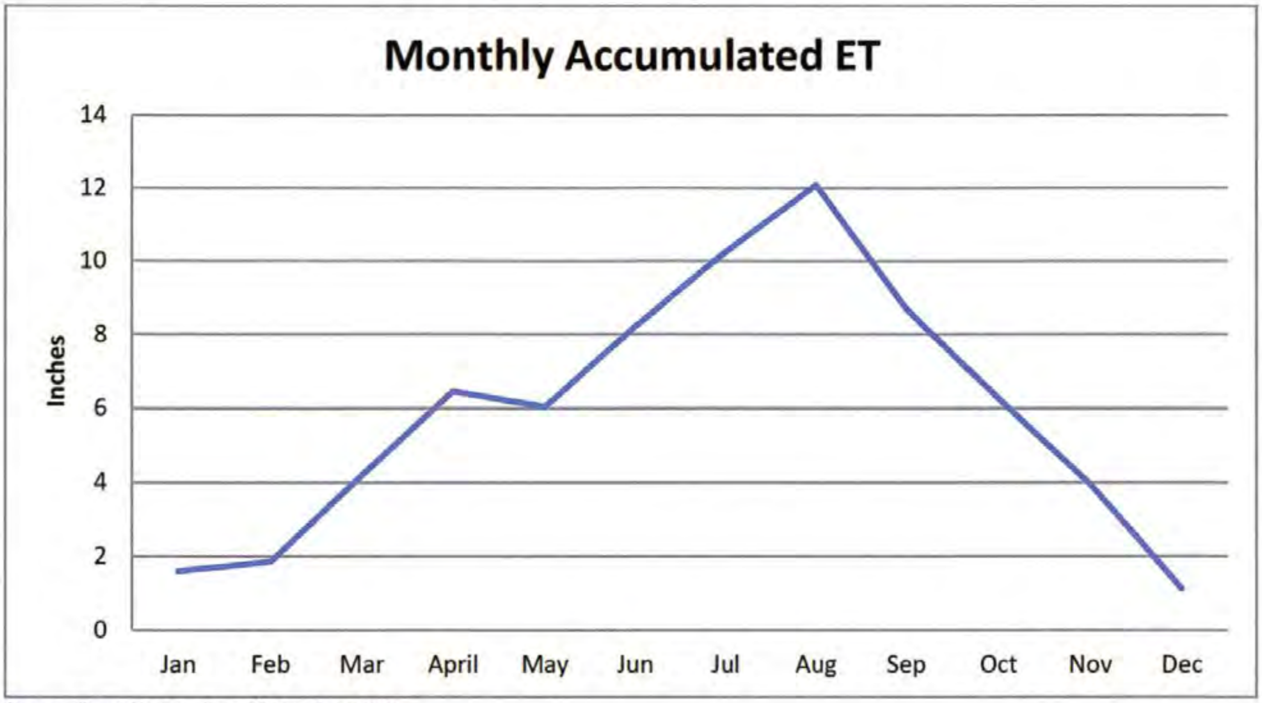


Source: South Dakota State University, 2008

Figure 2.5-37: Monthly Precipitation from the Project Meteorological Site

2.5.3.5 Potential Evapotranspiration

The potential ET data were taken from July 18, 2007 to July 14, 2008. The ASCE Standardized Reference Evapotranspiration Equation for a tall reference crop was used to estimate daily ET. The weather parameters needed to estimate ET using this method are daily, maximum and minimum temperature, maximum and minimum relative humidity, total solar radiation, and average wind speed. Most ET occurs during the months of July, August, and September with an average monthly accumulation of 10.3 inches (Figure 2.5-38) because of the high temperatures and unstable weather. During the winter low, ET occurs because of low temperatures and low solar radiation. The average ET during the winter months is 1.5 inches.



Source: South Dakota State University, 2008

Figure 2.5-38: Estimated Evapotranspiration Calculated Using Weather Data Collected at the Project Meteorological Site

2.5.3.6 Upper Atmosphere Characterization

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality.

The default mixing height of 100 meters was used for Dewey-Burdock MILDOS-AREA modeling. This is very conservative given that both morning and afternoon mixing heights at Rapid City, SD averaged much higher. Table 2.5-8 provides these average mixing heights, computed from upper air and surface data, at the Rapid City Airport, which is the closest site to the project area with upper air data.

For comparison purposes, average mixing heights were derived from the AERMOD calculations used for dispersion modeling, based on hourly data obtained from the NWS stations in Rapid City (upper air), Custer, and the local Edgemont station. The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided on a quarterly basis in Table 2.5-9. The annual average mixing height is 1,110 meters, an order of magnitude higher than the default used for modeling.

Table 2.5-8: Rapid City Mixing Height Averages, 1984-1991

Averaging Period	Morning	Afternoon
Average Mixing Height (meters)	333	1,547

Table 2.5-9: Quarterly Mixing Height Averages

Averaging Period	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Average Mixing Height (meters)	936	1,285	1,382	839

2.5.4 References

High Plains Regional Climate Center, 2008, "*Historical Climate Data Summaries*", retrieved August 2008 from High Plains Regional Climate Center Web Site: http://www.hprcc.unl.edu/ data/historical/

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Wyoming Water Research Center, 1985, "*Design Information for Evaporation Ponds in Wyoming,*" by L. Pochop, K. Warnaka, J. Borrelli and V. Hasfuther, retrieved September 2011 from Wyoming Water Research Center Web Site: http://library.wrds.uwyo.edu/wrp/85-21/85-21.html

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2.6 Geology

2.6.1 Regional Geology

The project is located in the Great Plains Physiographic province on the southwestern flank of the Black Hills uplift in southwestern South Dakota. To the west of the PA is the Powder River Basin of Wyoming. The regional geologic map of this region is shown in Figure 2.6-1.

2.6.1.1 Regional Structure

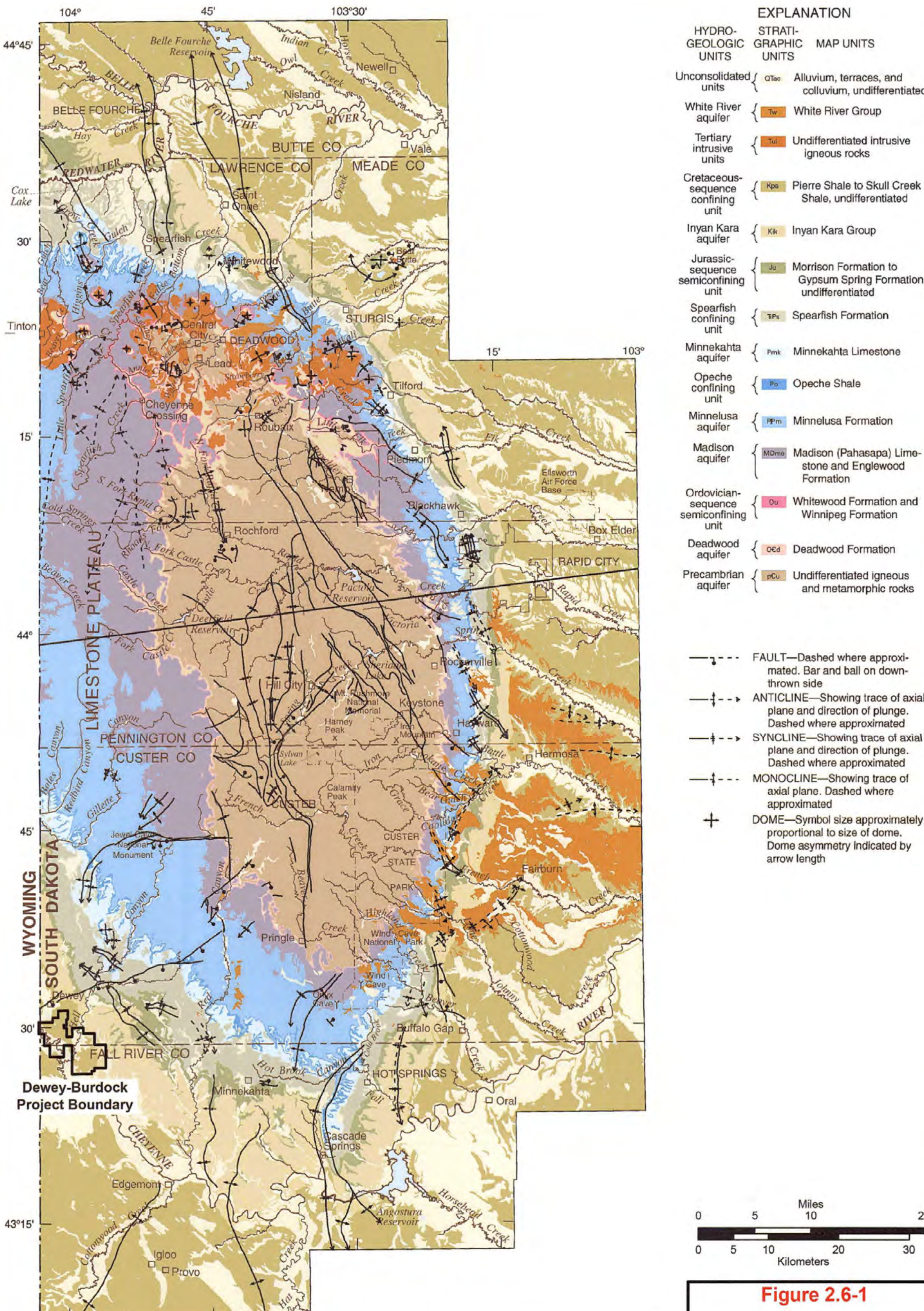
The dominant structural feature in this region is the Black Hills Uplift. This uplift is of Laramide age (65 million years ago) and is an elongate northwest trending dome about 125 miles long and 60 miles wide. Igneous and metamorphic Precambrian-age rock are exposed in the core of the uplift and are surrounded by outward-dipping Paleozoic and Mesozoic rocks that form cuestas and hogbacks around the core of the uplift. Folds constitute the major structural features in the Black Hills. In early Cretaceous time minor deformation along concealed northeast trending structures of Precambrian age affected the courses of the northwest flowing streams and their tributaries, thereby influencing the location of the fluvial sandstone deposits of the Inyan Kara Group.

2.6.1.2 Regional Stratigraphy

The oldest rocks in the region are Precambrian metamorphic rocks and granites. These form the core of the Black Hills Uplift and are exposed at the surfaced of this structural feature. Overlying these crystalline rocks are 2000-3000 feet of Paleozoic sediments. This sedimentary sequence contains several regional aquifers, to include the Deadwood Formation of Cambrian age, the Mississippian Madison Limestone and the Pennsylvanian/Permian-age Minnelusa Formation.

Mesozoic sediments include the Triassic age Spearfish Formation and the Sundance Formation, Unkpapa Sandstone, and Morrison Formation of Jurassic age. The Sundance Formation is a minor aquifer in the southern Black Hills region. A thick sequence of Cretaceous age sediments completes the Mesozoic section.

The Early Cretaceous sediments of the Inyan Kara Group consist of the Lakota Formation and the Fall River Formation and is a transitional unit, exhibiting a change from terrestrial to marine deposition. The basal Lakota Formation (Chilson Member) is a fluvial sequence, which grades upward into marginal marine sediments as the Cretaceous Seaway inundated a stable land surface. Basal units of the Lakota Formation scour into clays of the underlying Morrison Formation and display the depositional nature of a large braided stream system, crossing a broad, flat coastal plain



Base modified from U.S. Geological Survey digital data, 1:100,000, 1977, 1979, 1981, 1983, 1985
Rapid City, Office of City Engineer map, 1:18,000, 1996; Universal Transverse Mercator projection, zone 13

Source: Ground-Water Resources in the Black Hills Area, South Dakota. Water-Resources Investigations Report 03-4049, by J. M. Carter, D. G. Driscoll and J. F. Sawyer, Rapid City, South Dakota, 2003, p. 5.

Figure 2.6-1

Geologic Map of the Black Hills

Dewey-Burdock Project

DRAWN BY Bonner, Hetrick	POWERTECH (USA) INC.
DATE 19-Jun-2013	
FILENAME BlackHillsGeoMap.dwg	

and flowing toward the northwest. Younger fluvial sand units of the Lakota become progressively thinner and less continuous and are separated by thin deposits of overbank and flood plain silts and clays. At the top of the Lakota is the Fuson Member. The Fuson consists of shale with minor beds of fine grained sandstone and siltstone. The Fuson separates the underlying Lakota Formation from the overlying Fall River Formation. The Fall River consists of thick, widespread fluvial sands in the lower portion, grading to thinner, less continuous, marginal sands in the upper part. The Cretaceous Lakota and Fall River Formations are the hosts of the roll front uranium mineralization in the Black Hills region.

Following deposition of the Fall River, this region was covered by the North American Cretaceous Seaway, which resulted in the accumulation of vast thicknesses of marine sediments. From 3000-5000 feet of these marine sediments are represented by the Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, Niobrara Formation and Pierre Shale. In Late Cretaceous time, the modern Rocky Mountain Uplift began, forcing the retreat of the Cretaceous seaway.

Unconformably overlying the Cretaceous sediments in the Black Hills region is the Tertiary-age (Oligocene) tuffaceous White River Formation. This thick, tuffaceous sequence was the result of volcanic eruptions to the west and was rich in volcanic fragments. The White River sediments have primarily been removed by erosion and can be found only as erosional remnants. This unit is thought to be the source of the uranium deposits found in the Black Hills region and the Powder River Basin of Wyoming.

The most recent sediments in the region are Quaternary-age deposits consisting of local material derived as a result of post-Laramide-uplift erosion. Recent deposits include alluvium and floodplain terrace deposits.

Refer back to Figure 2.2-3 for a stratigraphic column of the Black Hills.

2.6.2 Site Geology

The site surface geology is shown in Figure 2.6-2. The Fall River Formation outcrops across the eastern part of the project and the Skull Creek Shale, Mowry Shale, and Belle Fourche Shale (collectively referred to as the Graneros Group) outcrop across the western part of the project. The formations dip west and southwest at 2 to 6 degrees.

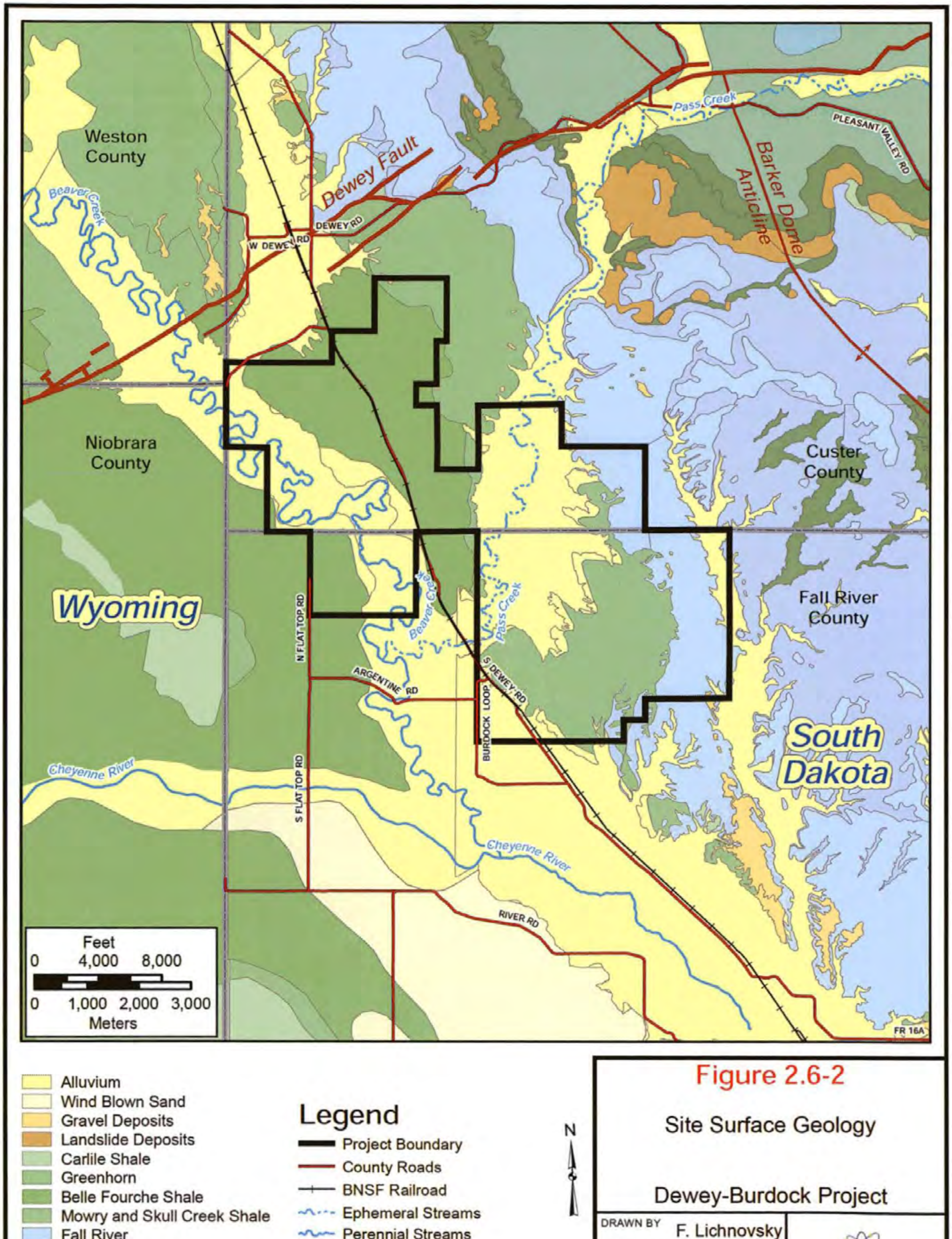


Figure 2.6-2

Site Surface Geology

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
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POWERTECH (USA) INC.

The geology of the project was developed through the interpretation of data gathered from thousands of exploration drill holes. For each drill hole there was a suite of down-hole electric logs run to characterize natural radioactivity and the lithology (rock type) of the sediments in the subsurface. Resistivity and Self Potential provide the rock types encountered in the subsurface (sandstone, siltstone, shale, etc.). This is further enhanced by a geologist's description of the drill cuttings. Figure 2.6-2a is an example of a "type log" from the project.

This log is a single, good quality drill hole log, with the purpose of presenting the overall, general stratigraphy and the relative position of stacked ore bodies (roll fronts) within the entire Dewey-Burdock project area. This log does not precisely represent the stratigraphy within all potential well fields across the project. The three major confining units (Graneros Group, or upper confining layer, Fuson Member, and Morrison Formation, or lower confining layer) are depicted on the log in their typical relationship to the host sands which are in the Fall River and Lakota Formations. Figure 2.6-2a clearly shows that there are no ore bodies within the Fuson Shale. The Fuson Shale is a confining unit, and uranium recovery will not and cannot occur within this unit.

2.6.2.1 Site Structure

The structure across the project is simple and shows sediments dipping gently 2 to 6 degrees to the southwest. This is illustrated by structure contour maps on the tops of the Unkpapa Sandstone (Plate 2.6-1), the Morrison Formation (Plates 2.6-2 and 2.6-2a), the Chilson Member of the Lakota Formation (Plates 2.6-3, 2.6-3a and 2.6-3b), the Fuson Shale (Plates 2.6-4 and 2.6-4a), and the Fall River Formation (Plate 2.6-5). Isopach maps are also provided for the Morrison Formation (Plates 2.6-6), Chilson Member (Plate 2.6-7 and 2.6-7a), Fuson Shale (Plate 2.6-8), Fall River Formation (Plates 2.6-9 and 2.6-9a), Graneros Group (Plate 2.6-10) and Alluvium (Plate 2.6-11).

The Dewey Fault, a northeast to southwest trending fault zone, is present approximately one mile north of the north and northwest parts of the PA. The Dewey Fault is a steeply dipping to vertical normal fault with the north side uplifted approximately 500 feet by a combination of displacement and drag. The USGS considers an area 7 miles southeast of the project as the Long Mountain Structural Zone. This northeast – southwest trend contains several small shallow surface faults in the Inyan Kara. No faults show up along this trend on subsurface structure maps of the underlying Madison Formation, Minnelusa Formation or the Deadwood Formation. Despite the presence of faulting north and south of the site, there are no identified faults within the Dewy-Burdock PA.

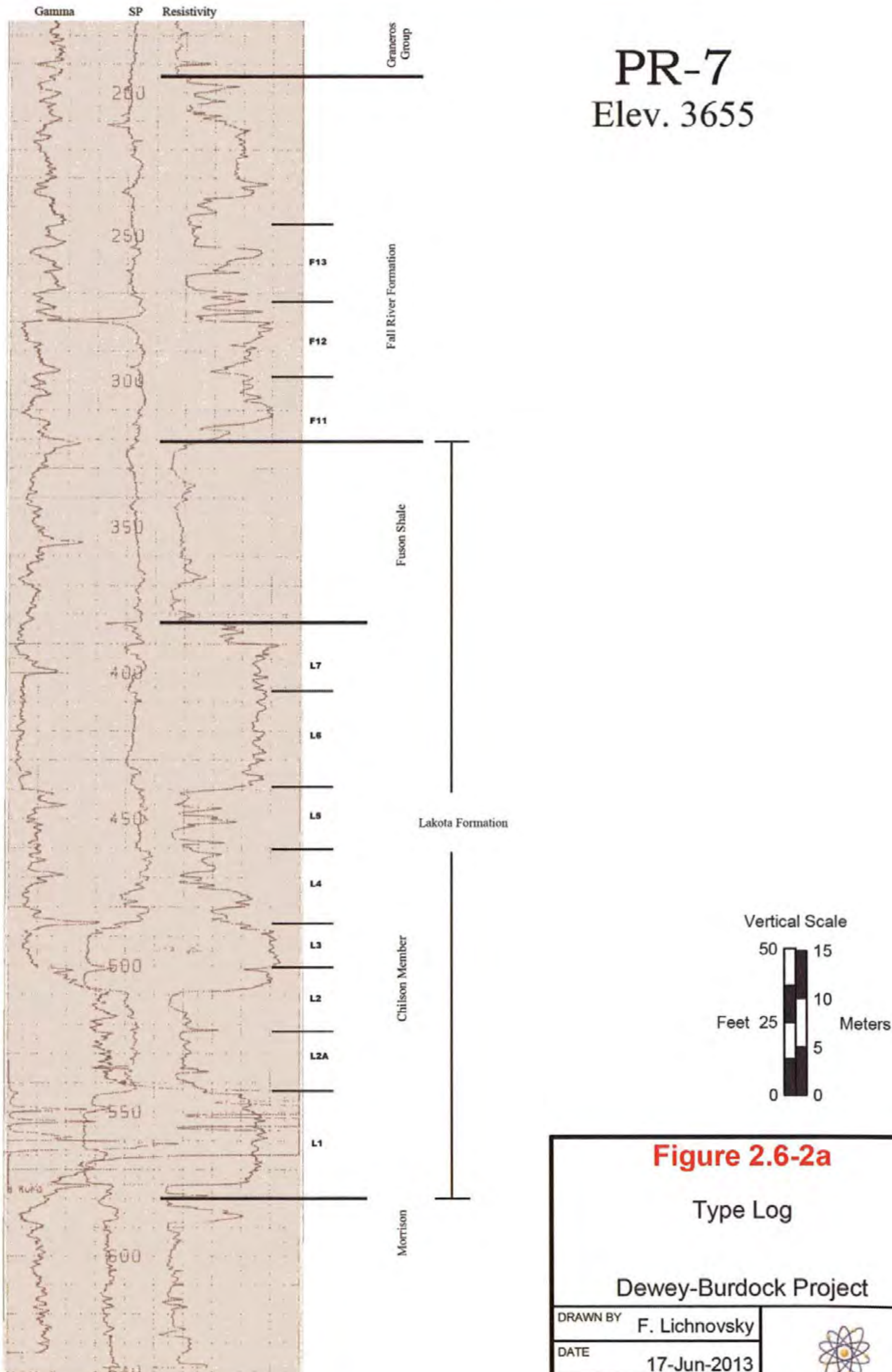

Figure 2.6-2a

Type Log

Dewey-Burdock Project

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There is some folding in the areas surrounding the project. East of the project is a northwest – southeast trending anticline that ends in a closed structure called the Barker Dome. To the west is the Fanny Peak Monocline. This monocline is the structural boundary between the Black Hills and the Powder River Basin.

2.6.2.2 Site Stratigraphy

The sedimentary rocks of primary interest that underlie the project range in age from Upper Jurassic to Early Cretaceous. The Upper Jurassic Morrison Formation is considered to be the Lowermost Confining Unit for the project. The uranium mineralization is contained within the Inyan Kara Group (specifically within the Fall River Formation and Chilson Member of the Lakota Formation). The Graneros Group is the Uppermost Confining Unit. Figure 2.6-2a is a type log for the PA, illustrating the relationship between these sedimentary units. Figure 2.2-3 demonstrates the relationship between these sedimentary units and underlying rocks, ranging in age from Jurassic to Precambrian.

The following is a brief description of the formations of interest at the project site:

Sundance Formation and Unkpapa Sandstone - The Sundance Formation is composed primarily of shale and sandstone with an average thickness of 280 feet thick near the project site. Where present, the Unkpapa Sandstone is 50 to 80 feet of well sorted, fine-grained, eolian sandstone.

Morrison Formation - The Upper Jurassic Morrison Formation was deposited as flood plain deposits. It is composed of waxy, unctuous, calcareous, noncarbonaceous massive shale with numerous limestone lenses and a few thin fine grained sandstones. Below the site, this formation has an average thickness of approximately 100 feet and is the Lower Confining Unit for the project. The confining properties of the Morrison Formation are well documented. An article entitled "Clay Mineralogy of the Morrison Formation – Black Hills Area," published in the Bulletin of the American Association of Petroleum Geologists, Vol. 40, No. 5, by Ronald Warren Tank (1956), provides an excellent description of Morrison clays in this area. The Morrison Formation is an extensive, low-permeability, terrestrial clay unit, with illite being the dominant clay mineral. Illite is a stable clay mineral that is usually deposited in fairly stagnant waters in an alkaline pH. Further, analyses of Morrison Formation core by Powertech (USA) indicate very small vertical permeabilities ranging from 0.012 to 0.043 millidarcies. The continuity, thickness, and lithology of the Morrison Formation ensure hydraulic isolation of the overlying Chilson sandstones.

Exploration holes drilled to evaluate the economic geology of the Lakota Formation were generally not continued the additional 100 feet required to penetrate the entire Morrison Formation. Powertech (USA) drilled eight holes that penetrated through the Morrison Formation, and records indicate that 16 historical TVA exploration holes penetrated the entire Morrison Formation. Two electric logs from plugged and abandoned oil test holes in the project area are also available to assist with evaluation of the Morrison Formation. Table 2.6-1a provides a listing of these 26 identified Morrison Formation penetrations.

Plate 2.6-2 is a structure contour map of the top of the Morrison Formation. This map was developed in response to an NRC staff request for information on holes that penetrated into the Morrison Formation. This structure map shows the Morrison Formation generally dipping 2½ degrees to the southwest – away from the southwestern flank of the Black Hills Uplift. As shown on this plate, the irregular contour lines in the Dewey and Burdock areas may indicate some minor scouring into the top of the Morrison Formation and subsequent deposition of the Lower Chilson sands. This minor scouring has not cut deeply into the Morrison clays, and the overall 60- to 140-foot thickness of this formation has not been significantly affected.

A good understanding of the Morrison Formation is important to the Dewey-Burdock Project. For this reason, in addition to providing the structure contour map of the Morrison Formation, Plate 2.6-6 provides an isopach map of the Morrison Formation. This map was based on the 26 drill holes that fully penetrated the Morrison Formation and shows the thickness of the Morrison varying from approximately 60 to 140 feet beneath the project area. Also shown on this isopach map is the location of cross section A-A'-A".

Plate 2.6-13 shows geologic cross section A-A'-A", which depicts the surface to the base of the Morrison Formation based on 10 of the drill holes used in the development of the isopach map. The electric logs shown on this cross section illustrate a consistent thick sequence of Morrison clays across the project area. Copies of all electric logs from test holes that penetrate the Morrison Formation are contained in Appendix 2.6-H of the approved license application. The A–A' portion of the cross section traverses the project in an "updip" direction through the initial proposed well field in the Dewey area. Due to the 2½ degree dip, the Fall River Formation is shown to rise from a depth of 550 feet below ground surface in the Dewey area to outcrop along the eastern edge of the project area near A' (drill hole DB08-1-7). The A'-A" portion of the cross section proceeds in a "downdip" direction from the outcrop and continues through the initial proposed well field in the Burdock area.

Table 2.6-1a: Drill Holes Penetrating the Morrison Formation

	Hole No.	Easting (ft)	Northing (ft)	Elevation (ft amsl)
1.	CAT1	1028330	444666	3738
2.	DRJ90	1037602	438720	3762
3.	FBR31	1038131	433097	3800
4.	RONA81	1033459	429385	3688
5.	PM159	1032551	433100	3651
6.	DWT48	1025864	444053	3702
7.	DWT49	1025235	442634	3661
8.	ELT14	1017626	444849	3617
9.	DWT40	1022610	445875	3681
10.	DWW190	1032799	450521	3760
11.	DWW192	1033149	450479	3740
12.	DY12	1025946	450088	3820
13.	DY17	1027335	455821	3818
14.	DY308	1012901	445124	3616
15.	HDA1	1028537	448585	3780
16.	TRM38	1035605	441152	3749
17.	DB07-11-31	1038312	429998	3731
18.	DB07-11-16C	1035139	429992	3698
19.	DB08-11-18	1035133	429986	3700
20.	DB08-32-12	1022352	439368	3590
21.	DB08-32-11	1020339	443666	3627
22.	DB08-5-1	1017626	444849	3629
23.	DB08-1-7	1042271	434137	3913
24.	DB09-21-1	1028628	453319	3822
25.	API 40 047 05095	1038166	433840	3792
26.	API 40 047 05093	1032429	423452	3576

Note: Coordinate system is NAD 27 South Dakota State Plane South

Cross section A-A'-A" also illustrates the presence of the project's uppermost confining unit (the Graneros Group) and the Fuson Shale confining unit between the Fall River Formation and the Chilson Member of the Lakota Formation. The thickness of the Graneros Group ranges from 0 feet at its outcrop within the eastern portion of the project area to over 550 feet in the southwestern portion of the project area. The Fuson Shale ranges from 20 to 80 feet thick throughout the project area.

Inyan Kara Group – This Group consists of the Lakota Formation and the Fall River Formation. Sandstones within these two formations are hosts to all the uranium mineralization for the project.

Lakota Formation - The Lakota Formation consists of three members; from lower to upper they are the Chilson Member, the Minnewaste Limestone Member and the Fuson Member.

Although present regionally, the Minnewaste Limestone Member of the Lakota Formation is not present within the Dewey-Burdock project area. Darton (1909) noted that the Minnewaste Limestone is some 20 feet thick at its type locality at the falls of the Cheyenne River (25 miles east of the project area, now under Angostura Reservoir). In USGS Professional Paper 763 (Gott et al., 1974), the Minnewaste Limestone is described in the type locality as being a pure limestone, but grading out laterally to a sandy limestone and to a calcareous sandstone at its margins. Gott et al. also state that it is discontinuous west and northwest of the type locality (toward the Dewey-Burdock project area).

A review of all drill hole and geologic lithology logs shows the Minnewaste Limestone does not occur within the project area. Geologic cross section E-E' (Plate 2.6-12e), along the northeastern portion of the project area, illustrates the geologic section where, if present, the Minnewaste Limestone would occur. If present, this limestone unit would occur immediately beneath the Fuson Shale confining unit and above the Chilson Member of the Lakota Formation. A limestone would have a characteristically high (off-scale) response on the resistivity curve on the electric logs. As shown on cross section E-E' (Plate 2.6-12e), no limestone is present.

The Chilson Member (commonly referred to as the Lakota Sandstone) is composed largely of fluvial deposits. These deposits consist of sandstone, shale, siltstone, and shale. The member consists of a complex of channel sandstone deposits and their laterally fine-grained equivalents. The Chilson Member consists of two units; a basal carbonaceous black mudstone and an overlying unit of channel sandstones with laterally fine-grained equivalents and interbedded shales. The sandstones are very fine to medium-grained and well sorted and were deposited by a northwest flowing river system. Analyses of core samples of these sandstones indicate these units exhibit high horizontal permeabilities, ranging from 2.6×10^{-3} cm/sec to 4.1×10^{-3} cm/sec (2697 millidarcies to 4161 millidarcies). The massive sandstone is made up of numerous individual sand filled channels, which contain the uranium deposits.

The isopach map of the Chilson Member of the Lakota Formation shows the thickness of the channel sandstones and interbedded shales within the Chilson Member. Thicknesses vary from 100 to 240 feet. This isopach map may not adequately show the total thickness of the Chilson Member because drilling usually did not penetrate its entire extent. Drilling was usually stopped in the lower carbonaceous shale unit of the Chilson Member and did not reach the Morrison Formation. (Plates 2.6-7 and 2.6-7a).

The Fuson Member is the upper most member of the Lakota Formation and the shale-siltstone portion of the Fuson has been used to divide the Lakota Formation from the Fall River Formation.

For clarification, the Fuson Shale is differentiated from the Fuson Member of the Lakota Formation by Powertech (USA) for the purpose of characterizing the site geology. The Fuson Shale has been mapped by Powertech (USA) and consists of 20 to 80 feet of low-permeability shales and clays, which generally occur at or near the base of the unit. The Fuson Member of the Lakota, in comparison, has been mapped by the USGS and others to be from 40 to 80 feet thick and consisting of interbedded fluvial shales, clays, mudstones, and sands.

The Fuson Member is described as having a lower discontinuous sandstone unit at its base and an upper discontinuous sandstone at the top of the member. If present the lower sandstone unit was mapped as Lakota sandstone. Similarly if the upper sandstone was present it was mapped as Fall River sandstone. The isopach map of the Fuson Shale shows the thickness of the shale – siltstone unit ranging from 20 to 80 feet (Plate 2.6-8). It shows thinning of the shale under the overlying channel sandstones of the Fall River Formation.

The shales and mudstones within the Fuson Shale are highly stratified and anisotropic. Due to the highly stratified nature of the interbedded shales and mudstones, the vertical permeability is estimated to be several orders of magnitude smaller than the horizontal permeability. Estimates of vertical hydraulic conductivity of the Fuson Shale developed from pumping tests conducted in the Fall River and Chilson near Burdock in 1979 range from 1×10^{-7} to 4.6×10^{-8} cm/s (Boggs and Jenkins, 1980). Further, analyses of core samples of these lithologies demonstrate low vertical permeabilities, ranging from 7.8×10^{-9} cm/sec to 2.2×10^{-7} cm/sec (0.008 millidarcies to 0.228 millidarcies). Detailed pump tests to be conducted after license issuance as a part of the well field hydrogeologic packages will provide additional quantification of the low hydraulic conductivity of the confining units (see Section 3.1.3.2).

The Fuson Member, being of fluvial origin, locally contains sand deposits (Schnabel and Charlesworth, 1963). The presence of the sand facies within the Fuson Member does not diminish the confining capacity of the Fuson Shale within the Fuson Member as defined and mapped by Powertech (USA). The geologic map of the Burdock quadrangle (Schnabel and Charlesworth, 1963) indicates that the Fuson Shale may pinch out in some areas. In particular, the interpretive fence diagram presented by Schnabel and Charlesworth shows an area approximately 1½ miles east and northeast of the project area, across Bennett Canyon, in the E/2

Section 30, T6S, R2E, where the Fuson Member pinches out. However, based on Powertech (USA)'s borehole logs no evidence of Fuson Shale pinch-out locations has been identified within the project area. The Fuson Shale is clearly continuous with a thickness of more than 20 feet across the entire project area.

Based on Powertech (USA)'s borehole and geophysical logs for more than 3,000 exploratory holes, the Fuson Shale is continuous and no less than 20 feet thick throughout the entire project area. A database providing the information to generate the Fuson Shale isopach (Plate 2.6-8) was provided to the NRC staff on November 4, 2010 in response to a request for clarification by NRC staff. The pervasive occurrence and continuity of the Fuson Shale throughout the project area is shown on the revised geologic cross sections (Plates 2.6-12a through 12h and 12j).

Fall River Formation - The Fall River formation is composed of carbonaceous interbedded siltstone and sandstone, channel sandstones, and a sequence of interbedded sandstone and shale. The lower part of the Fall River consists of dark carbonaceous siltstone interbedded with thin laminations of fine-grained sandstone. Channels were cut into this interbedded sequence by northwest flowing rivers and fluvial sandstones were deposited. These channel sandstones occur across various parts of the project and generally contain the uranium deposits. Overlying the channel sandstones is another sequence of alternating sandstone and shales. The sandstones are cross-bedded to massive, fine to medium-grained, and well-sorted.

The isopach map of the Fall River Formation shows a range of thickness of 120 to 160 feet. The thickening of the formation indicates the presence channel sandstones. Along the northeastern portion of the PA, this formation is exposed on the surface and erosion has taken place (Plate 2.6-9).

Skull Creek Shale - The Skull Creek Shale directly overlies the Fall River Formation and consists of dark-grey to black shale, organic material, and some silt sized quartz grains. The Skull Creek Shale has a thickness of approximately 200 feet and is part of the Graneros Group, which is the Uppermost Confining Unit for the project. Analyses of 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 Skull Creek Shale is eroded from the eastern parts of the project.

Mowry Shale – At the project the Skull Creek Shale is directly overlain by the Mowry shale, also considered to be part of the Graneros Group, which is the Uppermost Confining Unit. When present the Newcastle Sandstone is stratigraphically located between the Skull Creek Shale and the Mowry Shale. There is no Newcastle Sandstone on the surface or in the subsurface within the Dewey-Burdock project area. Figure 2.2-3 shows the regional presence of this unit. While the Newcastle Sandstone is present within the Graneros Group regionally, there are areas, including the Dewey-Burdock project area, where it is absent. As shown on Figure 2.2-3, the Newcastle Sandstone is equivalent to the Muddy Sandstone, which is a prolific oil producer in much of Wyoming and Colorado. Because the Muddy Sandstone (or its equivalent) has been the target of extensive oil & gas exploratory drilling, its regional presence (or absence) in the subsurface has been well delineated. Drilling on the Dewey-Burdock project area has encountered no Newcastle Sandstone. Geologic cross sections H-H' and J-J' (Plates 2.6-12h and 2.6-12j) illustrate the geologic sections where, if present, the Newcastle Sandstone would occur. On these sections, a 400-foot thickness of low-permeability Graneros Group shale is shown overlying the Fall River Formation. The lower 200 feet of the Graneros Group is made up of the Skull Creek Shale. If present, the Newcastle Sandstone would immediately overlie this shale unit. However, as shown on the cross sections, there is no sandstone in this interval; instead, the Mowry Shale overlies the Skull Creek Shale. The Mowry Shale consists of light gray marine shale with minor amounts of siltstone, fine grained sandstone, and a few thin beds of bentonite. Dark-gray to purple and black iron and manganese concretionary zones are common within the shale. The combined Graneros Group (Skull Creek, Mowry and Belle Fourche shales) reaches a thickness of over 500 feet in the western part of the project area. Plate 2.6-10 is an isopach map showing the combined thickness of the Graneros Group. In the northeastern portion of the PA, these units crop out and have been eroded.

Terrace Deposits - Along the sides of drainages are relatively flat terrace deposits representing floodplains and former levels of streams. The terraces are primarily overbank deposits of clay and silt with gravel beds. Gravel deposits consist of boulders and pebbles of chert, sandstone, and limestone.

Alluvium - The most recent sedimentary units deposited within the PA are the Quaternary age alluvium deposits. Alluvium is present in the major drainages and their tributaries. The alluvium consists of silt, clay, sand and gravel. An isopach of the alluvium is presented as Plate 2.6-11.

2.6.2.2.1 Site Stratigraphy of the Initial Dewey and Burdock Well Fields

Following is a description of the geologic and hydrologic characterization of the initial Dewey and Burdock well fields. It should be noted that much more detailed geologic and hydrologic characterization and well field design will be included in well field hydrogeologic data packages after license issuance but prior to commencement of any ISR operations. As described in Section 3.1.3.1.1, delineation drilling will be undertaken to further characterize the zones of mineralization and to identify the interbedded sand and clay intervals. Design of the injection and recovery well pattern for each well field, and associated monitoring system(s), will take into account the hydrogeology to ensure that production fluids can be contained within the production zone and adequately monitored. As detailed in Section 3.1.3.1.2, ISR operations will be monitored by perimeter monitor wells screened over the entire thickness of the production zone.

In addition to delineation drilling, well field scale pumping tests will be conducted prior to development of each well field to further evaluate the hydraulic characteristics within the production zone and to demonstrate continuity between the production zone and perimeter monitor well ring. Results of any hydrogeologic testing will also be included in the well field data package prior to commencement of any ISR operation.

The Fall River Formation and the Fuson Shale and Chilson Member of the Lakota Formation are of fluvial depositional origin and consist of interbedded channel and overbank deposits. The uranium deposits are associated with channel deposits very similar to those in many other states including Nebraska, Texas, and Wyoming that have been successfully developed for ISR operations.

Geologically, the Fall River Formation is physically and hydraulically separated from the underlying Chilson Member by the Fuson Shale. Similarly, the Chilson Member is physically and hydraulically isolated from the underlying regional aquifers by the Morrison Formation. A structural contour map for the top of the Fuson Shale in the vicinity of Dewey Well Field 1 is provided as Plate 2.6-4a, and a structural contour map of the top of the Morrison Formation is presented in Plate 2.6-2a. These maps are equivalent to structural contour maps for the base of the Fall River and base of the Chilson, respectively. A structure contour map of the Morrison Formation throughout the project area is provided as Plate 2.6-2.

These structure contour maps reflect the attitude and topography of the confining units underlying the Fall River Formation in the Dewey area and the Chilson Member in the Burdock area. In both areas, the confining units are shown to dip gently to the west and southwest, away from the core of the Black Hills Uplift. In the Dewey area, the structure contour map also may reflect some minor scouring, but cross sections in the area show a consistent 50-foot thickness of Fuson Shale. In the Burdock area, there is a depression on the Morrison structure contour map, but this appears to be related to depositional environment of the Morrison Formation as opposed to later scouring. Cross sections in this area show a consistent 80-foot thickness of Morrison shales.

Plate 2.6-12 is a cross section index map for nine geologic cross sections (Plates 2.6-12a through 2.6-12h and 2.6-12j) covering the project area. In addition to showing the scaled vertical location of each ore body proposed for uranium recovery, the nine cross sections also illustrate the continuity of the Graneros Group, the Fuson Shale and the Morrison Formation, the major confining units, across the entire project area:

1) The Graneros Group is the uppermost confining unit and overlies the Fall River Formation. This marine shale sequence has a maximum thickness of 550 feet in the project area. The Graneros Group is composed of several geologic formations including the Skull Creek, Newcastle (not present in the project area), Mowry and Belle Fourche.
2) The Fuson Member is the confining unit between the Fall River Formation and the Chilson Member of the Lakota Formation. The Fuson Shale is a low-permeability shale unit within the Fuson Member that ranges in thickness from 20 to 80 feet across the entire project area and crops out east of the project boundary.
3) The Morrison Formation is the lowermost confining unit and underlies the Chilson Member of the Lakota Formation. This low-permeability shale unit that ranges in thickness from 60 to 140 feet across the entire project area crops out east of the project boundary.

The nine cross sections of Plates 2.6-12a through 2.6-12h and 2.6-12j also provide detailed lithologic interpretations of the host sandstones within the Fall River Formation and the Chilson Member of the Lakota Formation. These interpretations show that interbedded clay beds are found locally within both the Fall River and Chilson sandstones and may be sufficiently continuous as to further subdivide the Fall River and Chilson into discrete, mappable fluvial sandstone packages (i.e., Upper Fall River, Lower Fall River, Upper Chilson, etc.). It appears that these interbedded clay beds may act as confining units within individual well fields. However, they cannot be considered as regional confining units because they are discontinuous. This will be confirmed through delineation drilling and aquifer pump tests. Potential use of these interbedded clay beds, as they relate to operational fluid control and monitoring, will be addressed in hydrogeologic packages prepared for each well field.

Cross section A-A' (Plate 2.6-12a) illustrates the proposed Burdock Well Field 1. While uranium mineralization can be seen in all three Chilson sand units, this well field is planned to be recovering uranium from the Lower Chilson sand. Exploration hole DB08-11-18 penetrates a 72-foot thick sequence of the Morrison Formation and the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. The thickness of the Fuson Shale ranges from 30 to 60 feet, and the thickness of the uppermost confining unit (the Graneros Group) varies from 30 to 200 feet along this cross section.

Cross sections C-C' (Plate 2.6-12c) and D-D' (Plate 2.6-12d) depict subsurface conditions at potential well fields in the Burdock area immediately east of B-WF1. There are no Fall River ore bodies within this portion of the project area; only Chilson sandstones are targeted. Cross section C-C' (Exhibit 2.7-1c) illustrates the subsurface beneath B-WF2 and B-WF4, which are proposed to target ore bodies within the Middle Chilson sandstone. Although there also is uranium mineralization present in the Upper and Lower Chilson sandstones, to date no ore bodies have been identified in these sand units in this area. The Fuson Shale, which overlies and confines the Chilson sandstones, maintains a thickness of 50 to 60 feet along this cross section.

Cross section D-D' (Plate 2.6-12d) is drawn through the vicinity of potential Burdock well fields B-WF2 and B-WF4. Both well fields target the Middle Chilson sandstone. Also shown is Burdock well field B-WF3 that targets ore bodies within the Upper Chilson sandstone. Overlying the Chilson sandstones in this area is a 50-foot thickness of Fuson Shale. As shown on the cross section, exploration hole RONA-81 fully penetrates the Morrison Formation, which is 85 feet thick at this locale and demonstrates the integrity of the lowermost confining unit in this portion of the project area.

Cross section H-H' (Plate 2.6-12h) is drawn through proposed Dewey Well Field 1. Exploration hole DB08-32-11 penetrates a 97-foot thick sequence of the Morrison Formation and the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. This provides a cross-sectional view of the lowermost confining unit (the Morrison Formation) as well as deeper stratigraphy below the project area. As shown in this cross section, all uranium ore bodies are contained in the Lower Fall River Sand in the F13, F12 and F11 roll fronts. There are over 400 feet of Graneros Group clays overlying the Fall River Formation, and the Fuson Shale maintains an average thickness of 50 feet along the cross section.

Cross section J-J' (Plate 2.6-12j) is drawn through potential Dewey Well Fields 2, 3 & 4. As shown on the cross section, exploration hole DB08-32-11 penetrates a 97-foot thick sequence of the Morrison Formation, the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. The log for this exploration hole provides an excellent cross sectional view of the lowermost confining unit (Morrison Formation) as well as deeper stratigraphy below the Dewey-Burdock site. As shown in this cross section, proposed D-WF2 targets ore bodies in the

Middle Chilson sandstone, proposed D-WF3 addresses resources in the Lower Fall River sandstone and proposed D-WF4 targets ore bodies in the Upper Chilson sandstone. There is not a high density of exploratory drilling in these potential well field areas, and a future delineation drilling program will be implemented to thoroughly delineate resources and to accurately define well field limits. However, this conceptual approach to identifying potential well fields is an important step in visualizing the spatial relationships of host formations and ore bodies to be developed in the future.

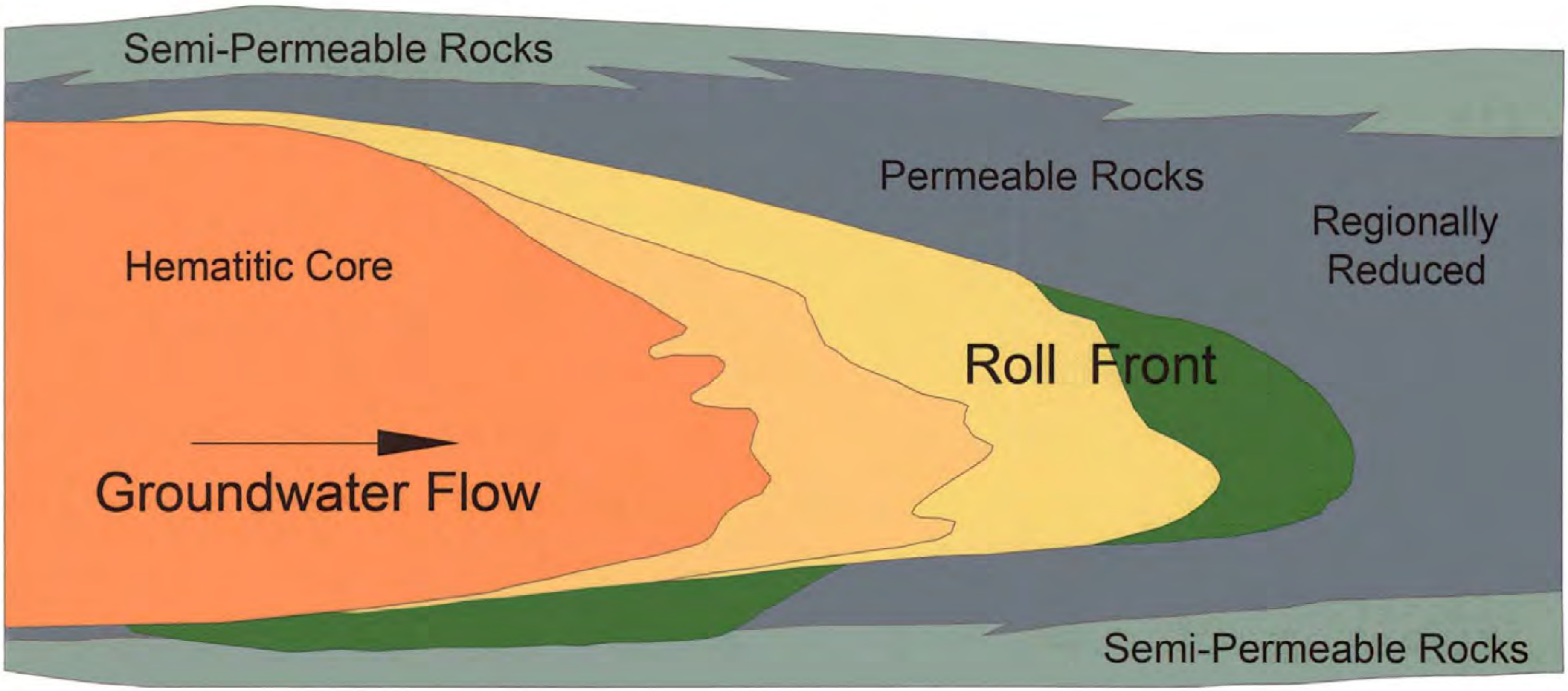
These cross sections show that the major geologic units are continuous throughout the project area, with consistent upper and lower confinement zones. These are virtually ideal conditions for a successful ISR operation, providing optimal control of fluids and minimal opportunity for vertical excursions.

The extent of current potential well fields is based on available drill hole data. Further delineation will take place after license issuance and will be used to prepare detailed well field hydrogeologic data packages for each potential well field.

As described in Section 3.1.3, detailed delineation drilling will be conducted to map smaller changes in the depositional environment which may have a potential to change flow on a smaller scale. Design of the pattern areas for each well field and the associated monitoring system will account for any of these potential flow features to ensure that lixiviant can be contained within the production zone and adequately monitored. Well field pump tests will also be conducted in order to demonstrate communication between production zones and perimeter monitor well rings. All of this mapping, design, and testing information will be included in the well field hydrogeologic packages (see Section 3.1.3.3), which will be prepared for each well field prior to operation.

2.6.3 Ore Mineralogy and Geochemistry

Uranium deposits within the project are classic, sandstone, roll-front type deposits, located along oxidation-reduction boundaries, similar to those in Wyoming, Nebraska and Texas. These type deposits are usually "C" shaped in cross section, with the concave side of the deposit extending up-dip, toward the outcrop. Roll-front deposits are a few tens of feet to 100 or more feet wide and often thousands of feet long. It is generally believed these epigenetic uranium deposits are the result of uranium minerals leached from the surface environment, transported down-gradient by oxygenated groundwater and precipitated in the subsurface upon encountering a reducing environment at depth. These roll-front deposits are centered at and follow the interface of naturally occurring chemical boundaries between oxidized and reduced sands (See Figure 2.6-2b). Roll-



Hematite	Alteration Envelope	Ore Stage Uranium	Ore-Stage Pyrite	Reduced Sandstone
Hematite Magnitite	Siderite Sulfur-S Ferroselite Goethite	Uraninite Pyrite FeS Selenium Ilsmannite	Molybdenite Pyrite Jordisite Calcite	Pyrite Jordisite Calcite

Source: DeVoto (1978).

Figure 2.6-2b

Conceptual Model of Uranium Roll Front Deposit

Dewey-Burdock Project

DRAWN BY Lichnovsky, Bonner
DATE 30-Oct-2013
FILENAME DeVotoRollFrontConcept.dwg

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front deposits similar to those in the Dewey-Burdock project area are generally described in the ISR GEIS, NUREG-1910, Section 2.1.2.

Within the project area, roll-front deposits occur at depths of less than 100 feet in the outcrop area of the Fall River Formation and at depths of up to 800 feet in sands of the Chilson Member of the Lakota Formation in the northwestern part of the project area. The mineralized sandstones are typically fine to medium grained quartz sands that are moderately to very well sorted and show subangular to subrounded grain angularity. Scattered pyrite concretions up to 1" in diameter are sometimes present as are very thin carbonaceous stringers and very well cemented calcite zones. The average thickness of this mineralization is 4.6 feet and the average grade is 0.21 percent U_3O_8 in the project area.

There is a geochemical "footprint" associated with these uranium roll-front systems, consisting of 1) a reduced zone, 2) an oxidized zone, and 3) an ore zone. The following is a geological and geochemical description of each of these zones for uranium deposits within the Dewey-Burdock project area. Information included in this description was obtained from a 1971 petrographic study of core from the Dewey portion of the project area by Homestake-Wyoming Partners utilizing microscopic, thin section, polished section, X-ray powder diffraction and spectrographic analyses (Honea, 1971).

> **Reduced Zone** – This zone represents the original character of the Inyan Kara sediments, unaffected by any mineralizing events. Today, it is the unaltered portion of the system, ahead of or down-gradient of the roll front. Reduced sandstones are grey in color, pyritic and/or carbonaceous. Organic material consists of carbonized wood fragments and interstitial humates. Pyrite is abundant within the host sandstones and present as very small cubic crystals or as very fine grained aggregates. Marcasite is also present as nodular masses in the sandstones. This disseminated pyrite resulted from replacement of original iron (magnetite or similar minerals) and organic material. This early-stage pyrite precipitation contains trace amounts of transition metals (Cu, Ni, Zn, Mo and Se) and resulted from either biogenic (bacterial) or inorganic reduction of groundwater sulfate. Plagioclase and potassium feldspar clasts are fresh and, with the exception of localized areas of calcite cementing, calcite is sparse -averaging only 0.15%. A heavy mineral suite (ranging from trace to 3%) of tourmaline, ilmenite, apatite, zircon and garnet is typical of those found in mature, siliceous sandstones.
>
> **Oxidized Zone** – This portion of the system, behind or upgradient of the roll front, is characterized by the presence of iron oxides resulting in a brown, pink, orange or red staining of host sandstones. The oxidized zone marks the progression of the down-gradient movement of mineralizing solutions through the host sandstones. Within the oxidized zone, original iron has been altered and is present as hematite or goethite as grain coatings,

clastic particles or as pseudomorphs after original pyrite. Goethite is considered to be metastable and is found near the oxidation/reduction boundary, while the more stable hematite is found greater distances upgradient from the roll front. The heavy mineral leucoxene – a white titanium oxide – is also present as a pseudomorph of ilmenite. All organic material has been destroyed in the oxidized zone, where quartz particles show solution or etching effects and feldspars have been replaced with clays.

In the oxidation process of the original pyrite, it is believed the transition metals (Cu, Ni, Zn, Mo and Se) were liberated and incorporated into the mineralizing solution. This solution was slightly alkaline, initially having a positive oxidation potential. Uranium was in solution as the anionic uranyl dicarbonate complex. Other metals associated with uranium were also carried in anionic complexes. Within the project area, the oxidized zone in Inyan Kara sands has been mapped over a lateral distance of 15 miles and found to extend up to 4-5 miles down-dip from the outcrop.

Ore Zone – This portion of the system is located at the oxidation/reduction boundary where metals were precipitated when mineralizing solutions encountered a steep Eh (oxidation/reduction potential) gradient and a strongly negative oxidation potential. Sandstones in this zone are greenish-black, black, or dark grey in color. The primary uranium minerals are uraninite and coffinite, which occur interstitial to and coating sand grains and as intergrowths with montroseite (VO(OH)) and pyrite. Other vanadium minerals (haggite and doloresite) are found adjacent to the uranium mineralization, extending up to 500 feet into the oxidized portion of the system. Overall, the V:U ratios can be as high as 1.5:1. The high concentrations of uranium and vanadium within the ore zone indicate the original source of these metals was external to the Inyan Kara sediments.

Transition metals were also precipitated at or adjacent to the oxidation/reduction boundary. Native arsenic and selenium are found adjacent to the uranium, in the oxidized portion of the front - filling pore spaces between quartz grains. Molybdenum is found as jordisite adjacent to the uranium on the reduced portion of the front. The relatively low concentrations of transition metals indicate their source could have been internal to the Inyan Kara sediments rather than having been introduced from overlying tuffaceous material which is believed to be the source of the uranium and vanadium.

Late stage deposition of calcite and pyrite also appear to be part of the ore-forming process. Filling of pore spaces by nodular and concretionary calcite is found with the uranium mineralization and extending out into the reduced portion of the front. It is believed that uranium was transported as a uranyl dicarbonate complex and carbonate deposition took place along with the precipitation of uranium. Late stage, coarse grained, nodular or concretionary pyrite is also found associated with uranium ore and adjacent to the uranium in the reduced portion of the front.

2.6.4 Historic Oil and Gas and Uranium Exploration Activities

2.6.4.1 Historic Oil and Gas Exploration Activities

No former or actively producing oil and gas wells exist within the project boundary or within two kilometers of the boundary. Within this overall area, the locations of 13 plugged and abandoned oil test wells have been identified, 3 of which are within the project area. The locations of these abandoned test wells are depicted on Figure 2.6-2c.

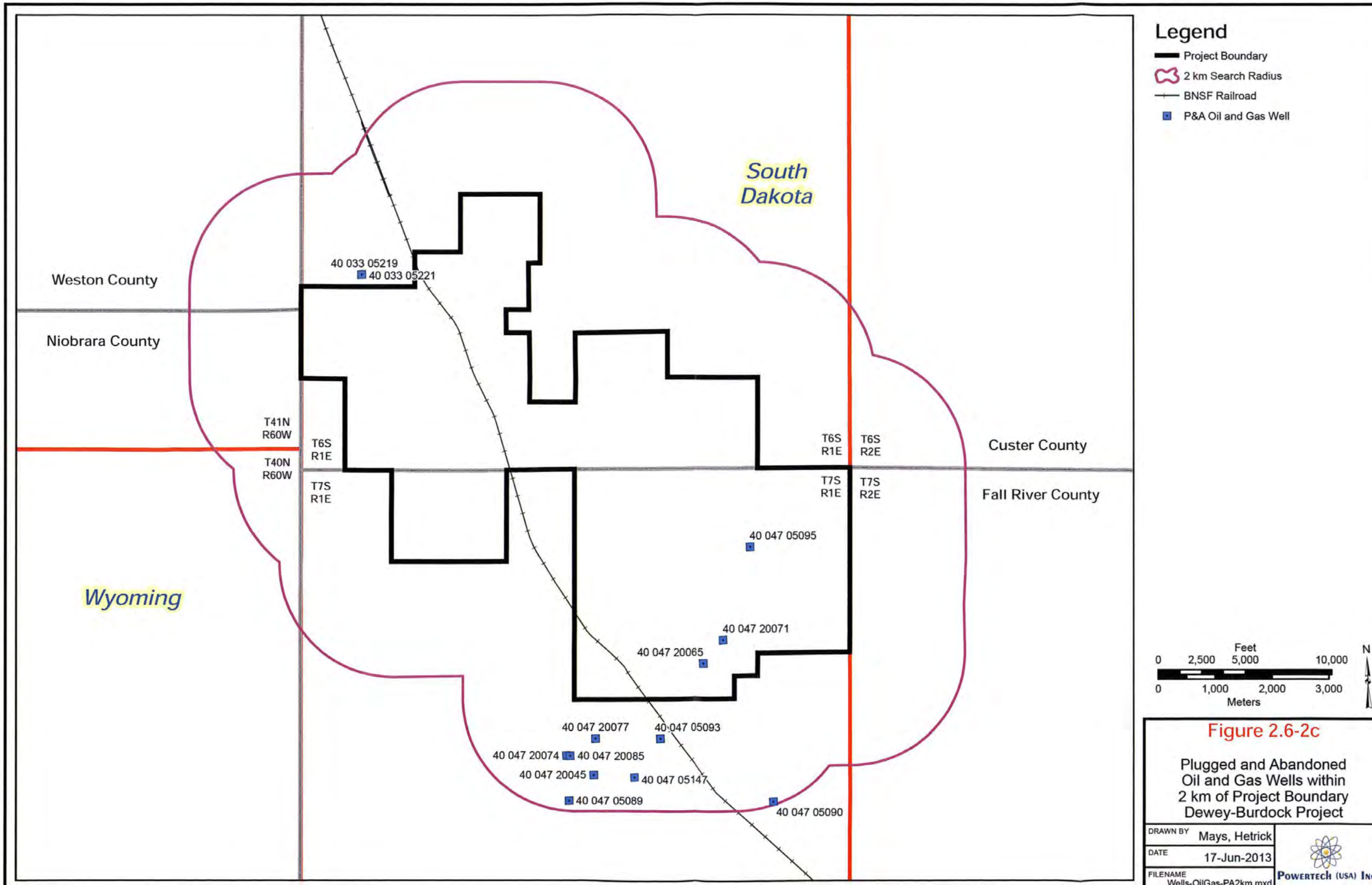
2.6.4.2 Historic Uranium Exploration Activities

Uranium was first discovered in the Edgemont District in 1952 by professors from the SDSMT. They mined about 500 pounds of ore and hauled it to Grand Junction, Colorado. The Atomic Energy Commission (AEC) announcement of a new district at Edgemont led to a boom of stacking, mining, and dealing in the summer of 1952. By 1953 the AEC had built a buying station in Edgemont. In July 1956 a 250-ton per-day mill went on stream and soon expanded to a 500-ton-per-day. In 1960 a vanadium circuit was added. Production from the Edgemont District (open pits in the Fall River), some mines in the Powder River basin and several mines in the Northern Black Hills continued until 1972. Susquehanna Western Inc. (SWI) bought the Edgemont mill and took control of the mines in the Edgemont District. Until the late 1960's early 1970's they were the only company active in the Edgemont District.

In 1967, Homestake Mining Company began exploration in the Dewey area. In 1974, Wyoming Mineral Corporation (Westinghouse) acquired the Dewey properties from Homestake. In 1974, TVA bought out the mill and mines from SWI. The mill was shut down, but exploration continued. Besides WMC and TVA, other companies exploring in the district were Union Carbide, Federal Resources, and Kerr McGee. TVA acquired the Dewey Project from WMC in 1978 and continued exploration until 1986. In total, over 4000 exploration drill holes were completed on this project.

In 1981 TVA completed a mine feasibility study on the project deposits. A DES was prepared by TVA to address the potential impacts of a proposed underground mine in the PA, but the NEPA process was never completed by TVA. Due to falling uranium prices the project leases were allowed to expire. In 1994 EFN acquired the mineral interests within the PA. Their intention was to mine the uranium deposits by ISL. EFN did no additional exploration drilling on the project. In 2000 the leases were dropped.

In 2005, Powertech (USA) acquired the property, consisting of approximately 10,580 acres. Since the spring of 2007, Powertech (USA) has drilled approximately 115 exploration holes, including 20 monitoring wells on the project. Both the historic and recent drill holes have helped to generate the geologic model and delineate the extent of the mineralized sands. Figure 2.6-3 is a map showing the location of all known drill holes. Appendix 2.6-A of the approved license application includes a table summarizing all historical exploration drilling.


Legend
Project Boundary
2 km Search Radius
BNSF Railroad
P&A Oil and Gas Well
South Dakota
Wyoming
Weston County
Niobrara County
Custer County
Fall River County
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
40 033 05219
40 033 05221
40 047 05095
40 047 20071
40 047 20065
40 047 20077
40 047 05093
40 047 20074
40 047 20085
40 047 20045
40 047 05147
40 047 05089
40 047 05090
Feet
0 2,500 5,000 10,000
0 1,000 2,000 3,000
Meters
N
Figure 2.6-2c
Plugged and Abandoned Oil and Gas Wells within 2 km of Project Boundary Dewey-Burdock Project
DRAWN BY Mays, Hetrick
DATE 17-Jun-2013
FILENAME Wells-OilGas-PA2km.mxd
POWERTECH (USA) INC.

There are underground mine workings along the eastern portion of the project area associated with four former, shallow underground uranium mines and two open pit adits. These are depicted on Figure 2.6-3a. All of the underground workings are associated with existing open-pit remnants that are clearly visible in the project area or, in the case of the Triangle mine, have been backfilled and reclaimed. There are no underground mines within the project area that are not associated with, adjacent to, or extensions of, the open pits, all of which are within the upper Fall River Formation. The underground mines consisted of declines (downward sloping ramps) ranging in depth from 0 to 80 feet below land surface. The adits (horizontal tunnels) were driven into the sidewalls of the historic open pit mines. All underground workings were conducted within sandstones of the Fall River Formation at or above the water table and above the Fuson Shale confining unit such that these workings did not penetrate or otherwise compromise the integrity of this confining unit. These workings will not be affected by Powertech (USA)'s ISR operations, since Powertech (USA) will not develop well fields within Fall River Formation sandstones in this portion of the project area (refer to Section 3.1.1.1.1) and the Fuson Shale confining unit is intact and undisturbed. The following discussion provides detailed information on these underground workings.

The first uranium mines in the Edgemont Mining District were developed in the 1950s by prospectors who followed mineralized Fall River outcrops into the subsurface by driving declines into the mineralized sandstones. Susquehanna-Western, Inc. consolidated all mining operations in the district in the late 1950s and operated both underground and surface mines. The locations of historic surface mining operations in the Triangle Mine area and the Darrow Mine area are depicted on Figure 2.6-3a. Susquehanna-Western often drove adits short distances into open pit walls to recover additional uranium ore that was adjacent to but not within the pit boundary. These types of underground workings were common at historic surface mines and were considered to be extensions of the open pit mining operations.

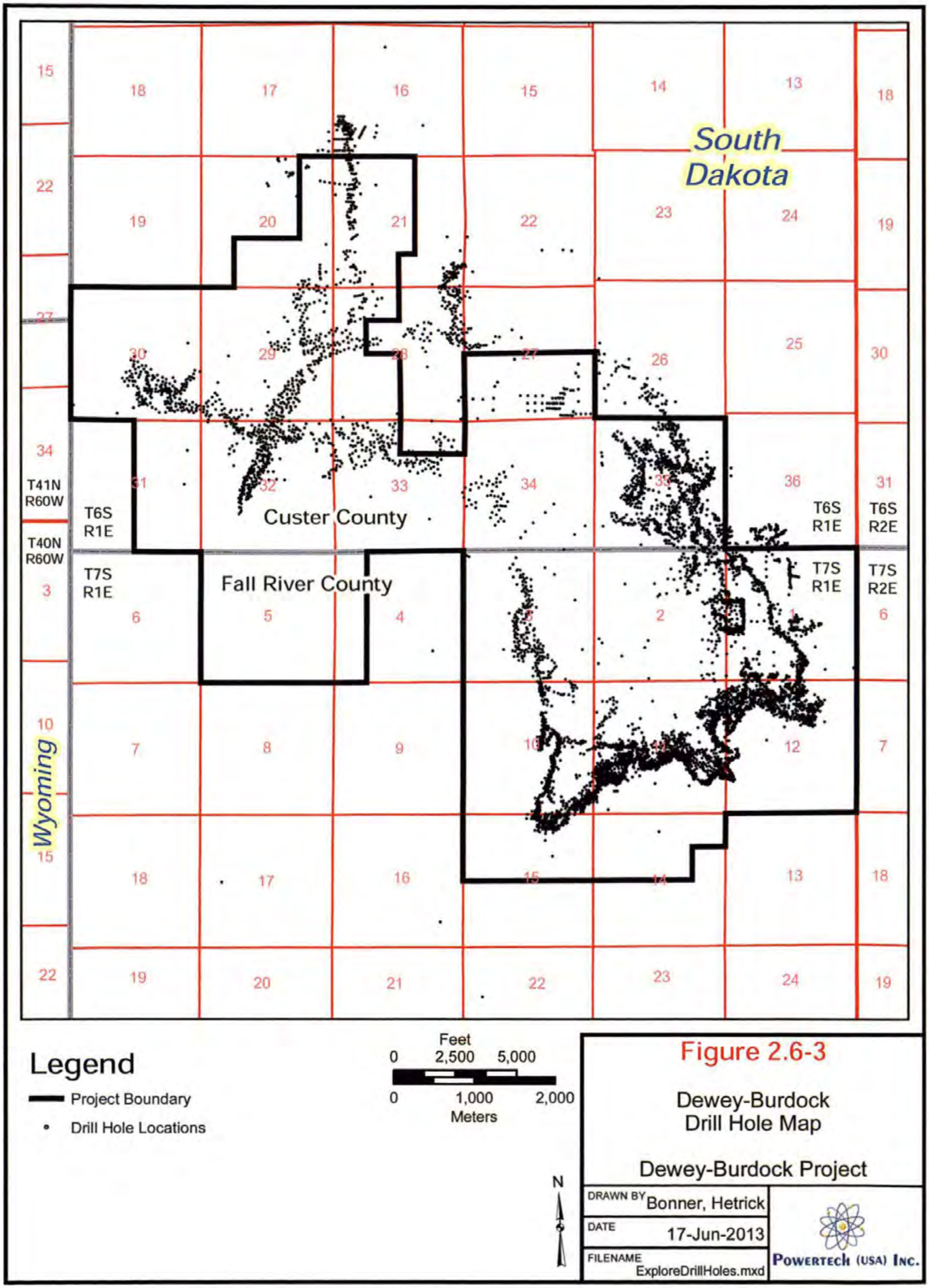
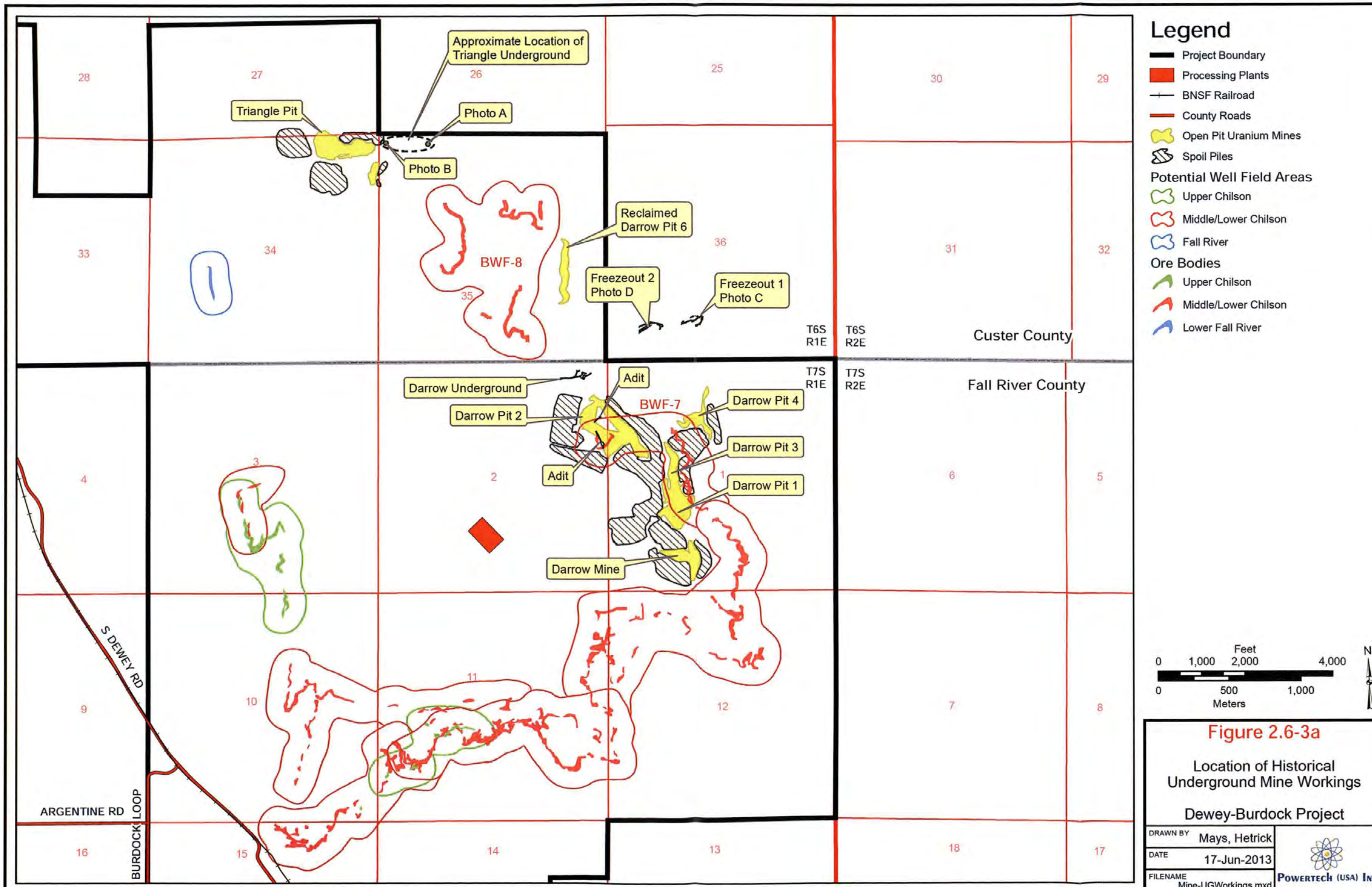


Figure 2.6-3

Dewey-Burdock Drill Hole Map

Dewey-Burdock Project


Legend
Project Boundary
Processing Plants
BNSF Railroad
County Roads
Open Pit Uranium Mines
Spoil Piles
Potential Well Field Areas
Upper Chilson
Middle/Lower Chilson
Fall River
Ore Bodies
Upper Chilson
Middle/Lower Chilson
Lower Fall River
Approximate Location of Triangle Underground
Triangle Pit
Photo A
Photo B
Reclaimed Darrow Pit 6
Freezeout 2 Photo D
Freezeout 1 Photo C
BWF-8
BWF-7
Darrow Underground
Adit
Darrow Pit 2
Darrow Pit 4
Darrow Pit 3
Darrow Pit 1
Darrow Mine
T6S R1E
T6S R2E
T7S R1E
T7S R2E
Custer County
Fall River County
S DEWEY RD
ARGENTINE RD
BURDOCK LOOP
28
27
26
25
30
29
33
34
35
36
31
32
4
3
2
1
6
5
9
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16
15
14
13
18
17
Feet
0
1,000
2,000
4,000
0
500
1,000
Meters
N
Figure 2.6-3a
Location of Historical Underground Mine Workings
Dewey-Burdock Project
DRAWN BY Mays, Hetrick
DATE 17-Jun-2013
FILENAME Mine-UGWorkings.mxd
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Triangle Mine Area

As shown on Figure 2.6-3a, the Triangle Mine was an open pit mining operation along the northeastern border of the project area in the SE/4 Section 34, T6S, R1E. Immediately east of this open pit was the Triangle Underground Mine. Although maps of the Triangle underground workings are not available, Powertech (USA) has obtained a description of this operation through personal communication with Donald Spencer (2011), a local rancher who worked in this underground mine.

Mr. Spencer advised that he worked in the Triangle underground mine in 1957-58. He showed Powertech (USA) personnel the location of the decline that was used to access the mine. The decline is located approximately 1,000 feet southeast and updip of the eastern boundary of the Triangle open pit in the NE/4 Section 35, T6S, R1E (see Photo 2.6-1). All photo locations are depicted on Figure 2.6-3a. As shown in the photo, the haulage road from the decline is still visible, but the entrance to the underground workings has been covered for safety reasons. There were about 1,000 feet of underground workings in the mine. The depth of these workings ranged from outcrop to 70 feet below ground surface. The mineralized sandstone of the Fall River Formation was unsaturated near the ground surface. Approximately 70 feet below the surface, the Fall River sands became saturated, resulting in 2-3 feet of water in the mine, requiring dewatering. Near the end of the underground workings, a vent shaft was installed approximately 400 feet from the eastern highwall of the Triangle open pit to provide air to the underground workings (see Photo 2.6-2). Powertech (USA) measured the depth to the bottom of this vent shaft and found it to be 68 feet below ground surface with approximately 3 feet of groundwater. Mr. Spencer stated that after the Triangle surface mine was completed, an adit was driven into the eastern wall of the pit which recovered additional ore from the mineralized trend. This adit connected the open pit with the abandoned underground workings.

In 1960, Susquehanna-Western began to develop the Triangle surface mine. A description of the mining zone was obtained through personal communication in 2011 with James F. Davis, the Susquehanna-Western geologist who directed the delineation drilling for this mine. He stated a single mineralized front progressed from the underground mine area through the surface mine area in an east-west direction. In the western portion of the surface mine area, the trend abruptly turned to the north and the grade of the mineralization quickly diminished. The Triangle surface mine area is down-dip from the underground workings; therefore, the depth to the mining horizon increased steadily. Mr. Spencer recalls the depth of the Triangle open pit to have been approximately 120 feet below ground surface.

Photo 2.6-1: Former Triangle Underground Mine Decline (Photo A on Figure 2.6-3a)

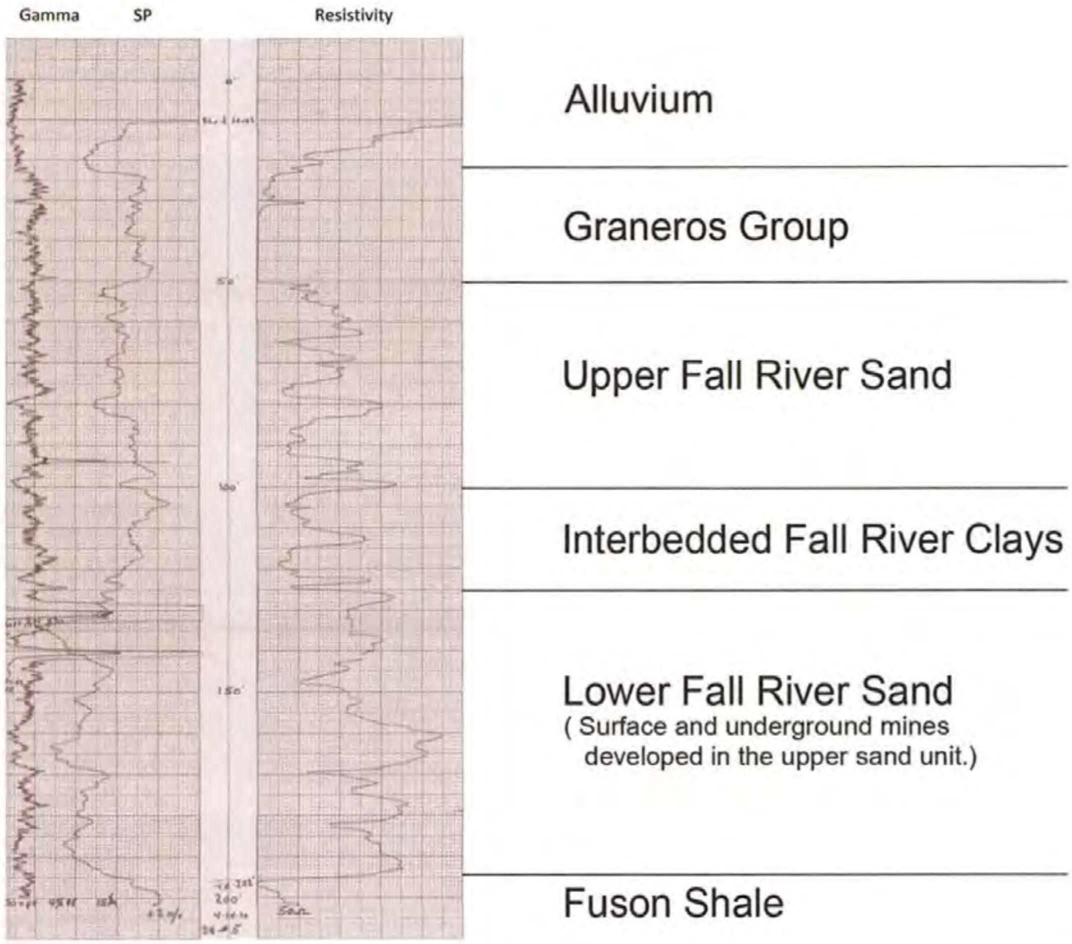
Photo 2.6-2: Triangle Underground Mine Vent Shaft (Photo B on Figure 2.6-3a)

Figure 2.6-3b is an electric log from an historical exploration drill hole located approximately 200 feet north of the mined area. The gamma activity shown in the type log corroborates the portion of the Fall River sand that was mined in the Triangle Mine and its position relative to the Fuson Shale confining unit. The top of the mineralized sand unit in the type log is at a depth of 125 feet below ground surface. The single mineralized front present within this sand unit correlates to Powertech (USA)'s F13 interval, which is the upper mineralized zone within the Lower Fall River sand, the bottom of which is approximately 45 feet above the Fuson Shale. All mining took place well above the Fuson Shale, which averages 50 feet thick in this area. Accordingly, these historic mining operations did nothing to compromise the integrity of the Fuson Shale confining unit.

Darrow Mines Area

Figure 2.6-3a depicts the location of the Darrow Mine surface pits in the eastern portion of the project area. These pits were developed within unsaturated sandstones of the Fall River Formation at depths ranging from 50 to 90 feet below ground surface. As illustrated on Figure 2.6-3a, the Freezeout underground mines were located approximately ½ mile north of the Darrow surface mines. These historic underground mines are outside of the project area in the SW/4 Section 36, T6S, R1E. Freezeout No. 1 and Freezeout No. 2 each have approximately 1,000 feet of underground workings. Plan view maps obtained from TVA show the underground workings at Freezeout No. 1 were accessed by two declines, and access to the workings of Freezeout No. 2 was provided by three declines. Photos 2.6-3 and 2.6-4 show the current condition of the declines for the Freezeout mines. The haulage roads are still visible but the access ways or portals to the underground workings have collapsed or have been covered. Figure 2.6-3c illustrates how these shallow underground mining operations were used to recover ore in this rugged terrain. It is important to note that the workings were above the water table and followed the dip of the mineralized sandstones. Accordingly, these mining operations did not intersect or compromise the integrity of the underlying Fuson Shale confining unit.

Figure 2.6-3a shows the location of the Darrow underground mine, approximately 500 feet northwest of Darrow Pit No. 2, in the NE/4 of Section 2. According to personal communication with Donald Spencer (2011), this underground mining consisted of approximately 1,200 feet of workings within a 250-foot x 700-foot area, which was also accessed by declines. The surface in this area has been reclaimed and all evidence of mining operations has been removed. Figure 2.6-3d is a plan view map of the Darrow underground workings taken from a TVA drill hole map. This map shows the locations of many Susquehanna-Western drill holes and air vents for



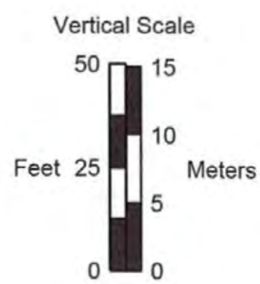


Figure 2.6-3b

Type Log
Triangle Mine Area

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	14-Jun-2013
FILENAME	Mine-TriangleTypeLog.dwg

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Photo 2.6-3: Former Freezeout Mine Decline (Photo C on Figure 2.6-3a)

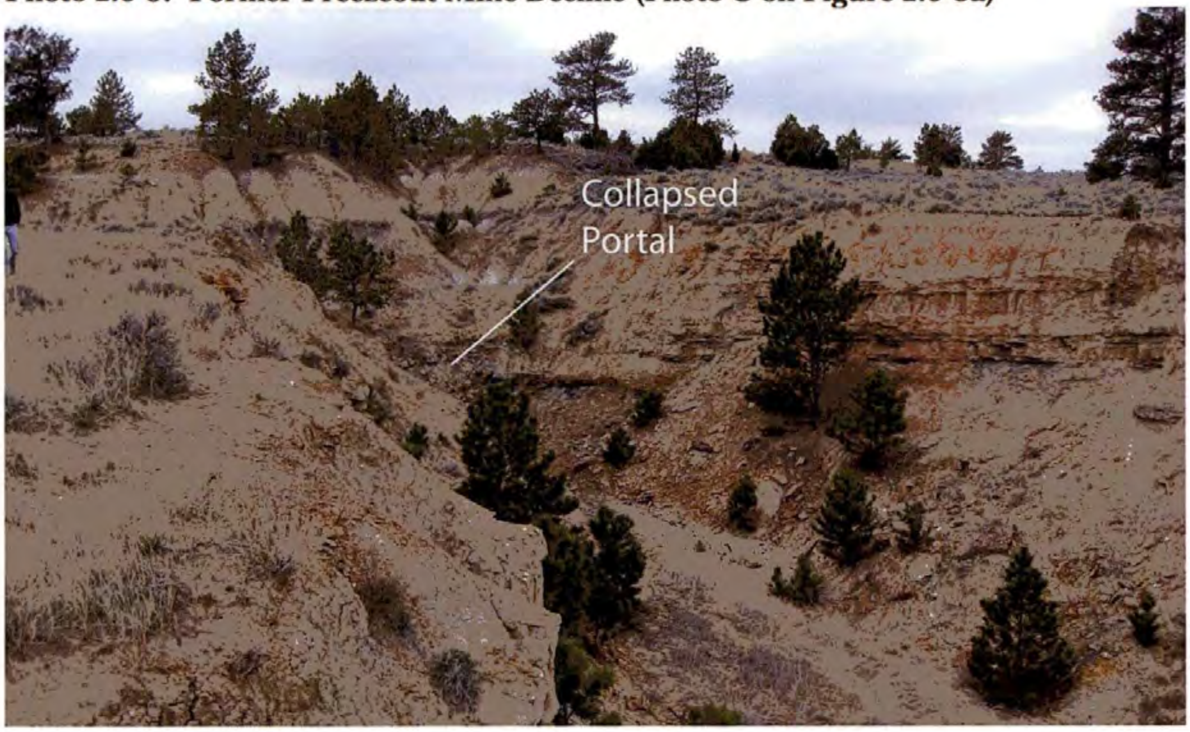
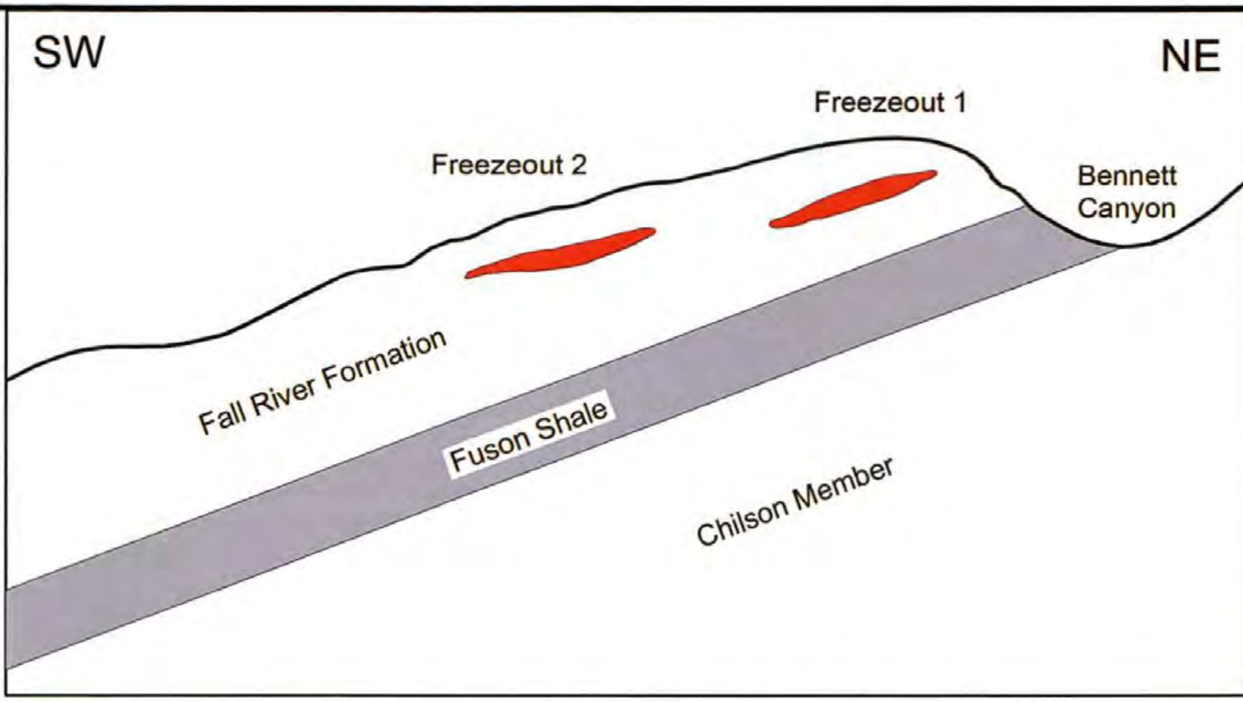
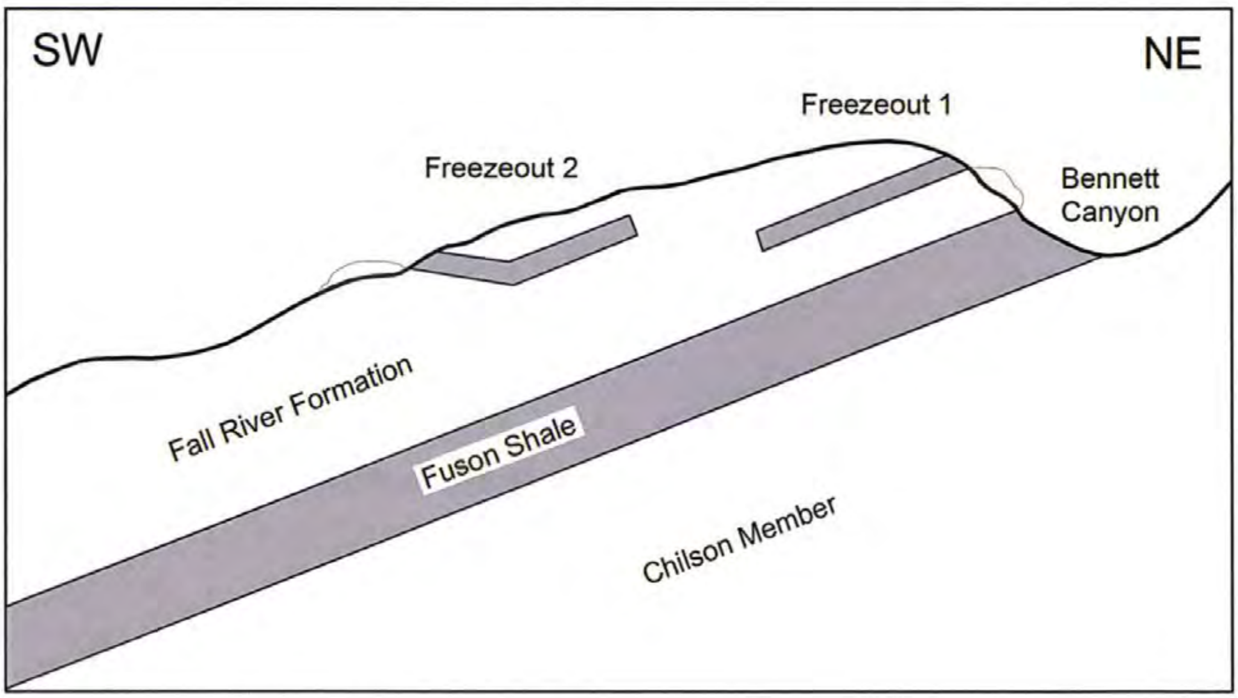


Photo 2.6-4: Former Freezeout Mine Decline (Photo D on Figure 2.6-3a)



A. Shallow ore bodies in Fall River



B. Declines developed to access Fall River ore bodies.

Figure 2.6-3c

Schematic - Underground Workings - Freezeout Mines

Dewey-Burdock Project

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DATE	14-Jun-2013
FILENAME	Mine-FreezeoutUGWork.dwg

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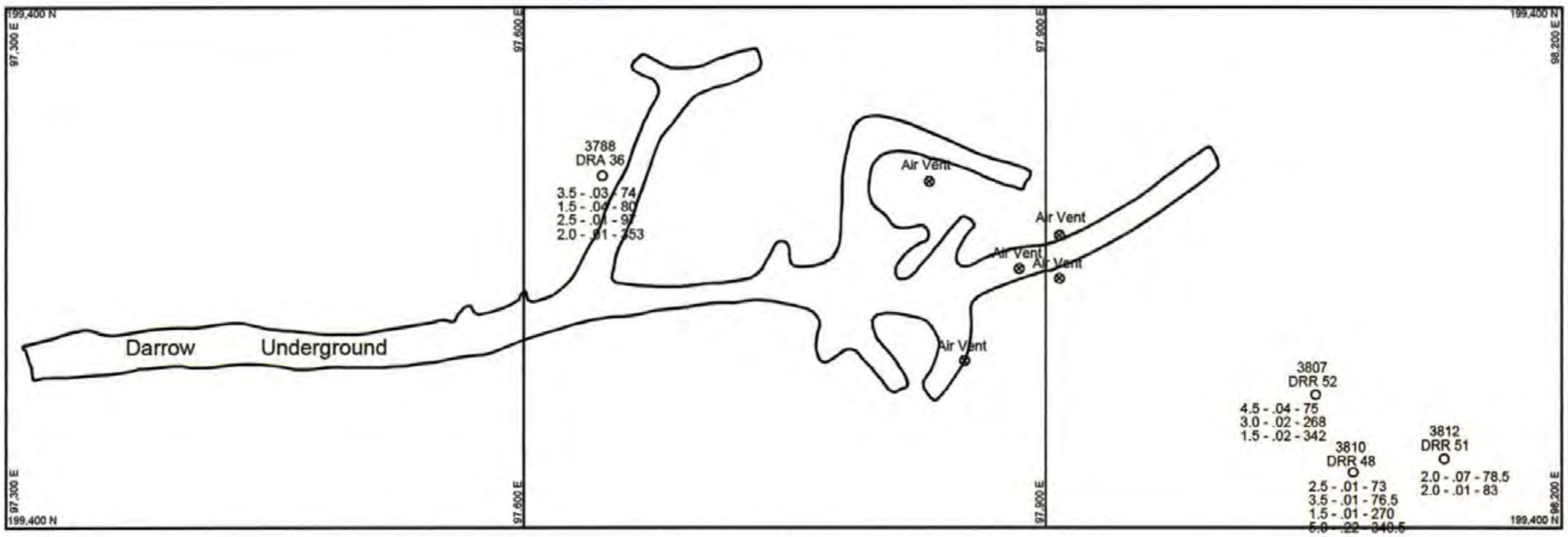

N

Feet: 0 50 100 200

Meters: 0 10 20 40 60

Legend

DRR 52 o Boreholes

Source: TVA drill hole map

Figure 2.6-3d

Plan View - Darrow Underground Mine

Dewey-Burdock Project

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DATE	14-Jun-2013
FILENAME	Mine-DarrowPlanView.dwg

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the underground workings. Also shown on this map are five TVA drill holes, one of which is located less than 20 feet from one of the underground drifts. The electric log from this drill hole (DRA-36) is an excellent representation of the mining horizon in these underground workings and is shown in Figure 2.6-3e. The gamma trace on this type log again corroborates that the top of the mining zone for this underground mine was at a depth of 73 feet below ground surface. The base of the mineralized sand lies 23 feet above the top of the Fuson Shale, which is more than 50 feet thick in this area. The Darrow underground mine workings were restricted to the mineralized sand interval, and these mining operations did not intersect or compromise the integrity of the underlying Fuson Shale confining unit.

Maps obtained from TVA show the locations of two adits within Darrow Pit No. 2 in the NE/4 Section 2, T7S, R1E (Figure 2.6-3a). Although not classified as underground mines, these adits consisted of two separate horizontal tunnels that were driven into the pit walls in order to access additional uranium ore that was not recovered in the surface mining operations. These two adits total approximately 650 feet of workings. Because of the horizontal nature of the adits, these workings were conducted at elevations equal to or above the elevation of the bottom of the pit and were considered to be an extension of the surface mining operations. These small operations did not intersect or compromise the integrity of the underlying Fuson Shale confining unit. The underground workings are also shown on cross section F-F1 (Plate 2.6-12f).

Figure 2.6-3f illustrates the stratigraphic separation of this Lower Chilson sand unit from the historical mining operations in sands of the Fall River Formation. The gamma activity shown within the Lower Chilson sand on the type log is representative of the proposed uranium recovery horizon in B-WF7. This interval is over 200 feet below the base of the Fall River Formation and is separated by 40 feet of the Fuson Shale confining unit, as well as two interbedded shale intervals within the Chilson Member – one 12 feet thick and the other 23 feet thick.

As demonstrated above, neither the surface mining activity nor the shallow underground workings intersected or compromised the integrity of the underlying Fuson Shale confining unit. Cross section F-F' (Plate 2.6-12f) illustrates the continuous Fuson Shale confining unit throughout this area. In addition, outcrop examinations of the Fuson Shale in Bennett Canyon, ½-mile up-dip from the Darrow Mine area, reveal the presence of continuous, low-permeability mudstones and shales.

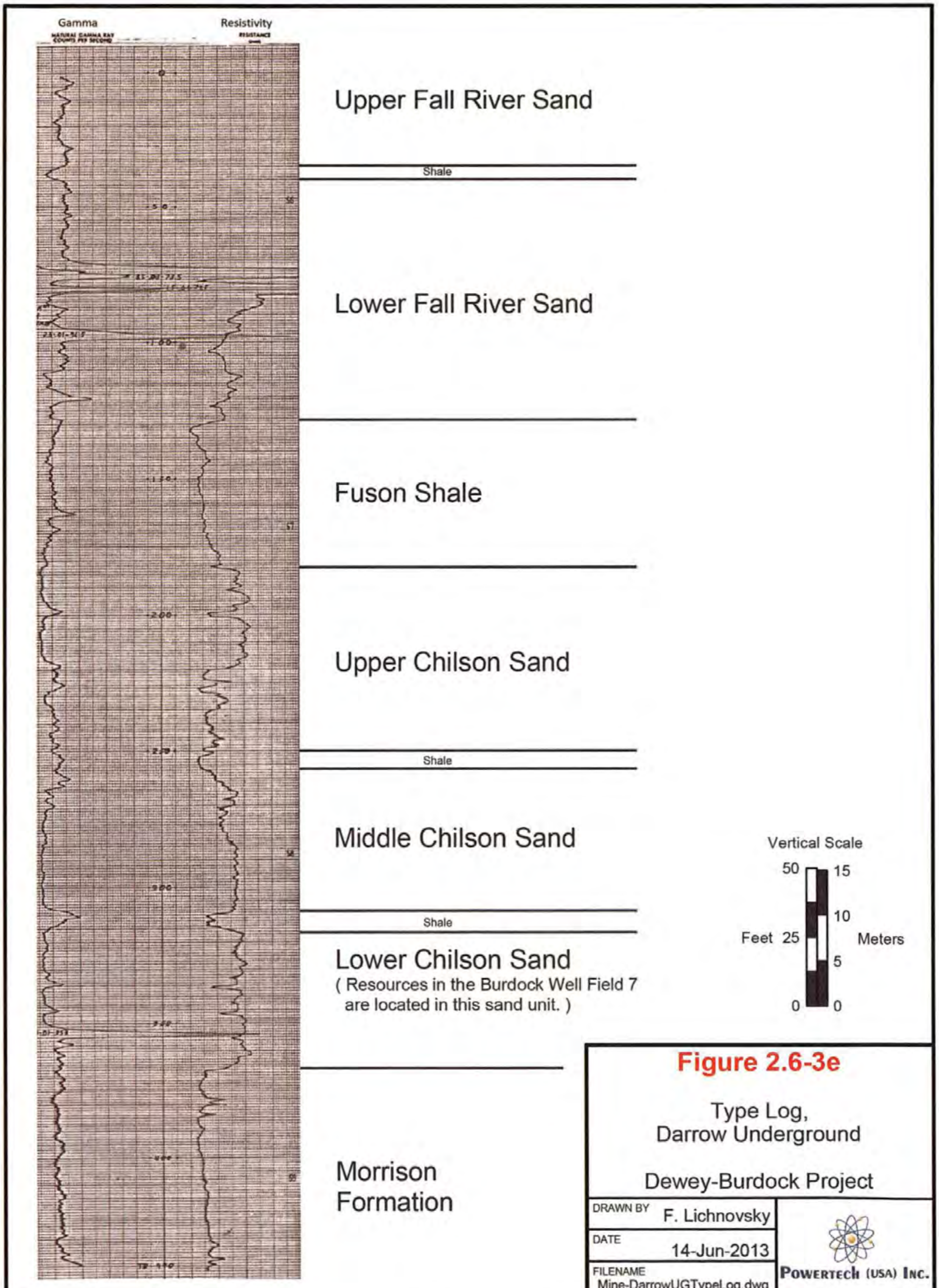
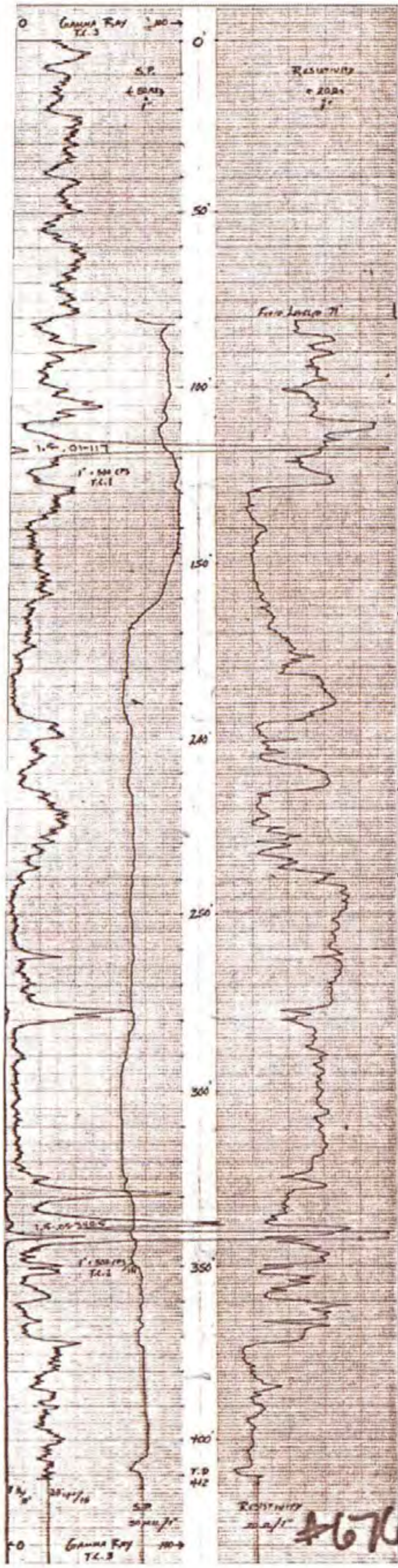


Figure 2.6-3e

Type Log, Darrow Underground

Dewey-Burdock Project



Upper Fall River Sand

Top estimated pick from structure map

Lower Fall River Sand
(surface mines and shallow underground workings located within this unit.)

Fuson Shale

Upper Chilson Sand
(Sand with interbedded Clays.)

Interbedded Chilson Clays

Middle Chilson Sand

Lower Chilson Sand
(Host sand for resources in Burdock Well field 7.)

Morrison Formation

Figure 2.6-3f

Type Log
Darrow Mine Area

Dewey-Burdock Project

DRAWN BY	R. Patton
DATE	14-Jun-2013
FILENAME	Mine-DarrowTypeLog.dwg

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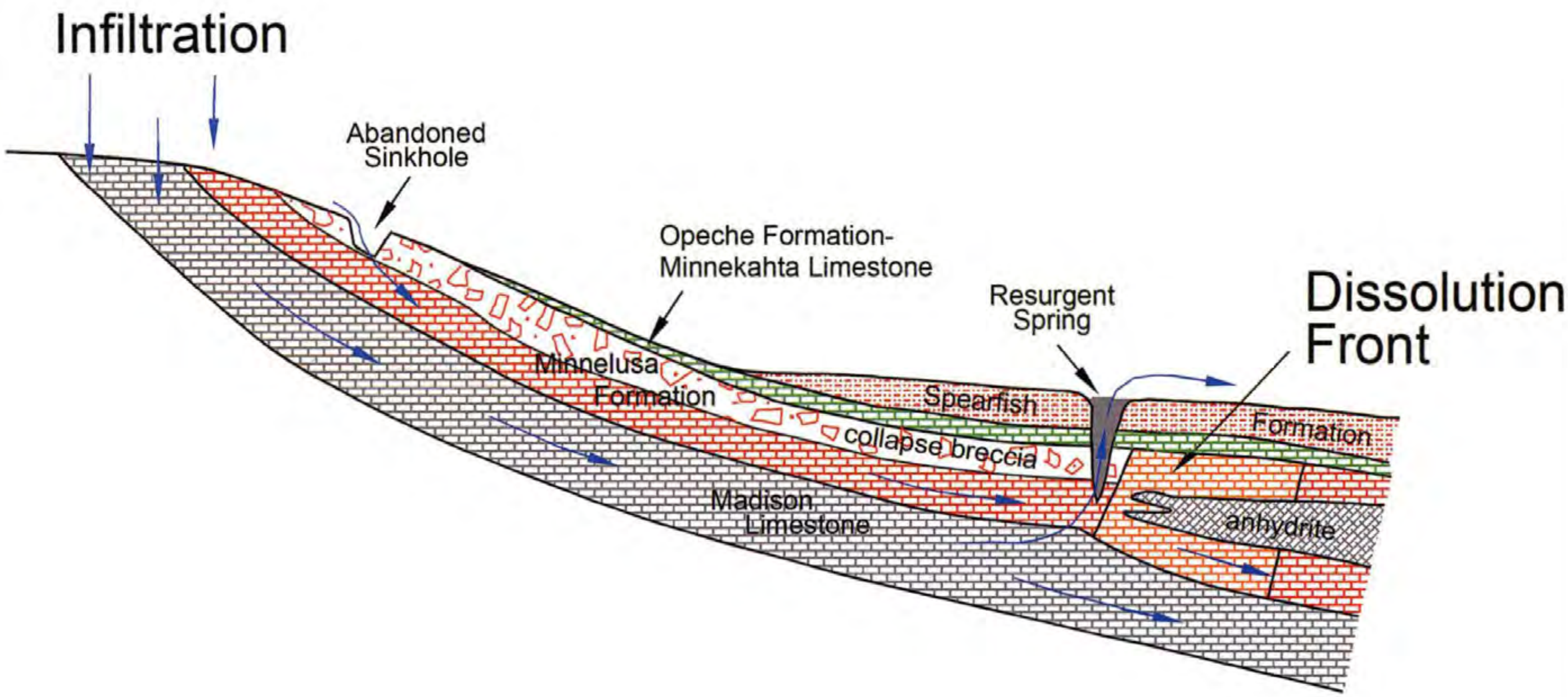
2.6.5 *Clarification of Breccia Pipes*

USGS Professional Paper 763 (Gott et al., 1974) describes the stratigraphy of the Inyan Kara Group along the southern flank of the Black Hills Uplift and presents a working theory on the localization of uranium deposits. The geologic mapping and stratigraphic descriptions contained in that report are comprehensive and provided an important source of information on the stratigraphy and depositional environment of Inyan Kara sediments in this region. However, theories presented in that report on uranium mineralization emplacement that are centered on and related to the presence of breccia pipes penetrating the Inyan Kara Group have not been proven and have been replaced by the classic "roll front" theory of uranium emplacement. Moreover, there appears to be no credible basis to support the theory that collapse features are acting as "conduits" for large volumes of ascending water to recharge the Inyan Kara Group.

Breccia pipes and collapse breccias were mapped in the southern Black Hills by Darton (1909). Gott et al. (1974) state that these collapse features originate in anhydrite and gypsum sequences within the upper portion of the Minnelusa Formation of Pennsylvanian age. Dissolution of these evaporite sequences by underlying Minnelusa and/or Madison artesian water created solution cavities into which overlying Permian sediments collapsed. On Plate 4 of Gott et al. (1974), locations of classic Black Hills collapse breccias occurring within Paleozoic sediments were identified. In addition, many other more speculative features occurring higher in the stratigraphic column were mapped. All breccia pipes or collapse structures located by Gott et al. (1974) and labeled as occurring in the Minnelusa Formation, Opeche Shale, Minnekahta Limestone or basal Spearfish Formation may be considered to be "documented" breccia pipe locations. All of these Paleozoic breccias pipes are located 8-25 miles north and east of the Dewey-Burdock project area, and none occur within the project area.

Geologic mapping and water resource reports have set limits on the expected areal extent of Minnelusa-based collapse breccias. As an example, Figure 2.6-3g, is based on an illustration in an article by Jack B. Epstein published in USGS Water-Resource Investigation Report 01-4011 (2001) and describes the maximum downdip limit of a dissolution front within the evaporite sequence of the upper Minnelusa Formation. In the Black Hills region, extensive dissolution of gypsum and anhydrite beds of the upper Minnelusa has taken place in the surface or near-surface environment. Up to 150 feet of these highly soluble sediments have been removed from the upper Minnelusa through a dissolution process. As illustrated in Photo 2.6-5, behind (up-gradient of) the dissolution front the upper Minnelusa has a distinctive appearance at the outcrop. In addition to an obvious lack of anhydrite and gypsum, its appearance indicates oxidation and



Source: USGS Water-Resources Report 01-401, 2001, Jack B. Epstein, pp. 30-37

Figure 2.6-3g

Minnelusa Dissolution Front

Dewey-Burdock Project

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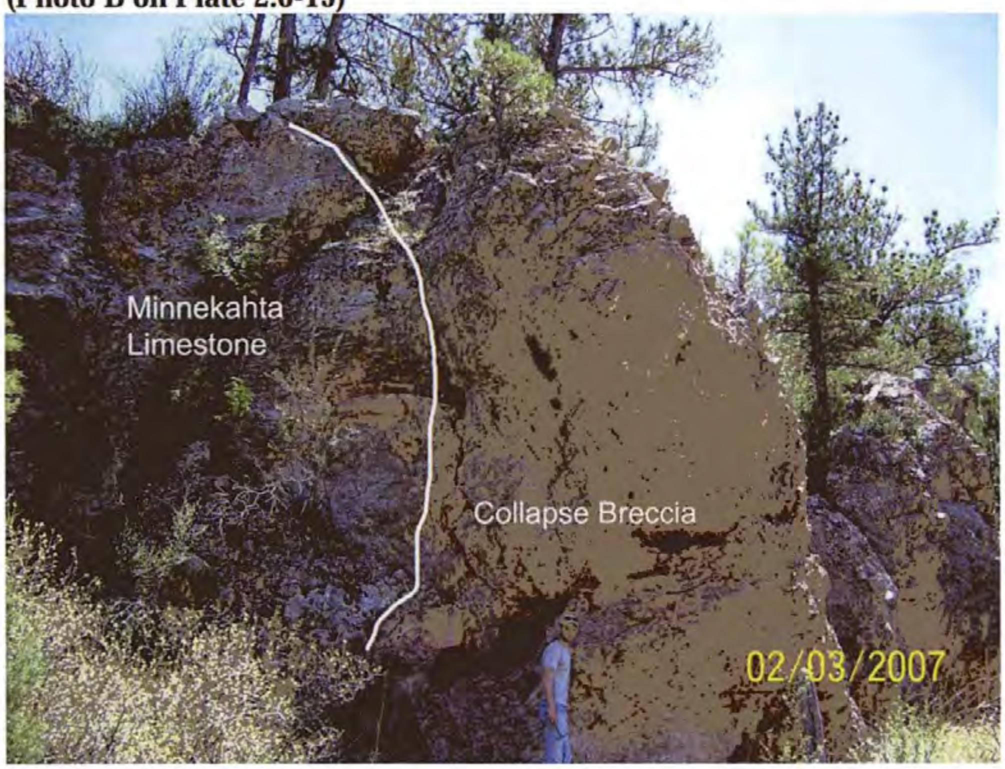
DATE	14-Jun-2013	
FILENAME	MinnDissFront.dwg	

Photo 2.6-5: Upper Minnelusa Outcrop (Outside Project Area) (Photo A on Plate 2.6-15)

Photo 2.6-6: Minnekahta Collapse Breccia (Outside Project Area) (Photo B on Plate 2.6-15)



weathering. The remaining sediments are extremely distorted, cavernous, brecciated and exhibit numerous flow features. The subsidence within this unit, due to the dissolution process, results in down-dropping of, and collapse breccias within, overlying sediments. Epstein shows that this dissolution extends only a few miles down-gradient in the subsurface, where he shows it stopping at a dissolution front. Down-dip from this front, no dissolution occurs and the evaporite sequences within the upper Minnelusa are intact. With no dissolution, no subsidence, collapse or brecciation can take place.

The presence of a dissolution front within the upper Minnelusa has been recognized for more than a half century. In 1955-56, the USGS mapping team of Braddock, Carter and Bridge compiled the geologic mapping for the Jewel Cave SW 7 ½ minute quadrangle map (Plate 2.6-14). This mapping included the upper Minnelusa Formation in the area of Hell Canyon, in which extensive dissolution has taken place. Within the sediments overlying the upper Minnelusa in this area, there are many collapse breccia features. In fact, this area of lower Hell Canyon (not within the project area) is one of the best locations to view classic Black Hills breccia pipes. Photo 2.6-6 shows a small collapse breccia developed in the Minnekahta Limestone within Hell Canyon. Disoriented blocks of Minnekahta Limestone and smaller breccia material can be seen in this collapse structure. Less than 2 miles down-gradient from the location of this breccia pipe, the USGS mapping team annotated on the geologic map "Probable limit of collapse breccias in Minnelusa Formation" – showing the down-dip extent of the dissolution front. This boundary for Minnelusa breccia pipes is some 6 miles northeast of the Dewey-Burdock project area.

Plate 2.6-15 is based on Plate 4 of Gott et al. (1974) and shows all suggested locations for the three categories of collapse features (using the terminology of Gott et al., 1974): 1) "breccia pipes or collapse features," 2) "structures of possible solution origin," and 3) "topographic depressions." It also illustrates the outcrop areas of the Minnelusa Formation and the Inyan Kara Group. The "red line" on this exhibit corresponds to locations where the downdip limit of the dissolution front in the upper Minnelusa has been mapped or projected. North of this line classic Black Hills breccia pipes have been mapped and identified. South of this line suggested locations of collapse features are more speculative and many features are identified as "structures of possible solution origin" and "topographic depressions." The identification and mapping of a solution front within the upper Minnelusa is critical to confirming the absence of breccia pipes at the Dewey-Burdock project area. As previously described, dissolution of the anhydrites and gypsum within the upper Minnelusa is essential for subsequent collapse brecciation and breccia pipe formation in overlying sediments. In areas where there has been no dissolution, there is no geologic foundation for the creation of breccia pipes in overlying sediments. Also shown on Plate 2.6-15 is the outline of the Jewel Cave SW 7½ minute quadrangle map (Plate 2.6-14) and the locations of all photographs.

Figure 2.6-3h shows the Mesozoic and a portion of the Paleozoic stratigraphy below the project site. This electric log is from an abandoned oil & gas test well (the Darrow well) in Section 2, T7S, R1E that penetrated the Minnelusa Formation. The character of the upper Minnelusa Formation under the project area is extremely important because all Black Hills breccia pipes are "rooted" in this unit. Three observations from Figure 2.6-3h are of major significance to this matter.

1) As discussed above, the dissolution front in the upper Minnelusa has been mapped north of the project area. This test well is located approximately 7 miles further down-gradient from and beyond the dissolution front. The electric log signature shows thick sequences of evaporites. There has been no dissolution within the upper Minnelusa under the project area.
2) The thickness of the upper Minnelusa in the Darrow test well also supports the fact that this test hole is located well in advance of a dissolution front. Hayes (1999) discusses the collapse brecciation at Cascade Springs and provides stratigraphic descriptions of the upper Minnelusa. He describes this interval as beginning at a red, mudstone-rich marker bed, locally known as the Red Marker and continuing upward to the Opeche Shale. He states that a 300-foot thickness of the upper Minnelusa is common in areas where anhydrite has been removed by solution and breccia pipes occur. Basinward (downdip), the upper Minnelusa is 150 feet thicker in the subsurface where dissolution of anhydrite beds has not taken place. The thickness of the upper Minnelusa in the Darrow test well is 442 feet, again indicating that there has been no dissolution under the project area.
3) As shown in the left margin of Figure 2.6-3h, the stratigraphic horizons that host classic Black Hills breccia pipes are the upper Minnelusa Formation, Opeche Shale, Minnekahta Limestone and the lower 200 feet of the Spearfish Formation. These geologic units are fully intact and over 1,000 feet below the ground surface at the Dewey-Burdock project area.

The following Powertech (USA) geological evaluations and environmental baseline analyses present additional evidence demonstrating that breccia pipes are not present at the Dewey-Burdock site.

1) Exploration Drilling - The large number of exploration drill holes (more than 4,000) completed within the project area without any indication of solution collapses bolsters the hypothesis that no breccia pipes have penetrated the Inyan Kara Group (Figure 2.6-3). If such an event had occurred, evidence of solution collapses would be observed in the

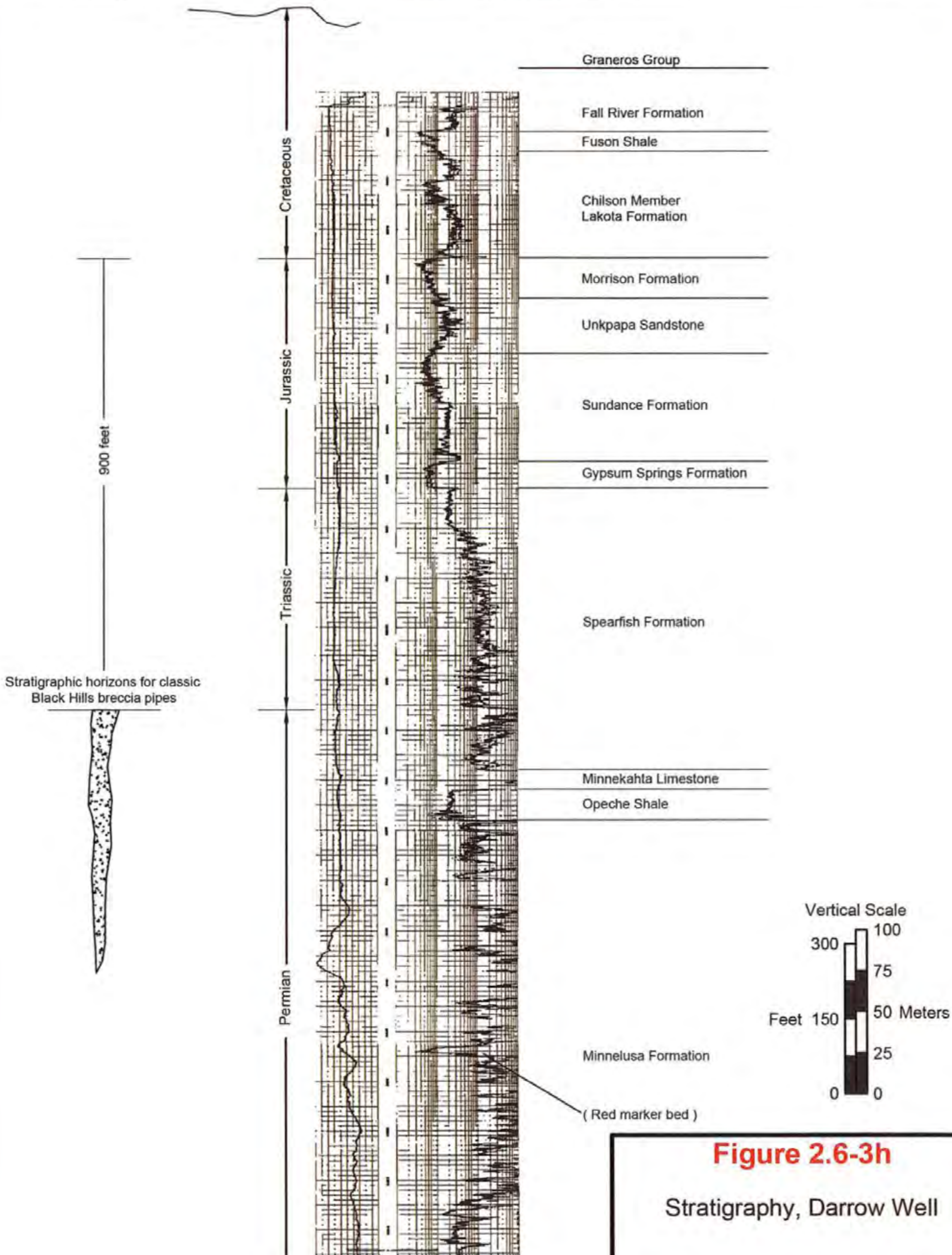


Figure 2.6-3h

Stratigraphy, Darrow Well

Dewey-Burdock Project

DRAWN BY	J. Bonner
DATE	14-Jun-2013
FILENAME	Mine-DarrowWellStratig.dwg

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correlation of the electric logs or from the structure maps developed on top of the Morrison Formation, Chilson Member, Fuson Shale or Fall River Formation. Any subsidence, collapse features or down-dropped sediments would have been evident while preparing cross sections or structure contour maps.

2) Field Investigations for Breccia Pipes - In Professional Paper 763, Gott et al. presented the theory that breccia pipes may extend upward into the Inyan Kara sediments. While there were no features identified within the project boundary, Powertech (USA)'s field investigation focused on "proposed" collapse features within Jurassic and Cretaceous sediments northeast of the project. Due to the high-grade uranium deposits that have been mined within breccia pipes in the Arizona Strip of northwest Arizona, the uranium industry has extensive experience in surface exploration techniques for these features (Figure 2.6-3i). As a comparison, Arizona Strip evaluation criteria were applied to the proposed Black Hills features. These criteria consisted of displaced sediments, brecciation, dip changes of surface beds, fracture patterns and alteration patterns. In addition, due to the Gott et al. theory that breccia pipes were conduits for high volumes of ascending groundwater as recharge to the Inyan Kara aquifer, the Powertech (USA) geologic team specifically searched for evidence of solution movement at these sites. Investigation sites correspond to photo locations shown on Plate 2.6-15.

   A. The first site examined was Cascade Springs, a classic Black Hills breccia pipe located south of Hot Springs, South Dakota. This breccia pipe area was the subject of the previously mentioned USGS Water-Resource Investigation Report 99-4168 (Hayes, 1999). Powertech (USA) staff believed it was important to examine a verified collapse breccia feature and collect "ground truth" before investigating other sites. At the subject site, the surface Minnekahta Limestone met several of the Arizona Strip evaluation criteria, including major fracture patterns, brecciation within the limestone, dip changes of surface beds in the fractured areas and obvious evidence of solution movement. Also of major importance, this feature is located upgradient or updip of the mapped upper Minnelusa dissolution front. Photos 2.6-7 and 2.6-8 illustrate some of these observed evaluation criteria.

   B. The second site focused on "breccia pipes" mapped by Gott et al. within Jurassic sediments approximately 2 miles north of the project area. This area is located 2 miles down-gradient from the mapped downdip limit of the dissolution front and no evidence of collapse or brecciation was observed. Instead, these features were found to be small normal faults within the Dewey Fault Zone. As shown in Photos 2.6-9 and 2.6-10, the sediments were subject to high compressional forces within the fault zone, resulting in folding and normal faulting. The area met none of the Arizona Strip evaluation criteria.

   C. The third and fourth sites examined were areas where Gott et al. mapped "breccia pipes" within Inyan Kara sediments approximately 2-3 miles northeast of the project area. These features were of primary interest because they had purportedly penetrated the Morrison Formation and Inyan Kara sediments. Powertech (USA) geologists spent two days investigating these features. These

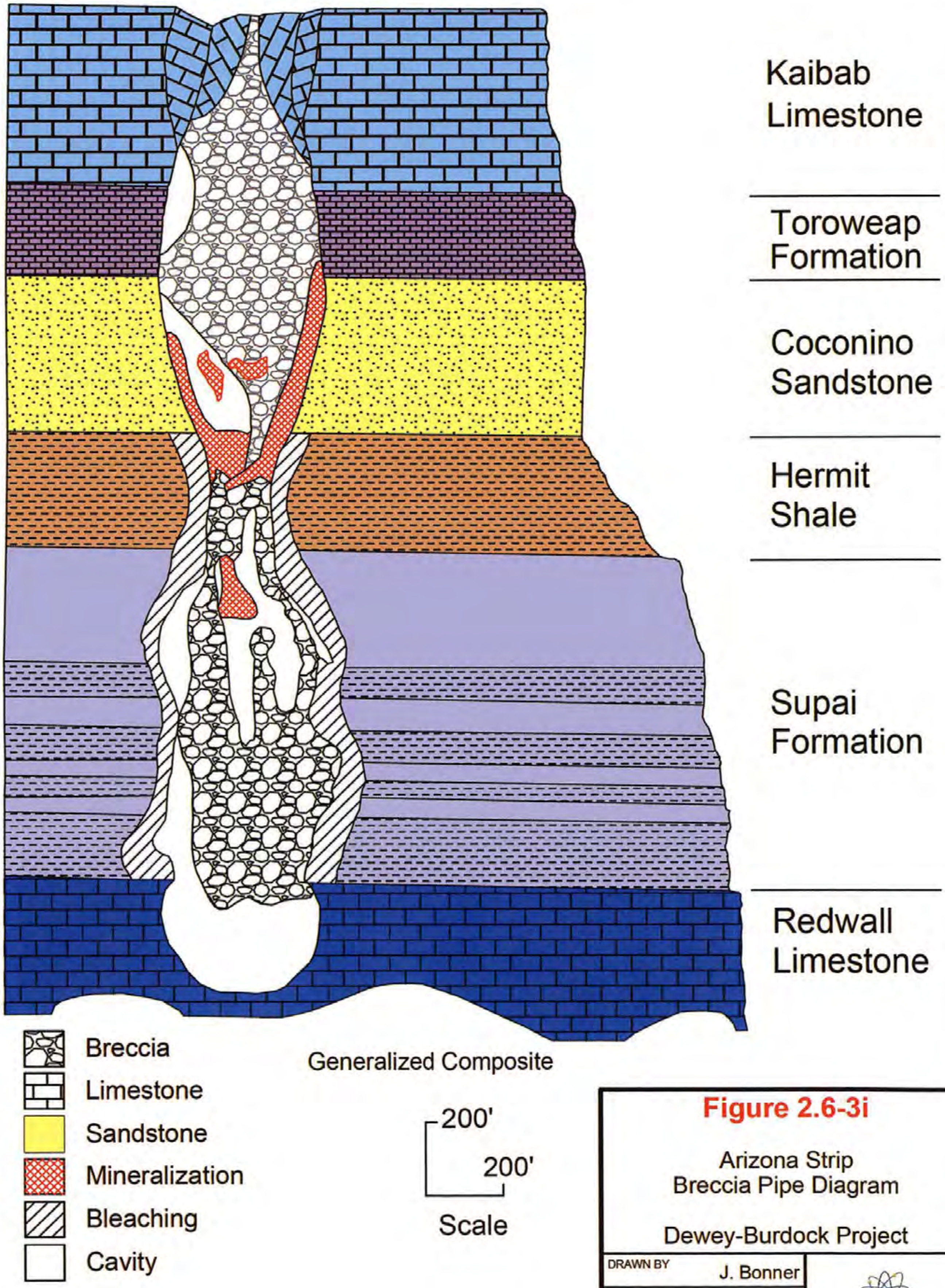

Figure 2.6-3i

Arizona Strip
Breccia Pipe Diagram

Dewey-Burdock Project

DRAWN BY	J. Bonner
DATE	14-Jun-2013
FILENAME	ZAStripBrecciaPipe.dwg

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Photo 2.6-7: Cascade Springs Breccia Pipe (Outside Project Area) (Photo C on Plate 2.6-15)

Photo 2.6-8: Cascade Springs Breccia Pipe (Outside Project Area) (Photo D on Plate 2.6-15)

Photo 2.6-9: Sundance Formation Fault (Outside Project Area) (Photo E on Plate 2.6-15)

Photo 2.6-10: Sundance Formation Fault (Outside Project Area) (Photo F on Plate 2.6-15)

features were located in Sections 21 and 24, T6S, R2E and were 2 miles down-gradient from the mapped dissolution front. These features were found in the bottoms of deep canyons with Chilson Member sandstones forming steep cliffs along the canyon walls. There was no evidence of collapse or brecciation and, as shown in Photos 2.6-11 and 2.6-12, it appears the features were the result of surface erosion and slump blocks caving off the steep canyon walls. The area met none of the Arizona Strip evaluation criteria.

In addition to the above sites, other "structures of possible solution origin" were investigated. All of these sites were located down-gradient of the mapped downdip limit of the dissolution front and met none of the Arizona Strip criteria. Further, there was no evidence of springs to indicate flow of ascending groundwater into the Inyan Kara aquifer. The signature surface expressions for breccia pipes are lacking in all areas examined; no surface geologic evidence could be found to support the presence of breccia pipes on or adjacent to the project area.

3) Inyan Kara Water Temperatures - Gott et al. also theorized that the rapidly ascending groundwater from the deeper Minnelusa Formation would have a higher temperature than the water in the Inyan Kara aquifer. This theory proposes that "water probably has been heated in deeper aquifers and then has ascended to the Inyan Kara Group" through breccia pipes. As supporting evidence of this theory, Gott et al. cite the presence of high geothermal gradients within Inyan Kara wells averaging 1.5° C per 100 feet, as opposed to an average geothermal gradient of 0.9° C per 100 feet for pre-Cretaceous rocks in the Black Hills area.

As part of Powertech (USA)'s environmental baseline analyses, field parameters (including groundwater temperature) were collected at each sampled well (Appendix 2.7-G of the approved license application). Water temperature measurements from 16 wells completed within the Inyan Kara aquifer were used to estimate geothermal gradients within the Inyan Kara aquifer at the Dewey-Burdock Project. In addition to these field measurements, Powertech (USA) also has accurate information on the screened interval for each of these wells, which provides reliable depths to groundwater (top of screened intervals).

Depths to groundwater in the 16 Inyan Kara wells ranged from 30 to 715 feet below ground surface. Water temperatures ranged from 11.55° C (in the shallowest well) to 15.39° C (in the deepest well). The average geothermal gradient of these 16 wells was calculated to be 0.42° C per 100 feet – well below one-half the gradient cited by Gott et al. for the Inyan Kara aquifer. Based on Powertech (USA)'s more accurate and concentrated water sampling results within the Dewey-Burdock project area, all evidence indicates the presence of a normal geothermal gradient within the Inyan Kara aquifer – not an elevated gradient due to rapidly ascending, heated groundwater from underlying aquifers as theorized by Gott et al.

4) Regional Pumping Tests - As described in Section 2.7.2, the pumping tests conducted by TVA in the early 1980s (Appendix 2.7-K of the approved license application) and by Powertech (USA) in 2008 (Appendix 2.7-B of the approved license application)

Photo 2.6-11: Mapped "Breccia Pipes" (Outside Project Area)
(Photo G on Plate 2.6-15)

Photo 2.6-12: Mapped "Breccia Pipes" (Outside Project Area)
(Photo H on Plate 2.6-15)

were "regional tests" aimed specifically at evaluating hydraulic transmission and storage characteristics of the mineralized zones within the Fall River Formation and the Chilson Member of the Lakota Formation and the intervening Fuson Shale confining unit. Based on the results of the regional pumping tests that have been conducted within the project area, the Fuson Shale, which is the confining unit between the overlying Fall River Formation and the underlying Chilson Member, may locally be "leaky"; that is, the observed aquifer response in the Fall River and Chilson suggests possible hydraulic communication between these units. In none of the aquifer tests that have been conducted to date, however, has a "recharge boundary" been observed which would suggest the existence of a significant source of water such as postulated by Gott et al. (1974). In other areas of the Black Hills, the surface discharge through breccia pipes is on the order of several cubic feet per second.

As described in Section 3.1.3.2, delineation drilling and "well field scale" pumping tests will be undertaken prior to the development of each well field. These well field scale pumping tests will specifically address potential leakage through confining beds, through improperly-sealed or unplugged exploration boreholes, or associated with naturally-occurring geologic features such as faulting, breccia pipes, etc.

5) Color Infrared (CIR) Imagery - 2010 CIR satellite imagery was obtained for an approximately 10-square-mile area, including the project area and surrounding vicinity. The imagery obtained through the National Agriculture Imagery Program (NAIP) of the USDA Farm Services Agency has a resolution of one meter.

   The imagery was examined visually for any anomalies that may suggest groundwater discharge at or near surface, such as from upward flow through a breccia pipe, an open borehole or a natural spring. Using a combination of CIR and field investigations, all surface water features within the project area were identified and no surface water features or groundwater flow sources were found within the project area indicative of a breccia pipe flowing to the surface.

6) Numerical Groundwater Modeling - An integral component of the groundwater modeling efforts was to simulate the aquifer response to "point-source recharge" such as might occur as a result of upward leakage through improperly-plugged or unplugged boreholes or a breccia pipe. These simulations included an evaluation of how leakage would be manifested in the observed aquifer response to pumping and during ISR operations.

   The results of the groundwater modeling are provided in Appendix 6.1-A of the approved license application.

2.6.6 Soils

Powertech (USA) conducted baseline soil sampling and mapping covering an estimated 7,964.26 acres as shown on Plate 2.6-16 in accordance with NUREG-1569 and RG-4.14.

Stripping depths for the PA were evaluated during mapping and sampling. Soil depths within a given mapping unit will vary based on any combination of the five primary soil forming factors, i.e., climate including effective precipitation, organisms, relief or topography, parent material, and time. Subtle differences in any one of the previously mentioned factors will impact development between series and within series designation but may not be as noticeable as when topography is a major factor. The topsoil salvage depths are based on laboratory data of the samples found within the borders of the area, as well as field observations and knowledge of the soils in Custer and Fall River Counties, South Dakota.

Soils in the PA are typical for semi-arid grasslands and shrublands in the Western United States. Parent material included colluvium, residuum, and alluvium. Most soils are classified taxonomically as Aridic Argiustolls, Aridic Ustorthents, and Aridic Haplusterts.

Almost all soils have some suitable topsoil. The primary limiting factors within the PA are electrical conductivity (EC), sodium adsorption ratio (SAR), calcium carbonates, and texture (clay percentage).

Refer to Appendix 2.6-B of the approved license application for the Soil Mapping Unit Descriptions. Refer to Appendix 2.6-C of the approved license application for the Soil Series Descriptions. Refer to Appendix 2.6-D of the approved license application for the Original Laboratory Data Sheets. Refer to Appendix 2.6-E of the approved license application for the Prime Farmland Designation. Refer to Appendix 2.6-F of the approved license application for the Site Photographs.

2.6.6.1 Methodology

2.6.6.1.1 Review of Existing Literature

The soils in this portion of Custer and Fall River Counties were studied and mapped to an Order 2 scale by the USDA, NRCS in 1982 and 1990. Information for Custer and Fall River Counties is available electronically as well as hard copy. The NRCS has also centralized dissemination of typical soil series descriptions; general information is available on the internet at www.nrcs.usda.gov.

2.6.6.1.2 Project Participants

BKS performed the 2007 soil survey field work and compiled the resulting report. All soil analysis was handled by Energy Labs in Gillette, Wyoming.

2.6.6.1.3 Soil Survey

Construction of the PA soil map was completed according to techniques and procedures of the National Cooperative Soil Survey. Guideline No. 1 (August, 1994 Revision) of the WDEQ-LQD was followed during all phases of the work.

A total of 7,960.77 acres were included in the final soil mapping of the PA, in which 3,065.74 of those acres were located in disturbance areas. Note that the reference to disturbance area in terms of baseline soil sampling and mapping does not reflect the actual area proposed for disturbance by Powertech (USA). When the soil mapping was completed, Powertech (USA) had not yet designed facilities and potential well field areas to the level of detail presented in this application. The 3,065.74 acres of disturbance area discussed in this section are based on an initial estimate of the orebody and monitoring ring extents. Refer to Table 2.6-1 for soil mapping unit designations and associated acreage within the PA. Table 2.6-1 also describes the soil map units in terms of actual map designations and slope percentages.

2.6.6.1.4 Field Sampling

Soil series were sampled to reflect recommended sample numbers in WDEQ Guideline 1 (August 1994 Revision) based on mapping acreage. Most samples were taken either in or near disturbed areas. Additional sampling of soils in the permit area will occur as the operation is expanded outside the current disturbed areas.

Series were sampled and described by coring with a mechanical auger, i.e., truck-mounted Giddings. The physical and chemical nature of each horizon within the sampled profile was described and recorded in the field. Each hole augured for series and map unit verification was plotted on the soils map included with this report. Sampled soil material was placed in clean, labeled, polyethylene plastic bags and kept cool to limit chemical changes. Samples were kept out of direct sunlight and transported to Energy Labs for analysis. A total of 33 sites on the PA were sampled for analysis; all had corresponding soil profile descriptions written. Refer to Table 2.6-2 Soils Series Sample Summary and Table 2.6-3 Soil Sample Locations.

Table 2.6-1: Soil Mapping Unit Acreages

Map Symbol	Map Unit Description	Permit Acreage	Disturbance Areas[1]	% Total PAProject Area
Aa	Alice, 0 to 6 percent slopes	36.99	0	0
Ar	Arvada, 0 to 6 percent slopes	258.3	121.78	3.97
As	Ascalon, 0 to 6 percent slopes	27.42	41.22	1.35
Bc	Barnum, 0 to 6 percent slopes	484.09	13.01	0.42
Bo	Boneek, 0 to 6 percent slopes	51.53	0	0
Br	Broadhurst, 6 to 15 percent slopes	60.22	190.74	6.22
Bw	Butche, 6 to 40 percent slopes	234.53	25.42	0.83
Cn	Colby, 6 to 15 percent slopes	72.2	0	0
Cy	Cushman, 6 to 15 percent slopes	110.06	12.26	0.40
Dg	Demar, 0 to 6 percent slopes	509.39	134.26	4.38
DA	Disturbed-Ag	196.05	41.36	1.35
GrA	Grummit, 0 to 6 percent slopes	250.81	37.85	1.24
GrB	Grummit, 6 to 15 percent slopes	632.43	369.1	12.04
GrC	Grummit, 15 to 60 percent slopes	550.67	48.43	1.58
Ha	Haverson, 0 to 6 percent slopes	233.1	0	0
He	Hisle, 0 to 6 percent slopes	307.65	54.52	1.78
Ky	Kyle, 0 to 6 percent slopes	471.39	333.96	10.89
Lo	Lohmiller, 0 to 6 percent slopes	38.06	5.66	0.19
Mm	Mathias, 15 to 40 percent slopes	331.62	34.08	1.11
MP	Mine Pit	340.48	18.31	0.60
Nf	Nihill, 15 to 50 percent slopes	11.36	25.61	0.84
No	Norka, 0 to 6 percent slopes	85.07	0	0
NuA	Nunn, 0 to 6 percent slopes	28.54	41.22	1.35
NuB	Nunn, 6 to 15 percent slopes	17.45	0	0
Pa	Paunsaugunt, 6 to 15 percent slopes	0.86	0	0
Pg	Penrose, 15 to 40 percent slopes	210.76	231.08	7.54
PeA	Pierre, 0 to 6 percent slopes	479.11	216.03	7.05
PeB	Pierre, 6 to 15 percent slopes	470.36	157.99	5.15
RO	Rock Outcrop	126.91	17.42	0.57
Sa	Samsil, 15 to 40 percent slopes	249.01	515.29	16.81
Sc	Satanta, 0 to 6 percent slopes	32.28	0	0
Sn	Shingle, 15 to 40 percent slopes	86.75	11.66	0.38
SS	Slickspots	536.39	148.77	4.85
Gs	Snomo, 6 to 15 percent slopes	179.92	106.06	3.46
Ta	Tillford, 0 to 6 percent slopes	171.69	7.84	0.26
W	Water	32.77	72.5	2.37
Wt	Winetti, 0 to 6 percent slopes	7.73	6.92	0.23
202	Worfka, 15 to 40 percent slopes	3.04	0	0
ZnB	Zigweid, 6 to 15 percent slopes	11.35	25.39	0.83
ZnC	Zigweid, 6 to 40 percent slopes	22.43	0	0
Total		**7,960.77**	3,065.74	**100**

[1] Note: The reference to disturbance area in terms of baseline soil sampling and mapping is based on an initial estimate of the orebody and monitoring ring extents and does not reflect the actual area proposed for disturbance. Refer to Section 6.2.2 for planned surface disturbance.

Table 2.6-2: Soil Series Sample Summary[1]

Soil Series	Number of Profiles Sampled for Chemical Analysis
Broadhurst	1
Kyle	3
Hisle	2
Nevee	1
Barnum	1
Ascalon	1
Cushman	1
Zigweid	1
Butche	1
Samsil	3
Paunsaugunt	1
Boneek	4
Arvada	1
Lohmiller	2
Pierre	2
Haverson	1
Demar	2
Penrose	1
Satanta	1
Snomo	1
Grummit	1
Shingle	1
Total	**33**

[1]Samples were taken within proposed disturbed area as defined by initial estimates of the orebody.

Table 2.6-3: Soil Sample Locations[1]

Soil Sample Number	Map Unit Designation	Soil Series
17	Broadhurst silty clay, 6 to 15 percent slopes	Broadhurst
27	Kyle noncalcareous variant, 0 to 6 percent slopes	Kyle
36	Kyle noncalcareous variant, 0 to 6 percent slopes	Kyle
39	Hisle silt loam, 0 to 6 percent slopes	Hisle
40	Hisle noncalcareous variant, 0 to 6 percent slopes	Hisle
41	Nevee silt loam, 6 to 15 percent slopes	Nevee
42	Barnum silt loam, 0 to 6 percent slopes	Barnum
43	Ascalon clay loam, 0 to 6 percent slopes	Ascalon
50	Cushman loam, 6 to 15 percent slopes	Cushman
56	Zigweid loam, 0 to 6 percent slopes	Zigweid
57	Butche clay loam, 3 to 15 percent slopes	Butche
60	Samsil clay loam, 15 to 40 percent slopes	Samsil
63	Paunsaugunt loam, 6 to 15 percent slopes	Paunsaugunt
64	Boneek silty clay loam, 0 to 6 percent slopes	Boneek
72	Arvada silty clay loam, 0 to 6 percent slopes	Arvada
73	Lohmiller loam, 0 to 6 percent slopes	Lohmiller
74	Pierre sandy clay loam, 0 to 15 percent slopes	Pierre
75	Haverson clay loam, 0 to 6 percent slopes	Haverson
76	Demar loam, 0 to 6 percent slopes	Demar
77	Penrose clay loam, 0 to 6 percent slopes	Penrose
79	Demar silty clay loam, 0 to 6 percent slopes	Demar
82	Satanta loam, 0 to 6 percent slopes	Satanta
83	Snomo silty clay loam, 0 to 6 percent slopes	Snomo
84	Lohmiller silty clay loam, 0 to 6 percent slopes	Lohmiller
85	Kyle loam, 0 to 6 percent slopes	Kyle
88	Samsil noncalcareous variant, 15 to 40 percent slopes	Samsil
89	Pierre silty clay loam, 0 to 15 percent slopes	Pierre
90	Grummit silty clay, 0 to 6 percent slopes	Grummit
91	Boneek clay loam, 0 to 6 percent slopes	Boneek
92	Samsil silty clay loam, 15 to 40 percent slopes	Samsil
93	Shingle loam, 15 to 40 percent slopes	Shingle
94	Boneek noncalcareous variant, 0 to 6 percent slopes	Boneek
95	Boneek loam, 0 to 6 percent slopes	Boneek

[1]Samples were taken within proposed disturbed area as defined by initial estimates of the orebody.

2.6.6.1.5 Laboratory Analysis

Samples were individually placed into lined aluminum pans to air dry. Coarse fragments were measured with a 10 mesh screen prior to grinding; the entire sample was then hand ground to pass 10 mesh. An approximate 20 ounce subsample was obtained through splitting with a series of riffle splitters and subsequently analyzed. A second subsample was maintained in storage at Energy Labs. Approximately 10 percent of the samples are run for duplicate analysis. Actual laboratory analysis follows the methodology outlined in WDEQ-LQD Guideline 1 (August 1994 Revision). In general, samples were analyzed within 45 days of receipt of the samples at the laboratory. All analytical data is presented in Appendix 2.6-D of the approved license application.

2.6.6.2 Results and Discussion

2.6.6.2.1 Soil Survey - General

General topography of the area ranged from nearly level uplands to very steep hills, ridges and breaks of dissected shale plains. The soils occurring on the PA were generally a clayey or very fine texture throughout with patches of sandy loam on upland areas and fine, clay textured soils occurring in or near drainages. The PA contained deep soils on level upland areas with shallow and very shallow soils located on hills, ridges and breaks.

2.6.6.2.2 Soil Mapping Unit Interpretation

The primary purpose of the 2007 fieldwork was to characterize the soils within the PA in terms of topsoil salvage depths and related physical and chemical properties. The total number of samples per series was established in line with WDEQ Guideline 1 (August 1994 Revision) recommendations based on estimated acreage of soil series known within the PA. Refer to Appendix 2.6-B of the approved license application and Appendix 2.6-C of the approved license application for soil mapping unit descriptions and soil series descriptions, respectively.

2.6.6.2.3 Analytical Results

Analyzed parameters, as defined in WDEQ Guideline 1 (August 1994 Revision), are in Appendix 2.6-D of the approved license application. Laboratory soil texture analysis did not include percent fine sands. Field observations of fine sands within individual pedestals as well as sample site topographic position were used in conjunction with laboratory analytical results to determine series designation. Where applicable, field observation of fine sands is also included in the textures found in the soil series descriptions in Appendix 2.6-C of the approved license application. In several of the pedestal sampling locations, laboratory analysis yielded finer than expected textures (based upon field observations). Where textures are finer than typical for the series, it is noted in the Range of Characteristics (according to field observations, lab analysis) in the soil series descriptions.

2.6.6.2.4 Evaluation of Soil Suitability as a Plant Growth Medium

Approximate salvage depths of each map unit series are presented in Table 2.6-4 and ranged from 0.0 to 5.0 feet. Within the PA, suitability of soil as a plant growth medium is generally affected by physical factors such as texture (clay percentage) and saturation percentage. Chemical limiting factors included selenium (Se), calcium carbonate content (based upon field observations of strong or violent effervescence), SAR, EC, pH, and boron (B). Marginal material, according to WDEQ Guideline 1, was found in 26 of the 33 profiles. Unsuitable material, according to WDEQ Guideline 1, was found in 14 of the 33 profiles. Marginal or unsuitable parameter information for sampled profiles is identified in Table 2.6-5. A summary of trends in marginal or unsuitable parameters as it relates to soil series is found in Table 2.6-6. Based on laboratory analysis and field observations, marginal material parameters primarily consisted of texture (clay percentage), calcium carbonates, EC, and SAR.

Table 2.6-4: Summary of Approximate Soil Salvage Depths

Map Symbol	Mapping Unit Description	Disturbance Areas[1]	Salvage Depth (feet)	Total Volume (Acre feet)
Ar	Arvada	121.78	1.5	182.67
As	Ascalon	41.22	1.17	48.23
Bc	Barnum	13.01	0.5	6.51
Br	Broadhurst	190.74	0.67	127.80
Bw	Butche	25.42	0.67	17.03
Cy	Cushman	12.26	2.08	25.50
Dg	Demar	134.26	0.21	28.20
DA	Disturbed-Ag	41.36	-	-
GrA	Grummit, 0 to 6 percent slopes	37.85	1.67	63.21
GrB	Grummit, 6 to 15 percent slopes	369.1	1.67	616.40
GrC	Grummit, 15 to 60 percent slopes	48.43	1.67	80.88
He	Hisle Noncalc. Variant Average	54.52	5 5 5	272.60
Ky	Kyle Noncalc. Variant Average	333.96	2.5 0.80 1.65	551.03
Lo	Lohmiller	5.66	0.34	1.92
Mm	Mathias	34.08	0	0
MP	Mine Pit	18.31	-	-
Nf	Nihill	25.61	0.42	10.76
Nu	Nunn	41.22	2	82.44
Pg	Penrose	231.08	3	693.24
PeA	Pierre, 0 to 6 percent slopes	216.03	0.71	153.38
PeB	Pierre, 6 to 15 percent slopes	157.99	0.71	112.17
RO	Rock Outcrop	17.42	-	-
Sa	Samsil Noncalc. Variant Average	515.29	0.42 1.5 0.96	494.68
Sn	Shingle	11.66	0.67	7.81
SS	Slickspots	148.77	-	-
Gs	Snomo	106.06	0	0
Ta	Tilford	7.84	3.33	26.11
W	Water	72.5	-	-
Wt	Winetti	6.92	0.33	2.28
Zn	Zigweid	25.39	5	126.95
Average Salvage Depth of Study Area			**1.44**	
Total		**3,065.74**		**3,731.80**

[1] Note: The reference to disturbance area in terms of baseline soil sampling and mapping is based on an initial estimate of the orebody and monitoring ring extents and does not reflect the actual area proposed for disturbance. Refer to Section 6.2.2 for planned surface disturbance.

Table 2.6-5: Summary of Marginal and Unsuitable Parameters within Sampled Profiles

Series	Sample Point	Depth (in)	Parameter
Broadhurst	17	0-3 3-8 8-24 24-40 40-54 54-60	Marginal clay %
Broadhurst	17	8-24	Marginal saturation %
Broadhurst	17	40-54	Marginal pH (Low)
Broadhurst	17	54-60	Unsuitable pH (Low)
Kyle	27	2-17 17-24 24-39 39-60	Marginal clay %
Kyle	27	24-39	Marginal saturation %
Kyle	27	17-24 24-39 39-60	Marginal SAR
Kyle	36	2-15 15-26 26-36 36-60	Marginal clay %
Kyle	36	2-15 26-36	Marginal saturation %
Kyle	36	15-26 26-36	Marginal SAR
Hisle	40	27-38 38-60	Marginal clay %
Nevee	41	21-36 36-45 45-60	Unsuitable EC (Conductivity) Unsuitable SAR Marginal Selenium
Nevee	41	21-36	Unsuitable Boron
Barnum	42	6-17 17-39	Unsuitable EC (Conductivity) Unsuitable SAR
Barnum	42	39-60	Marginal EC (Conductivity) Marginal SAR
Barnum	42	6-17	Marginal Selenium
Ascalon	43	2-14	Marginal clay %
Ascalon	43	38-60	Unsuitable SAR
Samsil	60	3-10	Marginal clay %
Samsil	60	10-18	Marginal EC (Conductivity) Marginal Selenium
Samsil	60	3-10 10-18	Marginal SAR
Boneek	64	17-33	Marginal pH (High)
Boneek	64	33-42	Marginal EC (Conductivity) Marginal Selenium
Arvada	72	18-28	Marginal clay %
Arvada	72	28-43 43-60	Marginal EC (Conductivity)

Table 2.6-5: Summary of Marginal and Unsuitable Parameters within Sampled Profiles (cont.)

Series	Sample Point	Depth (in)	Parameter
Arvada	72	28-43	Marginal SAR
Arvada	72	43-60	Unsuitable SAR
Arvada	72	18-28 28-43 43-60	Marginal Selenium
Lohmiller	73	3-15 15-23 23-34 34-38 38-60	Marginal clay % Unsuitable SAR
Lohmiller	73	15-23 23-34 38-60	Marginal saturation %
Lohmiller	73	15-23	Marginal EC (Conductivity)
Lohmiller	73	23-34 34-38 38-60	Unsuitable EC (Conductivity)
Lohmiller	73	15-23 23-34 34-38 38-60	Marginal Selenium
Pierre	74	15-27 27-38	Marginal pH (High)
Pierre	74	27-38 38-51 51-60	Unsuitable EC (Conductivity) Marginal Selenium
Pierre	74	15-27 27-38 38-51 51-60	Unsuitable SAR
Haverson	75	15-35	Marginal SAR
Haverson	75	35-46 46-60	Unsuitable SAR
Demar	76	2-21 21-29	Marginal clay % Marginal SAR
Demar	76	29-46 46-60	Unsuitable SAR
Demar	76	46-60	Marginal Selenium
Penrose	77	36-48	Unsuitable Boron
Demar	79	3-17 17-30 30-42 42-60	Marginal clay % Unsuitable pH (Low)
Satanta	82	0-4	Marginal pH (Low)
Snomo	83	3-17 17-33	Marginal clay % Marginal texture
Snomo	83	42-52	Marginal saturation %

Table 2.6-5: Summary of Marginal and Unsuitable Parameters within Sampled Profiles (cont.)

Series	Sample Point	Depth (in)	Parameter
Snomo	83	0-3 3-17	Unsuitable pH (Low)
Snomo	83	33-42 42-52 52-60	Unsuitable Boron
Lohmiller	84	18-37	Marginal clay % Marginal texture Unsuitable EC (Conductivity) Unsuitable SAR
Lohmiller	84	0-5 5-18	Marginal saturation %
Lohmiller	84	5-18 37-47 47-60	Marginal EC (Conductivity)
Lohmiller	84	5-18 37-47	Marginal SAR
Kyle	85	2-7	Marginal saturation %
Samsil	88	2-9	Marginal clay % Marginal texture
Pierre	89	0-2	Marginal pH (Low)
Pierre	89	2-18 18-31 31-37	Marginal clay % Marginal texture Marginal saturation %
Grummit	90	0-2 2-8 8-20	Marginal clay % Marginal texture Marginal saturation %
Boneek	91	4-19 40-48 48-60	Marginal saturation %
Boneek	91	19-40 40-48 48-60	Unsuitable EC (Conductivity) Unsuitable SAR
Boneek	91	48-60	Marginal Selenium
Samsil	92	7-19	Marginal clay % Marginal texture Marginal saturation %
Boneek	94	0-2 2-8 8-20 32-44 44-60	Marginal clay % Marginal texture Marginal saturation %
Boneek	94	20-32	Marginal saturation %
Boneek	95	24-38	Marginal Selenium

Table 2.6-6: Summary of Trends in Marginal and Unsuitable Parameters for Soil Series

Series	Unsuitable/Marginal Parameter
Arvada	Sodium/Salts, Selenium/Boron
Ascalon	Sodium/Salts
Barnum	Sodium/Salts, Selenium/Boron
Boneek	Texture, Sodium/Salts, Selenium/Boron
Broadhurst	Texture, pH
Demar	Sodium/Salts
Grummit	Texture
Haverson	Sodium/Salts
Hisle	Texture
Kyle	Texture
Lohmiller	Texture, Sodium/Salts
Nevee	Sodium/Salts, Selenium/Boron
Penrose	Selenium/Boron
Pierre	pH
Samsil	Texture
Satanta	pH
Snomo	Texture, pH, Selenium/Boron

2.6.6.2.5 Topsoil Volume Calculations

Based on the 2007 fieldwork with associated field observations and subsequent chemical analysis, the recommended topsoil average salvage depth over the PA was determined to be 1.43 feet. Refer to Table 2.6-4, Approximate Soil Salvage Depths.

2.6.6.2.6 Soil Erosion Properties and Impacts

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the PA 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 PA, the soils are more susceptible to erosion from water than wind. See Table 2.6-7 for a summary of wind and water erosion hazards within the PA.

Table 2.6-7: Summary of Wind and Water Erosion Hazards[1]

Soil Sample Number	Map Unit Description	Water Erosion Hazard	Wind Erosion Hazard
17	Broadhurst silty clay, 6 to 15 percent slopes	slight	very slight
27	Kyle noncalcareous variant, 0 to 6 percent slopes	moderate	very slight
36	Kyle noncalcareous variant, 0 to 6 percent slopes	moderate	very slight
39	Hisle silt loam, 0 to 6 percent slopes	moderate	slight
40	Hisle noncalcareous variant, 0 to 6 percent slopes	slight	very slight
41	Nevee silt loam, 6 to 15 percent slopes	moderate	slight
42	Barnum silt loam, 0 to 6 percent slopes	moderate	slight
43	Ascalon clay loam, 0 to 6 percent slopes	slight	slight
50	Cushman loam, 6 to 15 percent slopes	slight	moderate
56	Zigweid silty clay loam, 0 to 6 percent slopes	moderate	very slight
57	Butche clay loam, 3 to 15 percent slopes	slight	slight
60	Samsil clay loam, 15 to 40 percent slopes	slight	slight
63	Paunsaugunt loam, 6 to 15 percent slopes	slight	moderate
64	Boneek silty clay loam, 0 to 6 percent slopes	moderate	very slight
72	Arvada silty clay loam, 0 to 6 percent slopes	moderate	slight
73	Lohmiller loam, 0 to 6 percent slopes	very slight	slight
74	Pierre sandy clay loam, 0 to 15 percent slopes	negligible	severe
75	Haverson clay loam, 0 to 6 percent slopes	slight	slight
76	Demar loam, 0 to 6 percent slopes	slight	moderate
77	Penrose clay loam, 0 to 6 percent slopes	slight	slight
79	Demar silty clay loam, 0 to 6 percent slopes	slight	slight
82	Satanta loam, 0 to 6 percent slopes	very slight	severe
83	Snomo silty clay loam, 0 to 6 percent slopes	moderate	very slight
84	Lohmiller silty clay loam, 0 to 6 percent slopes	moderate	very slight
85	Kyle loam, 0 to 6 percent slopes	slight	slight
88	Samsil noncalcareous variant, 15 to 40 percent slopes	slight	slight
89	Pierre silty clay loam, 0 to 15 percent slopes	moderate	very slight
90	Grummit silty clay, 0 to 6 percent slopes	slight	negligible
91	Boneek clay loam, 0 to 6 percent slopes	slight	slight
92	Samsil silty clay loam, 15 to 40 percent slopes	slight	slight
93	Shingle loam, 15 to 40 percent slopes	slight	severe
94	Boneek noncalcareous variant, 0 to 6 percent slopes	slight	very slight
95	Boneek loam, 0 to 6 percent slopes	slight	moderate

[1]Based on lab analysis.

2.6.6.2.7 Prime Farmland Assessment

Prime farmland was assessed by Dan Shurtliff, the Acting State Soil Scientist out of Huron, South Dakota. The following sections in T6S R1E contain Prime farmland if irrigated: Sections 27, 30, 31, 32, 34, and 35. The following sections in T7S R1E contain Prime farmland if irrigated: Sections 1, 3, 4, 5, 10, 12, 14, and 15. The following sections in T7S R1E contain Farmland of statewide importance: Sections 2, 3, 4, 5, 10, 11, 12, 14, and 15. See Appendix 2.6-E of the approved license application for prime farmland designation. The following soil series have been listed as Prime farmland if irrigated: Alice, Ascalon, Barnum, Boneek, Haverson, Norka, Nunn, Satanta, and Tilford. The following soil series have been listed as Farmland of statewide importance: Kyle, Lohmiller, Nunn, Pierre, Satanta, and Stetter.

2.6.7 Seismology

2.6.7.1 Seismic Hazard Review

The seismic hazard review was based on analysis of available literature and historical seismicity for the PA. 10 CFR Part 40, Appendix A Criterion 4(e) states:

"The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term "capable fault" has the same meaning as defined in section III(g) of Appendix A of 10 CFR Part 100. The term "maximum credible earthquake" means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material."

There are no capable faults (i.e. active faults) with surface expression mapped within a radius of 100 kilometers (62 miles) from the center of the PA, according to the 2002 U.S. Geological Survey's Quaternary Fault and Fold Database. In addition, there are no capable faults mapped in the entire state of South Dakota. The closest capable faults to the site are located in central Wyoming, nearly 345 km (200 miles) to the west-southwest.

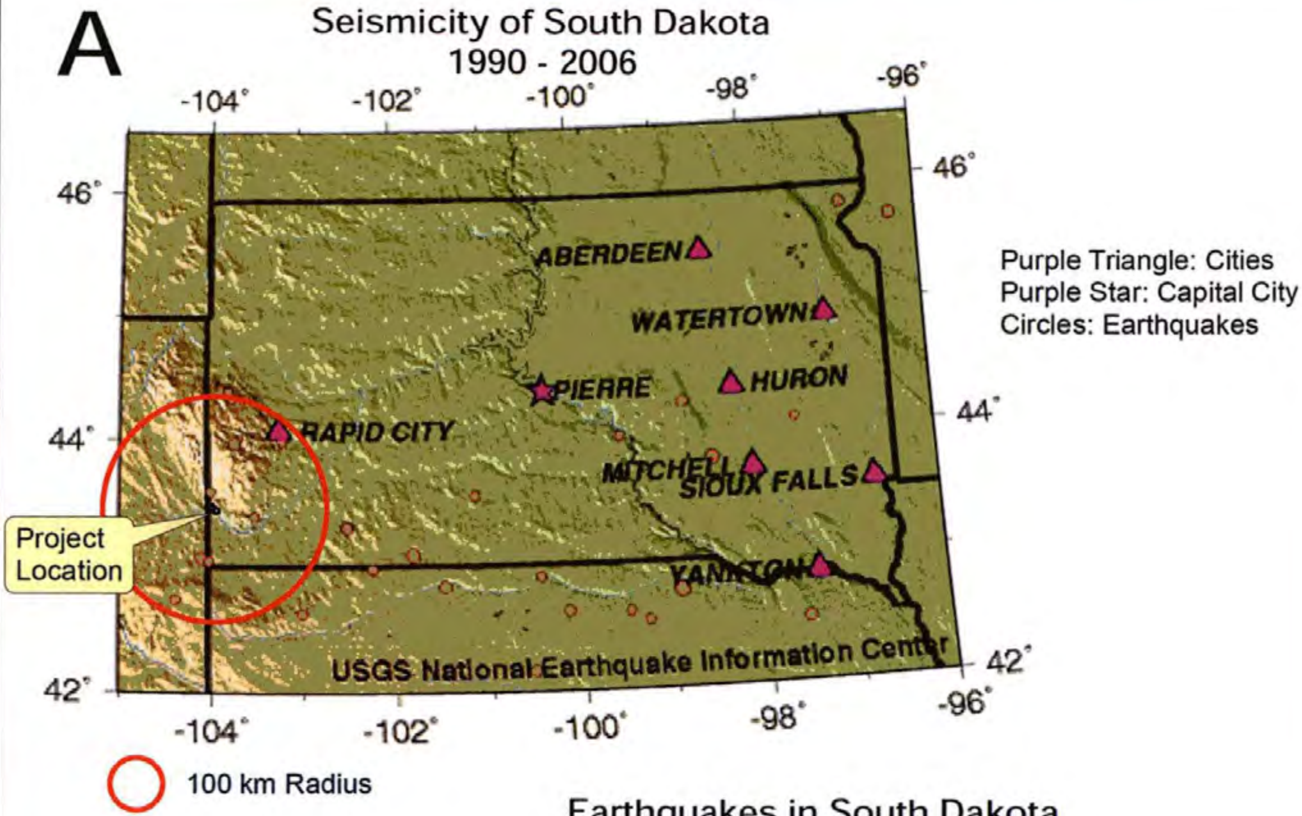
2.6.7.1.1 Seismicity

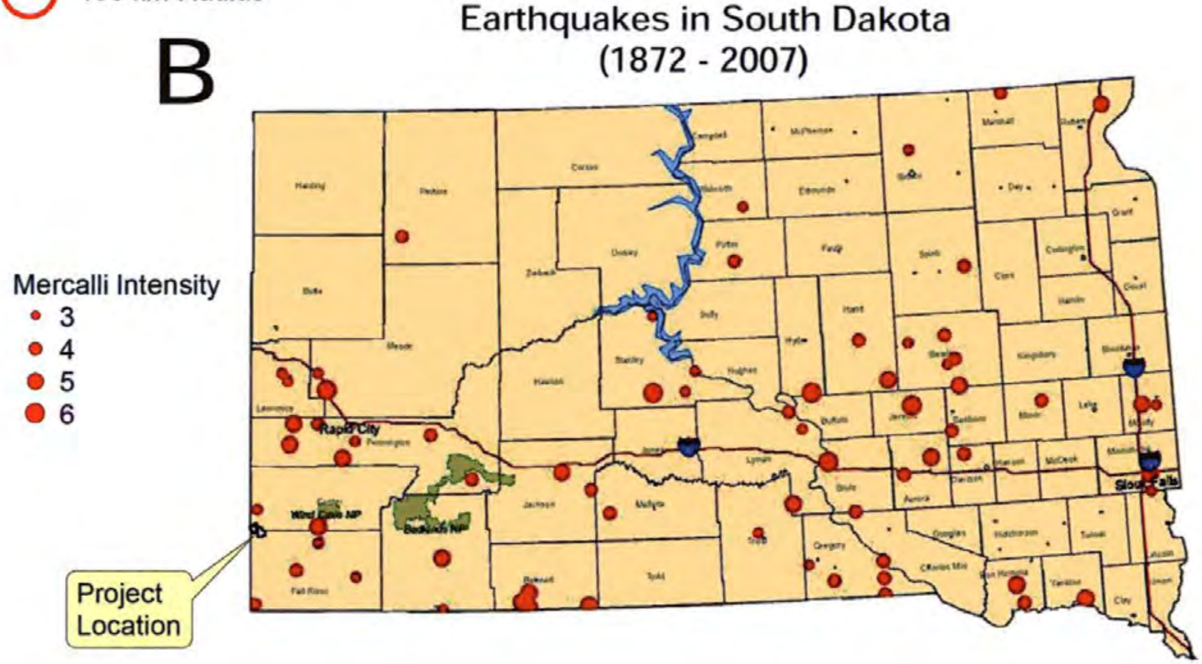
South Dakota has a comparatively higher rate of seismicity than other areas in the northern plains states, although earthquakes in the area tend to be relatively rare and of low to moderate magnitude, and no active faults have been mapped in the vicinity. It is unclear which earthquakes, if any, in the PA vicinity are associated with known faults. Since the Midwestern states are relatively stable in terms of earthquake activity, only a small number of seismograph stations are located in the region. South Dakota has one station located in Rapid City, which began operation in 1991. Two nearby stations are located in Golden, Colorado and French Village, Missouri.

Since 1872, a minimum of 65 earthquake epicenters have been identified in South Dakota (Hammond, 1992). These have mainly been concentrated in the southern and eastern regions of the state and are generally of low to moderate modified Mercalli intensity, with a maximum recorded intensity reaching VI. In general, the majority of the epicenters in the proximity of the project (see Figure 2.6-4) exhibit modified Mercalli intensities from III to V (corresponding to Richter magnitudes ranging from 2.2 to 4.1). However, a 1966 earthquake with intensity VI (approximate Richter magnitude 4.4) was recorded approximately 63 miles northeast of the project (17 miles northwest of Rapid City).

The U.S. Geological Survey Earthquake Database reports locations, times, and magnitudes for epicenters recorded since 1973. The database reports a total of 21 earthquakes with Richter magnitudes ranging from 2.1 to 4.0 within 100 km radius of the site (Appendix 2.6-G). This list includes epicenters in Wyoming and Nebraska. The most recent earthquake recorded with 100 kkm radius of the site took place on August 1, 2022, 3 km north of Buffalo Gap (approximately 35 miles heast of the project site) and displayed a magnitude of 2.1. The closest historical earthquake to the project site (magnitude 2.8) was recorded on January 5, 2004 approximately 13 km (8 miles) north of the center of the project area. The magnitude of the event was reported to be 2.8 on the Richter Scale, which is approximately equivalent to a modified Mercalli intensity of III (Burchett, 1979). Other information included in Appendix 2.6-G specific to this event includes the origin time, depth, and latitude and longitude.

According to Burchett (1979), a magnitude 2.8 earthquake (Richter Scale) would not result in people feeling any earth movement, nor would there be any structural damage. Seismic stability analyses for the pond designs are discussed in Sections 3.11.4 and 3.11.5 of the Dewey-Burdock Pond Design Report Appendix 3.1-A of the approved license application, which concludes, "The factors of safety indicate that the inner and outer slopes are stable under static and maximum credible earthquake seismic loading conditions."





Source: USGS/DEIC PDE Catalog
Map A: USGS website:
http://earthquake.usgs.gov/regional/states/south_dakota/seismicity.php
Map B: USGS website:
http://www.sdgs.usd.edu/digitalpubmaps/quakemap.html

Figure 2.6-4
Seismicity of South Dakota
1990 - 2006
and Earthquakes in South Dakota
1872 - 2007
Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	17-Jun-2013
FILENAME	SDQuakesSeismic.mxd

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According to the U.S. Geological Survey Earthquake Database (Appendix 2.6-G), the largest historical event recorded within 100 km (62 miles) of the project is a magnitude 4.0 earthquake. This event occurred on November 14, 2011, and was located 42 miles southeast of the site.

A zone of higher earthquake frequency is recorded along the eastern flank of the Black Hills (structural deformation also seems to be concentrated on the eastern flank; Geological Survey of South Dakota, 2004) and in the southwest corner of South Dakota (Figure 2.6-4). In addition, the PGA maps (USGS, 2002) of the area display an increase in ground motion to the west and southwest part of the state (Figures 2.6-5 and 2.6-6). Earthquakes may be concentrating along or near the boundaries of structural provinces (e.g. Black Hills and Missouri Plateau, or Missouri Plateau and High Plains) in the Precambrian, crystalline basement. Two possible faulting mechanisms may be at work: 1) initiation of movement along preexisting fractures due to crustal plate movements; or 2) fault movement and fracturing due to glacial rebound (South Dakota Department of Emergency Management website).

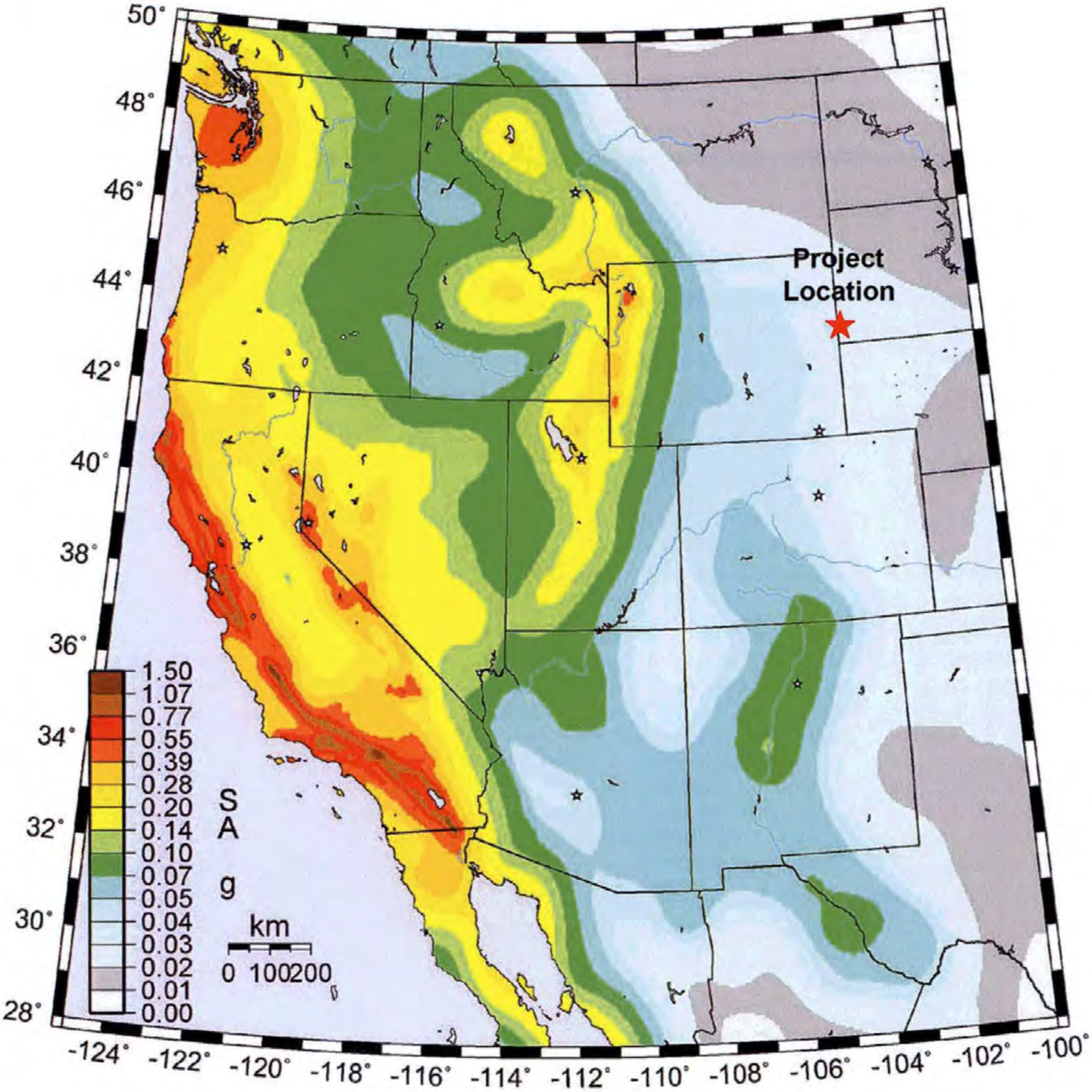
According to the U.S. Geological Survey's 2002 Seismic Hazard Mapping Program, the peak ground acceleration (PGA) derived from the probabilistic maximum bedrock acceleration with a 10 percent exceedance in 50 years (475-year return period) is 0.03g (Figure 2.6-5) for the southwestern part of South Dakota. The probabilistic maximum bedrock acceleration with a 2 percent chance of exceedance in 50 years (2,475-year return period) is 0.09g for the region (Figure 2.6-6).

2.6.7.1.2 Seismic Sources

Assessment of seismic hazards requires consideration of potential earthquake source zones, either identifiable faults or larger areas with common seismic characteristics. Once potential source zones have been identified, design earthquakes can be assigned based on a synthesis of geological and seismological data.

2.6.7.1.3 Capable Faults

The project is located in an area of historically low seismic potential. There are no known capable faults within 100 kilometers of the site and a relatively low number of historical earthquakes (Figure 2.6-4; Appendix 2.6-G). The closest capable fault zone to the project is located nearly 345 km (200 miles) west of the site in central Wyoming. Therefore, the randomly occurring 'floating' earthquake is considered to be the most significant seismic hazard for the PA



Source: USGS (2008)

Figure 2.6-5
Peak Ground Acceleration (PGA), Illustrating 10 Percent Probability of Exceedance in the Next 50 Years
Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2013
FILENAME	PGA10Pct50Yr.dwg

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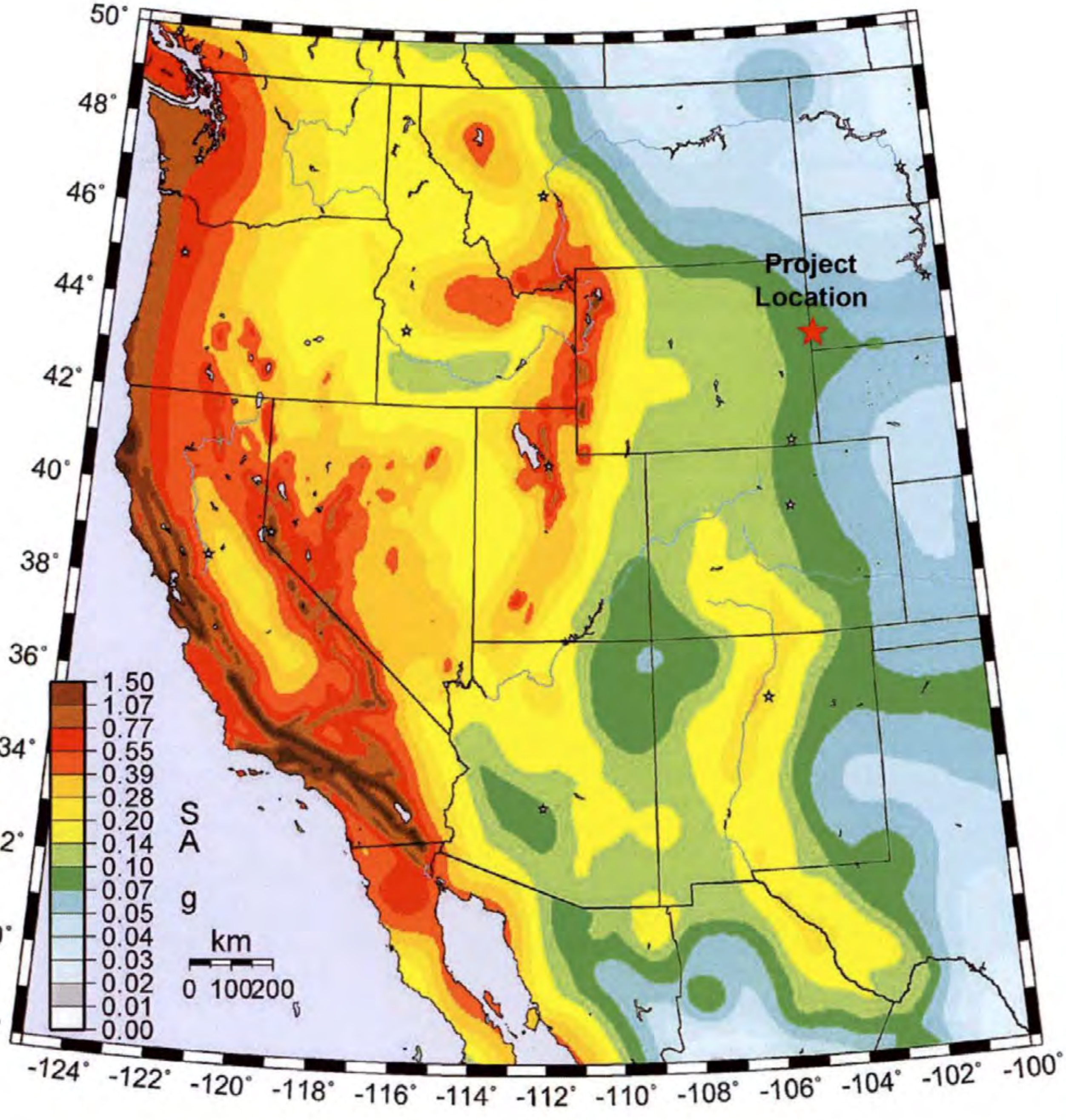

Source: USGS (2008)

Figure 2.6-6
Peak Ground Acceleration (PGA), Illustrating 2 Percent Probability of Exceedance in the Next 50 Years
Dewey-Burdock Project

DRAWN BY	S. Hetrick	POWERTECH (USA) INC.
DATE	14-Jun-2013	
FILENAME	PGA2Pct50Yr.dwg	

(discussed below), the same as the maximum credible earthquake as defined in 10 CFR Part 40, Appendix A Criterion 4(e), quoted above.

2.6.7.1.4 The Randomly Occurring 'Floating' Earthquake

Industry standards and federal regulations require an analysis of the earthquake potential in regions where the surface expression of active faults is not mapped or exposed, and where earthquake epicenters are associated with buried faults with no associated surface rupture. Earthquakes associated with buried faults are assumed to occur randomly and can occur anywhere within that area of uniform earthquake potential. In reality, random earthquake distribution may not be the case, since all earthquakes are associated with specific faults. However, since all buried faults in the PA have not been identified, it is reasonable to consider the distribution to be random. A 'floating' earthquake is an earthquake that is considered to occur randomly within a tectonic province.

The U.S. Geological Survey identified tectonic provinces for the contiguous United States (Algermissen et al., 1982). The project site is located in a source zone with a uniformly distributed seismicity which generally encompasses the Black Hills and surrounding environs. The zone is characterized by an earthquake with maximum magnitude M_{max}=6.1. This magnitude is used as the best estimate for the floating earthquake.

2.6.7.2 Conclusion

Seismic hazards at the project site include low to moderate ground shaking associated with regional and local earthquake sources. Figures 2.6-4 through 2.6-6 illustrate seismicity and PGA maps for the PA, and Appendix 2.6-G is a summary of the USGS database results for historical earthquakes recorded within 100 and 200 km from the site since 1973.

There are no capable faults (as defined in section III(g) of Appendix A of 10 CFR Part 100) known to be present within 100 km of the project site. The closest capable fault zone to the project is located nearly 345 kilometers (200 miles) west of the site in central Wyoming. Therefore, the most significant seismic hazard is considered to be the randomly occurring, or 'floating', earthquake for the PA. This is the maximum credible earthquake estimated for the project based on available literature, geologic information of the surrounding area, and historical data. A magnitude M_{max}=6.1 is estimated for this event.

According to the U.S. Geological Survey's 2002 Seismic Hazard Mapping Program, PGA derived from the probabilistic maximum bedrock acceleration with a 10 percent exceedance in 50 years (475-year return period) is 0.03g (Figure 2.6-5) for the southwestern part of South Dakota. The probabilistic maximum bedrock acceleration with a 2 percent chance of exceedance in 50 years (2,475-year return period) is 0.09g for the region (Figure 2.6-6). Both of these estimates are considered to reflect a relatively low ground motion hazard.

2.6.8 References

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2.7 Hydrology

Powertech (USA) conducted baseline surface water and groundwater quality monitoring in accordance with NRC Regulatory Guide 4.14 and NUREG-1569. The following sections describe the hydrology baseline assessment program and results.

2.7.1 Surface Water

2.7.1.1 Regional Hydrology

The PA is approximately 16.5 mi^2 and lies in southwestern Custer County and northwestern Fall River County in South Dakota (Figure 2.7-1). Precipitation incorporates both rainfall and snow which can differ greatly based on elevation of the area and time of year. According to historical precipitation data, the upper elevations of the Black Hills can receive up to 24 inches annually, while most of the lower plains receive significantly less (Driscoll and others, 2002).

The PA is in the Southern Black Hills, which includes two physiographic divisions that are characterized as the Black Hills and the Great Plains Divisions. The Black Hills Division generally consists of steep formations of metamorphosed and intensely compacted sedimentary rocks, which form a perimeter around an intrusion of Precambrian igneous and crystalline rocks. The sedimentary layers consist of aquifer formations that typically have high permeability, which allows for the transportation and storage of water. Aquifers are usually separated by an aquitard layer that restricts the vertical transport of water from one aquifer to the next. The aquifers generally receive a large amount of recharge from stream losses and infiltration. The infiltration rates can vary greatly due to variations in slope and soil and can have a significant impact on the base flow of natural streams (Driscoll and others, 2002).

The Great Plains physiographic division is characterized by relatively flat, rolling hills which are divided by low-sloping streams. The streams generally have well-developed natural drainage areas that primarily flow from west to east (Driscoll and others, 2002).

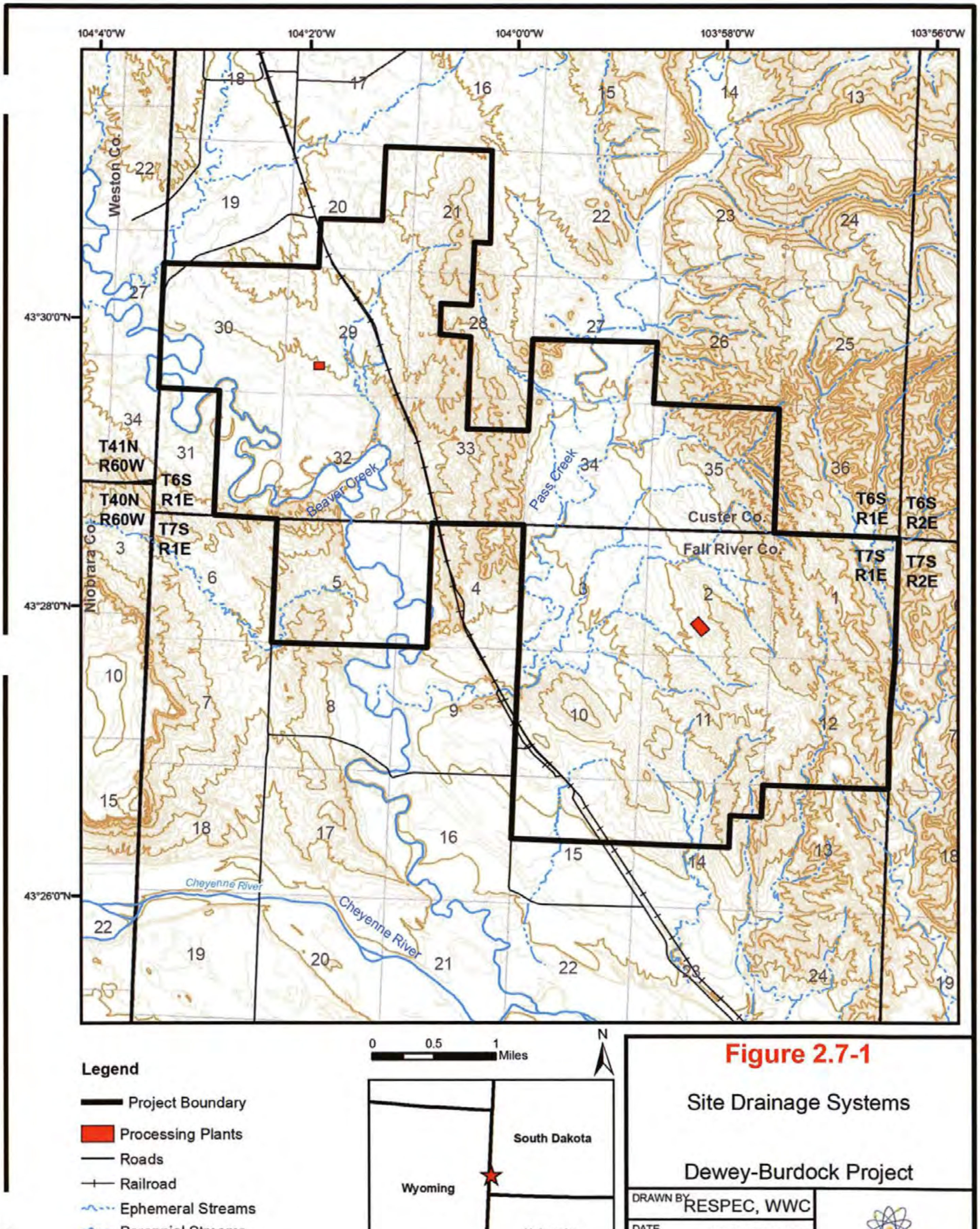

Figure 2.7-1

Site Drainage Systems

Dewey-Burdock Project

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2.7.1.2 Site Hydrology

The local hydrology and surface water resources are described for the PA and for the two main drainage systems that pass through the site (Beaver Creek and Pass Creek) (Figure 2.2-1).

2.7.1.2.1 Topography

The PA is characterized by low to moderately sloping brush land with areas of moderately steep ridges. The elevation ranges from approximately 3,600 feet to about 3,900 feet within the site. The slopes within the site range from 0 percent to 92 percent, with an average slope of nearly 6 percent. Two primary facility zones exist within the PA. Both the eastern and western facility zones have an average slope of nearly 3 percent.

2.7.1.3 Drainage Basins

The PA lies primarily within the Beaver Creek Basin and is drained by both Beaver Creek and Pass Creek. The Pass Creek watershed is a sub-basin within the Beaver Creek basin, but the two watersheds were characterized as separate basins. The Beaver Creek system flows through the northwestern section of the PA from the northwest to the southeast. The Pass Creek system flows south through the central portion of the PA and joins Beaver Creek southwest of the PA. Three miles south of this confluence, Beaver Creek converges with the Cheyenne River (Figure 2.7-1) which eventually flows into the Missouri River.

The nearest discharge gage on the Cheyenne River upstream of its confluence with Beaver Creek is USGS gage 06386500 near Spencer, WY. The nearest discharge gage downstream of the confluence of Beaver Creek and the Cheyenne River is USGS gage 06395000 at Edgemont, SD. This gage captures the contribution of flow to the Cheyenne River from Beaver Creek and Pass Creek between Spencer, WY and Edgemont, SD. Figure 2.7-2 shows an annual hydrograph for gage 06386500 from 1948 to 2008, and Figure 2.7-3 shows an annual hydrograph for gage 06395000 from 1903 to 2008. The lines in Figures 2.7-2 and 2.7-3 indicate the upper bound flow values for the 25th, 50th, and 95th flow percentiles for each of the 365 days per year. For example (in Figure 2.7-3), based on all of the January 1st flow values during 1903 to 2008 (106 data points), the flow was less than 1 cfs on 25 percent of those days (26 days), less than 4 cfs on 50 percent of those days (53 days) and less than 30 cfs on 95 percent of those days (101 days). Therefore, the graph indicates how variable the stream flow tends to be at various times during the year (e.g., more variable during a typical July than a typical November).

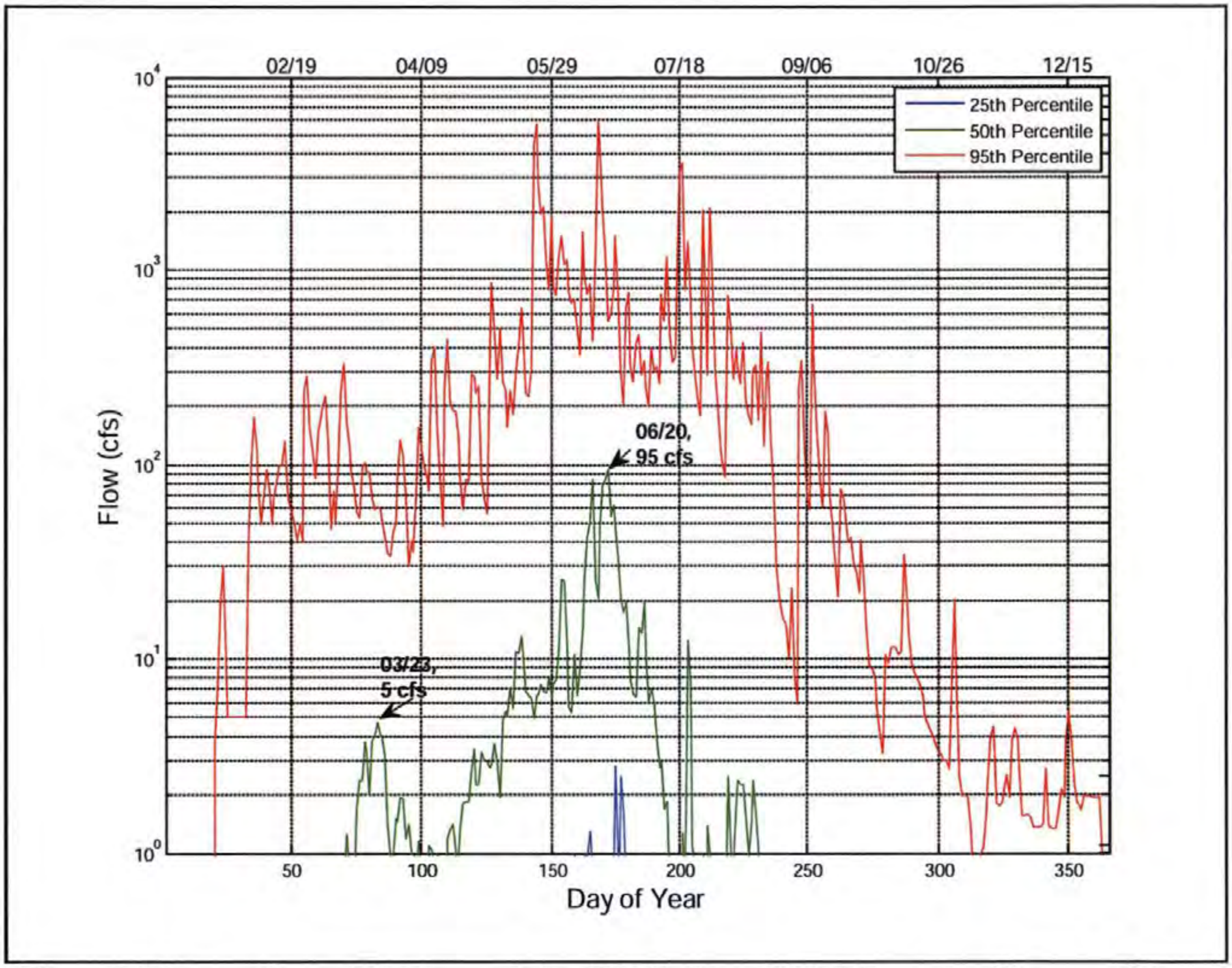


Figure 2.7-2: Annual Hydrograph for USGS Gage 06386500 on the Cheyenne River near Spencer, WY from 1948 to 2008

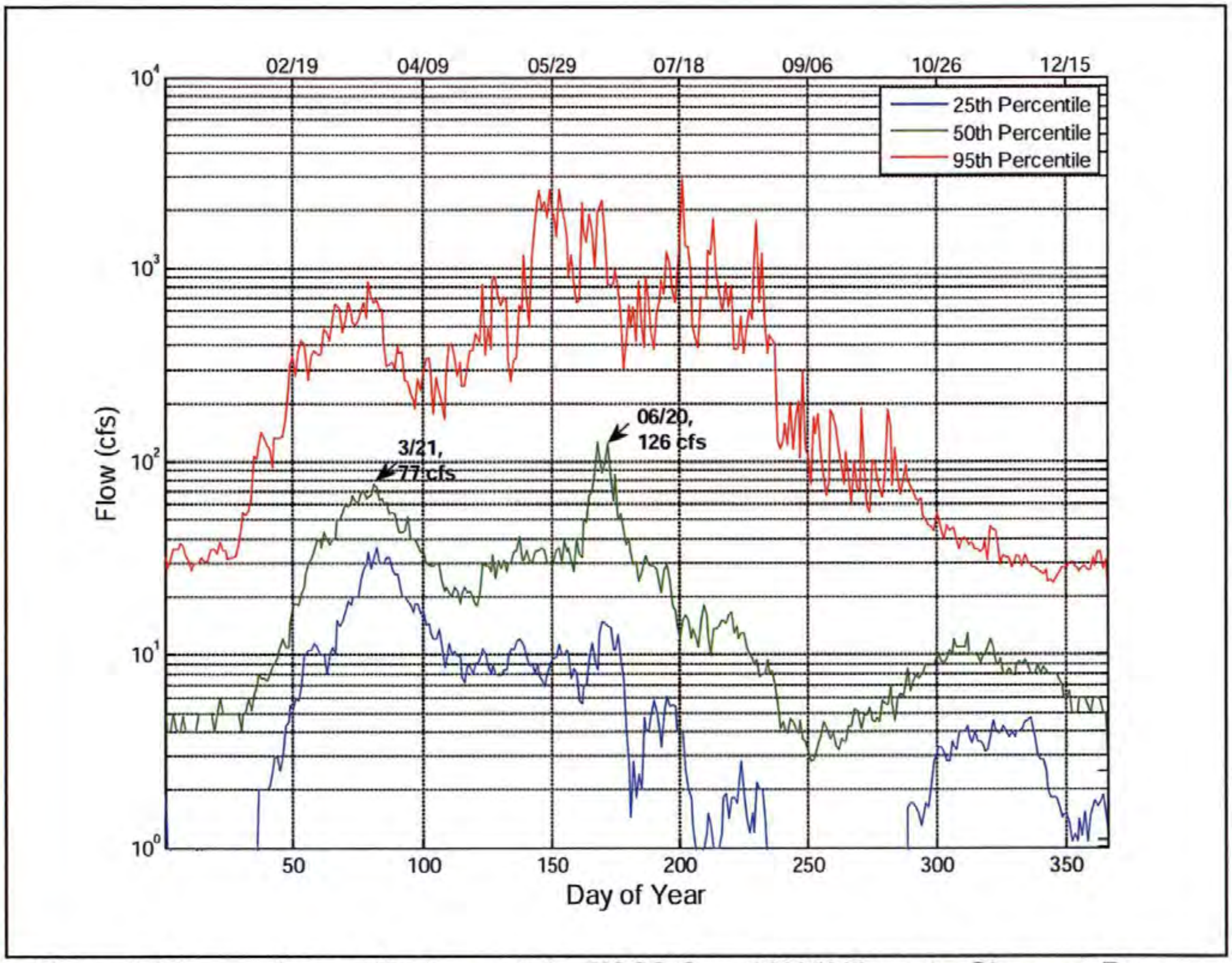


Figure 2.7-3: Annual Hydrograph for USGS Gage 06395000 on the Cheyenne River at Edgemont, SD from 1903 to 2008

2.7.1.3.1 Beaver Creek Basin

The Beaver Creek Basin is 1360 mi^2, excluding the Pass Creek sub-basin. It extends from a few miles northwest of Upton, WY to about eight miles southeast of Dewey, SD and lies within Weston, Niobrara and Crook Counties in Wyoming, and within Pennington, Custer and Fall River Counties in South Dakota. Beaver Creek is a perennial stream with ephemeral tributaries. Discharge data for Beaver Creek is collected at USGS gage 06394000 near Newcastle, WY (Figure 2.2-1). Figure 2.7-4 shows an annual hydrograph with the 25th, 50th and 95th flow percentiles for this gage from 1944 to 1998. Figure 2.7-5 shows monthly average flow data for this gage from 1944 to 1998.

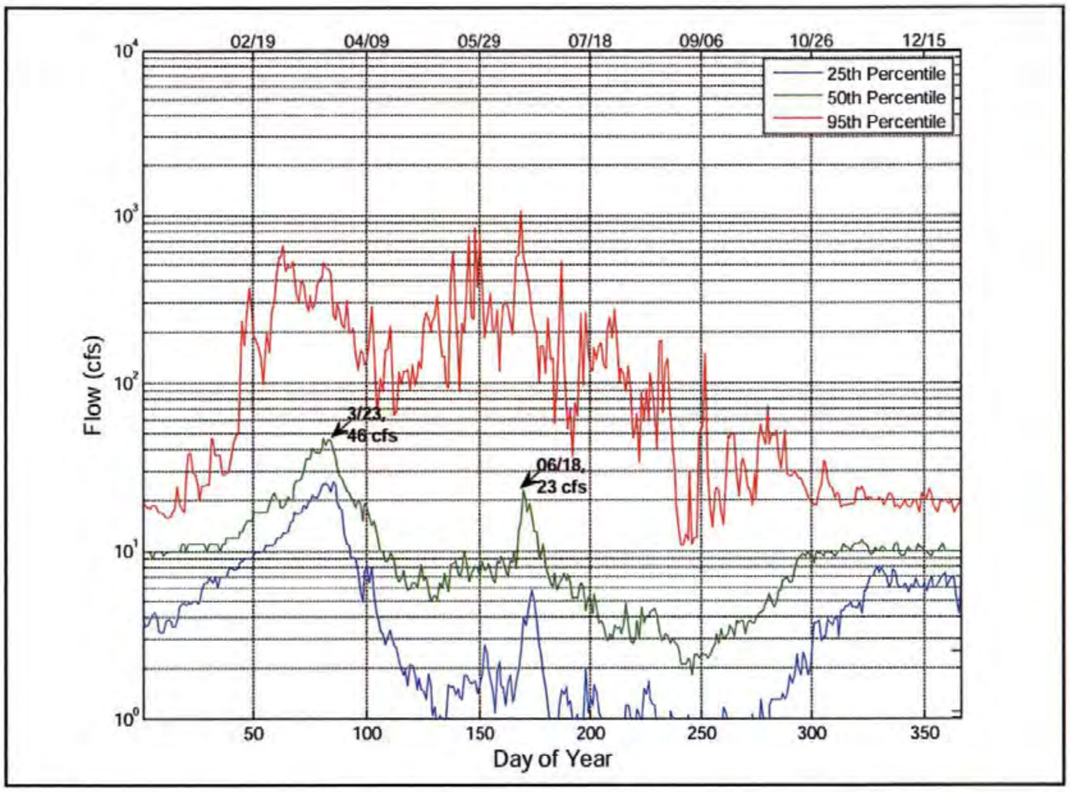


Figure 2.7-4: Annual Hydrograph for USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

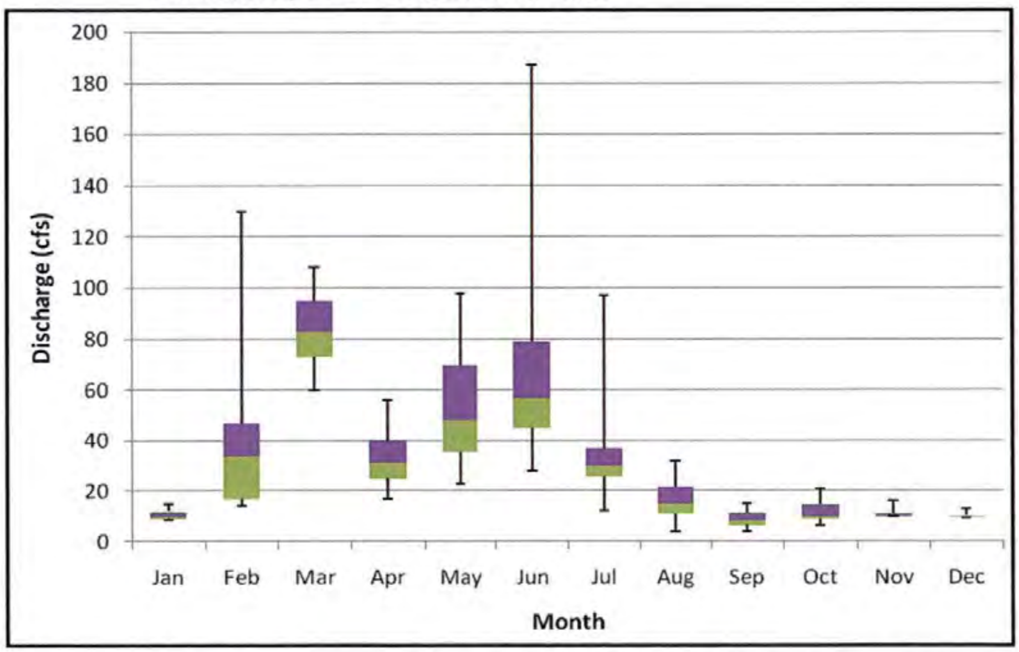


Figure 2.7-5: Monthly Average Flows at USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

2.7.1.3.2 Pass Creek Watershed

The Pass Creek watershed, characterized as a subbasin of the larger Beaver Creek Basin, comprises most of the east-southeast portion of the Beaver Creek Basin and is almost fully contained in South Dakota. The Pass Creek watershed is 230 mi^2 and is located in Custer, Fall River, and Pennington Counties in South Dakota and a very small portion of Weston County in Wyoming. Pass Creek is dry except for brief periods of runoff following major storms and snowmelt. There is no permanent stream flow gage stationed along Pass Creek.

2.7.1.3.3 Project Boundary

The northwestern section of the PA drains to Beaver Creek and ephemeral tributaries. The north-central and east-central section of the PA is drained via Pass Creek and smaller, ephemeral tributaries. The southeast portion of the PA is also part of the Cheyenne River Basin that drains into the Cheyenne River through East Bennett Canyon. The PA contains many intermittent streams and drainage channels, particularly in the eastern extent, that are consistently dry throughout the year. Stream flow only occurs in these channels after significant precipitation or snowmelt events and even then may not be of considerable amounts. Three small ephemeral stream channels cut through the primary facility zone in the eastern section of the PA. Most of the small impoundments that exist within the PA are dry during most of the year (Plate 5.7-1). Many of these existing impoundments are found along ephemeral streams and tributaries, particularly in the eastern section of the PA.

2.7.1.3.4 Proximity of Surface Water Features to Proposed ISL Facilities

Beaver Creek is the primary surface water resource in the PA. Pass Creek is a secondary surface water resource in the PA, although the ephemeral channel is dry except during infrequent runoff or snow melt events. The remaining surface water resources in the PA are small, ephemeral stream channels and small impoundments.

Section 3.1.7 describes the construction of ISL facilities in relation to surface water features. Plate 2.7-1 depicts the location of proposed facilities and potential well field areas in relation to the 100-year flood inundation areas for surface water features. Where possible, facilities will be located out of the 100-year flood inundation boundary. Facilities which must be located within such boundaries will be protected from flood damage by the use of straw bales, collector ditches, and/or berms.

2.7.1.4 *Surface Water Run Off*

2.7.1.4.1 *General Approach*

The potential for flood or erosion damage in the PA was evaluated by developing a design flood using statistical methods and a computer model for watershed hydrology in accordance with NUREG-1569. Peak discharge of the design flood was then transformed to a water level using a computer model for stream hydraulics. This approach provides a floodplain map that shows the maximum area inundated by the design flood, as well as detailed information on the depth and velocity of flood water at points of interest in the study area. The 100-year event was used for the design flood, along with a much less likely flood referred to as an upper-bound flow or an extreme flow.

The 100-year event represents an appropriate level of risk for the evaluation of flood potential near the PA facilities. The extreme flow event was used to demonstrate the additional extent of land that would be inundated between the 100 year event and floods that have an extremely low probability of occurring. The uncertainty in the analysis and the flood potential at various locations in the PA are evident when the two scenarios are compared. If a floodplain map shows a small increase in the area of land inundated by the 100 year and the extreme flows, compared to the distance and elevation difference between the edge of the 100-year floodplain and the nearest structure of concern, then the risk analysis is robust and the potential for flood damage to the nearest structure is extremely low. However, if a floodplain map shows a large increase in the area of land inundated between the 100 year and the extreme flows, compared to the distance and elevation difference between the edge of the 100 year floodplain and the nearest structure of concern, then the risk analysis may be too sensitive to the design event selected (i.e., the 100-year flood) and the potential for a flood to damage the nearest structure could be too high. This approach avoids attempts to quantify the 500-year or 1,000-year flood event for example, which involves significant uncertainty because the time period of the observed hydrologic data is too short for such a long return period.

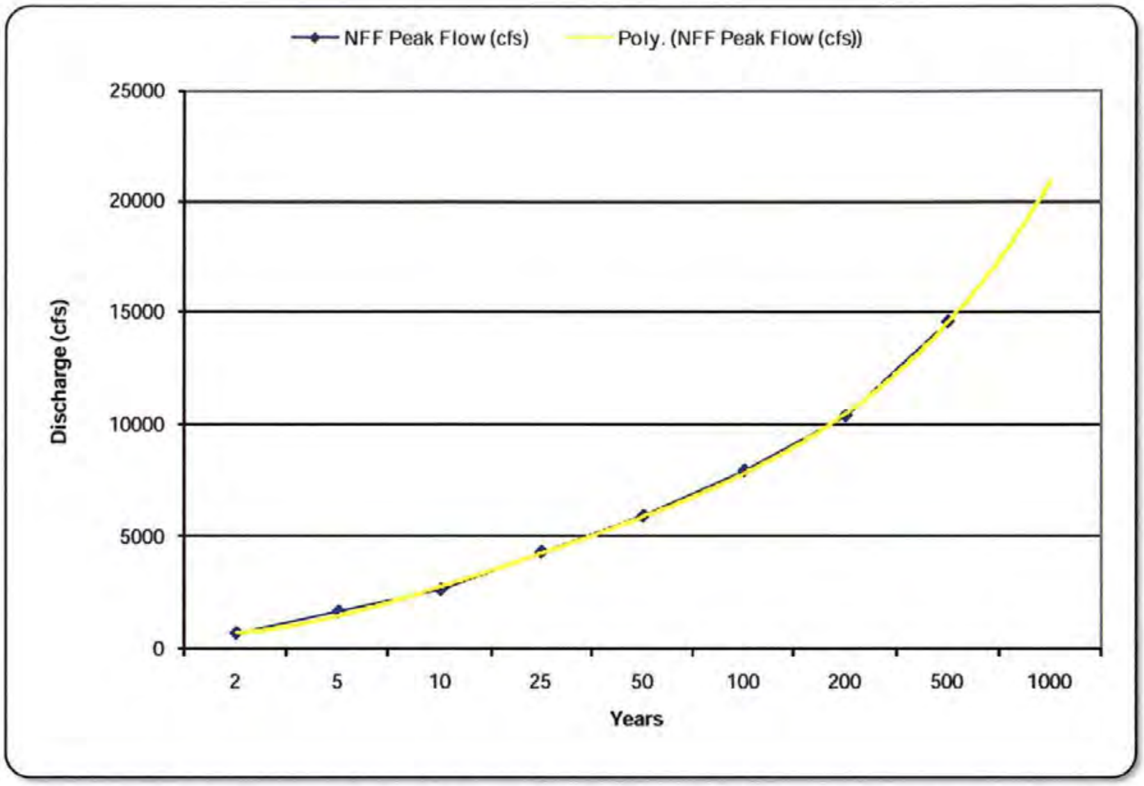
The 100-year flows were developed using hydrologic analyses for Beaver Creek, Pass Creek and ephemeral tributaries. These flows are then transformed to maximum water levels using a stream channel hydraulic model. Upper-bound flows, or extreme flows, were developed for Beaver Creek and Pass Creek and used for comparison with the 100-year event. Floodplain maps showing the proximity of primary facility zones to the maximum level of floodwater were generated for each scenario.

2.7.1.4.2 Hydrologic Analysis – Beaver Creek

USGS gage number 06394000 is located along Beaver Creek near Newcastle, WY (Figure 2.2-1). Statistical methods were used to estimate the design flows. Three software programs were used: National Flood Frequency (NFF) Program 3.2 (Ries and Crouse, 2002), PKFQWin 5.0 (Flynn and others, 2006), and a Matlab Flood Frequency Analysis program (Rao and Hamed, 2000).

The NFF program uses sub-watershed areas, geographical information, and precipitation averages to estimate flood events based on regional regression analyses. The PKFQWin and Matlab programs use the 55 years of historical peak flow at gage 06394000 to estimate flood events. The NFF and PKFQW in methods compute estimated floods ranging from 2- to 500-year frequencies. Beyond that range, a fourth-order polynomial trend-line was used to estimate an extreme condition flood with a relative return period of approximately 500 years to 1500 years.

The sub-watershed areas required by the NFF program were established using ArcHydro 9.2, a GIS watershed delineation tool. The watershed boundaries were in Regions Two (Central Basin and Northern Plains) and Four (Eastern Mountains). Watershed areas for these regions are 971 mi^2 and 387 mi^2, respectively. The analysis for Region Four also required values for mean March precipitation (1.05 inches) – obtained from the National Oceanic and Atmospheric Administration (NOAA) – and latitude of the basin outlet (43.6 degrees north). The discharge results from the NFF program with return periods ranging from 2 to 500 years are given in Figure 2.7-6. The figure also shows the fourth-order polynomial trend-line used to extrapolate the NFF results to an extreme condition flood. The flood estimates from the NFF approach are listed in Table 2.7-1.



Note: Obtained from the NFF program and extrapolated with a 4th order polynomial trend-line to estimate an extreme condition flood.

Figure 2.7-6: Beaver Creek Flood Estimates

Table 2.7-1: NFF Flood Estimate Results for Beaver Creek

Recurrence Interval (years)	Peak Flow (cfs)
2	700
5	1,660
10	2,640
25	4,320
50	5,930
100	7,950
200	10,400
500	14,600
Extreme Condition	22,000

The Matlab program used seven distributions to analyze the historical peak flows. The program ran a test hypothesis on the estimated flood events using the Klomo-Smirnov and Chi-squared procedures. Of the seven distributions, the Klomo-Smirnov method was accepted for the Log Pearson Type III distribution. The flood estimates from the Matlab programs are shown in Table 2.7-2.

Table 2.7-2: Matlab Flood Estimate Results for Beaver Creek

Recurrence Interval (years)	Peak Flow (cfs)
100	6,570
200	7,910
Extreme Condition	11,500

PKFQWin used a Pearson Type III distribution with a weighted and generalized skew, and computed slightly higher results than the NFF program. The PKFQWin results are shown in Table 2.7-3.

Table 2.7-3: PKFQWin Flood Estimate Results for Beaver Creek

Recurrence Interval (years)	Weighted Peak Flow (cfs)	Generalized Peak Flow (cfs)
5	1,840	1,870
10	2,750	2,700
25	4,340	4,070
50	5,940	5,350
100	7,980	6,870
200	10,560	8,680
500	15,030	11,600
Extreme Condition	23,000	17,000

The flood estimates for Beaver Creek are summarized in Table 2.7-4. The final flow values selected for the floodplain analysis of Beaver Creek were 7,990 cfs and 23,000 cfs representing the 100 year and extreme condition floods, respectively. These values were chosen because they represent the most conservative design flow estimates.

Table 2.7-4: **Summary Flood Estimate for Beaver Creek**

Recurrence Interval (years)	PKFQWin Estimate (cfs)	NFF Estimate (cfs)	MATLAB Estimate (cfs)
100	7,990	7,950	6,570
Extreme Condition	23,000	22,000	11,500

2.7.1.4.3 Hydrologic Analysis – Pass Creek

There are no gage sites along Pass Creek or its tributaries (Hell Canyon, West Hell Canyon, Sourdough Draw, and Tepee Canyon) to provide accurate flow data. To obtain design flow values for the stream channel of Pass Creek within the PA, a rainfall runoff model was used along with design rainfall to generate stream flows with a range of exceedance probabilities. The 100-year event was used as the primary condition for evaluating the risk of flooding and erosion in the Pass Creek area. An upper bound or extreme condition was represented by 50 percent of an estimated probable maximum flood, for comparison with the 100-year event.

The Hydrologic Modeling System (HEC-HMS) is designed to simulate the precipitation-runoff processes of dendritic watershed systems. The Geospatial Hydrologic Modeling Extension (HEC-GeoHMS) is a software package for use with the ArcView Geographic Information System (GIS). HEC-GeoHMS analyzes digital terrain information and transforms the drainage paths and watershed boundaries into a hydrologic data structure that represents the watershed response to precipitation.

In order to use the HEC-HMS model a high resolution DEM was developed. Contour data from the U.S. Geological Survey 1:24,000 topographic maps were used with ArcGIS to create a grid of elevation data. Plotting stream elevation values against distance downstream indicated that adjacent stream vertices were within two feet of each other, providing good accuracy for this type of analysis.

The HEC-GeoHMS basin model of the Pass Creek watershed was imported into HEC-HMS and the meteorological models and control specifications were created. The 100-year/24-hour storm and the probable maximum precipitation (PMP) were used as the driving precipitation events. Estimates for the 100-year/24-hour storm were obtained from the national depth-duration-frequency maps (US Department of Commerce) (Table 2.7-5). The PMP estimate was obtained from HMR-51 depth-area-duration maps (Schreiner and Riedel, 1978) (Table 2.7-6). The comprehensive approach of HMR-52 (Hansen, et al, 1982) for developing a probable maximum flood (PMF) was not used. Instead, a simplified approach was developed using the PMP estimate as with conventional rainfall runoff modeling techniques. The resulting flood is therefore referred to as an estimated probable maximum flood (estimated PMF) and represents an appropriate extreme event for comparison with the 100-year event. Figure 2.7-7 shows a graphical representation of the PMP estimates for the Pass Creek watershed's geographical location. The depths and durations for the PMP on the Pass Creek watershed are shown in Table 2.7-7.

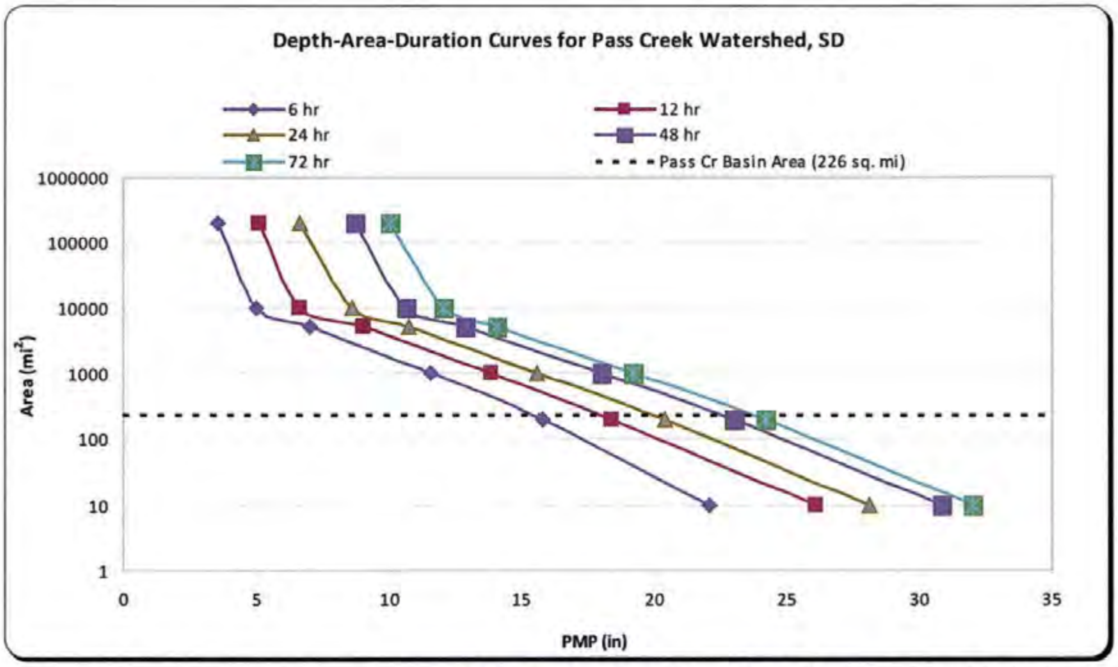
Table 2.7-5: Depth-Duration Data for the 100-Year Storm Event

100-year Storm	
Duration	Depth (in)
5 min	0.79
15 min	1.58
60 min	2.50
2 hour	3.00
3 hour	3.20
6 hour	3.60
12 hour	4.10
24 hour	4.80

Table 2.7-6: Probable Maximum Precipitation (PMP)

	Duration (hr)				
Area (mi^2)	6	12	24	48	72
10	22.1	26.1	28.1	30.8	32
200	15.8	18.4	20.4	23	24.2
1000	11.5	13.8	15.6	18	19.2
5000	7	9	10.7	12.8	14
10000	5	6.6	8.6	10.6	12
200000	3.5	5.1	6.6	8.7	10

Source: from HMR-51 (Schreiner and Riedel, 1978)
Note: Data in inches



Source: developed from probable maximum precipitation (PMP) estimates obtained from HMR-51 (Schreiner and Riedel, 1978)

Figure 2.7-7: Depth-Area-Duration Curves for the Pass Creek Watershed in SD

Table 2.7-7: Interpolated Estimates for the Probable Maximum Precipitation (PMP) for the Pass Creek Watershed in SD

	Duration (hr)				
Area (mi²)	6	12	24	48	72
226	15.7	18.3	20.2	22.8	24.0

Two control specifications (time periods used to capture the response of a watershed from a precipitation event) were created for the HEC-HMS model of the Pass Creek watershed. The first used a four-day duration with 15-minute time intervals for the 100-year/24-hour storm, and the second used a seven day duration with six hour time intervals for the PMP.

The loss and transform methods used in the HEC-HMS model of the Pass Creek watershed were the SCS Curve Number and SCS Unit Hydrograph, respectively. Both of these methods rely heavily on a curve number (CN) which is a characterization of soil type, land use and cover, and antecedent soil moisture. These parameters were estimated based on a field inspection of the Pass Creek watershed on May 21, 2008, on the Soil Survey Geographic (SSURGO) Database and on county land use data. Parameters for the loss and transform methods include CN, storage (S), initial abstraction (I_a) and lag time (t_l).

Curve numbers were assigned to different sub-watershed sectors, and area-weighted CNs were developed for the entire Pass Creek watershed for standard conditions (CN = 57) and for conservative conditions (CN = 63). An impervious area of five percent was also estimated based on field investigations. The CN of 63 was used in the model, providing a conservative approach because the higher CN would result in a larger percentage of rainfall becoming runoff.

The parameter values used in the loss and transform methods of the model were a CN of 63, S equal to 5.87 inches, I_a of 1.18 inches and t_l equal to about 1,231 minutes. The values of S, I_a and t_l are based on the CN in that their value is heavily influenced by the value of the CN.

The output results for both precipitation events in the HEC-HMS model of the Pass Creek watershed are shown in Table 2.7-8. Due to the extreme condition represented by the PMP meteorological model, the estimated PMF was reduced by a factor of 0.5. This resulted in a 50 percent estimated PMF peak discharge of approximately 32,800 cfs.

Table 2.7-8: Discharge Results for the Single Basin Model of the Pass Creek Watershed

Event	Peak Discharge (cfs)
100yr	5620
Estimated PMF	65600
50% Estimated PMF	32800

The final flow values used for input to the HEC-RAS model of Pass Creek were 5,620 cfs and 32,800 cfs representing the 100 year and extreme condition floods, respectively. These flow values resulted from a conservative approach to parameter estimation and modeling. The model used the higher CN and a single basin versus many smaller sub-basins with routing. This combination results in a larger instantaneous peak flow entering the stream channel of Pass Creek within the PA. The extreme condition flood is only included to illustrate the extent of the flood plain during an extremely low probability flood event, and its relation to the primary facility zones. The estimated PMF and 50 percent of the estimated PMF are extremely rare events and represent conditions much more severe than the design scenarios discussed in NRC 1569 for in situ leach extraction operations.

2.7.1.4.4 Floodplain Analysis – Beaver Creek and Pass Creek

The stream channels of both Beaver Creek and Pass Creek within the PA were each modeled using the Hydraulic Engineering Center River Analysis System (HEC-RAS) and the Geospatial River Analysis Extension (HEC-GeoRAS) to determine the spatial representation of the floodplains resulting from the simulated 100-year flood and extreme condition flood.

HEC-RAS software simulates one-dimensional steady and unsteady river hydraulics. The system can handle a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles.

The Geospatial River Analysis Extension (HEC-GeoRAS) is a set of ArcGIS tools specifically designed to process geospatial data for use with HEC-RAS. The extension enables efficient creation of a HEC-RAS import file containing geometric data from an existing digital terrain model (DTM) and a National Hydrography Dataset (NHD) flowlines shapefile. Results exported from HEC-RAS may also be processed using HEC-GeoRAS to create layers and floodplain maps in ArcMap.

The HEC-RAS model is based largely on a framework of geometric data which provides a representation of the physical characteristics of a river. For both Beaver Creek and Pass Creek, HEC-GeoRAS was used to extract the necessary elevation and geometric data for the channel and floodplain from the same DEM developed for the HEC-HMS analysis. The process for each creek was nearly the same except for the extra details required to characterize the two bridges spanning Pass Creek just downstream of the southern portion of the PA. The road and railroad bridges had the potential to cause backwater effects and were therefore included in the Pass Creek analysis though they were outside of the PA. The geometry and elevation data of both bridges were measured on April 12, 2008.

The geometry files generated with HEC-GeoRAS in ArcGIS were imported into HEC-RAS and inspected for completeness. For each creek, ineffective flow areas were added where necessary and Manning's n values were assigned for the left overbank, the channel, and the right overbank. Conservative Manning's n values were established during a field inspection of the Beaver Creek and Pass Creek channels within the PA on May 21, 2008 (Table 2.7-9). Figures 2.7-8 and 2.7-9 are photos of the Beaver Creek and Pass Creek stream channels along with their floodplains taken during the site inspection.

Data entry for the bridges in the downstream section of Pass Creek was manually performed. Low flow calculation methods for the road bridge and railroad bridge included the energy and momentum methods. Pressure and weir methods were used for high flow computation of the road bridge while energy only was used for the railroad bridge.

Table 2.7-9: Manning's n Values for the Beaver Creek and Pass Creek Channels

Creek	Manning's n Value		
	Left Overbank	Channel	Right Overbank
Beaver, upstream	0.060	0.045	0.060
Beaver, downstream	0.053	0.040	0.053
Pass	0.065	0.050	0.065

Note: based on field observations

Two steady flow profiles were created for each creek: the 100-year flood and the extreme condition flood (a 500-year – 1500-year flood for Beaver Creek and 50 percent of the estimated PMF for Pass Creek). Flow estimates generated from PKFQWin and HEC-HMS were entered for each profile of Beaver Creek and Pass Creek, respectively. Downstream boundary conditions used normal depth with updated slopes of the energy grade lines.

Note: location is in the northern extent of the PA along the South Dewey Road, looking west

Figure 2.7-8: The Beaver Creek Stream Channel and Floodplain

Note: location is in the southwest extent of the PA, just east of the confluence with Beaver Creek. Photo taken from the road bridge along South Dewey Road, looking east.

Figure 2.7-9: The Pass Creek Stream Channel and Floodplain

Floodplain Analysis – Results. The HEC-RAS analysis involved an iterative procedure of creating a model run – based on an input geometry file and a steady flow profile(s) – and reviewing output summary tables and warning and error messages. From this process, the geometry file was revised multiple times by adding cross sections to adequately balance the energy losses throughout the model for each creek.

The final model results for the spatial representation of the 100-year floodplains for Beaver Creek and Pass Creek within the PA are shown in Figures 2.7-10 and 2.7-11, respectively. These figures also depict the modeled 100-year flood inundation areas for ephemeral tributaries within the project area as described in Section 2.7.1.4.5. Plate 2.7-1 depicts the location of proposed facilities and potential well field areas in relation to the modeled 100-year flood inundation areas. The horizontal and vertical distances separating the primary facility zones and known ore bodies from the 100-year floodplain for each creek are shown in Table 2.7-10.

Table 2.7-10: Proximity Data for the 100 Year Floods of Beaver Creek and Pass Creek

Creek	Concern	Horizontal Distance (ft)	Vertical Distance (ft)
Beaver			
	Facilities	3,140	30
	Ore Bodies	300	5
Pass			
	Facilities	5,470	80
	Ore Bodies	210	5

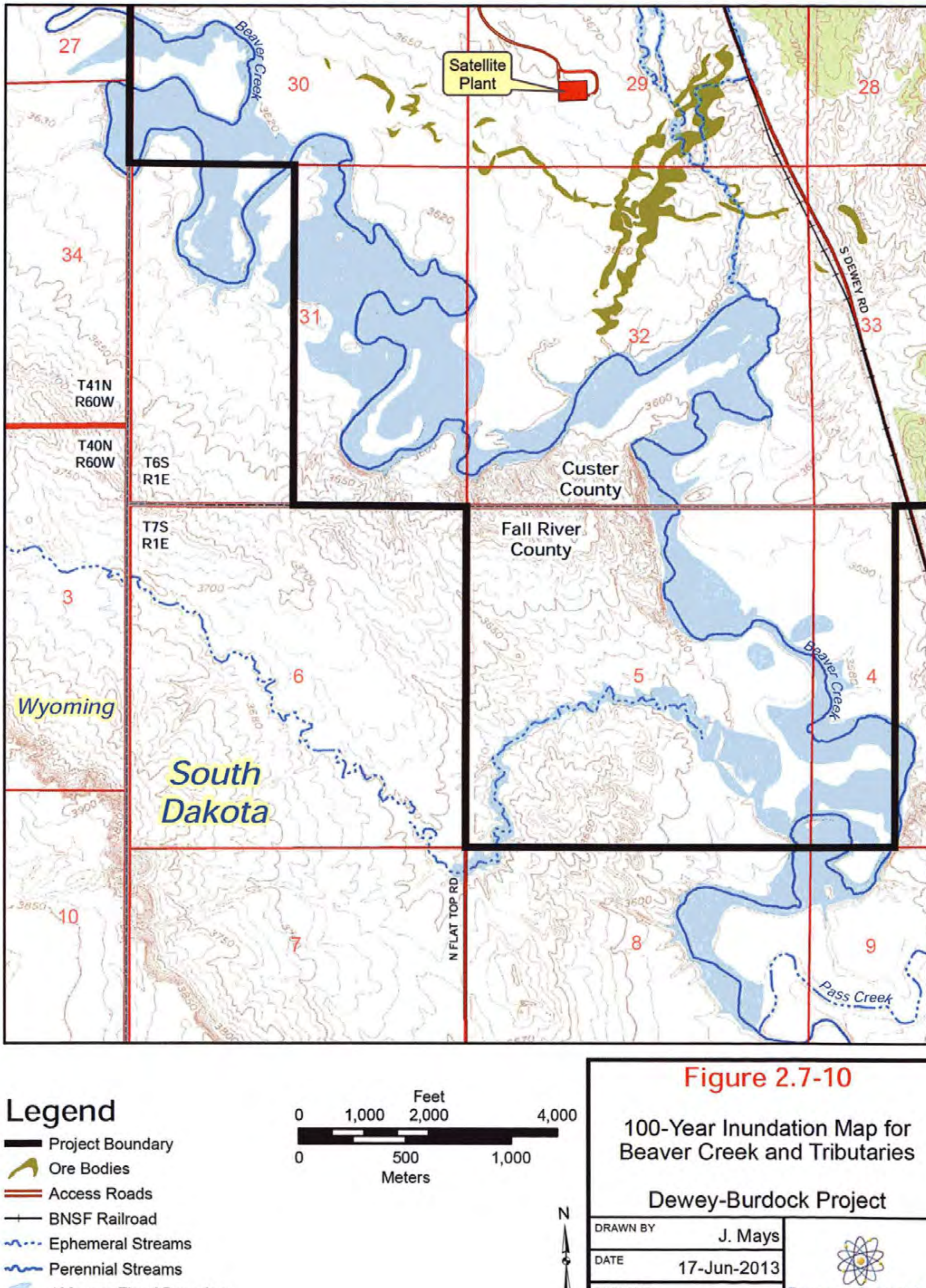


Figure 2.7-10

100-Year Inundation Map for Beaver Creek and Tributaries

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Flood100-BeaverCr.mxd

POWERTECH (USA) INC.

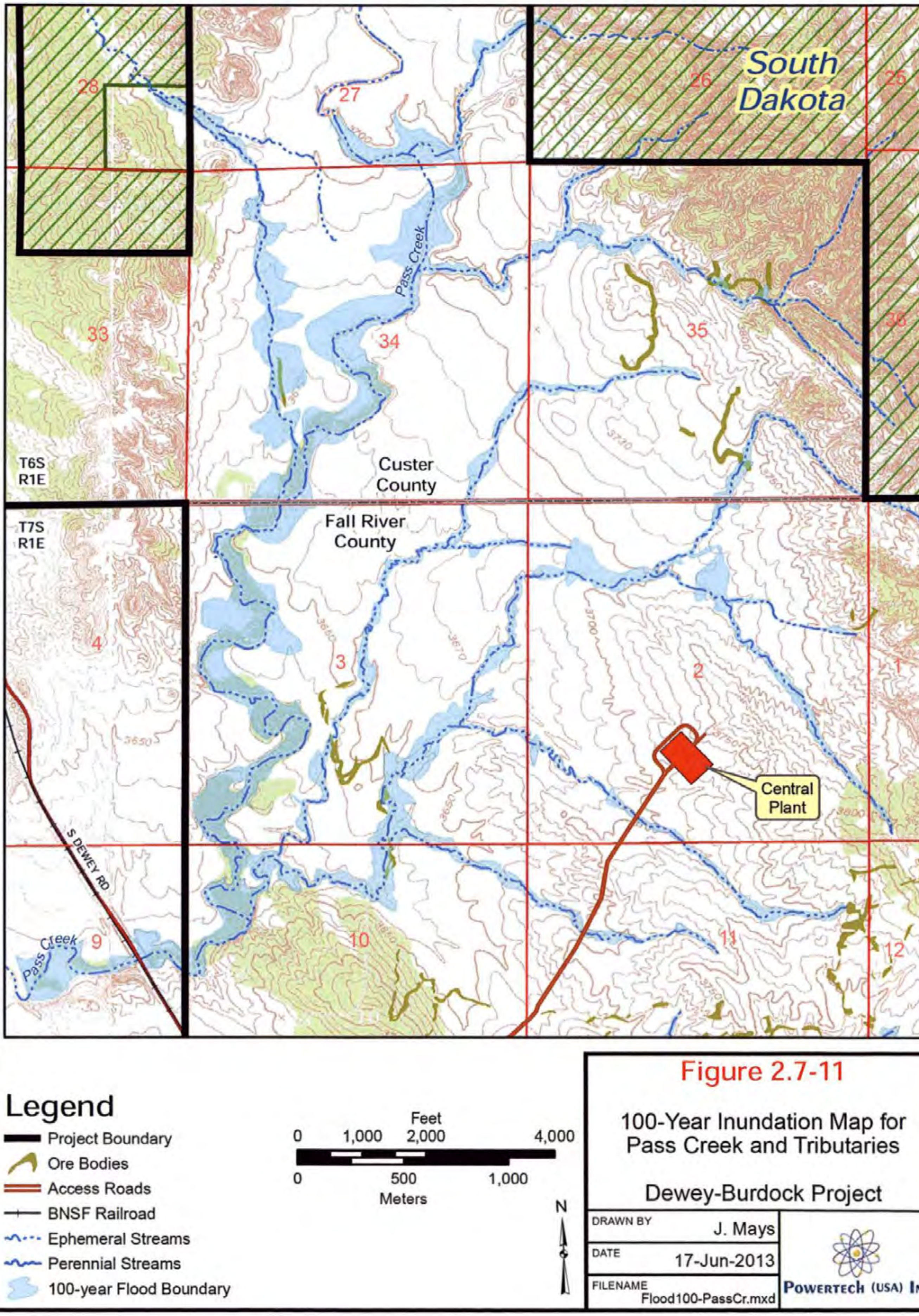


Figure 2.7-11

100-Year Inundation Map for Pass Creek and Tributaries

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Flood100-PassCr.mxd

POWERTECH (USA) INC.

The final model results for the spatial representation of the extreme condition floodplains for Beaver Creek and Pass Creek within the PA are shown in Figures 2.7-12 and 2.7-13, respectively. The figures indicate the relationship of the maximum extent of the extreme condition floodplain to the locations of the primary facility zones and the known ore bodies. The horizontal and vertical distances separating the primary facility zones and known ore bodies from the extreme condition floodplain for each creek are shown in Table 2.7-11. The sole purpose of including the extreme condition flood in the analysis for flood and erosion potential is to illustrate that there is very little additional land area inundated by the extreme condition floods than by the 100-year floods. The risk of flood or erosion damage to the PA facilities from Beaver and Pass Creeks is extremely low.

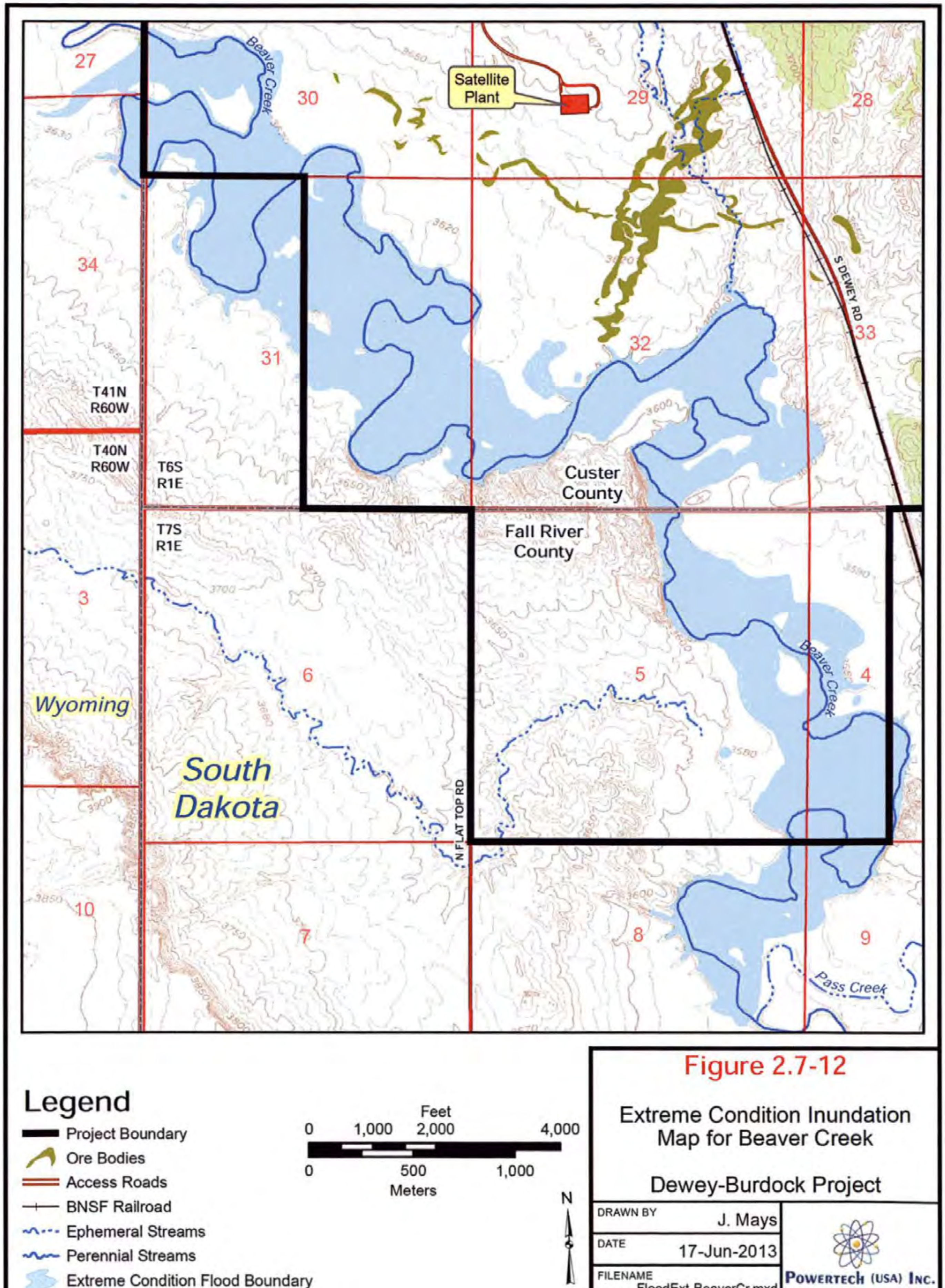
Table 2.7-11: Proximity Data for the Extreme Condition Floods of Beaver Creek and Pass Creek

Creek	Concern	Horizontal Distance (ft)	Vertical Distance (ft)
Beaver			
	Facilities	3,090	30
	Ore Bodies	80	5
Pass			
	Facilities	5,100	80
	Ore Bodies	70	5

The inundation maps of Pass Creek indicate that known ore bodies in the upstream section of the creek would become inundated. It is estimated that the water depths would be 15 feet for the 100-year flood and approximately 25 feet for the extreme condition flood.

2.7.1.4.5 Flooding and Erosion in Local Drainages

Smaller ephemeral drainages within the project area were modeled to evaluate potential for flooding. Results of the model are included in Appendix 2.7-M of the approved license application. As described in Appendix 2.7-M of the approved license application, HEC-HMS models were used to calculate peak discharges for various storm events for the drainages within the project area, and HEC-RAS models were used to predict the 100-year flood inundation boundary for the channels within the project area. The inundation boundaries are depicted on Plate 2.7-1.



Satellite Plant
Beaver Creek
Pass Creek
S DEWEY RD
N FLAT TOP RD
27
30
29
28
34
31
32
33
3
6
5
4
10
7
8
9
T41N R60W
T40N R60W
T6S R1E
T7S R1E
Custer County
Fall River County
Wyoming
South Dakota
Legend
Project Boundary
Ore Bodies
Access Roads
BNSF Railroad
Ephemeral Streams
Perennial Streams
Extreme Condition Flood Boundary
Feet
0 1,000 2,000 4,000
0 500 1,000
Meters
N
Figure 2.7-12
Extreme Condition Inundation Map for Beaver Creek
Dewey-Burdock Project
DRAWN BY J. Mays
DATE 17-Jun-2013
FILENAME FloodExt-BeaverCr.mxd
POWERTECH (USA) INC.

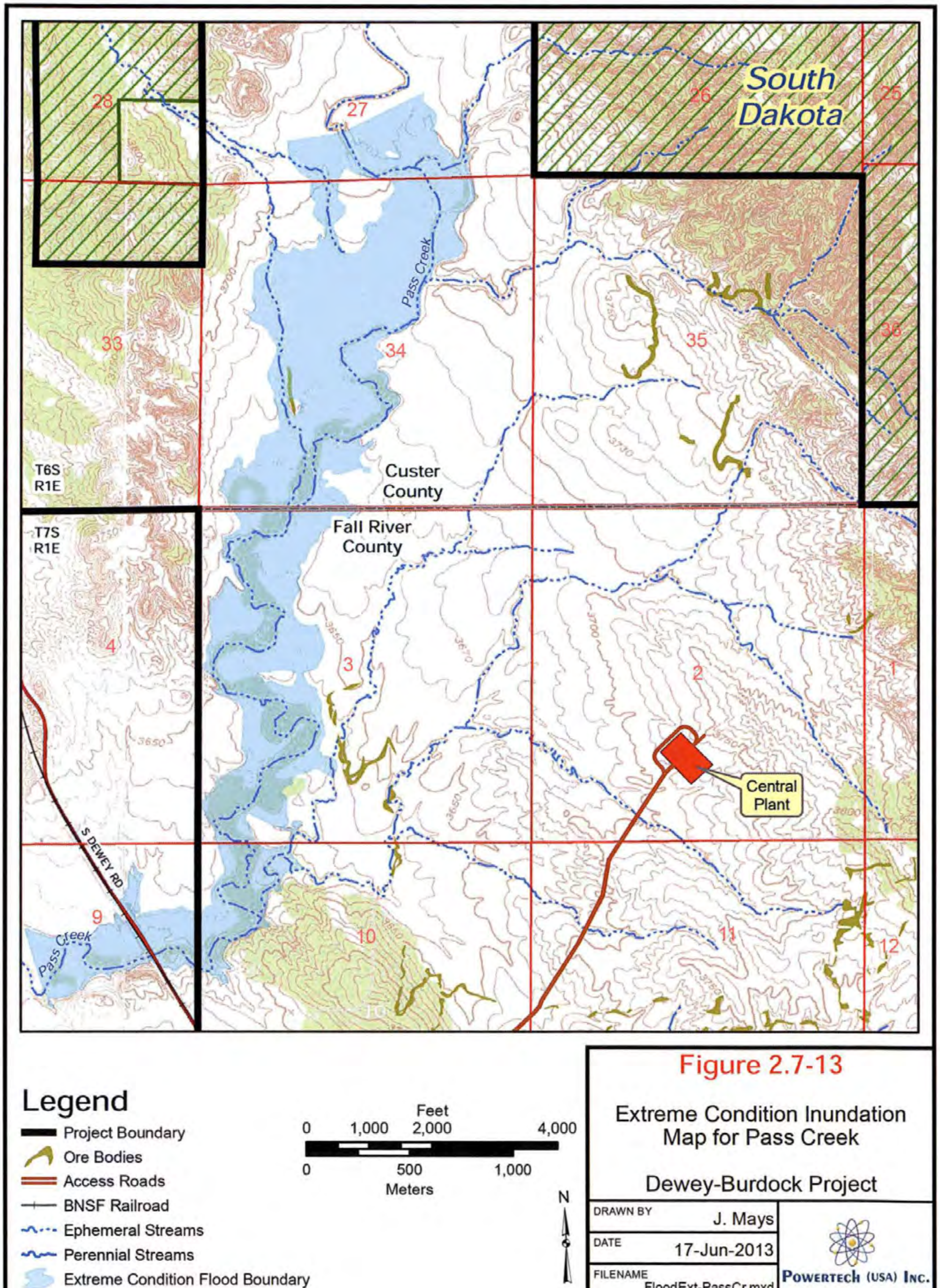


Figure 2.7-13

Extreme Condition Inundation Map for Pass Creek

Where possible, facilities will be located out of the 100-year flood inundation boundary. Facilities which must be located within the 100-year inundation boundary will be protected from damage by a system of structures such as straw bales, collector ditches, engineered diversion structures and/or berms. Additional information on facility construction in relation to flood inundation areas is found in Section 3.1.7.

2.7.1.4.6 Assessment of Levels of Surface Water Bodies

The purpose of the assessment is to characterize the typical seasonal ranges and averages as well as the historical extremes of levels of surface water bodies within the PA. Surface water bodies within the PA are surface impoundments such as ponds and old mine pits. Historical stage data for these surface water bodies is unavailable, and the stage data that has been collected is very limited. The available data for this assessment was collected at 16 sites from October 2, 2007 to July 18, 2008. A summary of this data is shown in Table 2.7-12 which was populated according to site location (Feature ID). Stage data at three of the 16 sites was collected only once while every other site had at least two records with one site having five records. Two of the 13 sites with at least two records had data recorded within three months of each record which would not capture the potential seasonal range of the water level for those two sites. The largest positive and negative changes in water levels over the period of collection were 2.43 feet and -0.48 feet, respectively. The smallest change overall was 0.04 feet. The largest rate of change in water level for each site over its period of collection was 0.011 feet per day or about 0.13 inches per day. The surface water bodies with the largest change in water level are located near the Darrow Mine Pits approximately two miles northeast of Burdock (Feature IDs 10032, 10033 and 10052). Another surface water body is located approximately two miles south of the Darrow Mine which represents the smallest change in water level of any of the surface water bodies (Feature ID 10040). These water level changes were recorded at sites with at least two records and a minimum time span of 206 days which represents the most sufficient data available to characterize the seasonal ranges for water levels of the surface water bodies within the PA. Further discussion about the interaction between ground water and surface water bodies is provided in Section 2.7.2.

2.7.2 Groundwater

2.7.2.1 Regional Hydrogeologic Setting

In this section, groundwater occurrence and flow are described specifically as they relate to the Dewey-Burdock Project. While the project area is generally similar to the Black Hills regional setting, the site hydrogeology has several unique characteristics as described below.

Table 2.7-12: Summary of Water Level Data Collected at Surface Water Bodies

Feature ID	Data Records	Time Interval of Greatest Stage Change (days)	Stage Change (ft)	Stage Change Rate (ft/day)
10024	2	32	0.19	0.0059
10025	2	229	-0.24	-0.0010
10027	1	*NA*		
10030	4	110	0.25	0.0023
10031	4	240	0.78	0.0033
10032	3	206	2.3	0.0112
10033	4	234	2.43	0.0104
10034	1	*NA*		
10039	2	89	0.52	0.0058
10040	2	206	0.04	0.0002
10050	2	234	1.35	0.0058
10051	3	215	0.54	0.0025
10052	3	229	-0.48	-0.0021
10054	3	229	0.75	0.0033
10059	1	*NA*		
10070	5	89	0.63	0.0071

Note: Feature ID denotes Surface Water Body

2.7.2.1.1 Regional Hydrostratigraphic Units

The Black Hills Uplift is the principal recharge area for the regional bedrock aquifer systems in southwestern South Dakota and northeastern Wyoming. The stratigraphy of the Black Hills area is summarized on Figure 2.2-3. Figure 2.2-2 provides an overview of the hydrogeologic setting and general hydrogeologic flow within the Black Hills. Regionally, four aquifers are utilized as major sources of water supply. These are the Inyan Kara Group, Minnelusa Formation, Madison Limestone, and Deadwood Formation. Table 2.7-13 summarizes hydraulic properties of major aquifers determined in previous investigations. In addition to these four major aquifers, other units including the Precambrian, Minnekahta Limestone, Sundance Formation, and Unkpapa Sandstone are utilized locally as sources of water supply at or near the outcrop areas in the central portion of the Black Hills. Within the project area, none of the deeper regional aquifers below the Sundance Formation is used as a water supply, mainly because of the availability of shallower sources and/or the poor water quality in the deeper aquifers. There are no water supply wells within 2 km of the project area completed in aquifers below the Sundance Formation. The closest municipal wells are the Edgemont Madison wells, which are approximately 15 miles to the south-southeast of the center of the project area.

In the 1990s, the USGS undertook an extensive study focusing on the evaluation of the hydrologic significance of selected bedrock aquifers in the Black Hills area – specifically the Deadwood,

Table 2.7-13: Estimates of Hydraulic Properties of Major Aquifers from Previous Investigations

Source	Hydraulic conductivity (ft/d)	Transmissivity (ft^2/d)	Storage coefficient	Total porosity/ effective porosity	Area represented
Precambrian aquifer					
Rahn, 1985	--	--	--	0.03/0.01	Western South Dakota
Galloway and Strobel, 2000		450 - 1,435		0.10/--	Black Hills area
Deadwood aquifer					
Downey, 1984	--	250 - 1,000	--	--	Montana, North Dakota, South Dakota, Wyoming
Rahn, 1985	--	--	--	0.10/0.05	Western South Dakota
Madison aquifer					
Konikow, 1976	--	860 - 2,200	--	--	Montana, North Dakota, South Dakota, Wyoming
Miller, 1976	--	0.01 - 5,400	--	--	Southeastern Montana
Blankennagel and others, 1977	$2.4x10^{-5}$ - 1.9	--	--	--	Crook County, Wyoming
Woodward-Clyde Consultants, 1980	--	3,000	$2x10^{-4}$ - $3x10^{-4}$	--	Eastern Wyoming, western South Dakota
Blankennagel and others, 1981	--	5,090	$2x10^{-5}$	--	Yellowstone County, Montana
Downey, 1984	--	250 - 3,500	--	--	Montana, North Dakota, South Dakota, Wyoming
Plummer and others, 1990	--	--	$1.12x10^{-6}$ - $3x10^{-5}$	--	Montana, South Dakota, Wyoming
Rahn, 1985	--	--	--	0.10/0.05	Western South Dakota
Cooley and others, 1986	1.04	--	--	--	Montana, North Dakota, South Dakota, Wyoming, Nebr.
Kyllonen and Peter, 1987	--	4.3 - 8,600	--	--	Northern Black Hills
Imam, 1991	$9.0x10^{-6}$	--	--	--	Black Hills area
Greene, 1993	--	1,300 - 56,000	0.002	0.35/--	Rapid City area
Tan, 1994	5 - 1,300	--	--	0.05	Rapid City area
Greene and others, 1999	--	2,900 - 41,700	$3x10^{-4}$ - $1x10^{-3}$	--	Spearfish area
Carter, Driscoll, Hamade, and Jarrell, 2001	--	100 - 7,400	--	--	Black Hills area
Minnelusa aquifer					
Blankennagel and others, 1977	$<2.4x10^{-5}$ - 1.4	--	--	--	Crook County, Wyoming
Pakkong, 1979	--	880	--	--	Boulder Park area, South Dakota
Woodward-Clyde Consultants, 1980	--	30 - 300	$6.6x10^{-5}$ - $2.0x10^{-4}$	--	Eastern Wyoming, western South Dakota

Table 2.7-13: Estimates of Hydraulic Properties of Major Aquifers from Previous Investigations (cont.)

Source	Hydraulic conductivity (ft/d)	Transmissivity (ft^2/d)	Storage coefficient	Total porosity/ effective porosity	Area represented
Minnelusa aquifer—Continued					
Rahn, 1985	--	--	--	0.10/0.05	Western South Dakota
Kyllonen and Peter, 1987	--	0.86 - 8,600	--	--	Northern Black Hills
Greene, 1993	--	12,000	0.003	0.1/--	Rapid City area
Tan, 1994	32	--	--	--	Rapid City area
Greene and others, 1999	--	267 - 9,600	$5.0x10^{-9}$ - $7.4x10^{-5}$	--	Spearfish area
Carter, Driscoll, Hamade, and Jarrell, 2001	--	100 - 7,400	--	--	Black Hills area
Minnekahta aquifer					
Rahn, 1985	--	--	--	0.08/0.05	Western South Dakota
Inyan Kara aquifer					
Niven, 1967	0 - 100	--	--	--	Eastern Wyoming, western South Dakota
Miller and Rahn, 1974	0.944	178	--	--	Black Hills area
Gries and others, 1976	1.26	250 - 580	$2.1x10^{-5}$ - $2.5x10^{-5}$	--	Wall area, South Dakota
Boggs and Jenkins, 1980	--	50 - 190	$1.4x10^{-5}$ - $1.0x10^{-4}$	--	Northwestern Fall River County
Bredehoeft and others, 1983	8.3	--	$1.0x10^{-5}$	--	South Dakota
Rahn, 1985	--	--	--	0.26/0.17	Western South Dakota
Kyllonen and Peter, 1987	--	0.86 - 6,000	--	--	Northern Black Hills

Source: Driscoll et al. (2002)

Madison, Minnelusa, Minnekahta, and Inyan Kara aquifers. In these evaluations, the USGS placed priority on the Madison and Minnelusa aquifers, both of which are used extensively elsewhere in the region for water supplies.

While the review of regional hydrology is prudent and necessary for this application, it should be noted that the site hydrology within the project area is unique compared to the regional Black Hills hydrology. In this regard, intermediate groundwater flow systems in the Fall River Formation and the Chilson Member of the Lakota Formation are independent of the regional flow system. These intermediate flow systems have their origin in the areas within the eastern portion of the project area (Fall River) and immediately to the east and north of the project area (Fall River and Chilson) where the Fall River and Chilson crop out at the land surface. Both of these flow systems are recharged directly by precipitation and infiltration of surface runoff along the outcrops in and near the eastern portion of the project area.

2.7.2.1.1.1 Inyan Kara Aquifer

At distance from the central core of the Black Hills Uplift, the Inyan Kara Group typically contains the first significant aquifer encountered. The Inyan Kara includes two sub-aquifers, the Chilson Member of the Lakota Formation and the Fall River Formation, which are separated by the Fuson Shale confining unit. Refer to Section 2.6.2.2 for a description of confining units relevant to ISR. The Inyan Kara aquifer is heterogeneous, which results in the two sub-aquifers exhibiting large variations in their hydraulic characteristics at some locations. Regionally, the Inyan Kara ranges from 250 to 500 feet thick, exhibits a large effective porosity (17 percent), and can yield considerable quantities of water from storage (Driscoll et al., 2002). Within the Black Hills, the transmissivity of the Inyan Kara ranges from 1 to 6,000 ft^2/day (Table 2.7-13). The Inyan Kara is confined below by the Jurassic Morrison Formation and above by the Cretaceous Graneros Group.

2.7.2.1.1.2 Minnelusa Aquifer

The Minnelusa Formation consists of interbedded siltstone, sandstone, anhydrite, and limestone. The Minnelusa aquifer occurs primarily in saturated sandstone and anhydrite beds within the upper part of the formation (Williamson and Carter, 2001). Within the Black Hills, the Minnelusa ranges in thickness from 375 to 1,175 feet (Driscoll et al., 2002). The porosity is dominantly primary porosity within the sandstone beds, although secondary porosity is present in association with fractures and dissolution features (Williamson and Carter, 2001). Various studies have found the transmissivity of the Minnelusa to range from 1 to 12,000 ft^2/day (Table 2.7-13). The Minnelusa aquifer is confined above by the Opeche Shale and below by the lower permeability layers at the base of the Minnelusa.

Locally, the Minnelusa produces oil and gas in the Barker Dome to the east of the project area.

2.7.2.1.1.3 Madison Aquifer

The Madison Limestone, also known as the Pahasapa Limestone, is the source of municipal water supplies in numerous communities within the Black Hills including Rapid City and Edgemont.

The hydraulic characteristics of the Madison aquifer have been extensively studied; aquifer characteristics of the Madison based on the numerous regional investigations are summarized in Table 2.7-13. The Madison aquifer is mainly a dolomite unit and is characterized by extensive secondary porosity resulting from fractures and associated karstic features (Williamson and Carter, 2001). The thickness of the Madison ranges from 200 feet in the southern Black Hills to 1,000 feet regionally. In the Rapid City area, Greene (1993) found the transmissivity to vary between 1,300 and 56,000 ft^2/day. The aquifer varies from unconfined at its outcrop areas to confined, where reported storativity values range from 10^{-3} to 10^{-6} (Table 2.7-13). Regionally, water quality data indicate that low permeability layers within the overlying Minnelusa Formation isolate the Madison from the Minnelusa. At some locations distant from the project area on the core of the Black Hills Uplift, these confining layers may be absent or exhibit poorly confining hydraulic characteristics such that communication between the Madison and Minnelusa occurs. Regionally, the Madison may be in direct communication with the underlying Deadwood aquifer where the Whitewood and Winnipeg confining units are absent; locally, however, the available data indicate that the Madison Limestone and Deadwood Formations are isolated beneath the project area (refer to the Class V UIC application, Appendix 2.7-L of the approved license application).

2.7.2.1.1.4 Deadwood Aquifer

The Cambrian Deadwood Formation overlies the Precambrian basement and consists of basal conglomerates, sandstone, limestone, and mudstone. The Deadwood ranges from zero to 500 feet thick (Driscoll et al., 2002). Rahn (1985) estimated the effective porosity of the Deadwood to be about 5 to 10 percent. In the northern Black Hills, the effective porosity is presumably lower where the formation has undergone hydrothermal alteration. The transmissivity of the Deadwood is estimated to be in the range of 250 to 1,000 ft^2/day (Table 2.7-13; Downey, 1984). Regionally, the Precambrian rocks act as a lower confining unit to the Deadwood although a localized direct connection between the two units can occur at or near the outcrop areas (Williamson and Carter, 2001). Regionally, the Deadwood may be in contact with the overlying Madison aquifer except where the Whitewood and Winnipeg Formations are present and act as semi-confining units (Strobel et al., 1999). As noted, available data indicate that the Madison Limestone and Deadwood Formation are isolated beneath the project area.

2.7.2.1.1.5 Minor Aquifers

Minor aquifers in the Black Hills include the Minnekahta Limestone, Sundance Formation, Unkpapa Sandstone, Newcastle Sandstone, and Quaternary alluvium. Where present and saturated, these units can yield small amounts of water. In isolated locations distant from the project area, beds within the confining units also may contain water-bearing units (Driscoll et al., 2002). These minor aquifers are generally not widely utilized because of the availability of more reliable water-supply sources.

2.7.2.1.2 Regional Potentiometric Surfaces

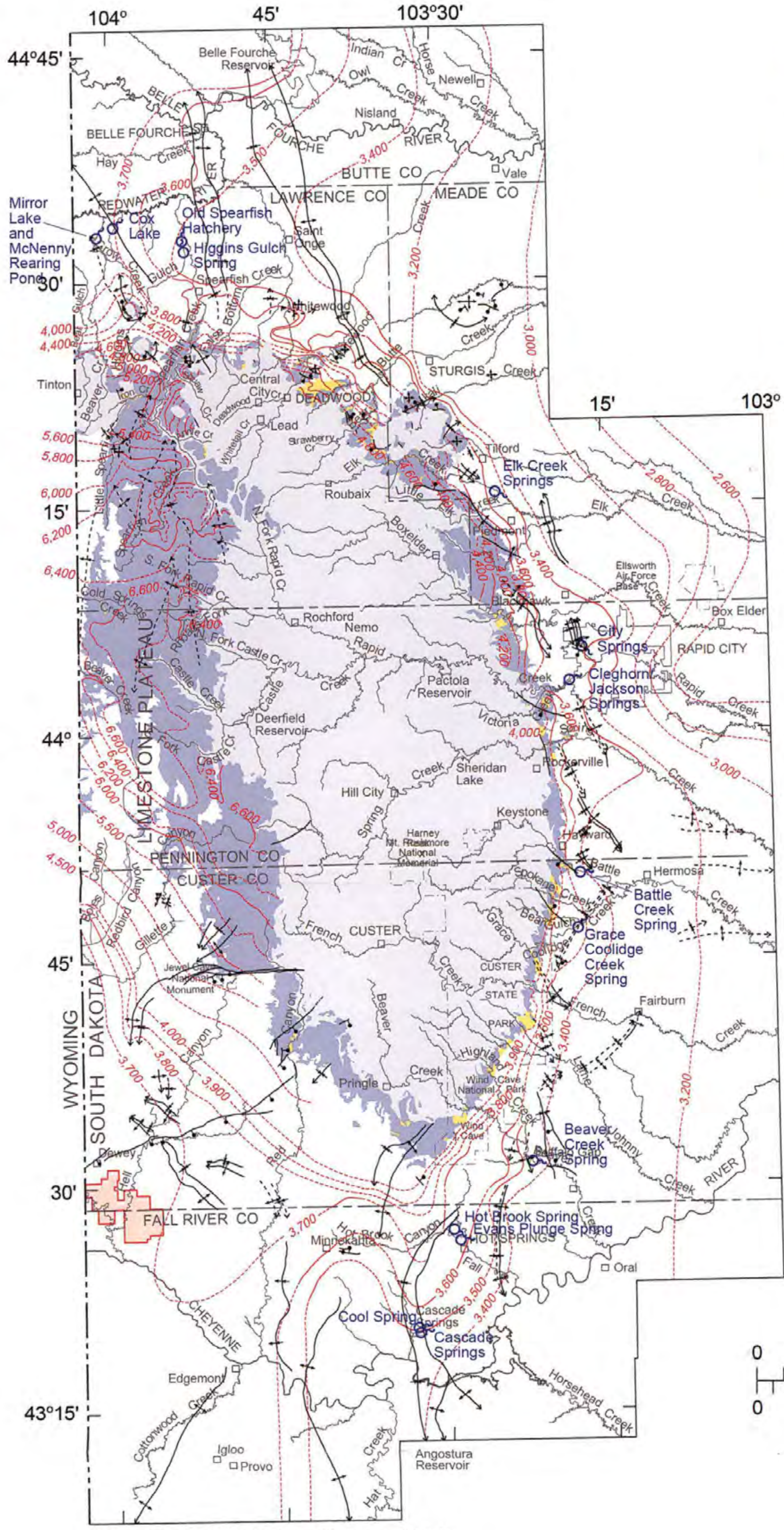
As part of its 1990s study of the hydrologic significance of selected bedrock aquifers, the USGS developed 1:100,000-scale potentiometric contour maps for the Inyan Kara, Minnekahta, Minnelusa, Madison, and the Deadwood (Strobel et al., 2000a thru 2000e). These maps provide a basis for evaluating regional groundwater flow direction and hydraulic gradients in the Black Hills. Figures 2.7-14 and 2.7-15 depict the regional potentiometric contour maps of the Madison and Minnelusa aquifers, respectively. In the development of these potentiometric maps, structural features such as faults and folds were considered. Of significance, no major structural features were identified in or within the immediate vicinity of the project area other than the Dewey Fault, which is located north of the project area, and the Long Mountain Structural Zone, which is located approximately 7 miles south of the project area.

Based on the USGS potentiometric contour maps, regional groundwater flow within the five selected bedrock aquifers is generally consistent and radially outward from the central Black Hills highlands toward the plains. All five of the aquifers are hydraulically unconfined (partially saturated) near their outcrops in the central highlands and become confined by the overlying strata with distance away from the central highlands. Locally, the potentiometric surface of the aquifers may be above land surface.

The Black Hills are relatively arid with the annual precipitation ranging from about 12 to 28 inches regionally and averaging approximately 16 inches in the project area. While most precipitation can be accounted for as surface runoff and evapotranspiration, regionally, the percentage of precipitation that recharges the aquifers is estimated to vary from 30 percent in the northwestern Black Hills to 2 percent or less in the drier southwestern Black Hills, which includes the project area.

Other sources of recharge to individual units can occur from leakage between aquifers. In general, the potentiometric elevation increases with depth within the stratigraphic section, which provides an upward potential for groundwater flow and limits the potential for downward recharge, which occurs regionally but not locally.

Most interconnection between aquifers appears to be associated with the thinning or absence of confining units between aquifers. Some investigators have suggested that solutioning and subsequent collapse (i.e., karsting) of the overlying strata may provide a pathway for upward groundwater movement (Gott et al., 1974). This is reported to occur some 6 miles northeast of the



EXPLANATION

OUTCROP OF MADISON LIMESTONE (from Strobel and others, 1999)

MADISON LIMESTONE PRESENT, BUT OVERLAIN BY SURFICIAL DEPOSITS (from Carter and Redden, 1999d)

MADISON LIMESTONE ABSENT (from Carter and Redden, 1999d)

—3,000— POTENTIOMETRIC CONTOUR--Shows altitude at which water would have stood in tightly cased, nonpumping wells (modified from Strobel and others, 2000a). Contour interval 100, 200, or 500 feet, where appropriate. Dashed where inferred. Datum is sea level

FAULT--Dashed where approximated. Bar and ball on downthrown side

ANTICLINE--Showing trace of axial plane and direction of plunge. Dashed where approximated

SYNCLINE--Showing trace of axial plane and direction of plunge. Dashed where approximated

MONOCLINE--Showing trace of axial plane. Dashed where approximated

DOME--Symbol size approximately proportional to size of dome. Dome asymmetry indicated by arrow length

ARTESIAN SPRING

Base modified from U.S. Geological Survey digital data, 1:100,000, 1977, 1979, 1981, 1983, 1985
Rapid City, Office of City Engineer map, 1:18,000, 1996
Universal Transverse Mercator projection, zone 13

Legend

Dewey-Burdock Project Boundary

From:
Water-Resources Investigations Report 02-4094
(modified by Driscoll et al., 2002)

Figure 2.7-14
Regional Potentiometric Contour Map, Madison Limestone
Dewey-Burdock Project

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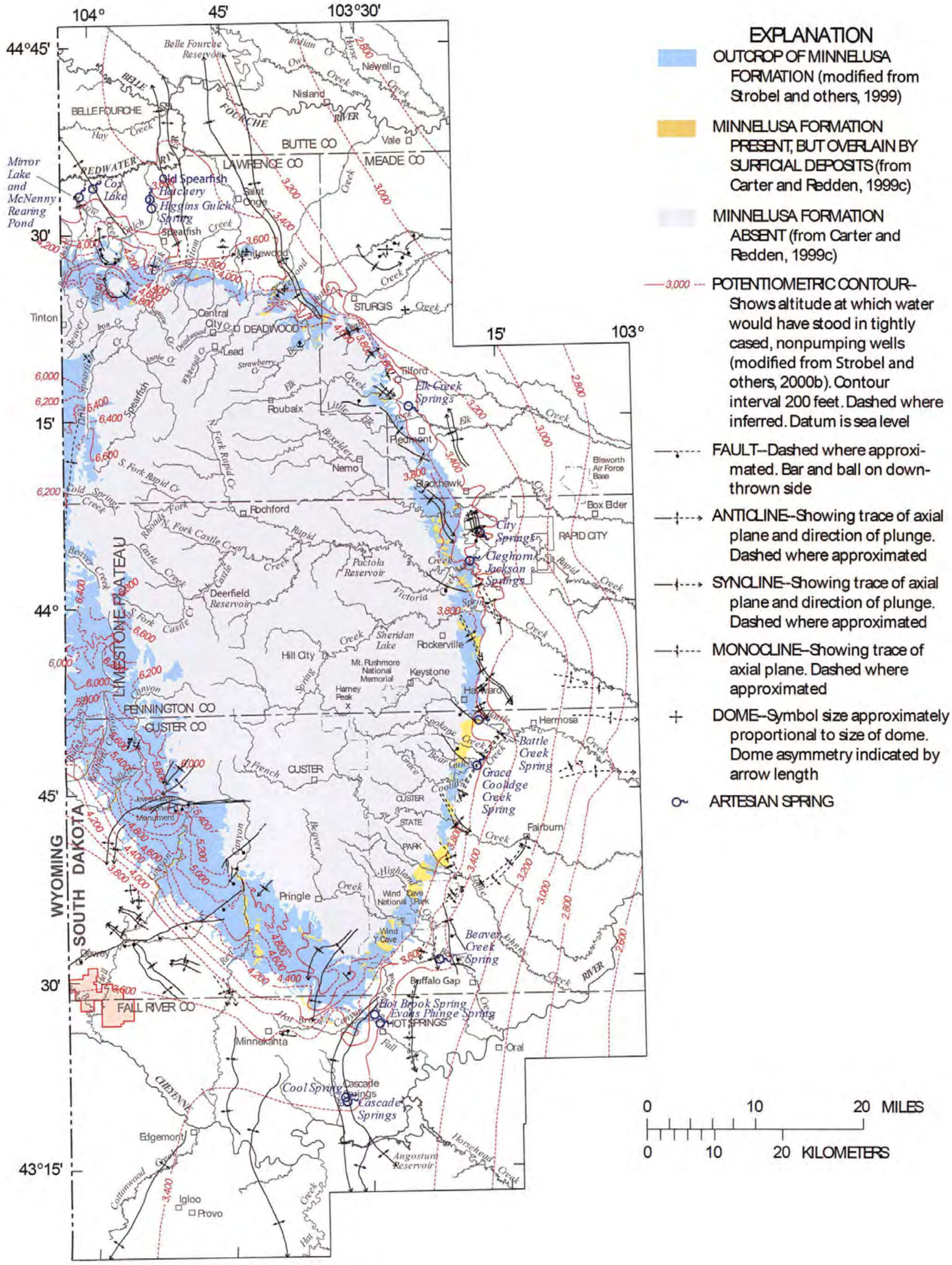

Base modified from U.S. Geological Survey digital data, 1:100,000, 1977, 1979, 1981, 1983, 1985
Rapid City, Office of City Engineer map, 1:18,000, 1996
Universal Transverse Mercator projection, zone 13

Legend

Dewey-Burdock Project Boundary

From:
Water-Resources Investigations Report 02-4094
(modified by Driscoll et al., 2002)

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Figure 2.7-15
Regional Potentiometric Contour Map, Minnelusa Formation
Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	1-Nov-2011
FILENAME	2011_Fig_2.7-15.ai

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project area, but no evidence of karsting has been observed in the project area. A detailed analysis of the potential occurrence of breccia pipes and karsting north and east of the project area is presented in Section 2.6.5.

2.7.2.2 Site Hydrogeology

The main aquifers to be utilized by the Dewey-Burdock Project (the Fall River and Chilson) are recharged locally and are isolated from the deep regional flow system in the Paleozoic formations that typically characterize regional groundwater flow and are the focus of numerous USGS research studies.

In the project area, the sedimentary rocks dip gently to the southwest at 2 to 6 degrees. As the land surface is generally flatter than the dip of the underlying bedrock strata, younger strata crop out at the ground surface sequentially from east to west.

The structure is illustrated by the structural contour maps on top of the Fall River (Plate 2.6-5), Chilson Member of the Lakota (Plates 2.6-3, 2.6-3a and 2.6-3b) and Unkpapa Sandstone (Plate 2.6-1). Based on the logs for thousands of exploration holes, no major faults or other structural features have been identified within the project area.

2.7.2.2.1 Site Hydrostratigraphic Units

Refer to Figure 2.2-3 for a regional stratigraphic column and Section 2.6.2.2 for a more detailed discussion of the site stratigraphy. The Fall River Formation and Chilson Member of the Lakota Formation are the principal sources of water in the vicinity of the project area for domestic, livestock, and agricultural uses. These same formations are the host rocks for the uranium mineralization within the project area. Within the project area, the deeper regional aquifers are not used as a source of water supply mainly because of their depth of occurrence, availability of shallower sources, relatively low productivity and low historical water demands. There are no water supply wells within 2 km of the project area completed in aquifers below the Sundance Formation. The closest municipal wells are the Edgemont Madison wells, which are approximately 15 miles south-southeast of the center of the project area.

In the following discussion, the site hydrogeological characterization focuses on groundwater occurrence and the groundwater flow regimes above the Morrison Formation. The Morrison Formation is the lowermost confining unit for ISR operations within the Dewey-Burdock Project (refer to Section 2.6.2.2). Because of the low vertical permeability, thickness and continuity of the Morrison Formation across the entire project area and due to the existence of an upward hydraulic gradient between the underlying Unkpapa Sandstone and the Inyan Kara, the proposed ISR activities will not impact any of the formations below the Morrison Formation. The only exception is potential pumping from the Madison or another suitable deep formation for aquifer restoration makeup water and for CPP water supply or use of the Minnelusa and/or Deadwood for management of wastewater in Class V disposal wells.

The Morrison Formation is underlain, in turn, by the Unkpapa Sandstone, Sundance Formation and Spearfish Formation. Based on the results from limited exploratory drilling, the Spearfish in the project area averages approximately 320 feet thick and due to its low vertical permeability is considered a hydrologic barrier between the overlying Jurassic and Cretaceous aquifers and the underlying Paleozoic aquifers.

The Spearfish Formation is overlain by the Sundance Formation, which consists of a 250 to 450-foot thick sequence of red shale and siltstone. In the project area, the Sundance consists mainly of shale and sandstone with an average thickness of 280 feet. In turn, the Sundance is overlain by the Unkpapa Sandstone. Where present, the Unkpapa consists of 50 to 80 feet of well-sorted, fine-grained, aeolian sandstone. Since there is not an intervening confining unit separating the two, the Sundance and Unkpapa are generally considered to be a single hydrostratigraphic unit. The Sundance/Unkpapa is used locally as a water supply within the project area.

2.7.2.2.1.1 Morrison Formation

The Morrison Formation, because of its low permeability and continuity beneath the project area, is the lowermost confining unit for the proposed ISR operations. The Morrison averages 100 feet thick and is composed of waxy, calcareous, non-carbonaceous massive shale with numerous limestone lenses and a few thin, fine-grained sandstones. Analyses of core samples within the project area have shown the vertical permeability of the Morrison clays to be very low and to range from 9×10^{-9} to 3×10^{-8} cm/sec (0.012 to 0.043 millidarcies; see Table 2.7-16).

2.7.2.2.1.2 Inyan Kara Group

The Jurassic Morrison Formation is unconformably overlain by the Inyan Kara Group, which consists of the Lakota and the Fall River Formations. The sandstone packages within the Fall River Formation and Chilson Member of the Lakota Formations are the host rocks to the uranium mineralization at the Dewey-Burdock Project. The Inyan Kara consists of interbedded sandstone, siltstone, and shale. Based on measured outcrop sections and drill hole data, the Inyan Kara averages about 350 feet thick in the project area.

The Lakota Formation regionally consists of three members which are, from oldest to youngest, the Chilson, Minnewaste Limestone, and the Fuson members. The Minnewaste Limestone Member is not present in the project area.

Chilson Member

The Chilson Member consists of a complex of fluvial channel sandstone deposits and their fine-grained lateral equivalents and varies from about 100 to 240 feet thick. The Chilson Member is confined below by the Morrison Formation and above by the Fuson Shale. Analyses of core samples of Chilson sandstones within the project area indicate these units exhibit high horizontal permeabilities, ranging from 2.6×10^{-3} to 4.1×10^{-3} cm/sec (2,697 to 4,161 millidarcies; see Table 2.7-16).

Fuson Member

The Fuson Member is the uppermost member of the Lakota and separates the Chilson Member from the Fall River Formation. As discussed in Section 2.6.2.2, Powertech (USA) has differentiated the Fuson Shale from the Fuson Member of the Lakota Formation for the purpose of characterizing site geology. The Fuson Shale has been mapped by Powertech (USA) and consists of 20 to 80 feet of low-permeability shales and clays, which generally occur at or near the base of the unit (Plate 2.6-8).

The shales and mudstones within the Fuson Shale are highly stratified. Due to this stratification, the vertical permeability is several orders of magnitude smaller than the horizontal permeability. Based on analyses of core samples from the Fuson Shale within the project area, vertical permeabilities range from about 7.8×10^{-9} to 2.2×10^{-7} cm/sec (0.008 to 0.228 millidarcies; see Table 2.7-16). Estimates of vertical hydraulic conductivity of the Fuson Shale from the 1979 pumping tests conducted in the Fall River and Chilson near Burdock range from 4.6×10^{-8} to 1×10^{-7} cm/sec (Boggs and Jenkins, 1980). Well field-scale pumping tests will be conducted after NRC license issuance and the results contained in the well field hydrogeologic data packages (refer to Section 3.1.3.3). This additional testing will provide additional quantification of the low hydraulic conductivity of the confining units.

Fall River Formation

The Fall River Formation is composed of carbonaceous interbedded siltstone and sandstone, channel sandstones, and a sequence of interbedded sandstone and shale. The Fall River ranges from about 120 to 160 feet thick.

The Fall River is confined above by the Graneros Group, a thick sequence of dark shales that varies in thickness from zero, where the Inyan Kara outcrops near the eastern edge of the project area, to more than 500 feet in the northwestern portion of the project area. Because of its thickness and low permeability, the Graneros Group precludes vertical migration of water between the Inyan Kara, overlying alluvial aquifers, and the ground surface.

2.7.2.2.1.3 Graneros Group

The Cretaceous Graneros Group consists of several geologic units, including the Skull Creek Shale, Newcastle Sandstone (where present), Mowry Shale, and Belle Fourche Shale, which act as a single confining unit overlying the Inyan Kara. In the project area, the thickness of the Graneros Group ranges from zero at the outcrop of the Fall River to more than 500 feet (Plate 2.6-10). The members comprising the Graneros Group are described in Section 2.6.2.2. Analyses of core samples of the Skull Creek clays indicate low vertical permeabilities on the order of 6.8×10^{-9} cm/sec (0.007 millidarcies).

2.7.2.2.1.4 Terrace Deposits and Quaternary Alluvium

The most recent sedimentary units within the project area are the Quaternary alluvial deposits present along the major drainages and their tributaries. The alluvium varies from 0 to 50 feet thick and consists of an unconsolidated mixture of silt, clay, sand and gravel.

An isopach map depicting the thickness of the alluvium in the Beaver Creek and Pass Creek drainages is shown on Plate 2.6-11.

2.7.2.2.2 Groundwater Occurrence and Flow

Potentiometric contour maps for the Fall River and the Chilson Member of the Lakota are shown on Figures 2.7-16 and 2.7-17, respectively. These maps were prepared using water level measurements taken over a 5-day period from April 25 through April 29, 2011, rather than based on "average" water levels taken over several years. The data used to generate Figures 2.7-16 and 2.7-17 are presented in Appendix 2.7-A of the approved license application. There are other wells within the project area listed in Appendix 2.2-A of the approved license application, but not used in the development of potentiometric contour maps. The reasons certain wells were not used previously in the development of the potentiometric contour maps are summarized in Table 2.7-14. Also listed are mitigative actions taken to correct problems with the use of certain wells. For well location information and completion intervals, refer Appendix 2.2-B of the approved license application. The procedures for measuring static water levels in and calculating the water level elevations in monitoring wells are summarized in Section 2.7.3.2.2.

The potentiometric contour maps provide a regional flow direction and hydraulic gradient in accordance with the guidance in NUREG-1569, Section 2.7.3(3). Based on pump test results showing variable transmissivity, variations in the configuration of the potentiometric surfaces for the Fall River and Chilson are acknowledged and expected.

The potentiometric surface map for the Fall River (Figure 2.7-16) shows a relatively uniform hydraulic gradient across the project area, with the potentiometric levels decreasing to the southwest. The potentiometric surface for the Chilson (Figure 2.7-17) shows a slight flattening of the hydraulic gradient across the northwestern portion of the project area but with heads also decreasing to the southwest. Many factors can influence the observed potentiometric surface; most commonly they are due to changes in hydraulic properties or changes in groundwater flux. Increasing groundwater flux through an area will actually result in a steeper hydraulic gradient, not a flattening, because more water must move through the same cross sectional area of the aquifer.

A more plausible explanation of the flattening of the Chilson potentiometric surface (and therefore the hydraulic gradient) in the northwest portion of the project area is that the transmissivity of the Chilson is higher in that area. Evidence to support this explanation can be found in the pumping tests that were conducted by TVA in 1980 in the Dewey area (Boggs, 1983). The Chilson was pumped at a rate of 495 gpm for 11 days during this test, a much greater production rate than encountered in other pumping tests within the project area in either the Fall River or Chilson. The transmissivity of the Chilson near Dewey was estimated at nearly 600 ft^2/day, more than twice the value determined from the Burdock area pumping tests (Boggs and Jenkins, 1980). The TVA pumping test reports are provided in Appendix 2.7-K of the approved license application.

2.7.2.2.2.1 Groundwater Flow Systems

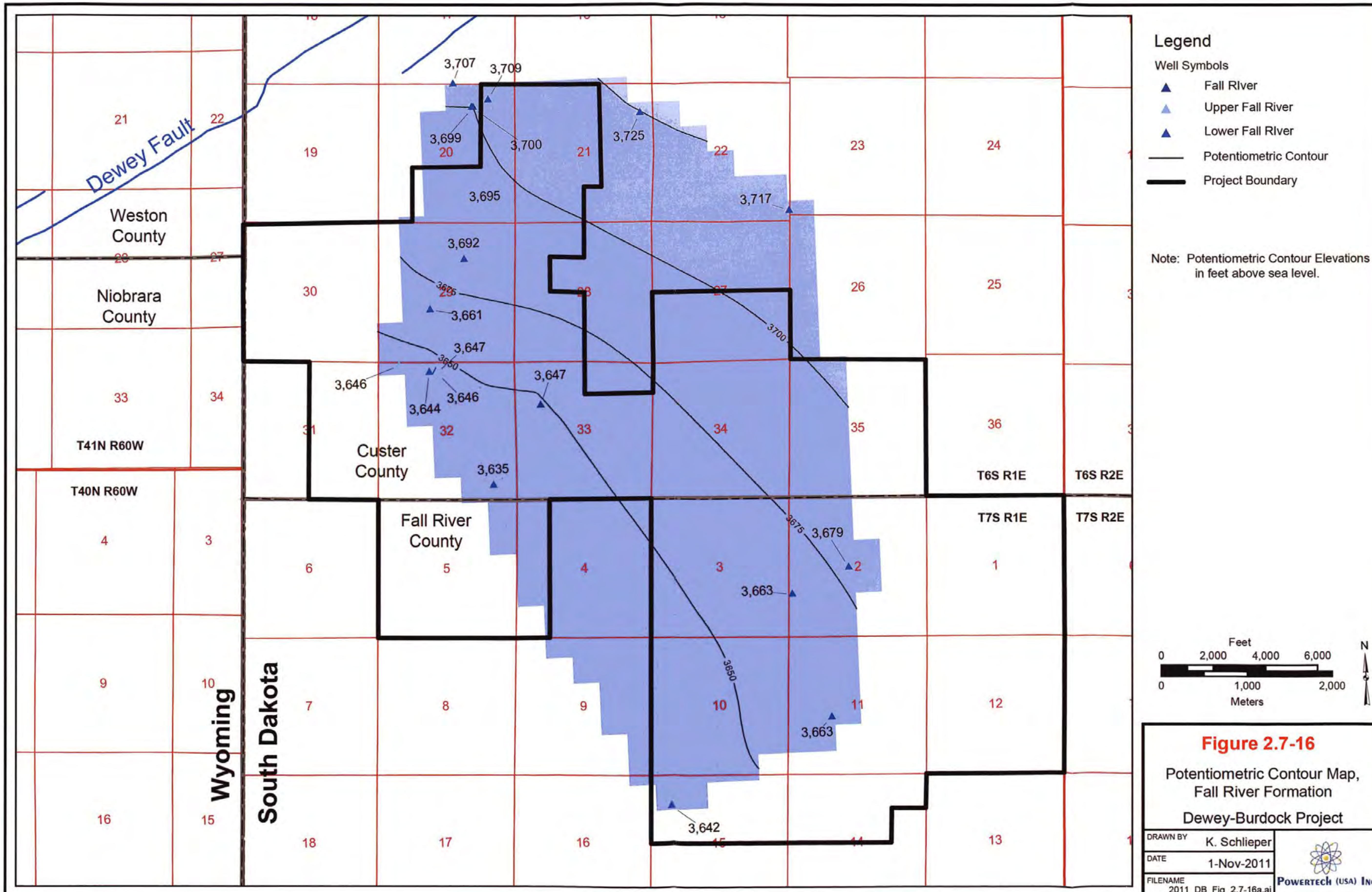
Based on the regional and site-specific hydrogeological characterization, groundwater occurrence and flow in the project area can be subdivided into three main components, or flow regimes. These

Table 2.7-14: Reasons Wells Not Used in Development of Potentiometric Contour Map

Hydro ID	Reason(s) Wells Not Used in Development of Potentiometric Contour Maps
1	Well cannot be shut in.
2	Well cannot be shut in.
7	Domestic water well with pump – measurement of water level requires well to be removed from service.
8	Domestic water well with pump – measurement of water level requires well to be removed from service.
13	Domestic water well with pump – measurement of water level requires well to be removed from service.
14	Well has now been accessed and included in monthly monitoring program
16	Domestic water well with pump – measurement of water level requires well to be removed from service.
17	Well currently being monitored; verification of completion interval is pending.
18	Domestic water well with pump – measurement of water level requires well to be removed from service.
20	Domestic water well with pump – measurement of water level requires well to be removed from service.
42	Domestic water well with pump – measurement of water level requires well to be removed from service.
51	Well cannot be shut in.
96	Domestic water well with pump – measurement of water level requires well to be removed from service.
115	Domestic water well with pump – measurement of water level requires well to be removed from service.
147	Well currently being monitored for water levels; survey of measurement point is pending.
510	Well currently being monitored for water levels; verification of completion interval and survey of measurement point are pending.
620	Well currently being monitored for water levels; verification of completion interval is pending.
696	Flowing artesian well; well currently being monitored for water levels.
697	Flowing artesian well; well currently being monitored for water levels.
7002	Well cannot be shut in.

include the deep regional flow system, a shallow perched groundwater flow system, and an intermediate groundwater flow system that includes the Fall River and Chilson aquifers.

As described in Driscoll et al. (2002), there are multiple deep regional groundwater flow systems within the Paleozoic section. These regional flow systems are associated with the permeable strata within various geologic formations at depth within the Deadwood, Madison, Minnelusa, Sundance/Unkpapa, and the minor aquifers. These deep regional flow systems and associated aquifers are isolated from the shallower formations that are the target of the proposed ISR operations in the Inyan Kara Group in the project area by low-permeability layers, or confining beds.


Legend
Well Symbols
Fall RIver
Upper Fall River
Lower Fall RIver
Potentiometric Contour
Project Boundary
Note: Potentiometric Contour Elevations in feet above sea level.
Dewey Fault
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T6S R2E
T7S R1E
T7S R2E
Feet
0 2,000 4,000 6,000
0 1,000 2,000
Meters
N
Figure 2.7-16
Potentiometric Contour Map, Fall River Formation
Dewey-Burdock Project
DRAWN BY K. Schlieper
DATE 1-Nov-2011
FILENAME 2011_DB_Fig_2.7-16a.ai
Powertech (USA) Inc.

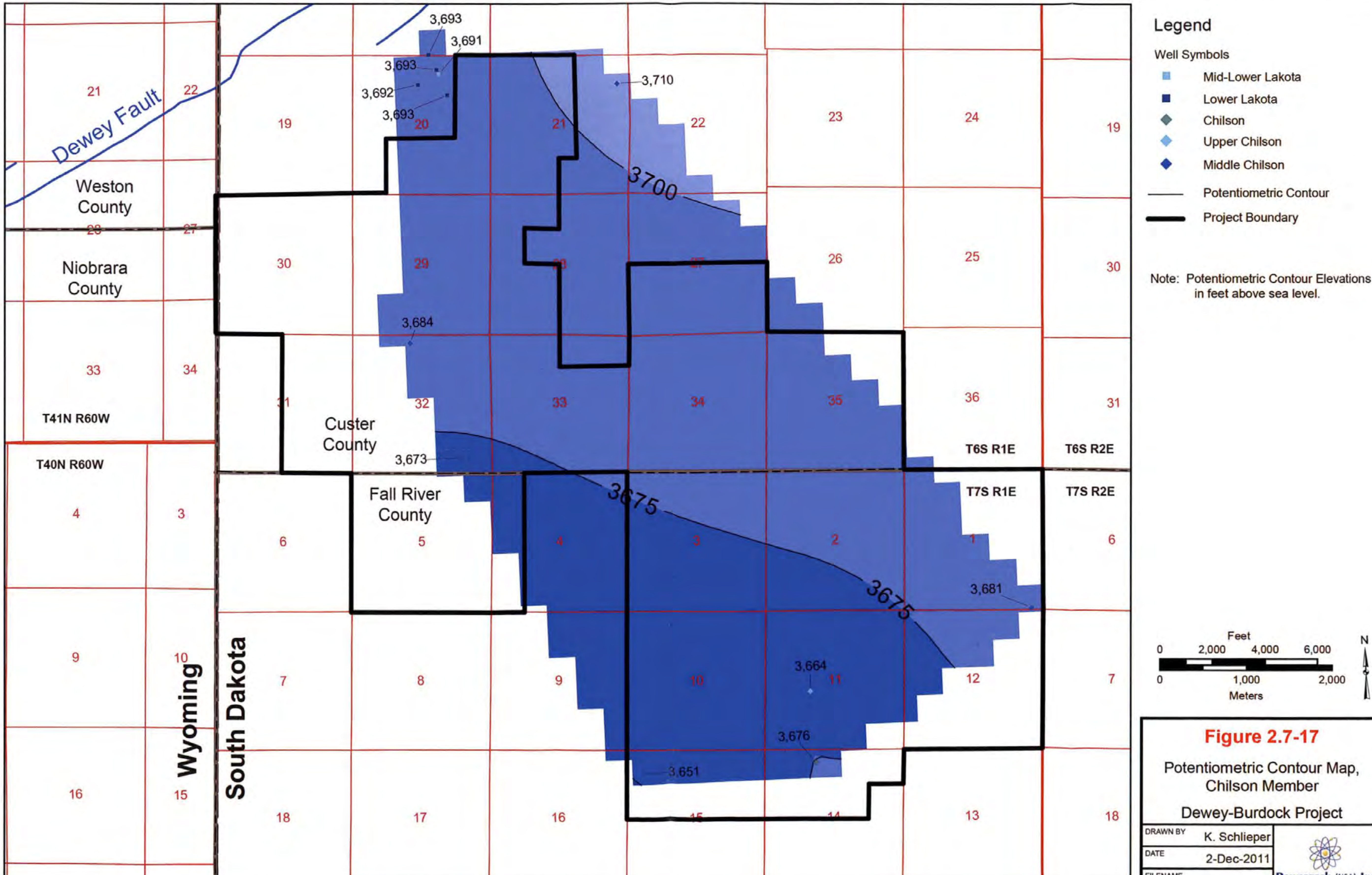


Figure 2.7-17

Potentiometric Contour Map, Chilson Member

Dewey-Burdock Project

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Shallow, perched groundwater systems exist within the alluvium associated with Beaver Creek, Pass Creek, and Bennett Canyon. These alluvial systems are perched above the top of the Graneros on the western portion of the project area. Groundwater flow within the alluvium is controlled by the configuration of the drainage channel on the top of bedrock and in most situations is generally parallel to surface drainage patterns. In the case of Bennett Canyon, the alluvium directly overlies the Chilson Member of the Lakota. As such, the alluvial groundwater is a potential source of recharge to the underlying Chilson. Bennett Canyon is approximately ½ mile east of the easternmost potential well fields within the project area.

Intermediate groundwater flow systems exist within the Fall River Formation and the Chilson Member of the Lakota. These intermediate flow systems have their origins in the areas within the eastern portion of the project area (Fall River) and immediately to the east and north of the project area where the Fall River and Chilson crop out at the land surface. Both of these flow systems are recharged directly by precipitation that falls on the land surface and by infiltration of surface runoff, primarily in the Pass Creek and Bennett Canyon drainages north and east of the project area, respectively.

Within the project area, the Fall River and the Chilson dip gently to the southwest at 2 to 6 degrees away from their outcrop areas. As a result, groundwater flow within the Fall River and Chilson generally occurs from the northeast to the southwest toward the Powder River Basin. On a broad regional basis, water from lower Cretaceous aquifers including the Inyan Kara eventually moves northeastward to discharge areas in eastern North Dakota and South Dakota (Whitehead, 1996).

2.7.2.2.2.2 Groundwater Recharge and Discharge

The hydrologic characterization for the project area included the measurement of water levels in wells completed in the Inyan Kara, overlying alluvium, and the underlying Sundance/Unkpapa. The current data collection programs began in 2007 and are continuing.

Potentiometric surface maps for the Fall River and Chilson (Lakota) are shown on Figure 2.7-16 and Figure 2.7-17, respectively. The water level data collected to date from the Unkpapa within the project area do not have sufficient spatial variability or temporal consistency to construct a potentiometric contour map of the Unkpapa. Information available to date shows substantially higher potentiometric head in the Unkpapa than in the Fall River and Chilson. Powertech (USA) anticipates that, with installation of additional wells, the monitoring in the Unkpapa conducted as part of the operational groundwater monitoring network (Section 5.7.8.2) will provide sufficient information to construct an Unkpapa potentiometric contour map prior to operations.

Alluvial groundwater flow systems occur within the alluvial deposits in the Pass Creek and Beaver Creek drainages, which are within the project area, and in Bennett Canyon, which is located on and beyond the eastern edge of the project area. Where these alluvial deposits overlie the Fall River and Chilson in Bennett Canyon, they represent a potential source of recharge to these underlying units.

The Pass Creek watershed north of the project area is a major source of recharge to both the Fall River and Chilson where they are exposed at the land surface or subcrop beneath the alluvium.

The Fall River Formation rises to the north and east and crops out at the ground surface. To the southwest the Fall River Formation dips at a steeper angle than the ground surface and is mantled by the overlying Graneros Group. The primary recharge areas for the Fall River and Lakota (Chilson) are where they are exposed at the ground surface and are shown on Figure 2.7-18. The areas where the Fall River subcrops below the surface alluvium and crops out near the eastern edge of the project area also are recharge areas for the Fall River sands. A similar area of recharge occurs north of the project area where Pass Creek alluvium crosses the subcrops of the Fall River and the Chilson. Recharge was observed during runoff events in 2011 where flowing streams disappeared into the Fall River and Chilson sandstones.

The recharge areas for the regional groundwater flow systems within the Minnelusa Formation, Madison Limestone, and Deadwood Formation are in their outcrop areas further to the east on the flanks of the Black Hills Dome. As a result of the rise in elevation, the older formations outcrop closer to the center of the dome at higher elevations and exhibit greater potentiometric elevations. Because of this, the potentiometric levels within the geologic section increase with depth, as noted previously.

2.7.2.2.2.3 Groundwater/Surface Water Interactions

Powertech performed extensive investigation into all surface water features within the project area. This included field investigations during the initial baseline monitoring period and the use of color infrared (CIR) imagery. All surface water features and sources of groundwater flow to the surface are believed to have been identified within the project area.

Extensive site investigations undertaken by Powertech (USA) and others have revealed no known natural springs within the project area. With one exception, groundwater discharging to the ground surface is limited to flowing artesian wells, which will be controlled. The only feature identified that was indicative of groundwater discharge from exploration holes at or near surface was the

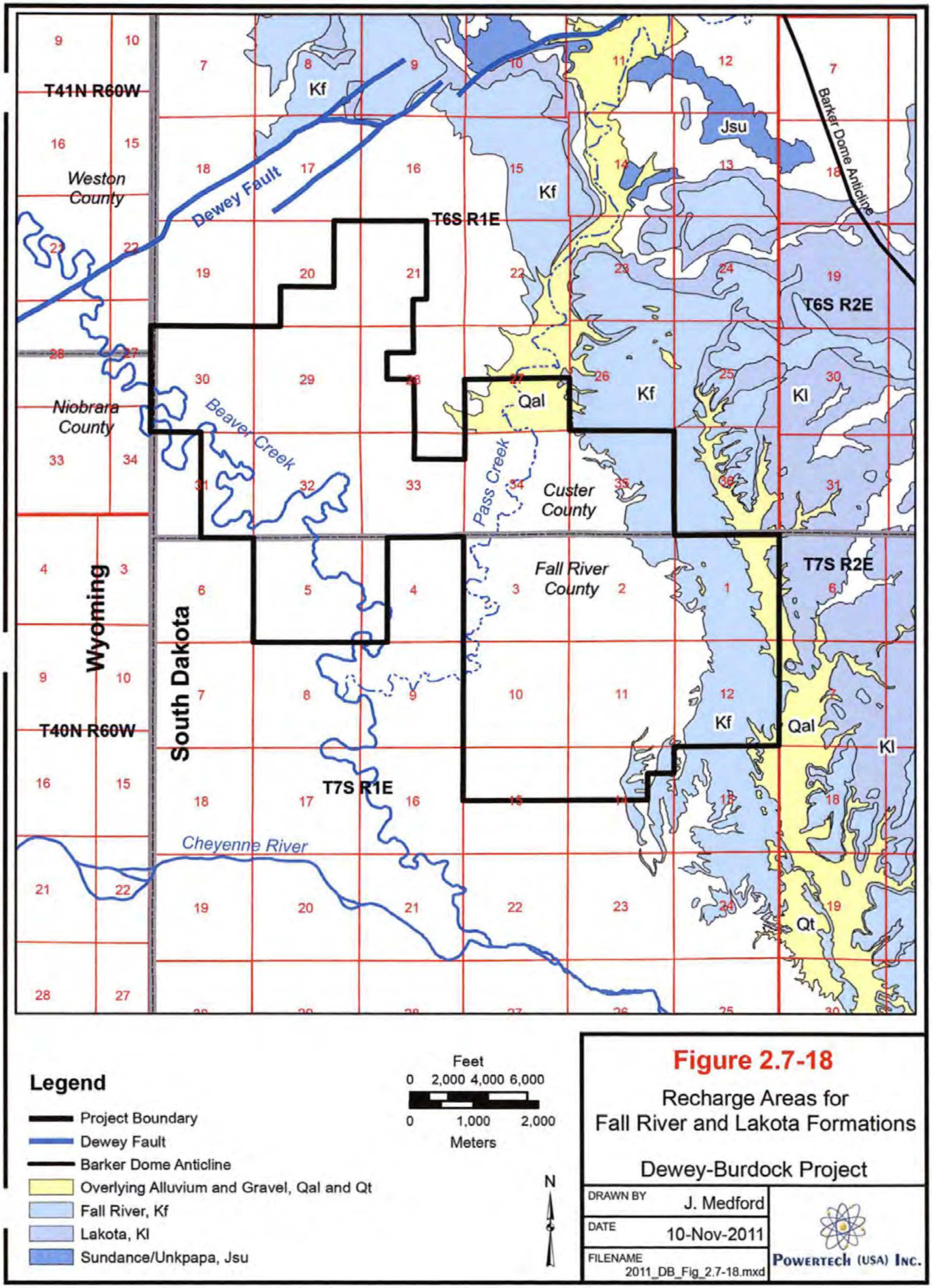

Figure 2.7-18

Recharge Areas for Fall River and Lakota Formations

Dewey-Burdock Project

"alkali area" in the southwestern corner of the Burdock portion of the project area (N/2 NE/4 Section 15, T7S, R1E). This is an area of known discharge from the Fall River and Chilson to the surface through abandoned exploration holes documented by TVA. The significance of this area as it relates to ISR operations will be evaluated further after NRC license issuance during delineation drilling and well field-scale pumping tests prior to any well field development.

Recharge areas for the Fall River and Chilson are described in the previous section and include outcrop areas and areas where these formations subcrop below the alluvium. Downgradient of the known recharge areas, there is no evidence of surface discharge from the Fall River via seeps or springs. The following paragraphs describe the investigations performed to evaluate potential groundwater/surface water interactions.

Potentiometric Surface Evaluation

Powertech (USA) has evaluated areas where the potentiometric surfaces of the Fall River and Chilson are above the ground surface or above the base of the alluvium in order to assess the potential for groundwater discharge to the alluvium. Those areas within the Beaver Creek and Pass Creek drainages where the potentiometric surfaces for the Fall River and Chilson are above the ground surface are depicted on Figures 2.7-19 and 2.7-20, respectively. Note that the potentiometric surfaces are anticipated to be above ground surface to the west and southwest of the areas depicted on Figures 2.7-19 and 2.7-20; the boundaries shown in these directions are due to the data extents. The potential for groundwater discharge to alluvium from an operating well field is limited to those areas where the well field overlaps alluvium and the potentiometric surface of the Fall River or Chilson is above the base of the alluvium.

Alluvial Drilling Program

An alluvial drilling program was completed in May 2011 to further address potential discharge to the alluvium from underlying aquifers. Nineteen borings were drilled into the alluvium along Beaver Creek and Pass Creek, many of which were dry. Three borings were completed as alluvial monitor wells. The thickness of the saturated alluvium in these wells ranged from 10 to 12 feet. The alluvium in the Pass Creek drainage up to 50 feet thick; in the Beaver Creek drainage, the alluvium is up to 30 feet thick.

A potentiometric surface contour map for the Pass Creek and Beaver Creek alluvium is shown on Figure 2.7-21. An isopach map for the alluvium is shown on Plate 2.6-11. The potentiometric surface within the alluvium shows typical down-valley gradients consistent with the surface

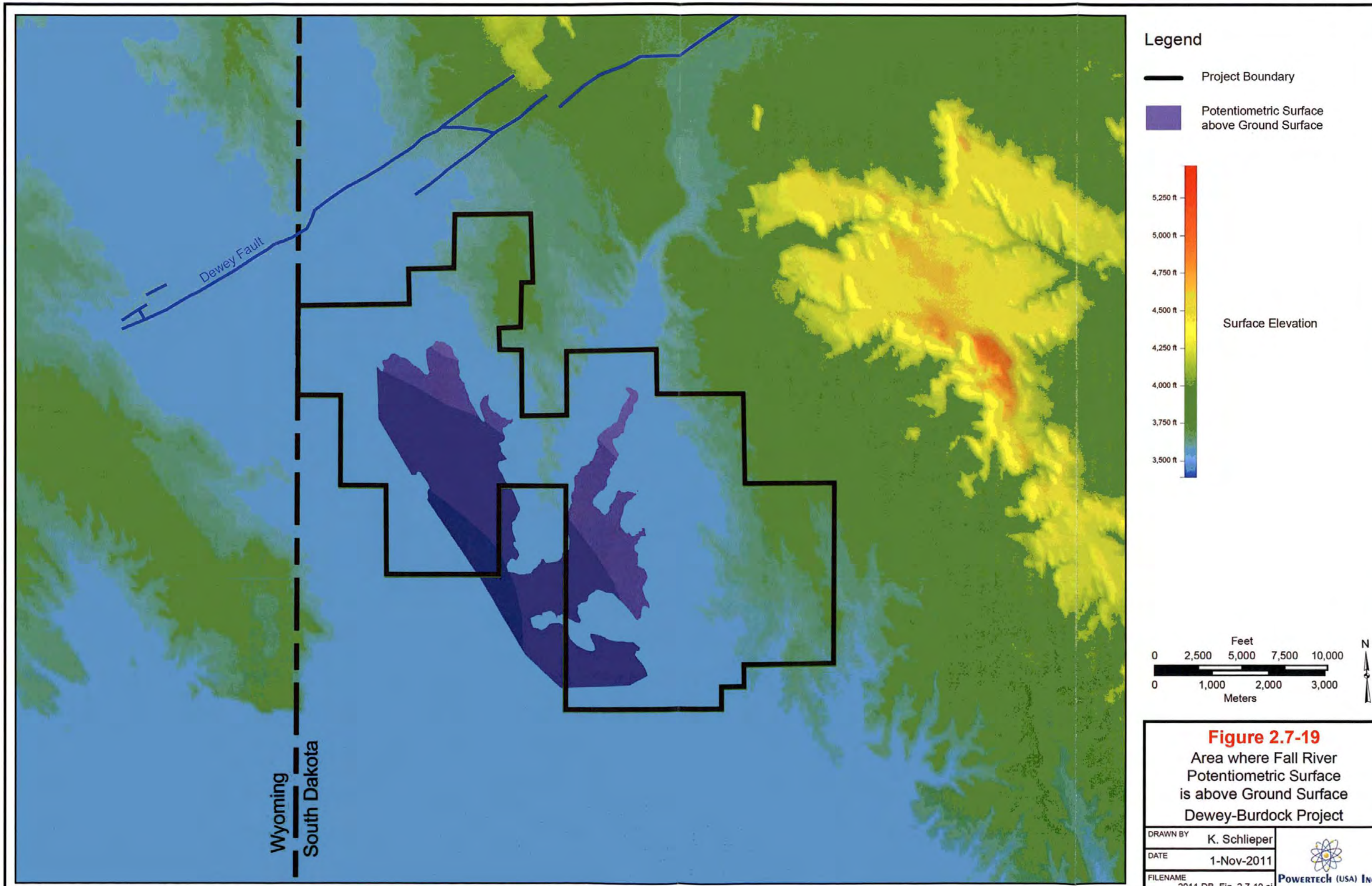

Figure 2.7-19
Area where Fall River Potentiometric Surface is above Ground Surface
Dewey-Burdock Project

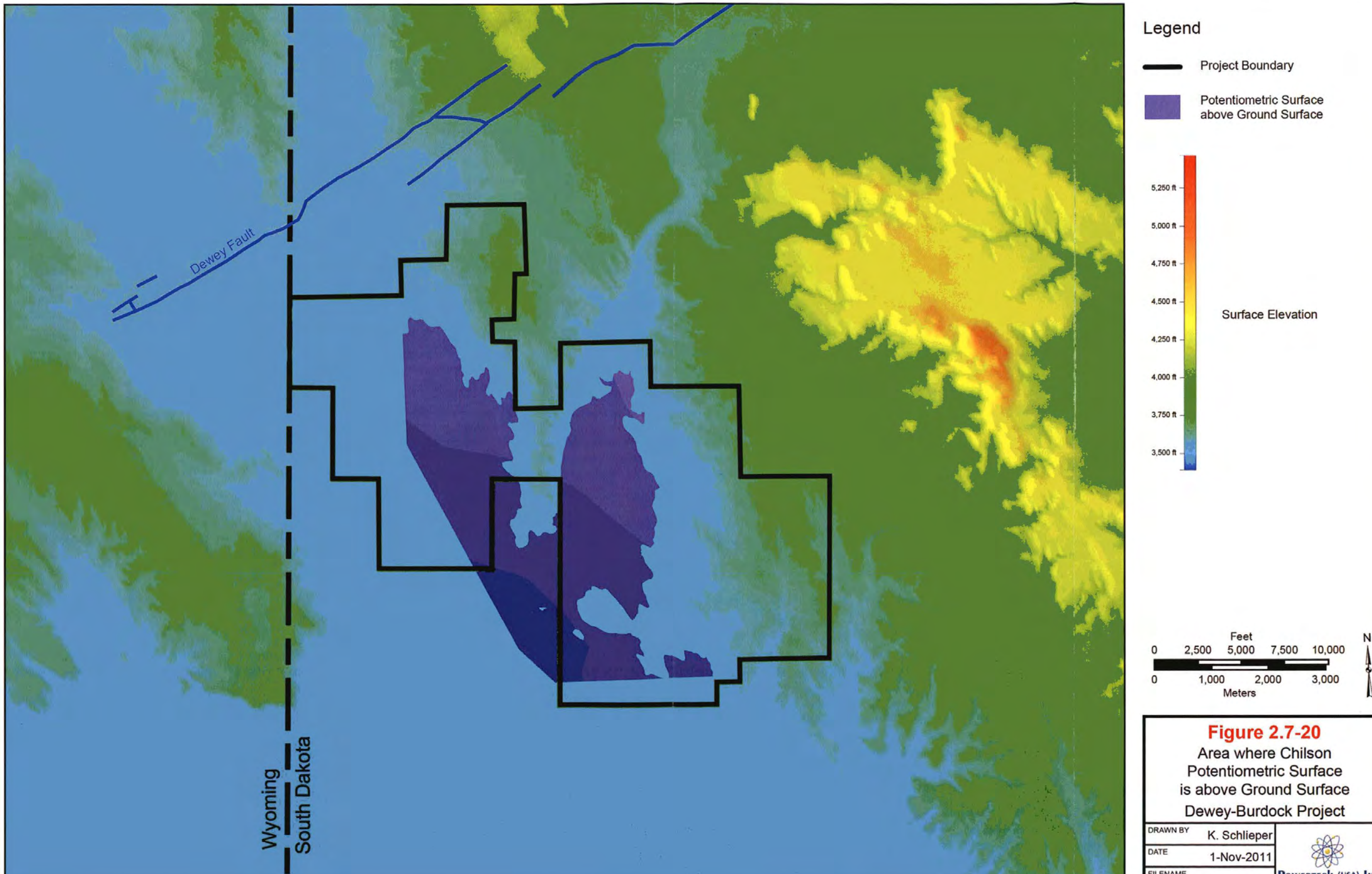

Figure 2.7-20
Area where Chilson Potentiometric Surface is above Ground Surface
Dewey-Burdock Project

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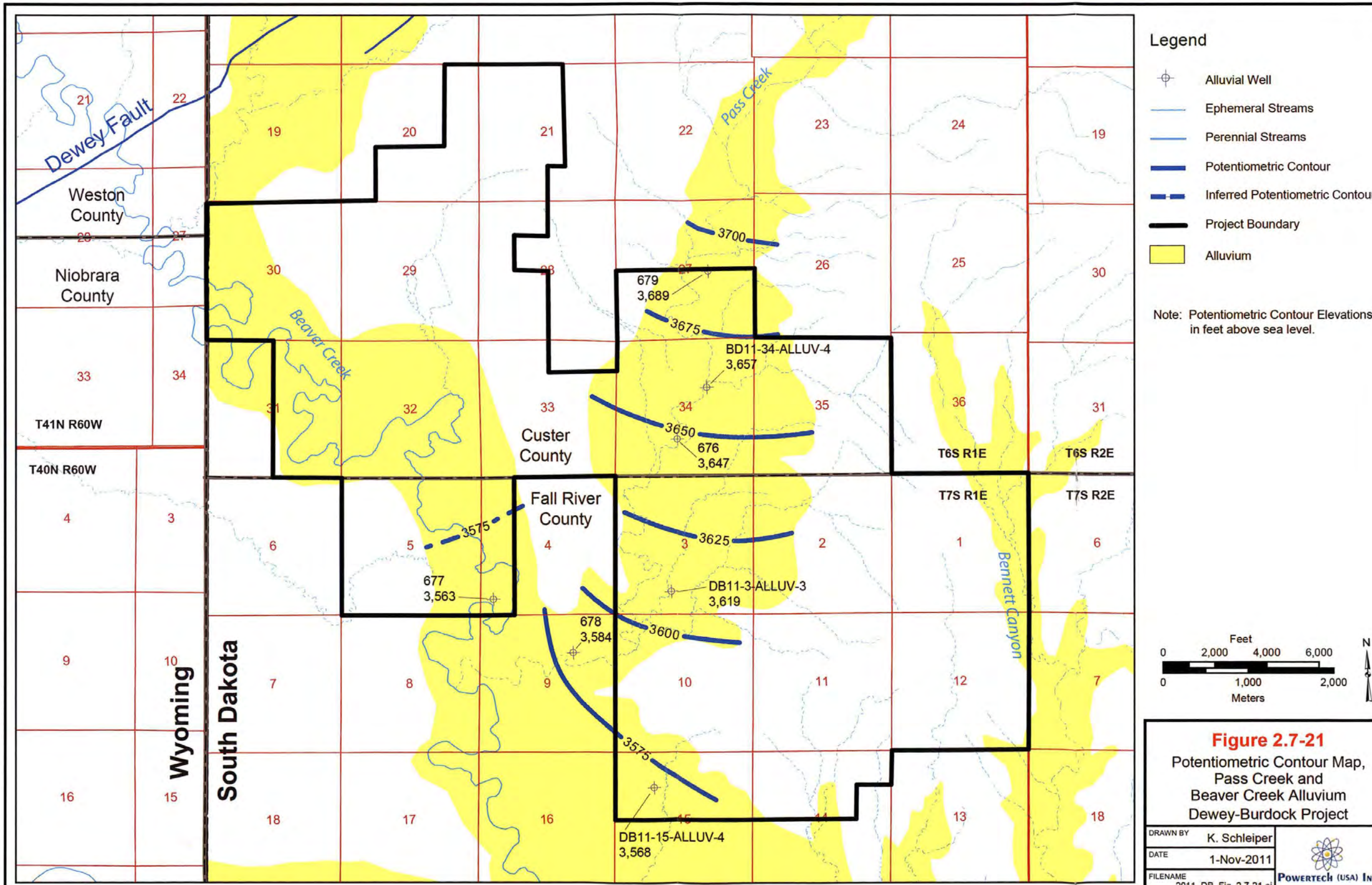

Figure 2.7-21
Potentiometric Contour Map, Pass Creek and Beaver Creek Alluvium
Dewey-Burdock Project

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topography. The water level data lack any anomalous readings such as would be expected in the case of bedrock discharge to the alluvium.

Results of the alluvial drilling program (occurrence/lack of water; potentiometric levels, and water quality data) did not indicate any areas of discharge to the alluvium from underlying aquifers but rather were consistent with limited recharge occurring from surface waters in the upland portions of the project area. The results from the May 2011 alluvial drilling program in the Beaver Creek and Pass Creek drainages are consistent with the historical field observations in that neither the past field investigations nor the recent drilling program identified any areas other than the "alkali area" noted above where there was evidence to suggest groundwater discharge into the alluvium or at the ground surface from the underlying bedrock formations.

CIR Imagery

To further evaluate possible groundwater discharge to the alluvium within the Beaver Creek and Pass Creek drainages, CIR satellite imagery was obtained from the National Agriculture Image Program (NAIP) of the USDA Farm Services Agency for the project area and vicinity. The imagery was photographed in 2010 and produced with a resolution of one meter. CIR imagery is commonly used to delineate areas of active vegetative growth; in semiarid regions such as the project area, such areas often are indicative of enhanced water supply, such as occurs with irrigation or subirrigation.

CIR imagery for the project area and vicinity is presented in Figure 2.7-22. The CIR imagery was examined visually for any anomalies that may suggest groundwater discharge at or near the surface, such as from upward flow through an open borehole or natural spring. Within the project area, there are several flowing artesian wells that at times are allowed to discharge groundwater to the surface. These areas generally are visible on the CIR imagery. The "alkali area" has a noticeable signature on CIR (ponded water surrounded by discolored soils) and is depicted on Figures 2.7-23 and 2.7-24.

Outside the project area, the CIR imagery clearly shows two springs near the town of Dewey along the Dewey Fault (Figure 2.7-25). These locations were later verified by Powertech (USA) personnel as springs. The results of this investigation strongly support the use of CIR data to identify areas of groundwater discharge, and with the exception of the "alkali area," support the lack of such discharge from exploration boreholes within the project area. Powertech (USA) will continue to use CIR imagery to assess the potential for groundwater discharge to the surface or alluvium within the project area. The obvious evidence of groundwater discharge in the "alkali

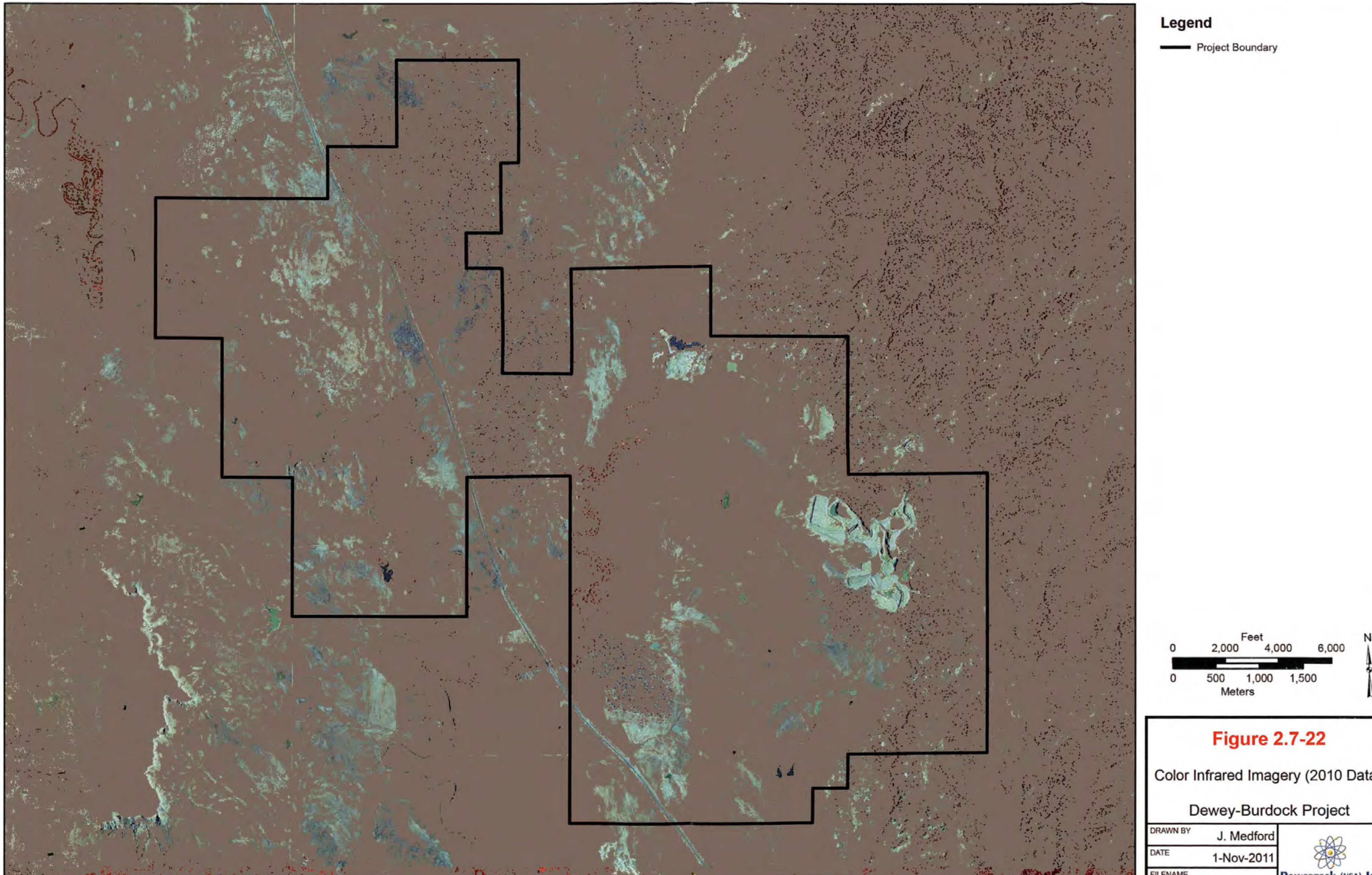

Figure 2.7-22

Color Infrared Imagery (2010 Data)

Dewey-Burdock Project

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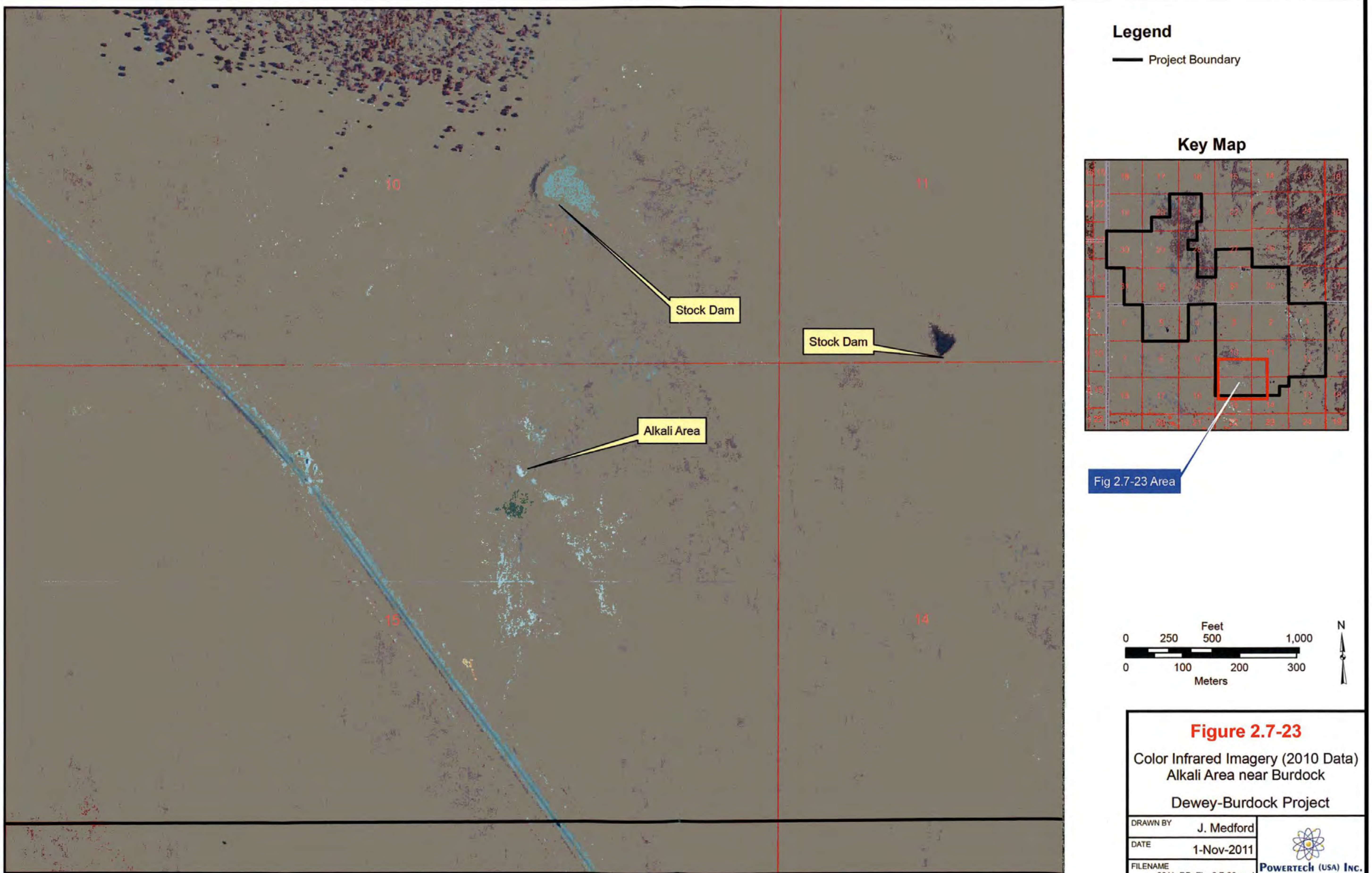

Figure 2.7-23

Color Infrared Imagery (2010 Data)
Alkali Area near Burdock

Dewey-Burdock Project

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Legend

Project Boundary

Key Map

Scale: None

Figure 2.7-24

Photograph of Alkali Area, Looking South, near Burdock

Dewey-Burdock Project

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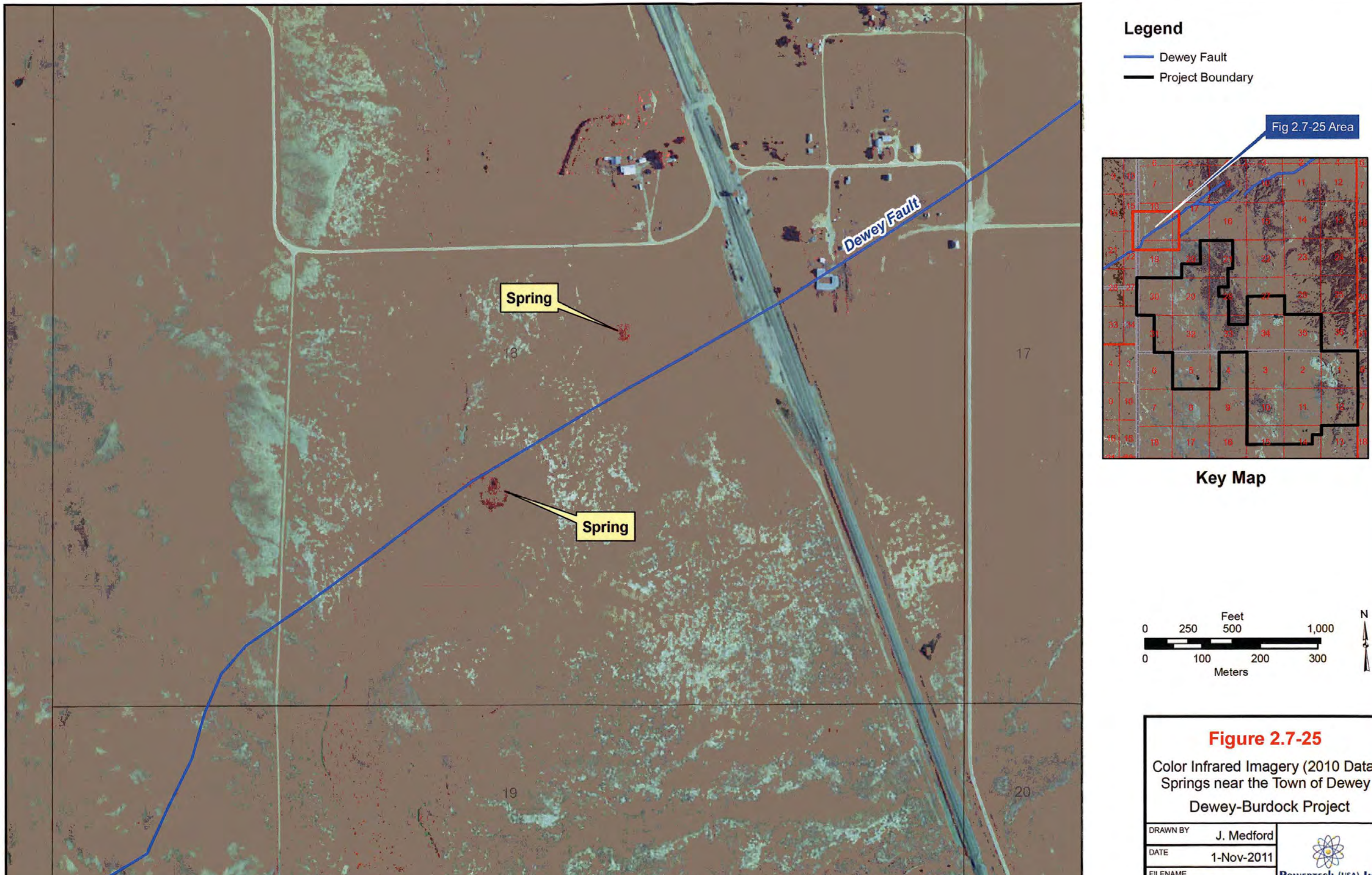

Figure 2.7-25

Color Infrared Imagery (2010 Data)
Springs near the Town of Dewey

Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-25.mxd

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area" suggests that if similar situations existed at other locations in the project area they would be readily detectable.

Well Field Delineation Drilling and Pump Testing

Further evaluation during the planned delineation drilling and well field-scale pump testing prior to the development of each well field will demonstrate adequate confinement to prevent potential upward groundwater movement through unplugged or improperly plugged boreholes or natural geologic features (refer to Section 3.1.3.2).

Historical Mining Areas

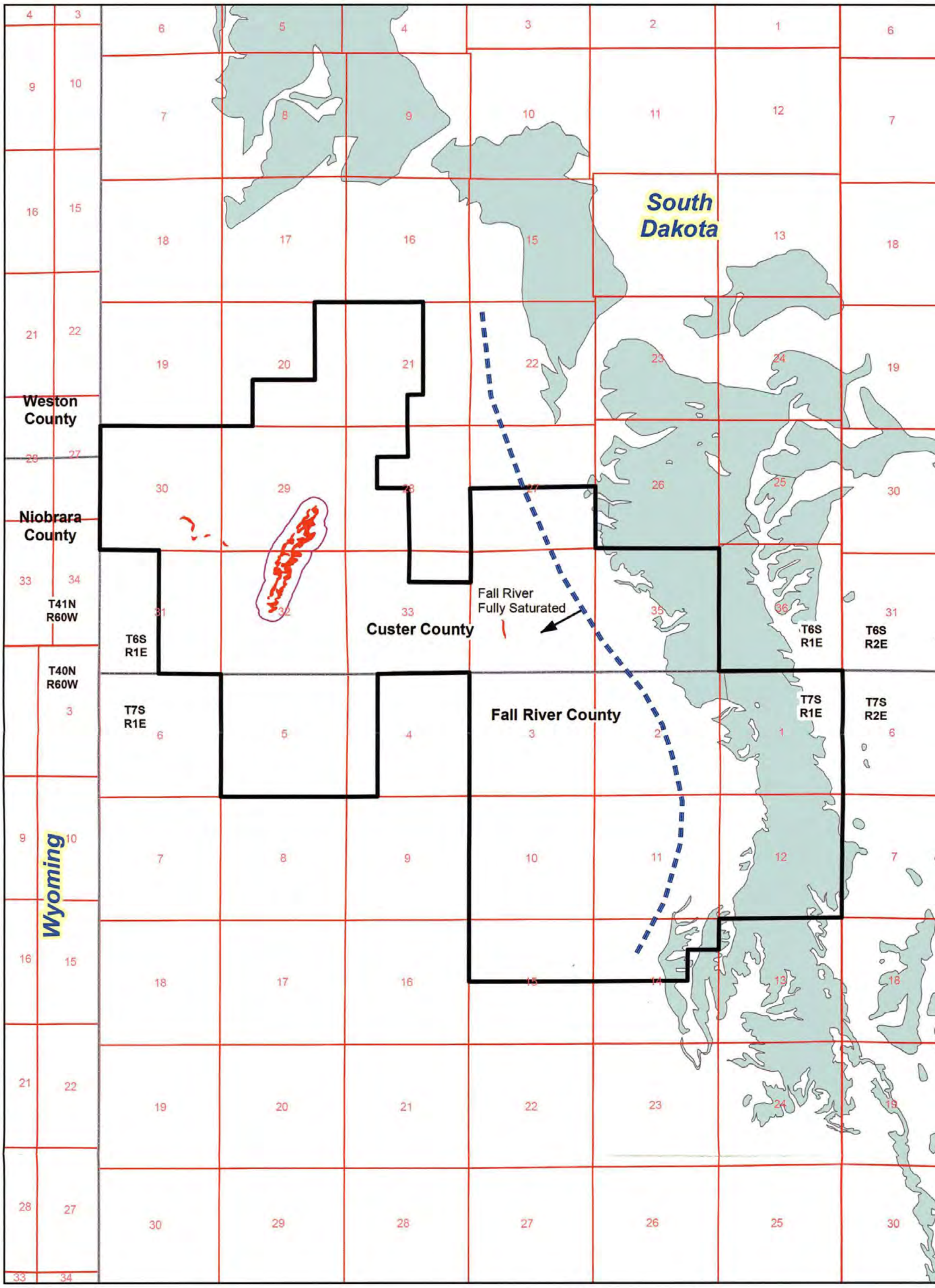
As discussed in Section 2.6.4.2, historical mining operations (surface [open pit] and underground) were conducted in the vicinity of the Dewey-Burdock Project. All those operations were conducted in the Fall River Formation. In all cases, the mining operations were above the Fuson Shale and in areas that will not be utilized by Powertech (USA) for ISR operations in the Fall River. The approach to well field development with respect to historical mining operations is described in Section 3.1.1.1.1.

The bottoms of the Darrow pits, with the exception of Pit #2, are above the Fall River potentiometric surface. These Darrow pits are usually dry but occasionally contain water that collects from runoff events. Darrow Pit #2, however, usually contains water suggesting that the base of the pit may be below the potentiometric surface of the Fall River. The pH of the water in Darrow Pit #2 is low (i.e., acidic) suggesting that surface drainage may be influencing the water chemistry in the pit. This implies that at least a portion of the water in Darrow Pit #2 is derived from surface runoff.

The bottom of the Triangle Pit is below the potentiometric surface of the Fall River. The Triangle Pit is therefore hydraulically connected to the Fall River Formation.

Partially Saturated Conditions

The uppermost portion of the Fall River Formation crops out in the eastern portion of the project area in the vicinity of the Darrow pits, and the full section crops out further east in Bennett Canyon. In these areas, the Fall River is geologically unconfined. As the Fall River rises to the east, it becomes partially saturated as the top of the formation rises above the groundwater table, as shown on Plate 2.6-12a (Cross Section A-A'). The approximate boundaries between fully saturated and partially saturated conditions in the Fall River and underlying Chilson are shown in Figures 2.7-26 and 2.7-27, respectively. As the Fall River dips basinward to the southwest,



Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters

N

Legend

- Project Boundary
- Potential Dewey Well Field #1
- Ore Bodies in Fall River
- Fall River Outcrop
- Approximate Edge of Fully Saturated Fall River

Figure 2.7-26

Location of Fully Saturated Portion of Fall River Formation

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	01-Nov-2011
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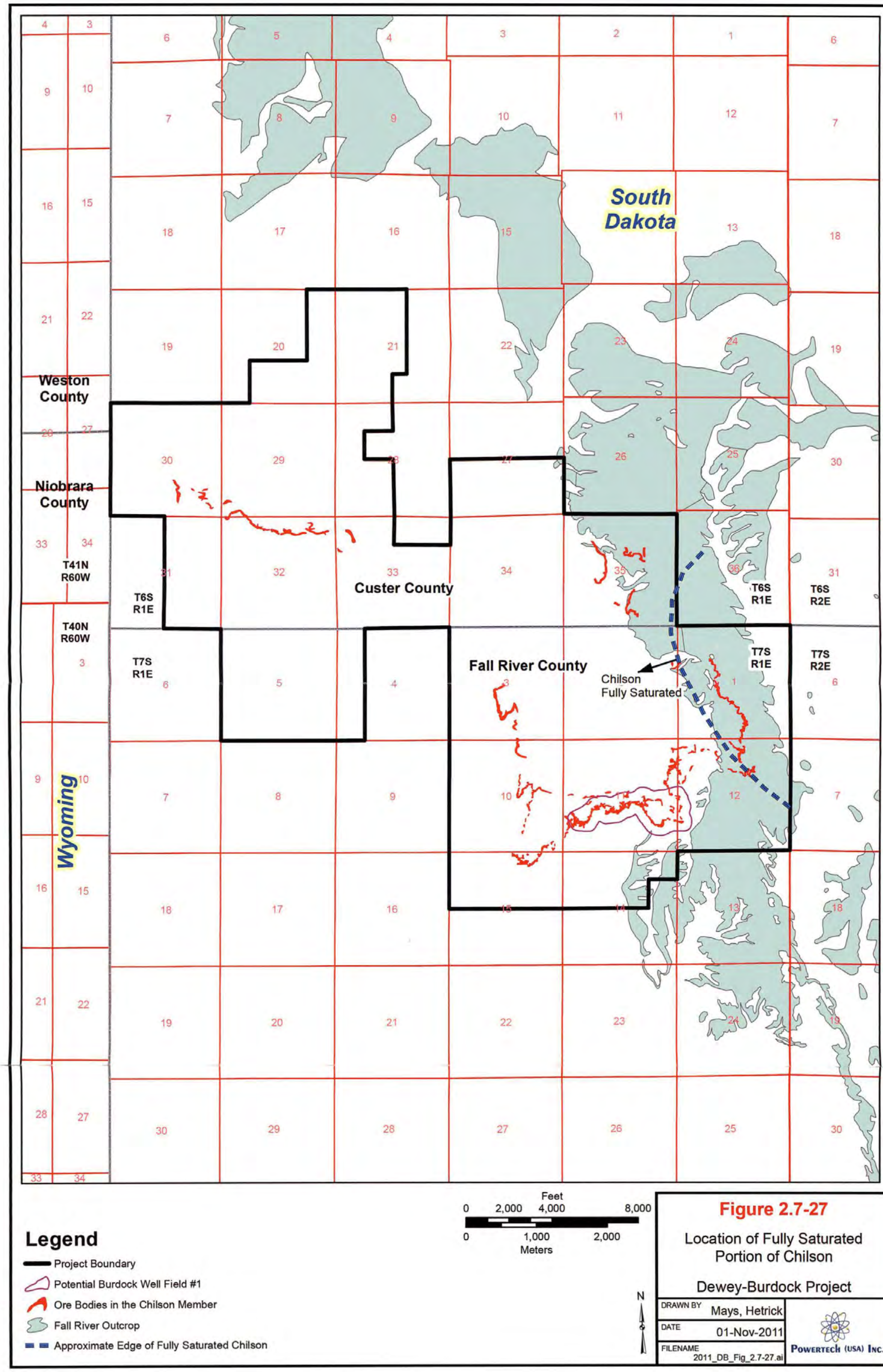

Figure 2.7-27
Location of Fully Saturated Portion of Chilson
Dewey-Burdock Project

the potentiometric surface is above the top of the formation, as shown on Plate 2.6-12a. Beneath the Beaver Creek and Pass Creek drainages, the potentiometric surface for the Fall River is above the ground surface.

Similarly, the Chilson Member rises in elevation to the northeast and subcrops beneath the alluvium in Bennett Canyon. The potentiometric surface elevation for the Chilson is projected to be below the top of the formation on the eastern edge of the project area. Only in this limited area, the Chilson, although geologically confined by the overlying Fuson Shale, is partially saturated (i.e., the water table is below the top of the formation).

Refer to Section 3.1.1.1.2 for a description of well field development with respect to partially saturated conditions. After NRC license issuance but prior to well field development, delineation drilling and well field pumping tests will be conducted to fully characterize the existing geologic and hydrogeologic conditions and to confirm sufficient head is available to perform normal ISR operations.

2.7.2.2.2.4 Hydraulic Isolation of Aquifers

Regionally, the Inyan Kara Group is geologically confined. In the project area, the Graneros Group shale serves as the overlying confining unit above the Fall River in the western portion of the project area. There are no major aquifers above the Inyan Kara. Below the Inyan Kara, the Morrison Formation serves as a confining unit. In the project area, results from recent pump tests show that the Morrison effectively confines the underlying Unkpapa aquifer since no measurable drawdown in the Unkpapa was observed while pumping in the Inyan Kara. For a more detailed discussion on the regional and site hydrostratigraphic units see Sections 2.7.2.1.1 and 2.7.2.2.1.

As described in the previous section, the only area where the Fall River Formation is geologically unconfined is in the eastern part of the project area in the general vicinity of the Darrow pits. Powertech (USA) does not propose to conduct ISR operations in the Fall River in this area (refer to Section 3.1.1.1.1), but does propose to conduct ISR operations in the underlying Chilson Member of the Lakota where ISR operations would not be affected by the presence of historical workings. The Chilson throughout the project area is physically and hydraulically separated from the overlying Fall River Formation by the Fuson Shale.

Based on Powertech (USA)'s borehole and geophysical logs for more than 3,000 exploratory holes, the Fuson Shale is continuous and no less than 20 feet thick throughout the entire project area. An isopach map showing the thickness and continuity of the Fuson Shale throughout the project area is presented as Plate 2.6-8. The pervasive occurrence and continuity of the Fuson Shale throughout the project area are shown on the geologic cross sections (Plates 2.6-12a through h and j).

2.7.2.3 Summary of Previous Pumping Tests

This section describes the pumping tests previously conducted by TVA and Powertech (USA). Section 3.1.3.2 describes the pre-operational pump testing that will be conducted for each well field.

2.7.2.3.1 Summary of TVA Pumping Tests

TVA conducted groundwater pumping tests from 1977 through 1982 as part of its uranium mine development project near the towns of Edgemont and Dewey. The results of these tests are summarized in two reports provided in Appendix 2.7-K of the approved license application: "Analysis of Aquifer Test Conducted at the Proposed Burdock Uranium Mine Site" (Boggs and Jenkins, 1980) and "Hydrogeologic Investigations at Proposed Uranium Mine near Dewey, South Dakota" (Boggs, 1983).

Two pumping tests conducted by TVA at the Burdock site in 1977 were unsuccessful. The results of these tests were considered inconclusive because of questionable discharge measurements, improperly constructed observation wells, and malfunctioning pressure gauges. No data from the 1977 tests are available.

TVA conducted two successful pumping tests in 1979 near the Burdock portion of the project area and one in 1982 about 2 miles north of the Dewey portion of the project area. The results of these tests are described below.

<u>Burdock Area</u>

The Burdock tests were conducted in 1979 near S. Dewey Road at the location shown on Figure 2.7-28. The Burdock tests consisted of separate pumping tests from the Lakota (Chilson) and Fall River in April and July of 1979. The tests used the same pumping well with packers to alternatively isolate screens open to the respective formations. Test durations were 73 hours for the Lakota (Chilson) test and 49 hours for the Fall River test. Pumping rates were about 200 gpm from the Lakota (Chilson) aquifer and 8.5 gpm from the Fall River. The reason for the unexpected low pumping rate from the Fall River aquifer was not specified in the TVA report.

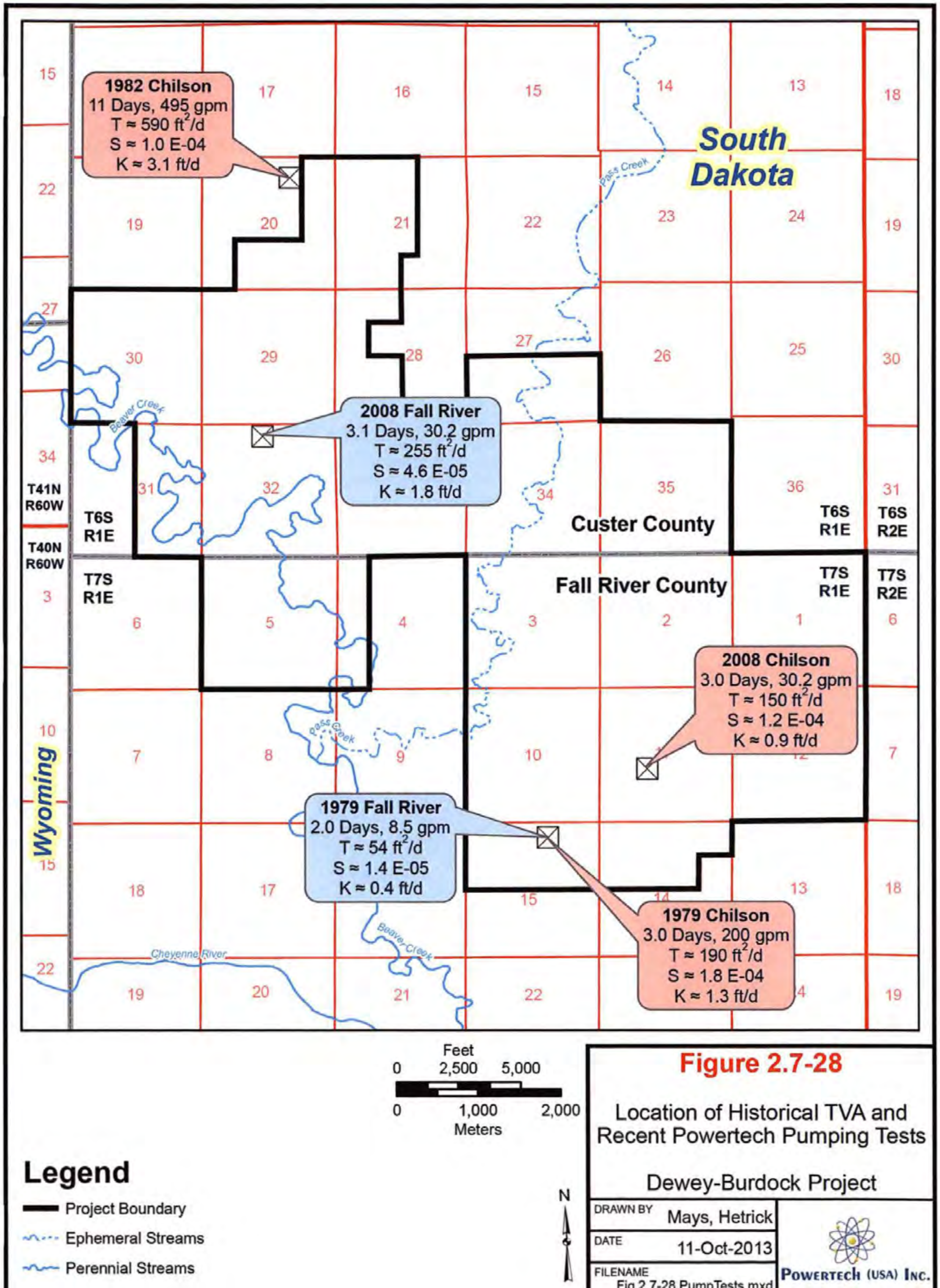

Figure 2.7-28

Location of Historical TVA and Recent Powertech Pumping Tests

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	11-Oct-2013
FILENAME	Fig 2.7-28 PumpTests.mxd

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Based on review of the testing results by Powertech (USA), significant conclusions from the TVA testing indicate:

- Transmissivity of the Chilson based on the analysis of late time data averaged about 1,400 gpd/ft (190 ft^2/day) and storativity was determined to be approximately 1.8×10^{-4} (dimensionless).
- Transmissivity of the Fall River averaged about 400 gpd/ft (54 ft^2/day) and storativity approximately 1.4×10^{-5} (dimensionless).
- The vertical hydraulic conductivity of the Fuson aquitard calculated using the Neuman-Witherspoon ratio method (Neuman and Witherspoon, 1972) ranged from 1×10^{-3} to 1×10^{-4} ft/day; storativity was not determined, and specific storage was assumed to be about 10^{-6} ft^{-1}.
- The reported "leaky aquifer" response likely is related to (1) Well 668 that is completed in both the Chilson and Fall River and can provide a direct communication pathway, and/or (2) the presence of open boreholes that may provide communication between the Fall River and Lakota (Chilson) in a limited area near the Burdock test, or communication between the Fall River and land surface. The test results do not support a leaky confining zone (Fuson Shale).

Dewey Area

The Dewey test was conducted in 1982 northeast of S. Dewey Road at the location shown on Figure 2.7-28. The test consisted of pumping in the Lakota Formation (Chilson) at an average rate of 495 gpm for 11 days. The significant results are as follows:

- Transmissivity of the Chilson averaged about 4,400 gpd/ft (590 ft^2/day).
- Storativity of the Chilson was about 1.0×10^{-4} (dimensionless).
- The vertical hydraulic conductivity of the Fuson aquitard using the Neuman-Witherspoon ratio method (Neuman and Witherspoon, 1972) was 2×10^{-4} ft/day; storativity of the Fuson Shale was not determined and specific storage was about 7×10^{-7} ft^{-1}.
- A barrier boundary or decrease in transmissivity due to lithologic changes with distance from the test site, or both, were observed; a possible geologic feature corresponding to a barrier was noted to be the Dewey Fault Zone, located about 1.5 miles north of the test site, where the Chilson and Fall River Formations are structurally offset.

2.7.2.3.2 2008 Pumping Tests

In 2008 pumping tests were performed in the Dewey and Burdock portions of the project area (Figure 2.7-28), along with laboratory tests on related core samples, to assess aquifer properties. A work plan (Knight Piésold, 2008a) was prepared and distributed to interested representatives of state and federal agencies, including DENR and EPA.

A detailed description of the aquifer testing methodology and analysis of the results are contained in the aquifer test report (Knight Piésold, 2008b; Appendix 2.7-B of the approved license application). The report results are briefly summarized in the following sections.

2.7.2.3.2.1 Burdock Area

Summary of Burdock Pumping Test Results

Pump testing was conducted within the lower Lakota (Chilson) at pumping well DB07-11-11C. Three observation wells were monitored in the same horizon. An observation well was also monitored in the upper Chilson. Single observation wells were monitored in the overlying Fall River and underlying Unkpapa. The well was pumped at an average rate of 30.2 gpm for 4,320 minutes (3.0 days).

Drawdown at the pumping well was approximately 91 feet, and between 3.1 feet and 17.0 feet in the lower Lakota (Chilson) observation wells. The upper Lakota (Chilson) well response was delayed, but 3.4 ft of drawdown was observed in this well. Approximately 1 foot of drawdown was observed in the overlying Fall River well and no response was observed in the underlying Unkpapa well.

A summary of aquifer parameters for the 2008 Burdock pumping test (conducted in the Chilson Member of the Lakota Formation) and related laboratory core testing is as follows:

- Nine determinations of transmissivity (Table 2.7-15) ranged from 120 to 223 ft^2/day with the median value of 150 ft^2/day.
- Based on 170 feet of saturated thickness in the aquifer, hydraulic conductivities ranged from 0.7 ft/day to 1.3 ft/day, with a median value of 0.9 ft/day.
- Four storativity determinations (Table 2.7-15) ranged from 6.8×10^{-5} to 1.9×10^{-4} with the median value of 1.2×10^{-4}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 2,100 feet.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 2.7-16) were made on sandstone layers similar to that tested in the pump test; measured horizontal hydraulic conductivity ranged from 5.9 to 9.1 ft/d, the mean value was 7.4 ft/d and the mean ratio of horizontal to vertical hydraulic conductivity in Burdock area sandstone was 2.47:1.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 2.7-16) were made on shale layers from two major confining units for the Lakota (Chilson) in the pump test area with the following results:

Table 2.7-15: Summary of Aquifer Hydraulic Characteristics for the Burdock Pumping Test

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft^2/day)	u or u' (unitless)	Storativity (unitless)	Note
Ore zone (lower Chilson Sandstone)							
11-11C	Pumping	0.25 (0.33)	Theis DD(1)	145	-	2.9E-09(a)	-
			CJ DD (3)	150	<0.01	-	-
Pumping Well Efficiency = 65%(3)							
			CJ Recovery (3)	140	<0.01	-	-
11-15	Obs #1	243	Theis DD(1)	67	-	1.30E-03	-
			CJ Recovery (3)	100	<0.1	-	-
11-14C	Obs #2	250	Theis DD(1)	128	-	6.80E-05	-
			H-J DD(1)	120	-	6.90E-05	
			Theis Recovery(1)	174	<0.01	-	-
			CJ Recovery (3)	160	<0.01	-	-
11-02	Obs #3	1,292	Theis DD(1)	223	-	1.90E-04	-
			H-J DD(1)	185	-	1.70E-04	-
			CJ Recovery (3)	260	<0.15	-	-
Upper Chilson Sandstone							
11-19	Obs	50	Theis DD(2)	260	-	1.00E-01	-
			CJ Recovery (3)	190	<0.15	-	-
Fall River (lower sandstone layer)							
11-17	Obs	50	Noordbergum Effect and response cannot be interpreted analytically				
Unkpapa Sandstone							
11-18	Obs	35	No response during pumping test.				-
Distance Drawdown (11-14C, 11-15, 11-02)(2)				145	<0.08	2.20E-04	r^2 = 0.76 (3 point line)
Pumping Well Efficiency = 61% to 63%							
Summary:	Median			150		1.20E-04	
Average/Geometric Mean(5)				158		1.12E-04	
	TVA(4)			190		1.80E-04	

(1) Calculated by automated curve fitting in AquiferWin32™ software (ESI, 2003).
(2) Knight Piésold spreadsheet after methods in Driscoll (1986).
(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).
(4) Summary values from p. 17 in Boggs and Jenkins (1980).
(5) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.
(a) Storativity not valid at pumping well.
(b) Based on 6 inch casing (8 inch borehole).

'158' = Accepted value based on conformance with theory discussed in the text.

Table 2.7-16: Laboratory Core Analyses at Project Site

Sample Number	Depth (ft)	Confining Stress (psig)	Porosity (%)	Air Intrinsic Permeability(1) ka (mD)	Particle Density (g/cm³)	Notes	Water Hydraulic Conductivity Kw(2)(3) (cm/s)	Core Kh (ft/day)	Core Kv (ft/day)
DB 07-11-11C Burdock									
1H	252.20	600	10.50	1.040	2.356	Fuson Shale	8.0073E-07		
1V	252.35	600	10.15	0.228	2.356	Fuson Shale	1.7555E-07		
4H	412.30	600	9.68	0.041	2.511	Fuson Shale	3.1567E-08		
4V	412.45	600	9.59	0.015	2.514	Fuson Shale	1.1549E-08		
DB 07-29-1C Dewey									
2H	480.70	600	8.90	0.078	2.613	Skull Creek shale	6.0055E-08		
2V	480.80	600	9.30	0.007	2.610	Skull Creek shale	5.3896E-09		
3H	609.10	600	12.26	0.073	2.603	Fuson Shale	5.6205E-08		
3V	609.10	600	10.84	0.008	2.793	Fuson Shale	6.1595E-09		
DB 07-11-14C Burdock									
5H	423.60	600	29.56	3,207	2.645	Chilson Sand	2.4692E-03	7.0	
5V	423.35	600	30.34	1,464	2.645	Chilson Sand	1.1272E-03		3.2
6H	430.20	600	31.90	4,161	2.640	Chilson Sand	3.2037E-03	9.1	
6V	430.35	600	30.16	939	2.646	Chilson Sand	7.2297E-04		2.1
7H	453.50	600	10.86	1.000	2.519	Morrison Shale	7.6994E-07		
7V	453.45	600	11.82	0.043	2.543	Morrison Shale	3.3107E-08		
DB-07-11-16C Burdock									
8H	420.40	600	30.50	2,697	2.643	Chilson Sand	2.0765E-03	5.9	
8V	420.10	600	30.17	1,750	2.651	Chilson Sand	1.3474E-03		3.8
9H	455.90	600	6.99	0.004	2.536	Morrison Shale	3.0797E-09		
9V	455.45	600	7.65	0.012	2.556	Morrison Shale	9.2392E-09		
10H	503.30	600	12.96	0.697	2.474	Morrison Shale	5.3665E-07		
10V	503.45	600	No data						
DB 07-32-4C Dewey									
11H	573.25	600	29.15	2,802	2.641	Fall River Sand	2.1574E-03	6.1	
11V	573.40	600	29.04	619	2.645	Fall River Sand	4.7659E-04		1.4
Summary									
Average Lakota Sand Kh, Kv								7.4	3.0

(1) Assumed air temperature = 70°F.
(2) Assumed water temperature = 52.8°F, water density = 0.999548 g/cm³, and water dynamic viscosity = 0.012570 g/cm-s.
(3) $K_w = k_a \times (\rho_w g/\mu_w)$, and 1.0 mD = 0.987×10^{-11} cm²

- Fuson Shale: the laboratory core data indicate vertical permeabilities of about 2×10^{-7} to 1×10^{-8} cm/sec (average 2.7×10^{-4} ft/d) for shale samples from within the Fuson Shale.
- Morrison Shale: the laboratory core data for the shales in the underlying Morrison Formation indicate vertical permeabilities of 9×10^{-9} to 3×10^{-8} cm/sec (average 6.0 $\times 10^{-5}$ ft/d).

Burdock Pumping Test Conclusions

The Burdock pumping test in 2008 may be directly compared to the 1979 TVA test for the Lakota (Chilson) aquifer as the tests were nearly at the same location (Figure 2.7-28). The average transmissivity and storativity values determined from the TVA tests were 190 ft^2/d and 1.8×10^{-4} (see p. 17 in Boggs and Jenkins, 1980). Comparing the median transmissivity of 150 ft^2/d and storativity of 1.2×10^{-4} determined in the 2008 test to the TVA test, the new aquifer parameters for the lower Chilson are respectively about 80 and 70 percent of the 1979 results. Because transmissivity and storativity depend on aquifer thickness, comparing the results suggests that there may be some scaling effect between the tests due to the differing lengths of screened intervals.

The 1979 TVA test transmissivity of 190 ft^2/day is considered representative of the entire Chilson aquifer for a regional application (Table 2.7-15).

Previous conclusions and interpretations from this pump test submitted to NRC and EPA indicated that the Chilson behaved as a leaky aquifer system (e.g., a drawdown response was observed in the overlying Fall River observation well and the Chilson wells consistent with a leaky system based on a match of the data to the Hantush-Jacob solution). Further review of the site geology and hydrology suggest that those interpretations were not representative of site conditions.

The laboratory core data from samples collected within the project area indicate an average vertical permeability of 9.3×10^{-8} cm/s (2.7×10^{-4} ft/day) for shale samples from the Fuson Shale (Table 2.7-16). The shale core permeability values are about one to two orders of magnitude smaller than the pumping test values determined in the 1979 TVA test at Burdock, where the vertical hydraulic conductivity of the Fuson aquitard was calculated using the Neuman-Witherspoon ratio method to be about 1×10^{-3} ft/day (see pg. i in Boggs and Jenkins, 1980).

For the Lakota (Chilson) sandstone, the laboratory core data from samples collected within the project area indicate an average horizontal hydraulic conductivity of 2.5×10^{-3} cm/sec (7 ft/day) and range as high as 3.2×10^{-3} cm/sec (9.1 ft/day, Table 2.7-16). Pump test results indicate an average horizontal hydraulic conductivity of approximately 0.9 ft/d (3.2×10^{-4} cm/s).

Site-wide geologic data (logs, cross-sections and isopach maps) clearly demonstrate the continuity of the Fuson Shale across the project area. Those data, combined with data from the pump tests and core results, indicate that the leaky behavior observed in the 2008 Chilson test likely is the result of (1) communication between the Chilson and Fall River via Well 668 that is completed in both sands, and/or (2) the presence of open boreholes that may provide communication between the Fall River and Lakota (Chilson) in a limited area near the Burdock test.

2.7.2.3.2.2 Dewey Area

Summary of Dewey Pumping Test Results

Pump testing was conducted in the lower sandstone interval of the Fall River at pumping well DB07-32-3C. This well was pumped at a rate of 30.2 gpm for 3.1 days (4,440 minutes). Three observation wells between 240 and 2,400 feet from the pumping well were monitored in the same horizon. An upper Fall River observation well was also monitored. Single observation wells were monitored in the underlying Lakota (Chilson) and Unkpapa aquifers.

Drawdown at the pumping well was at 44.8 feet, and drawdown in the lower Fall River observation wells varied with distance from the pumping well to between 1.5 and 13 feet. Drawdown in the upper Fall River approximately 40 feet from the pumping well was approximately 4 feet. No drawdown response was observed in the underlying Lakota (Chilson) or Unkpapa aquifers.

A summary of aquifer parameters for the 2008 Dewey pumping test (conducted in the Fall River Formation) and related laboratory core testing is as follows:

- Ten determinations of transmissivity (Table 2.7-17) ranged from 180 to 330 ft^2/day with the median value of 255 ft^2/day.
- Based on 140 feet of saturated thickness in the Fall River, hydraulic conductivities range from 1.3 ft/day to 2.4 ft/day, with a median value of approximately 1.8 ft/day.
- Five storativity determinations (Table 2.7-17) ranged from 2.3×10^{-5} to 2.0×10^{-4} with the median value of 4.6×10^{-5}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 5,700 feet.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 2.7-16) were made on shale samples from the two major confining units overlying and underlying the pump test area with the following results:
  - Skull Creek Shale: laboratory core data for the shale sample from the overlying Skull Creek Shale (Graneros Group) indicate a vertical permeability of 5.4×10^{-9} cm/sec (1.5×10^{-5} ft/day).

- Fuson Shale: laboratory core data for the shale sample from the underlying Fuson Shale indicate a vertical permeability of 6.2 x 10^{-9} cm/sec (1.8 x 10^{-5} ft/day).

Dewey Pumping Test Conclusions

The Dewey pumping test in 2008 in the Fall River aquifer is not directly comparable to the 1982 TVA test because the underlying Lakota (Chilson) aquifer was tested in 1982.

The 2008 test indicates that the lower and upper sandstone portions of the Fall River Formation behave as a single, confined, aquifer with some form of lateral barrier due to changing lithology, such as a channel boundary. The TVA test in 1982 observed a barrier boundary in the underlying Lakota Formation, likely the result of the Dewey Fault Zone. Apparently, both the Chilson and Fall River Formation in the general Dewey area are highly transmissive and show barrier boundaries. These test results are more definitive than the 1982 TVA test concerning the proximity of the barrier boundary, because the 2008 radius of influence was about 1 mile, or about ⅓ to ½ the distance to the fault zone.

Confinement provided by the Fuson Shale between the Fall River and underlying Chilson Member of the Lakota Formation was demonstrated by the 2008 testing. The Chilson and Fall River aquifers at the Dewey test site are hydraulically isolated by the intervening Fuson Shale with nearly 40 feet head difference between the two units. The laboratory core data indicate a very low vertical permeability of 6.2 x 10^{-9} cm/sec (1.8 x 10^{-5} ft/day) for a shale sample from the Fuson Shale within the project area (Table 2.7-16).

The laboratory core data for the shale sample from the Skull Creek Shale, which overlies the Fall River Formation, indicate a very low vertical permeability of 5.4x10^{-9} cm/sec (1.5x10^{-5} ft/day), which is representative of an effective aquitard or aquiclude (Table 2.7-16).

For the sandstone of the Fall River Formation, the laboratory core data indicate a horizontal hydraulic conductivity of 6.1 ft/day (2.2 x10^{-3} cm/s, Table 2.7-16). Based on pump test results, the average horizontal conductivity is approximately 1.8 ft/day (6.4 x 10^{-4} cm/s). Within the lower Fall River Formation, the test results indicate transmissive, rapid response (2 to 3 minutes) between pumping and observations wells up to 467 feet apart with nearly 10 feet of drawdown. Response was nearly 9 feet of drawdown at 1,400-foot distance. This indicates that the aquifer was stressed to produce good quality analytical results.

Table 2.7-17: Summary of Aquifer Hydraulic Characteristics for the Dewey Pumping Test

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft^2/day)	u or u' (unitless)	Storativity (unitless)	Note
Ore zone (lower Fall River Sandstone)							
32-3C	Pumping	0.25 (0.33)	Theis DD[1]	250	-	1.2E-06[b]	-
			CJ DD[3]	250	<0.01	-	-
Pumping Well Efficiency = 80%(3)							
			CJ Recovery[3]	270	<0.01	-	-
32-5	Obs #1	243	Theis DD[1]	294	-	3.30E-05	--
			Theis Recovery[1]	260	<0.01	-	-
			CJ Recovery[3]	280	<0.01	-	-
32-4C	Obs #2	467	Theis DD[1]	333	-	5.60E-05	-
			CJ Recovery[3]	120[a]	<0.01	-	
29-7	Obs #3	2,400	Theis DD[2]	178	-	2.00E-04	
			CJ Recovery[3]	Insufficient recovery for analysis			-
Fall River Aquifer Stock Well (Screened in top half of Fall River)							
GW-49	Stock	1,400	Theis DD[1]	177	-	2.30E-05	-
			CJ Recovery[3]	110	<0.05	-	-
Upper Fall River Sandstone							
32-9C	Obs	41	Theis DD[1]	217	-	1.60E-02	-
			CJ Recovery[3]	150	<0.05	-	--
Chilson Sandstone Layer							
32-10	Obs	61	No response during pumping test.				--
Unkpapa Sandstone							
32-11	Obs	50	No response during pumping test.				-
Distance Drawdown (32-5, 32-4C, 29-7, GW-49)[2]				218	<0.05	4.60E-05	r^2 = 0.78 (4 point line)
Pumping Well Efficiency = 93% to 95%							
Summary:	Median			255		4.60E-05	
Average/Geometric Mean[4]				251		5.23E-05	

Notes/References: DD = drawdown, CJ = Cooper -Jacob, Obs = Observation Well

(1) Calculated by automated curve fitting in AquiferWin32™ software (ESI, 2003).

(2) Knight Piésold spreadsheet after methods in Driscoll (1986).

(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).

(4) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.

(a) Only slope satisfying u 'criterion occurs after intersection with barrier boundary.

(b) Not accepted due to anomalous response at well, see text.

2.7.2.4 Groundwater Use

The four principal aquifers used as major sources of water supply in the Black Hills include the Deadwood, Madison, Minnelusa, and Inyan Kara. Each of these aquifers is used to varying degrees, depending on location, depth of occurrence and location related to population.

The estimated groundwater use in Custer and Fall River counties is summarized in Table 2.2-4. Within the project area, the Inyan Kara Group, which includes the Fall River Formation and Chilson Member of the Lakota Formation, is the principal source of water for livestock, domestic use and other purposes.

Historical records and field investigations of the project area and 2-km surrounding area were used to develop the well inventory. A preliminary investigation of the wells was completed in 2007, and additional surveys were conducted in 2011 to evaluate the use and condition of the wells. A total of 106 wells have been identified within 2 km of the project area. There are also 26 wells with historical records that currently are not present at the surface and 8 wells with historical records that have been visually confirmed as plugged and abandoned. Appendix 2.2-A of the approved license application contains the well inventory summary tables, and Appendix 2.2-B of the approved license application contains the detailed well inventory, well completion records and associated documentation. Plate 2.7-2 depicts existing wells within 2 km of the project area.

Table 1 in Appendix 2.2-A of the approved license application summarizes the well inventory. Those wells have one of the following uses:

Domestic: Are currently used or reasonably can be expected to be used for domestic water use (e.g., drinking, washing, sanitary use, etc.), including wells which also are used for livestock watering. This category also includes formerly used domestic wells which through agreements with Powertech (USA) no longer will be used as drinking water wells. (19 wells)

Stock: Watering of livestock is sole use; well cannot be used for domestic water use (i.e., no piping to domestic water system, etc.). (41 wells)

Monitor: Sole use is for monitoring. (46 wells)

Table 2 in Appendix 2.2-A of the approved license application lists the wells identified in historical records that were not evident at the surface during the field investigations. These wells are depicted on Figure 2.7-29. Several of these wells are suspected of being plugged and abandoned. Powertech (USA) will continue to search for these wells. During design of well fields, pump testing will be designed to locate any such wells and to detect any potential impacts from such wells on the ISR operations.

Table 3 in Appendix 2.2-A of the approved license application lists all of the wells within 2 km of the project area that have been confirmed by Powertech (USA) to have been plugged and

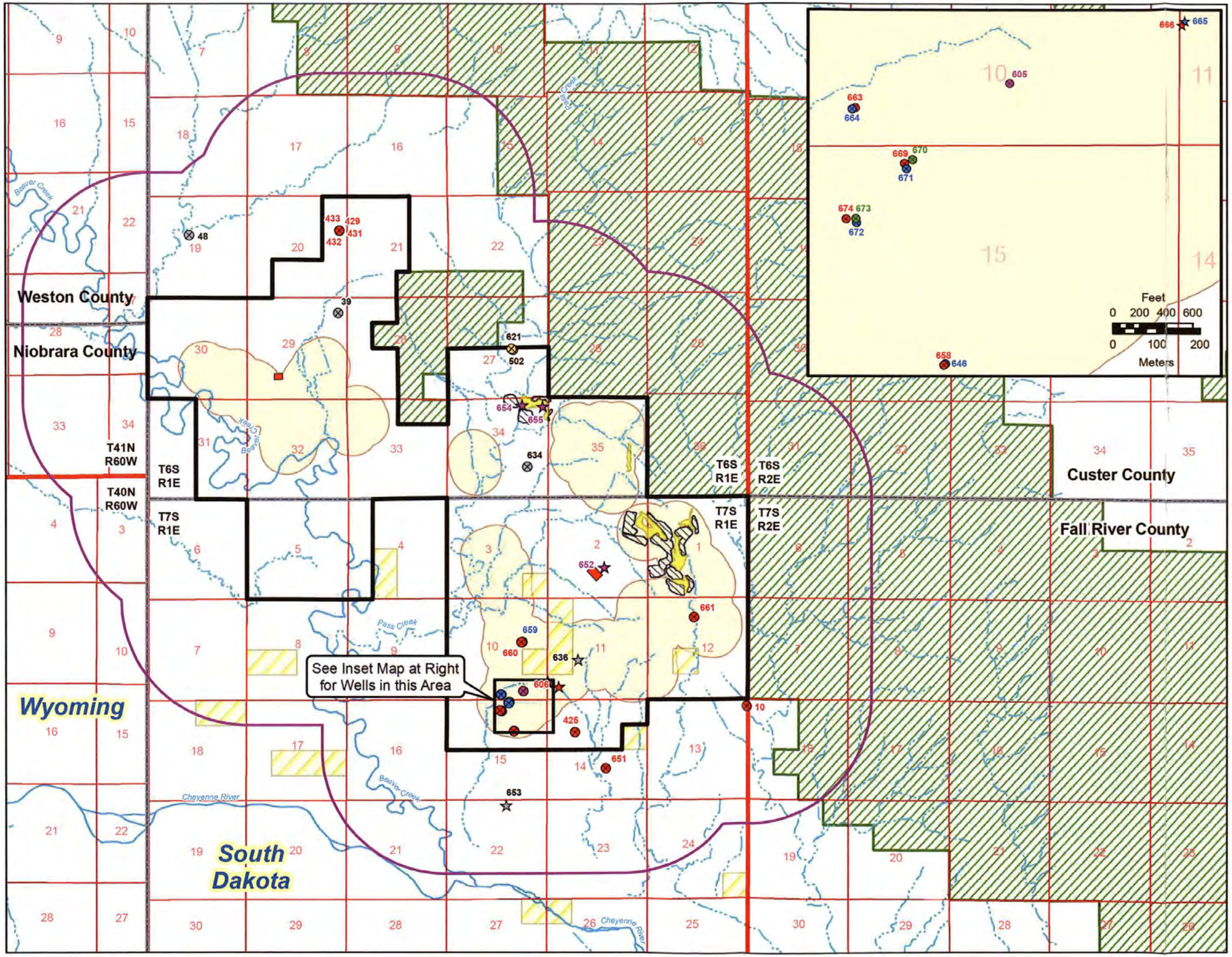

Figure 2.7-29

Historical Wells Not Present or Plugged & Abandoned

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Wells-Historic-NP-PA.mxd

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abandoned. Each well was visually inspected, and it has been determined that cement was placed within the well bore.

2.7.2.4.1 Operational Water Use

During ISR 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 the cone of depression necessary within any production or restoration activity. The design nominal bleed rate is 0.875 percent as described in Section 4.2.2.4.1. ISR circulates significant quantities of water through the ore zone but consumes only a small fraction of that amount because most water is reinjected 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 that a cone of depression is maintained and that no leach fluids are released from the recovery area.

It is anticipated that up to four well fields will be in production at one time, with up to two in restoration. Aquifer restoration will begin as soon as each well field has been depleted of uranium, beginning approximately two years after the start of operations. When one well field is depleted, it will be restored at the same time production continues in another well field along the ore front.

2.7.2.4.1.1 Water Requirement for the Facilities

The water balance is presented in Section 4.2.2.4. Water requirements of the CPP will typically be about 12 gpm. It is expected that most of this water will be derived from one or more water supply wells in the Madison formation. Some of this water may be withdrawn from the Inyan Kara aquifer, but if so, it will not occur in a fashion to affect any well field operations.

2.7.2.4.1.2 Water Usage with Reverse Osmosis and without Reverse Osmosis

Total net water use for production operations (as well field bleed) will be approximately 35 gpm from the Inyan Kara (refer to Figure 4.2-1). During aquifer restoration, the amount of water consumption from the Inyan Kara will depend on whether or not groundwater sweep is used. As described in Section 4.2.2.4.2, the restoration bleed will typically be approximately 1% of the restoration flow rate unless groundwater sweep is used, in which case it will be approximately

17%. This equates to 5 to 85 gpm during restoration without concurrent production. The typical Inyan Kara usage during concurrent production and restoration will therefore total approximately 40 to 120 gpm.

As described in Section 4.2.2.4, water from the Madison Limestone or another suitable aquifer will be used to supply water to the CPP and as a clean water source for aquifer restoration. The quantity of Madison water used will depend on the aquifer restoration method, which in turn will depend on the liquid waste disposal option. In the deep disposal well option, RO permeate will be injected into well fields undergoing aquifer restoration, and the quantity of make-up water from the Madison Limestone or another suitable aquifer will be approximately 80 to 160 gpm. In the land application option, water from the Madison Limestone or another suitable aquifer will replace all of the water withdrawn from the well fields undergoing aquifer restoration. In this case, the usage of water from the Madison Limestone or another suitable aquifer will be about 430 to 510 gpm.

Tables 2.7-18 (without groundwater sweep) and 2.7-18a (with groundwater sweep) present the estimated Inyan Kara Group and Madison Limestone usage in the deep disposal well option. Table 2.7-19 (without groundwater sweep) and 2.7-19a (with groundwater sweep) present the estimated water usage in the land application option.

Table 2.7-18: Net Water Usage, Deep Disposal Well Option (without Groundwater Sweep)

	Net Water Usage at Nominal Bleed Rate (Deep Disposal Well Option)										Cumulative
INYAN KARA	Without Groundwater Sweep										Water Usage
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	(million gallons)
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration**											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	495	495	495	495	495	495	495	
Permeate	0	0	0	350	350	350	350	350	350	350	
Madison				145	145	145	145	145	145	145	
Well field bleed				5	5	5	5	5	5	5	
Bleed rate (%)				1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	5	5	5	5	5	5	5	16
Total	0	35	35	40	40	40	40	40	40	5	163
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	145	145	145	145	145	145	145	476
Total	0	12	12	157	157	157	157	157	157	145	526

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

Table 2.7-18a: Net Water Usage, Deep Disposal Well Option (with Groundwater Sweep)

INYAN KARA	Net Water Usage at Nominal Bleed Rate (Deep Disposal Well Option) With Groundwater Sweep										Cumulative Water Usage (million gallons)
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration**											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	415	415	415	415	415	415	415	
Permeate	0	0	0	350	350	350	350	350	350	350	
Madison				65	65	65	65	65	65	65	
Well field bleed				85	85	85	85	85	85	85	
Bleed rate (%)				17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	85	85	85	85	85	85	85	279
Total	0	35	35	120	120	120	120	120	120	85	426
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	65	65	65	65	65	65	65	214
Total	0	12	12	77	77	77	77	77	77	65	264

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

Table 2.7-19: Net Water Usage, Land Application Option (without Groundwater Sweep)

INYAN KARA	Net Water Usage at Nominal Bleed Rate (Land Application Option) Without Groundwater Sweep										Cumulative Water Usage (million gallons)
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration**											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	495	495	495	495	495	495	495	
Permeate	0	0	0	0	0	0	0	0	0	0	
Madison				495	495	495	495	495	495	495	
Well field bleed				5	5	5	5	5	5	5	
Bleed rate (%)				1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	5	5	5	5	5	5	5	16
Total	0	35	35	40	40	40	40	40	40	5	163
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	495	495	495	495	495	495	495	1626
Total	0	12	12	507	507	507	507	507	507	495	1676

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

Table 2.7-19a: Net Water Usage, Land Application Option (with Groundwater Sweep)

	Net Water Usage at Nominal Bleed Rate (Land Application Option)										Cumulative
INYAN KARA	With Groundwater Sweep										Water Usage
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	(million gallons)
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	415	415	415	415	415	415	415	
Permeate	0	0	0	0	0	0	0	0	0	0	
Madison				415	415	415	415	415	415	415	
Well field bleed				85	85	85	85	85	85	85	
Bleed rate (%)				17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	85	85	85	85	85	85	85	279
Total	0	35	35	120	120	120	120	120	120	85	426
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	415	415	415	415	415	415	415	1363
Total	0	12	12	427	427	427	427	427	427	415	1413

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

2.7.3 Site Baseline Water Quality

2.7.3.1 Surface Water

In compliance with NRC Regulatory 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 PA were sampled upstream and downstream of the permit boundary. Tables 2.7-20 and 2.7-21, respectively, list stream and impoundment water quality sampling sites within and adjacent to the PA. Plate 2.5-1 shows the locations of the pre-operational stream and impoundment sampling sites. Stream sampling locations BVC04, CHR05, and BEN01 are not within the scale of Plate 2.5-1. Refer to Figure 2.9-11 for these pre-operational sampling locations. Following is a summary of the pre-operational surface water quality sampling program.

Stream Sampling

Surface water sampling locations were chosen based on the NRC Regulatory Guide 4.14 (RG 4.14) sampling requirements and the South Dakota mining rules ARSD 74:29 which require background radiological data to be collected for surface waters "that could be affected by the proposed operations."

The following eight stream sampling sites were established on Beaver Creek, Pass Creek, the Cheyenne River, Bennett Canyon, and unnamed tributaries 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).

The baseline monitoring program included monthly visits to each site. Grab samples were collected from the sites on Beaver Creek and the Cheyenne River, when available, while automated samplers were installed at the sites on Pass Creek, Bennett Canyon and an unnamed tributary south of the project area. Table 2.7-20 provides a baseline stream sampling summary. The table includes the eight stream monitoring sites and illustrates which sites were sampled during each monthly sampling event or provides a reason why a sample could not be collected.

Section 5.7.8.1 describes how the stream sampling sites were evaluated against guidance in Regulatory Guide 4.14 to establish an operational monitoring program. A total of 10 stream sampling sites including 6 new sites are proposed for operational monitoring. After license issuance but prior to ISR operations, Powertech (USA) proposes to sample each site, monthly (including the initial samples) for 12 consecutive months in accordance with Regulatory Guide 4.14 pre-operational monitoring recommendations.

Of the original eight stream sampling sites, four will be relocated (BVC01, BVC04, PSC01 and PSC04) prior to ISR operations as described in Section 5.7.8.1. Justification for continue use of UNT01 follows. UNT01 was established for the baseline surface water monitoring program to characterize surface waters downstream from proposed activities in the eastern portion of the project area. Due to steepness of the valley walls, the site could not be located at the license boundary. Instead UNT01 was installed downstream at an accessible location, which was more conducive to passive sampler installation and operation. Powertech (USA) proposes that this site is justified since it is near the license boundary and there are no major intervening tributaries between the license boundary and UNT01.

Impoundment Sampling

Powertech (USA) sampled surface water impoundments within the project area, including stock dams and mine pits. Surface water impoundments were originally identified on topographic maps and aerial photographs. Subsequently a field survey was completed in July 2007 to fully identify and gather impoundment-location data. A summary of impoundment sampling for the regional baseline surface water monitoring program is provided in Table 2.7-21a. The table includes 40 impoundments. During the regional baseline monitoring program, 11 of the 40 impoundments were visited on a quarterly basis. Table 2.7-21 illustrates which of these impoundments were sampled during each quarterly sampling event or provides a reason why a sample could not be collected. Refer to Section 2.9.8 for additional information regarding the number of samples collected and constituents analyzed during baseline impoundment monitoring.

As described in Section 5.7.8, Powertech (USA) proposes to sample 24 impoundments during operation of the Dewey-Burdock Project. Justification for the impoundments not proposed for operational monitoring is provided in Table 5.7.8-1 and typically is due to the impoundment not being located downgradient of proposed facilities.

Table 2.7-21: Regional Baseline Impoundment Sampling

Site	Type/Name	Baseline Sampling				Downgradient of Proposed Facilities*
		3Q07	4Q07	1Q08	2Q08	
Sub01	Stock Pond	1	1	X	X	No
Sub02	Triangle Mine Pit	X	X	X	X	No
Sub03	Mine Dam	1	X	1	X	Yes
Sub04	Stock Pond	1	X	1	X	Yes
Sub05	Mine Dam	1	1	1	1	Yes
Sub06	Darrow Mine Pit Northwest	X	X	X	X	Yes
Sub07	Stock Dam	X	X	X	X	Yes
Sub08	Stock Pond	X	X	X	X	Yes
Sub09	Stock Pond	1	1	X	X	Yes
Sub10	Stock Pond		1	X	X	Yes
Sub11	Stock Pond	X	X	X	X	Yes
Sub20	Stock Pond					Yes
Sub21	Stock Pond					Yes
Sub22	Stock Pond					Yes
Sub23	Stock Pond					No
Sub24	Stock Pond			X		No
Sub25	Stock Pond					No
Sub26	Stock Pond					No
Sub27	Stock Pond					Yes
Sub28	Stock Pond					Yes
Sub29	Stock Pond					Yes
Sub30	Stock Pond					Yes
Sub31	Stock Pond					Yes
Sub32	Stock Pond					Yes
Sub33	Stock Pond					Yes
Sub34	Stock Pond					Yes
Sub35	Stock Pond					Yes
Sub36	Stock Pond					Yes
Sub37	Stock Pond					Yes
Sub38	Stock Pond					No
Sub39	Stock Pond					No
Sub40	Darrow Mine Pit Southeast					Yes
Sub41	Stock Pond					Yes
Sub42	Stock Pond					No
Sub43	Stock Pond					No
Sub44	Stock Pond					No
Sub45	Stock Pond					No
Sub46	Stock Pond					No
Sub47	Stock Pond					No
Sub48	Stock Pond					No
Sub49	Darrow Mine Pit					Yes
Sub50	Darrow Mine Pit					Yes

* Potentially subject to surface runoff from satellite facility, CPP, ponds, potential land application areas, pipelines, or potential well field areas.

Notes: X – Sample collected
1 – No sample collected due to impoundment being dry during quarterly visit

2.7.3.1.1 Sample Collection and Analysis Methods

A surface water quality sample constituent list was developed based on NUREG-1569 groundwater parameters (minus radon), Regulatory Guide 4.14 parameters, and added parameters from a constituent-list review with South Dakota DENR. NUREG-1569 gives no specific requirements for sampling constituents of surface water bodies. Table 2.7-22 lists constituents analyzed for in surface water samples and the analytical method for each constituent.

The following methodology was applied to 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* (SDDENR, 2003).
  - Field methods included measuring and recording 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 project boundary, the Cheyenne River was also sampled monthly upstream and downstream of confluences with streams passing through the permit boundary.
- Due to the unexpected and sudden nature of tributaries and remote 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).

Table 2.7-22: Surface Water and Groundwater Quality Parameter List

Constituent	Units	Analytical Method
Field Parameters		
Field Conductivity	umhos/cm	Field
Field Dissolved Oxygen	mg/L	Field
Field pH	s.u.	Field
Field Temperature	°C	Field
Field Turbidity	NTUs	Field
Water Level Elevation[1]	ft AMSL	Field
Microbiological		
Bacteria, Fecal Coliform[2]	CFU/100 mL	A9222 D
Physical Properties		
Conductivity @ 25 °C	umhos/cm	A2510 B
Oxidation-Reduction Potential[1]	mV	A2580 B
pH, Laboratory	s.u.	A4500-H B
Sodium Adsorption Ratio (SAR)	unitless	Calculated
Solids, Suspended Sediment SSC @ 105 °C[2]	mg/L	D3977
Solids, Total Dissolved TDS @ 180 °C	mg/L	A2540 C
Solids, Total Suspended TSS @ 105 °C[2]	mg/L	A2540 D
Common Elements and Ions		
Alkalinity, Total as $CaCO_3$	mg/L	A2320 B
Bicarbonate as HCO_3	mg/L	A2320 B
Calcium	mg/L	E200.7
Carbonate as CO_3	mg/L	A2320 B
Chloride	mg/L	E300.0
Fluoride	mg/L	E300.0
Magnesium	mg/L	E200.7/E200.8
Nitrogen, Ammonia as N	mg/L	A4500-NH3 G
Nitrogen, Nitrate as N	mg/L	E300.0/E353.2
Nitrogen, Nitrite as N[1]	mg/L	E300.0/E353.2
Potassium	mg/L	E200.7
Silica	mg/L	E200.7/E200.8
Sodium	mg/L	E200.7
Sulfate	mg/L	E300.0
Metals, Dissolved and Total		
Aluminum (sw - dissolved and total, gw - dissolved only)	mg/L	E200.7/E200.8
Antimony (total only)[1]	mg/L	E200.8
Arsenic	mg/L	E200.8
Barium	mg/L	E200.7/E200.8
Beryllium (total only)[1]	mg/L	E200.7/E200.8
Boron	mg/L	E200.7
Cadmium	mg/L	E200.8
Chromium	mg/L	E200.8
Chromium, hexavalent (total only)[2]	mg/L	A3500-Cr B
Chromium, trivalent (total only)[2]	mg/L	Calculated
Copper	mg/L	E200.8
Iron	mg/L	E200.7
Lead	mg/L	E200.8
Manganese	mg/L	E200.7/E200.8
Mercury	mg/L	E200.8/E245.1
Molybdenum	mg/L	E200.8

Table 2.7-22: Surface Water and Groundwater Quality Parameter List (con'd)

Constituent	Units	Analytical Method
Metals, Dissolved and Total		
Nickel	mg/L	E200.8
Selenium	mg/L	A3114 B
Selenium-IV (sw - dissolved and total, gw - dissolved only)	mg/L	A3114 B
Selenium-VI (sw - dissolved and total, gw - dissolved only)	mg/L	A3114 B
Silver	mg/L	E200.8
Strontium (total only)[1]	mg/L	E200.7/E200.8
Thallium (total only)[1]	mg/L	E200.8
Thorium 232 (sw - dissolved and total, gw - dissolved only)	mg/L	E200.8
Uranium	mg/L	E200.8
Vanadium (sw - dissolved and total, gw - dissolved only)	mg/L	E200.7/E200.8
Zinc	mg/L	E200.7/E200.8
Metals, Suspended		
Thorium 232[2]	mg/L	E200.8
Uranium	mg/L	E200.8
Radionuclides, Dissolved, Suspended, and Total		
Gross Alpha (sw - total only, gw - dissolved only)	pCi/L	E900.0
Gross Beta (sw - total only, gw - dissolved only)	pCi/L	E900.0
Gross Gamma (sw - total only, gw - dissolved only)	pCi/L	E901.1
Lead 210	pCi/L	E909.0M
Polonium 210	pCi/L	RMO-3008/E912.0
Radium 226	pCi/L	E903.0
Radon 222 (total only)[1]	pCi/L	D5072-92
Thorium 230	pCi/L	E907.0
Data Quality Parameters		
A/C Balance (± 5)	%	A1030 E
Anions	meq/L	A1030 E
Cations	meq/L	A1030 E
Solids, Total Dissolved Calculated	mg/L	A1030 E
TDS Balance (0.80 - 1.20)	dec. %	A1030 E

[1] Analyzed in groundwater samples only
[2] Analyzed in surface water samples only
gw - groundwater
sw - surface water

2.7.3.1.2 Results

Tables 2.7-23, 2.7-24, 2.7-25, and 2.7-26 give results and statistical summaries for field water quality parameters collected at the Beaver Creek and Cheyenne River sites. Months without data indicate either a completely frozen stream or absence of water. Other surface-water-quality sites do not have enough data to justify running statistical analyses on measurements.

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 14 percent (3 of 21) 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.

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 2.7-23: 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	7.67	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	10	10	10	10
Mean	52.3	26	10.79	3680	221
Median	54.5	175	11.04	3473	10.2
Std Dev	18.2	0.41	1.85	2308	559
Min	31.9	7.67	6.86	860	1.7
Max	81.6	8.91	13.57	7678	1790

Table 2.7-24: 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 2.7-25: 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 2.7-26: 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

Surface water quality summary tables for each sampling location are provided in Appendix 2.7-C of the approved license application. Consistent with Section 2.7.4 of NUREG-1569, surface water analytical data are presented in tables on a date-by-date, parameter-by-parameter, and surface water location-by-surface water location basis. The following describes the presentation of data in Appendix 2.7-C of the approved license application.

All field-measured parameters are presented with the corresponding laboratory data. Footnotes on each surface water quality table indicate the sampling frequency and reasons why samples were not collected during a scheduled sample event (frozen, dry, etc.). For concentrations reported as non-detect by the laboratory, the data are reported as "< RL" where RL is the laboratory reporting limit. In cases where the laboratory reported a numerical value less than the RL, the numerical results are provided along with the value of the RL, with a footnote explaining the reporting convention. The summary tables present the minimum, maximum and mean concentrations for each parameter at each sample location. Means were calculated using a value of ½ of the RL when non-detect data occurred.

Appendix 2.7-D of the approved license application provides the minimum and maximum result for all sampled constituents detected at or above the PQL, the sampled site and the date of sampling. Appendix 2.7-E of the approved license application provides a comparison between water quality constituents in impoundments and streams that were detected at or above the PQL. Constituents in italics are those in which the absolute difference in percent detections between streams and impoundment 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.

Analytical results are provided in Appendix 2.7-F of the approved license application. Duplicate sample results are not included in Appendix 2.7-F of the approved license application. Table 2.7-27 summarizes the results of baseline stream sampling on Beaver Creek, Pass Creek and the Cheyenne River.

2.7.3.2 Groundwater Quality

This section provides details on the monitoring network, methods, and results for the baseline groundwater quality sampling plan.

Table 2.7-27: Stream Water Quality

Constituent	Units	Beaver Creek	Pass Creek	Cheyenne River
Field Parameters				
Field Temperature	°C	-0.1 - 27.6	13.6 - 17.1	-0.1 - 27
Field pH	s.u.	7.5 - 8.9	8.1	7.4 - 8.4
Field Dissolved Oxygen	mg/L	6.5 - 13.7	9.5 - 10.3	3.7 - 13.1
Field Conductivity	umhos/cm	733 - 7,678	1,696 - 1,844	350 - 7,847
Field Turbidity	NTU	1.7 - 1,790	1,672 - 1,780	1 - 1,798
Microbiological				
Bacteria, Fecal Coliform	CFU/100 mL	<2 - 5,700	3,700 - 7,500	<2 - 3,500
Physical Properties				
Conductivity @ 25°C	umhos/cm	514 - 7,540	1,240 - 1,840	367 - 7,530
pH	s.u.	7.7 - 8.8	7.2 - 7.3	7.6 - 8.3
Sodium Adsorption Ratio (SAR)	unitless	1.9 - 13	<0.1	1.2 - 15
TDS @ 180 °C	mg/L	520 - 6,100	1,100 - 1,700	340 - 7,200
TSS @ 105 °C	mg/L	<5 - 4,600	140 - 3,700	<5 - 4,900
Common Elements and Ions				
Alkalinity, Total as $CaCO_3$	mg/L	78 - 220	50 - 62	80 - 352
Bicarbonate as HCO_3	mg/L	85 - 268	61 - 76	98 - 429
Carbonate as CO3	mg/L	<5	<5	<5
Calcium	mg/L	52 - 499	270 - 510	30 - 525
Chloride	mg/L	9 - 1,730	1.6 - 2.8	2 - 912
Fluoride	mg/L	<0.1 - 0.9	0.14 - 0.2	<0.1 - 0.7
Magnesium	mg/L	13 - 210	10.1 - 30.5	9 - 380
Nitrogen, Ammonia as N	mg/L	<0.1	0.1 - 0.2	<0.1 - 0.1
Nitrogen, Nitrate as N	mg/L	<0.1 - 0.6	0.56 - 0.77	<0.1 - 0.6
Potassium	mg/L	5 - 15	6 - 12.4	5 - 26
Sodium	mg/L	89 - 1,240	1.7 - 6.3	28 - 1,530
Sulfate	mg/L	286 - 2,670	645 - 1,400	86 - 4,520
Silica	mg/L	<1 - 15.5	1.7 - 16.5	2.6 - 14.1
Metals - Dissolved				
Aluminum	mg/L	<0.1	<0.1	<0.1
Arsenic	mg/L	<0.001 - 0.002	0.002	<0.001 - 0.001
Barium	mg/L	<0.1 - 0.1	<0.1 - 0.1	<0.1
Boron	mg/L	0.2 - 0.6	<0.1	<0.1 - 0.4
Cadmium	mg/L	<0.005	<0.005	<0.005
Chromium	mg/L	<0.01	<0.01 - 0.02	<0.05
Copper	mg/L	<0.01	<0.01	<0.01
Iron	mg/L	<0.03 - 0.18	<0.03 - 0.1	<0.03 - 0.15
Lead	mg/L	<0.001	<0.001	<0.001
Manganese	mg/L	<0.01 - 0.83	0.03 - 0.04	<0.01 - 3.01
Mercury	mg/L	<0.001	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1	<0.1
Nickel	mg/L	<0.01 - 0.01	<0.01 - 0.03	<0.01 - 0.01
Selenium	mg/L	<0.001 - 0.004	<0.005	<0.0001 - 0.003

Table 2.7-27: Stream Water Quality (cont.)

Constituent	Units	Beaver Creek	Pass Creek	Cheyenne River
Metals - Dissolved				
Silver	mg/L	<0.005	<0.005	<0.005
Thorium-232	mg/L	<0.005	<0.005	<0.005
Uranium	mg/L	0.002 - 0.027	0.0007 - 0.005	0.002 - 0.037
Vanadium	mg/L	<0.1	<0.1	<0.1
Zinc	mg/L	<0.01	<0.01	<0.01 - 0.02
Metals – Dissolved – Speciated				
Selenium-IV	mg/L	<0.001 - 0.002	<0.001	<0.001
Selenium-VI	mg/L	<0.001 - 0.004	<0.001	<0.001 - 0.002
Metals – Suspended				
Thorium-232	mg/L	<0.001 - 0.013	<0.001 - 0.002	<0.001 - 0.035
Uranium	mg/L	<0.0003 - 0.003	0.0004 - 0.0009	<0.0003 - 0.0067
Metals - Total				
Aluminum	mg/L	<0.1 - 99.3	58.7 - 85.9	<0.1 - 170
Arsenic	mg/L	<0.001 - 0.048	0.003 - 0.031	<0.001 - 0.029
Barium	mg/L	<0.1 - 1.1	0.2 - 0.8	<0.1 - 0.9
Boron	mg/L	<0.1 - 0.6	<0.1 - 0.3	<0.1 - 0.6
Cadmium	mg/L	<0.005	<0.005	<0.005
Chromium	mg/L	<0.05 - 0.19	<0.05 - 0.17	<0.05 - 0.19
Copper	mg/L	<0.01 - 0.11	<0.01 - 0.1	<0.01 - 0.1
Iron	mg/L	0.05 - 137	0.28 - 128	0.06 - 108
Lead	mg/L	<0.001 - 0.088	0.002 - 0.074	<0.001 - 0.118
Manganese	mg/L	0.05 - 1.82	0.12 - 2.55	0.1 - 2.94
Mercury	mg/L	<0.001	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1	<0.1
Nickel	mg/L	<0.05 - 0.15	<0.05 - 0.15	<0.05 - 0.1
Selenium	mg/L	<0.001 - 0.004	<0.001 - 0.003	<0.001 - 0.003
Silver	mg/L	<0.005	<0.005	<0.005
Thorium-232	mg/L	<0.005 - 0.04	0.012 - 0.02	<0.005 - 0.046
Uranium	mg/L	0.003 - 0.026	0.0012 - 0.025	0.0043 - 0.0378
Vanadium	mg/L	<0.1 - 0.4	<0.1 - 0.1	<0.1 - 0.3
Zinc	mg/L	<0.01 - 0.54	0.02 - 0.34	<0.01 - 0.47
Metals – Total – Speciated				
Selenium-IV	mg/L	<0.001 - 0.001	<0.001	<0.001
Selenium-VI	mg/L	<0.001 - 0.004	<0.001	<0.001 - 0.003
Radionuclides - Dissolved				
Lead-210	pCi/L	<1 - 26	1.7 - 2.2	<1 - 6.6
Polonium-210	pCi/L	<1 - 3	0.2 - 0.7	<1 - 2.4
Radium-226	pCi/L	<0.2 - 2	0 - 0.1	<0.2 - 1.4
Thorium-230	pCi/L	<0.2 - 1.7	0	<0.2 - 0.3
Radionuclides – Suspended				
Lead-210	pCi/L	<1 - 15.3	-0.8 - 0.9	<1 - 22
Polonium-210	pCi/L	<1 - 3.7	0.3	<1 - 4.1
Radium-226	pCi/L	<0.2 - 3.1	-0.2 - 0.1	<0.2 - 4
Thorium-230	pCi/L	<0.2 - 3.4	0.2 - 0.5	<0.2 - 3.8

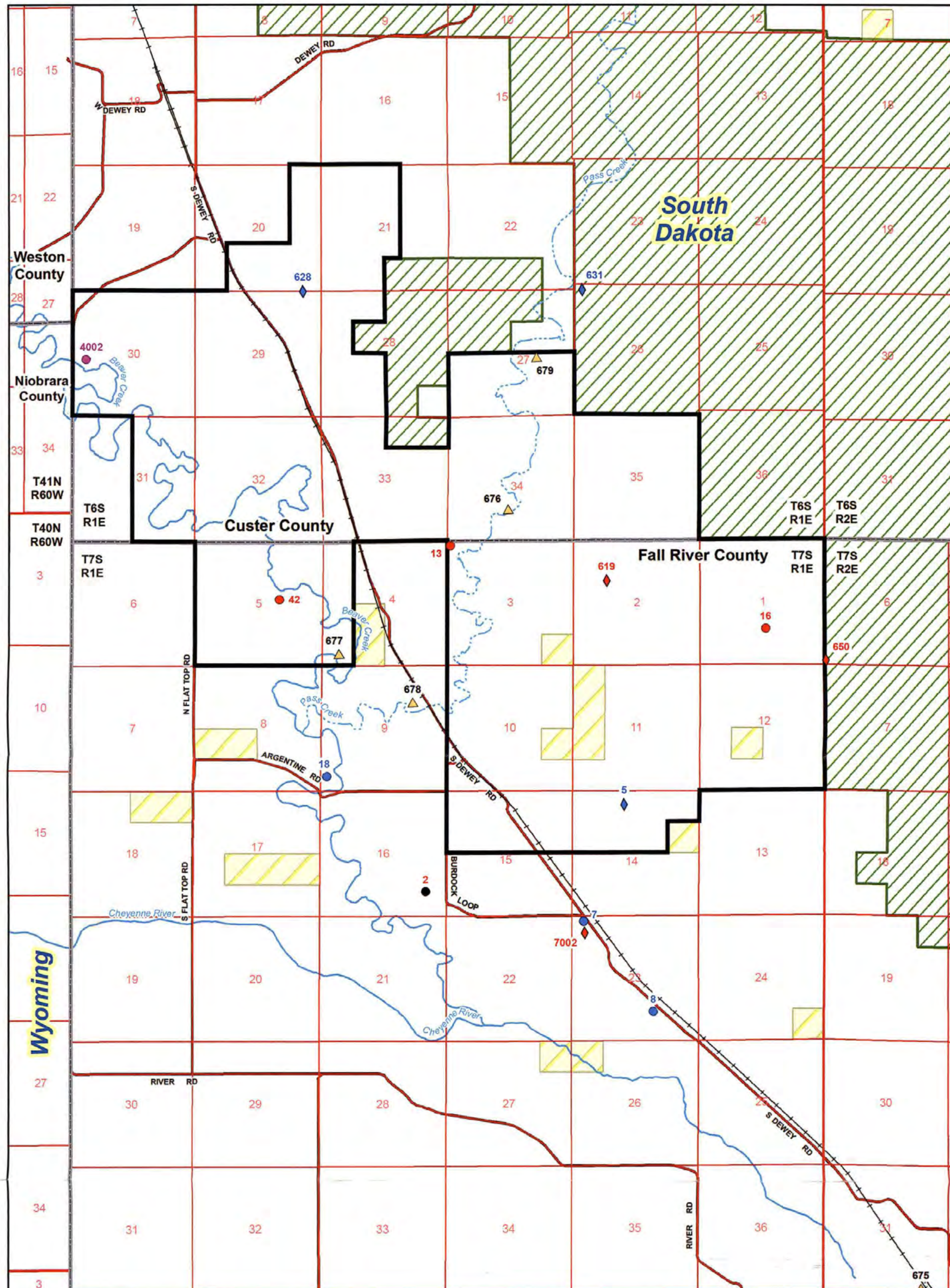
Table 2.7-27: Stream Water Quality (cont.)

Constituent	Units	Beaver Creek	Pass Creek	Cheyenne River
Radionuclides - Total				
Gross Alpha	pCi/L	2.3 - 65.8	1.9 - 8.8	4 - 35.3
Gross Beta	pCi/L	<2 - 48.1	-7 - 15.1	<2 - 38
Gross Gamma	pCi/L	<20 - 1,310	0	<20 - 1,140
Lead-210	pCi/L	<1 - 35	0 - 3	<1 - 22
Polonium-210	pCi/L	<1 - 4.4	0.5 - 1	<1 - 4.6
Radium-226	pCi/L	<0.2 - 5.1	<0.2 - 0.7	<0.2 - 5.1
Thorium-230	pCi/L	<0.2 - 3.4	0.2 - 0.5	<0.2 - 3.8

2.7.3.2.1 Groundwater Monitoring Network and Parameters

Baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980) as appropriate to ISL operations. 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. For the baseline study for the NRC permit, 19 groundwater wells (14 existing and five newly drilled) were selected in response to an NRC suggestion to characterize point of contact water quality and water within overlying, production, and underlying aquifers (Figure 2.7-30, Table 2.7-28). The existing wells selected for sampling include eight domestic wells, six stock watering wells, and five monitor wells. The subset includes wells within the Fall River Formation (6), Chilson Member of the Lakota Formation (7), Inyan Kara Group (Fall River and Chilson) (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from the 3rd quarter 2007 through the 2nd quarter 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 14 wells were sampled monthly beginning in early 2008 and continuing through early 2009 (Figure 2.7-31, Table 2.7-29). Of these 14 wells, six wells are in the Dewey area, six wells are near Burdock, and two wells are north of the project area. The goal of the monthly sampling program was to select wells, upgradient, within, and downgradient of the proposed operations. In addition to the baseline sampling plan, one water quality sample was collected from each of the monitor wells used during the May 2008 aquifer pump tests (Wells 49, 682, 684-687 and 690-693 in Table 2.7-30). One sample also was collected from two new Unkpapa domestic wells (703 and 704 in Table 2.7-30). One sample also was collected from well 704 after it was completed in the Chilson.



Legend

- Project Boundary
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Perennial Streams
- BLM Land
- Black Hills National Forest

Screened Interval

- Alluvium
- Fall River
- Inyan Kara
- Chilson

Well Use

- Monitor
- Stock
- Domestic

Feet: 0, 2,000, 4,000, 8,000
Meters: 0, 1,000, 2,000

N

Figure 2.7-30

Baseline Water Quality Quarterly Sampled Wells

Dewey-Burdock Project

DRAWN BY	R. Blubaugh
DATE	17-Jun-2013
FILENAME	Wells-BLQtrGndH2OQlty.mxd

POWERTECH (USA) INC.

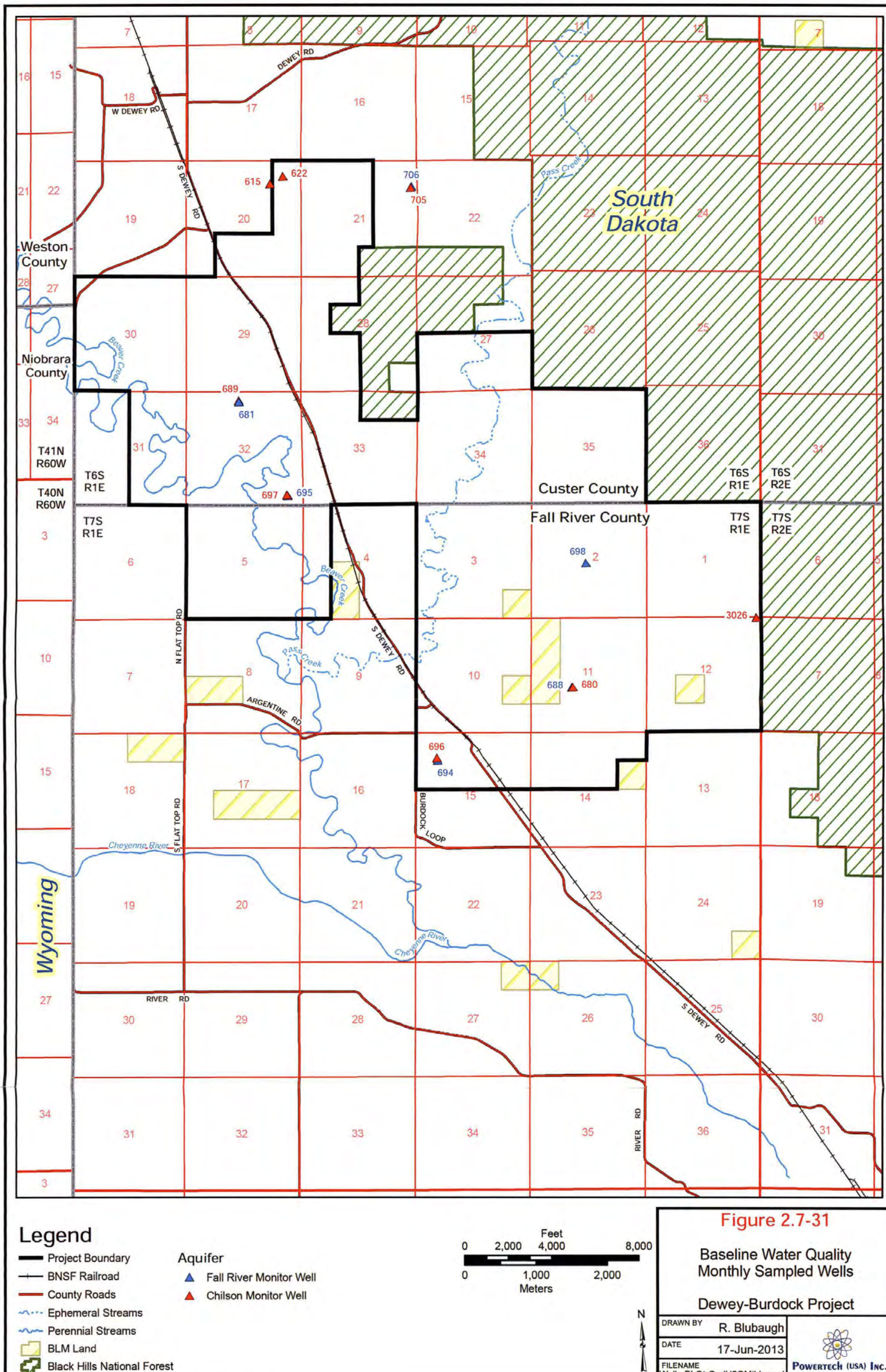


Figure 2.7-31

Baseline Water Quality Monthly Sampled Wells

Dewey-Burdock Project

DRAWN BY	R. Blubaugh
DATE	17-Jun-2013
FILENAME	Wells-BLQtrGndH2OMthly.mxd

POWERTECH (USA) INC.

Table 2.7-28: Quarterly Sampled Groundwater Quality Well Data

Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location[2]	Well Use
2	7	1	16	SESE	1026724	423922	Chilson	Domestic
5	7	1	14	NENW	1035181	427284	Fall River	Stock
7	7	1	23	NWNW	1033304	422417	Fall River	Domestic
8	7	1	23	SWSE	1036052	418515	Fall River	Domestic
13	7	1	3	NWNW	1028360	438470	Chilson	Domestic
16	7	1	1	NESW	1041428	434446	Chilson	Domestic
18	7	1	9	SWSW	1022812	428960	Fall River	Domestic
42	7	1	5	SWNE	1021144	436481	Chilson	Domestic
619	7	1	2	SENW	1034866	436729	Chilson	Stock
628	6	1	20	SESE	1022496	449718	Fall River	Stock
631	6	1	26	SWSW	1034177	449309	Fall River	Stock
650	7	1	1	SESE	1043781	433331	Chilson	Stock
675	7	2	31	SWSE	1046941	406352	Alluvium	Monitor
676	6	1	34	SESW	1030846	439891	Alluvium	Monitor
677	7	1	4	SWSW	1023527	434077	Alluvium	Monitor
678	7	1	9	SWNE	1026522	431925	Alluvium	Monitor
679	6	1	27	NWSE	1032294	446245	Alluvium	Monitor
4002	6	1	30	NWSW	1013414	446931	Inyan Kara	Domestic
7002	7	1	23	NWNW	1033333	421931	Chilson	Stock

Notes: [1] Coordinate system is NAD 27 South Dakota State Plane South.
[2] Inyan Kara indicates that screened interval includes both Chilson and Fall River.

Table 2.7-29: Monthly Sampled Groundwater Quality Well Data

Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location	Well Use
615	6	1	20	NWNE	1022172	453708	Chilson	Monitor
622	6	1	20	NENE	1022776	454033	Chilson	Monitor
680	7	1	11	NESW	1035078	429969	Chilson	Monitor
681	6	1	32	NENW	1020330	443725	Fall River	Monitor
688	7	1	11	NESW	1035027	429974	Fall River	Monitor
689	6	1	32	NENW	1020316	443789	Chilson	Monitor
694	7	1	15	NWNW	1028717	426836	Fall River	Monitor
695	6	1	32	SESE	1022385	439312	Fall River	Monitor
696	7	1	15	NWNW	1028538	427141	Chilson	Monitor
697	6	1	32	SESE	1022350	439347	Chilson	Monitor
698	7	1	2	NESW	1035909	435651	Fall River	Monitor
705	6	1	21	NENE	1028624	453314	Chilson	Monitor
706	6	1	21	NENE	1028589	453276	Fall River	Monitor
3026	7	1	12	NENE	1043638	432833	Chilson	Monitor

Note: [1] Coordinate system is NAD 27 South Dakota State Plane South.

Table 2.7-30: Additional Well Data

Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location	Well Use
49	6	1	32	NWNW	1018932	444022	Fall River	Stock
682	7	1	11	SENW	1035139	431257	Chilson	Monitor
684	7	1	11	NESW	1035191	429744	Chilson	Monitor
685	6	1	32	NWNE	1020690	443409	Fall River	Monitor
686	7	1	11	NESW	1034970	429749	Chilson	Monitor
687	6	1	32	NENW	1020081	443724	Fall River	Monitor
690	7	1	11	NESW	1035114	429970	Unkpapa	Monitor
691	6	1	32	NENW	1020364	443698	Fall River	Monitor
692	7	1	11	NESW	1035075	430014	Chilson	Monitor
693	6	1	32	NENW	1020327	443661	Unkpapa	Monitor
703	7	1	1	SWSE	1041621	434334	Unkpapa	Domestic
704	7	1	5	SWNE	1020966	436647	Unkpapa/Chilson[2]	Domestic

Notes: [1] Coordinate system is NAD 27 South Dakota State Plane South.
[2] Well was originally completed in the Unkpapa and later in the Chilson.

Figure 2.7-32 shows the wells that are upgradient, near and downgradient of the proposed production areas at the site. Results of these samples were included in the statistical analyses.

Groundwater samples were analyzed for constituents listed in Table 2.7-22, which was developed based on NUREG-1569 groundwater parameters, Regulatory Guide 4.14 parameters, and added parameters from a constituent list review with DENR.

The procedures for measuring the static water level and calculating the water level elevation, or potentiometric surface elevation, in monitor wells are summarized below for non-flowing and flowing wells.

<u>Non-Flowing Wells</u>

The following procedures apply to wells where the static water level is below the top of the casing (non-flowing wells):

- Measure the depth to water in the well using either an electric water level tape or a chalked tape. All measurements are made from a fixed reference point, either notched or clearly marked on the top of the casing. This reference point is surveyed so the elevation is known to the nearest 0.01 ft. For each well this reference point is the measuring point elevation (MPE). The depth to water is measured to the nearest one hundredth (0.01) of a foot.

- Record the measured depth to water in the log book, indicating the date and time that the measurement was taken.

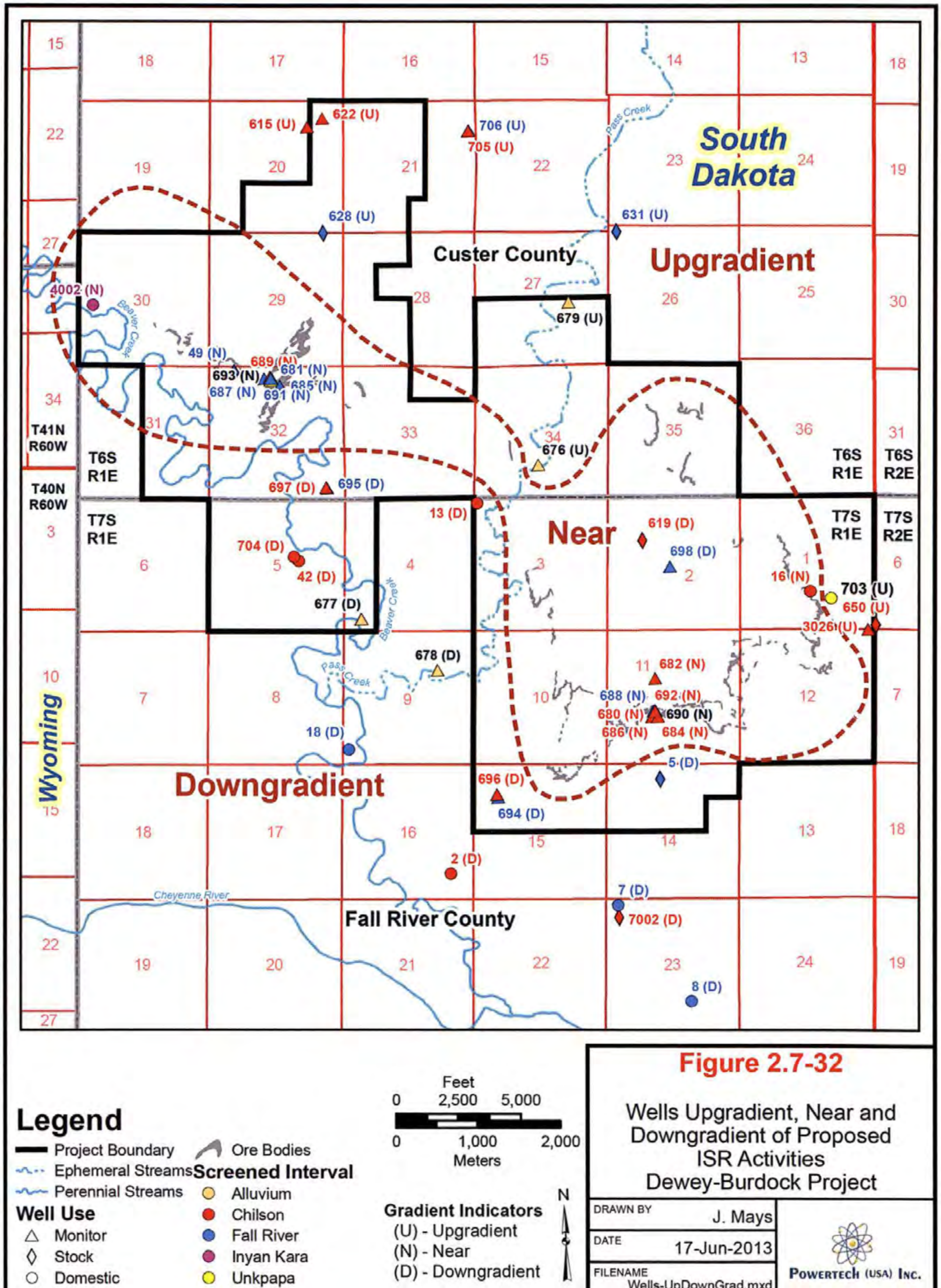


Figure 2.7-32

Wells Upgradient, Near and Downgradient of Proposed ISR Activities
Dewey-Burdock Project

- Note any field observations regarding the condition of the well, well casing, any leakage around the casing, noticeable odor, water color, etc. in field log book.

- Subtract the depth to water from the MPE to get the water surface elevation (potentiometric surface elevation) for that well on that date.

Flowing Artesian Wells

The following procedures are followed for wells in which the static water level is above the top of the casing (flowing wells):

- Install pressure gauge at the well head.
- Allow well to flow freely at surface to bleed off any air that may be trapped in the casing.
- Shut in well by closing all valves at the well head and check for leaks. Allow the pressure at the well head to stabilize.
- Measure and record the vertical distance between the surveyed reference point elevation (MPE) for each well and the center of the pressure gauge.
- Observe and record any field observations regarding condition of well head, well casing, piping and valves, leakage from the piping or around the casing, color of the water, odor, or inability to attain a constant pressure reading in the shut-in well.
- Read pressure gauge to nearest 0.01 pounds per square inch (psi) or 0.01 foot; record reading in field log book, noting date and time the measurement was taken.
- Convert pressure gauge reading to feet of water if necessary (psi x 2.307 = ft of water). This is the height of the potentiometric surface above the elevation of the pressure gauge.
- Add (or subtract) the difference in elevation between the MPE and the pressure gauge to get the elevation of the pressure gauge.
- Add the pressure reading in feet to the elevation of the pressure gauge to get the potentiometric surface elevation for that well on that date.

Non-flowing wells had permanent pumps installed in order to obtain samples. Continuous free-flowing wells were sampled before pressure measurements were made and were not purged before sampling. It was assumed that free-flowing well water quality represented formation water. Pumped wells were purged of at least 3 well casing volumes and until field water quality parameters had stabilized.

Additional steps taken during groundwater sampling include the following:

- Sampling procedures involved labeling each sample bottle with site ID, date, and time of sampling, triple rinsing with sample water, then filling and capping.
- 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.

2.7.3.2.2 Groundwater Quality Sampling Results

Water quality summary tables providing groundwater quality results for all aquifers are provided in Appendix 2.7-G of the approved license application, and analytical data are provided in Appendix 2.7-H of the approved license application. Appendix 2.7-N of the approved license application gives statistics for all groundwater constituents detected at or above PQL by constituent.

Appendix 2.7-O of the approved license application gives the minimum and maximum value for all sampled constituents detected at or above the PQL, and the site ID and date of the sample that had minimum and maximum detection value.

Consistent with NRC guidance in Section 2.7.4 of NUREG-1569, groundwater analytical data are presented in tables on a date-by-date, parameter-by-parameter, and well-by-well basis, including the eight wells sampled during the 2008 pumping tests (Well IDs 49, 682, 684, 685, 686, 687, 691, and 692). An additional well, 683, was not sampled during the 2008 pump tests as originally planned. The following describes the presentation of data in Appendix 2.7-G of the approved license application.

All field-measured parameters, including water level elevations for groundwater sampling locations, are presented with the corresponding laboratory data. For concentrations reported as non-detect by the laboratory, the data are reported as "< RL" where RL is the laboratory reporting limit. The summary tables present the minimum, maximum and mean concentrations for each parameter at each sample location. Means were calculated using a value of ½ of the RL when non-detect data occurred. Maximum values were calculated as the highest detected value for each constituent at each well, even where a detected concentration is lower than a previous RL.

Groundwater quality summary tables are provided at the beginning of Appendix 2.7-G of the approved license application describing the mean, standard deviation, minimum, and maximum values for each constituent in the four zones monitored. The monitored zones, in descending order, are the alluvium, Fall River Formation, Chilson Member of the Lakota Formation, and Unkpapa Sandstone.

Table 2.7-31 provides a summary of the range of water quality within each formation. The ranges shown represent the range of the average concentrations for the wells in each monitoring zone. They do not represent the minimum and maximum absolute sample concentrations for any one well. The alluvial wells are characterized by high TDS concentrations ranging from 2,525 to 9,325 mg/L. TDS concentrations in the Fall River ranged from 774 to 2,250 mg/L, and TDS concentrations in the Chilson ranged from 708 to 2,358 mg/L. The Unkpapa generally had the lowest concentrations of dissolved constituents, with TDS concentrations ranging from 1,300 to 1,400 mg/L. Table 2.7-32 compares baseline groundwater quality to parameters with EPA MCLs and other standards.

Table 2.7-31: Summary of Water Quality by Formation

Constituent	Units	Alluvium	Fall River	Chilson	Unkpapa
Field Parameters					
Water Level Elevation	ft AMSL	3482.6 - 3685.5	3574.6 - 3725.1	3647.9 - 3709.7	NM
Field Temperature	°C	10.10 - 12.03	11.1 - 14.9	9.4 - 15.4	11.9 - 20.1
Field pH	s.u.	6.8 - 7.4	6.7 - 8.4	6.9 - 8.3	9.2 - 11.1
Field Dissolved Oxygen	mg/L	0.8 - 9.4	0.07 - 5.4	0.1 - 3.3	NM
Field Conductivity	umhos/cm	2,670 - 11,260	1,223 - 2,623	958 - 2,750	2,083 - 2,500
Field Turbidity	NTU	3.8 - 799	0.1 - 13.1	0.4 - 29.3	9.2 - 13.2
Physical Properties					
Conductivity @ 25°C	umhos/cm	2,460 - 11,375	1,201 - 2,870	1,055 - 2,688	1,570 - 2,420
Oxidation-Reduction Potential	mV	193 - 253	129 - 258	32 - 236	88 - 220
pH	s.u.	7.2 - 7.6	7.1 - 8.5	7.1 - 8.1	9.0 - 11.4
Sodium Adsorption Ratio	unitless	0.9 - 16.3	1.0 - 11.4	0.9 - 10.2	9.1 - 17
TDS @ 180°C	mg/L	2,525 - 9,325	774 - 2,250	708 - 2,358	1,300 - 1,400
Common Elements and Ions					
Alkalinity, Total as $CaCO_3$	mg/L	145 - 497	117 - 197	71 - 261	38 - 148
Carbonate as CO3	mg/L	<5	<5 - 7.9	<5 - 3.1	<5 - 12
Bicarbonate as HCO_3	mg/L	177 - 606	143 - 240	87 - 318	32 - 180
Calcium	mg/L	425 - 515	30 - 368	35 - 386	23 - 73.7
Chloride	mg/L	12 - 1,625	9.5 - 47	5.0 - 17.5	16 - 70
Fluoride	mg/L	0.23 - 0.64	0.3 - 0.5	0.1 - 0.6	0.3 - 0.8
Magnesium	mg/L	97.6 - 442	10.5 - 134	11.8 - 124	<0.5 - 35.2
Nitrogen, Ammonia as N	mg/L	<0.1 - 0.3	<0.1 - 0.4	<0.1 - 0.6	0.3 - 1.6
Nitrogen, Nitrate as N	mg/L	0.06 - 1.2	<0.1 - 0.06	<0.1 - 0.08	<0.1 - 0.2
Nitrogen, Nitrite as N	mg/L	<0.1	<0.1	<0.1 - 0.15	<0.1
Potassium	mg/L	11.3 - 24.9	7.1 - 16	7.2 - 21	6.8 - 14
Sodium	mg/L	76.9 - 1,965	87 - 503	47 - 283	342 - 437
Sulfate	mg/L	1,485 - 4,425	425 - 1,443	389 - 1,509	807 - 886
Silica	mg/L	8.5 - 13.6	5.2 - 11.2	1.2 - 8.6	<0.2 - 5
Metals - Dissolved					
Aluminum	mg/L	<0.1	<0.1	<0.1 - 0.19	<0.1
Arsenic	mg/L	<0.001 - 0.001	<0.001 - 0.002	<0.01 - 0.016	<0.001
Barium	mg/L	<0.1	<0.1	<0.1	<0.1
Boron	mg/L	0.4 - 1.4	<0.1 - 0.43	<0.1 - 0.15	0.3 - 1
Cadmium	mg/L	<0.005	<0.005 - <0.01	<0.005 - <0.01	<0.005
Chromium	mg/L	<0.05	<0.05	<0.05	<0.05
Copper	mg/L	<0.01	<0.01	<0.01 - 0.025	<0.01
Iron	mg/L	<0.03 - 0.55	<0.03 - 2.58	<0.03 - 6.2	<0.03 - 0.06
Lead	mg/L	<0.001	<0.001 - 0.0011	<0.001 - 0028	<0.001
Manganese	mg/L	0.01 - 3.11	0.03 - 2.41	0.04 - 1.5	<0.01
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1	<0.1 - 0.067	<0.1
Nickel	mg/L	<0.05	<0.05 - 0.03	<0.05 - 0.024	<0.05
Selenium	mg/L	0.001 - 0.013	<0.001 - 0.0014	<0.001 - 0.0014	<0.001
Silver	mg/L	<0.005	<0.005 - <0.01	<0.005 - <0.01	<0.005

Table 2.7-31: Summary of Water Quality by Formation (cont.)

Constituent	Units	Alluvium	Fall River	Chilson	Unkpapa
Metals - Dissolved					
Thorium-232	mg/L	<0.005	<0.005	<0.005	<0.005
Uranium	mg/L	0.014 - 0.055	<0.0003 - 0.11	<0.0003 -	<0.0003 - 0.0003
Vanadium	mg/L	<0.1 - 0.088	<0.1 - 0.06	<0.1 - 0.05	<0.1
Zinc	mg/L	<0.01 - 0.013	<0.01 - 0.0125	<0.01 - 0.06	<0.01- 0.03
Metals – Dissolved – Speciated					
Selenium-IV	mg/L	<0.001	<0.001 - 0.0007	<0.001 -	<0.001
Selenium-VI	mg/L	<0.001 - 0.012	<0.001 - 0.0007	<0.001 -	<0.001
Metals – Suspended					
Uranium	mg/L	0.001 - 0.020	<0.0003 -	<0.0003 -	<0.0003
Metals - Total					
Antimony	mg/L	<0.003	<0.003	<0.003 - 0.002	<0.003
Arsenic	mg/L	0.001 - 0.011	0.0008 - 0.0038	0.001 - 0.023	<0.001
Barium	mg/L	<0.1 - 0.275	<0.1	<0.1 - 0.067	<0.1
Beryllium	mg/L	<0.001 - 0.002	<0.001 - <0.005	<0.001 -	<0.001
Boron	mg/L	0.175 - 1.5	<0.1 - 0.45	<0.001 - 0.17	0.4 - 1.1
Cadmium	mg/L	<0.001 - <0.005	<0.005	<0.005	<0.005
Chromium	mg/L	<0.05 - 0.038	<0.05	<0.05	<0.05
Copper	mg/L	<0.01 - 0.063	<0.01	<0.01 - 0.043	<0.01
Iron	mg/L	0.03 - 33.3	0.04 - 4.8	0.08 - 15.3	0.68 - 1.48
Lead	mg/L	<0.001 - 0.03	<0.001 - 0.002	<0.001 - 0.026	<0.001 - 0.019
Manganese	mg/L	0.46 - 3.21	0.03 - 2.49	0.04 - 1.74	<0.01 - 0.04
Mercury	mg/L	<0.0001 -	<0.001	<0.001	<0.0002 - <0.001
Molybdenum	mg/L	<0.1 - 0.03	<0.01 - 0.03	<0.01 - 0.075	<0.1
Nickel	mg/L	<0.05 - 0.063	<0.05	<0.05	<0.05
Selenium	mg/L	0.003 - 0.014	<0.001 - 0.001	<0.001 -	<0.001 - 0.005
Silver	mg/L	<0.005	<0.005 - <0.02	<0.005 - <0.02	<0.005
Strontium	mg/L	7.6 - 10.8	0.65 - 6.2	0.7 - 7.5	2.1 - 2.6
Thallium	mg/L	<0.001	<0.001	<0.001 -	<0.001
Uranium	mg/L	0.016 - 0.064	<0.0003 - 0.11	<0.0003 - 0.02	<0.0003
Zinc	mg/L	<0.01 - 0.16	<0.01 - 0.01	<0.01 - 0.13	<0.01 - 0.2
Radionuclides - Dissolved					
Gross Alpha	pCi/L	18.5 - 63.0	5.6 - 1,505	3.6 - 4,991	-3 - 42.6
Gross Beta	pCi/L	-7.5 - 18.1	3.2 - 484	7.8 - 1,629	-5 - 14.2
Gross Gamma	pCi/L	280 - 697	216 - 4,994	70 - 15,530	0 - 1,100
Lead-210	pCi/L	0.93 - 3.65	-1.9 - 29.7	-5.6 - 19.3	1 - 1.8
Polonium-210	pCi/L	0.9 - 1.4	0.02 - 2.36	0.02 - 2.03	-0.02 - 0.7
Radium-226	pCi/L	0.13 - 1.2	1.2 - 388	1.2 - 1,289	0.04 - 0.6
Thorium-230	pCi/L	0.08 - 0.18	0.01 - 0.13	0.04 - 0.20	0.0 - 0.1
Radionuclides - Suspended					
Lead-210	pCi/L	-2.1 - 0	-1.5 - 11.8	-1.65 - 22.1	-5.7 - 1.1
Polonium-210	pCi/L	0.3 - 0.8	0.03 - 2.2	0.02 - 4.1	-0.015 - 0.1
Radium-226	pCi/L	0.4 - 3.9	-0.2 - 7.9	-0.15 - 6.3	-0.4 - 0.2
Thorium-230	pCi/L	0.1 - 1.1	-0.07 - 1.29	-0.14 - 0.3	-0.2 - 0.3

Table 2.7-31: Summary of Water Quality by Formation (cont.)

Constituent	Units	Alluvium	Fall River	Chilson	Unkpapa
Radionuclides - Total					
Lead-210	pCi/L	<1 - 14	<1	<1 - 57	NM
Polonium-210	pCi/L	<1	<1 - 6.4	<1 - 13	NM
Radium-226	pCi/L	<0.2 - 2.5	<0.2 - 15.2	1.1 - 120	NM
Radon-222	pCi/L	522 - 1,413	277 - 278,030	197 - 180,750	153 - 424
Thorium-230	pCi/L	<0.2 - 1.9	<0.2	<0.2	NM

Table 2.7-32: Groundwater Quality Comparison with EPA MCLs and Other Public Water Supply Standards

Test Analyte/Parameter	Units	MCL[a] or Other Standard	Number of Samples Analyzed*	Number of Detections	Number of Detections Equal to or Above Referenced Standard
Bulk Properties					
pH	standard units	<6.5; >8.5[b]	271	271	0; 8
TDS	mg/l	500[b]	271	271	271
Cations/Anions					
Sodium, Na	mg/l	20[c]; <30[d]; >60[d]	271	271	271 ; 0 ; 267
Chloride, Cl	mg/l	250[b]	271	271	4
Fluoride, F	mg/l	4; 2[b]	271	266	0; 0
Sulfate, SO4	mg/l	250[b]	271	271	271
Nitrate (as Nitrogen)	mg/l	10	271	30	0
Nitrite (as Nitrogen)	mg/l	1	271	1	0
Nitrate and Nitrite (Combined)	mg/l	10	271	158	0
Trace Metals (Total)					
Antimony, Sb	mg/l	0.006	228	1	0
Arsenic, As	mg/l	0[e]; 0.010	228	191	191; 28
Barium, Ba	mg/l	2	228	6	0
Beryllium, Be	mg/l	0.004	228	3	0
Boron, B	mg/l	6[f]	228	54	0
Cadmium, Cd	mg/l	0.005	228	0	0
Chromium, Cr (total)	mg/l	0.1	228	2	1
Copper, Cu	mg/l	1.0[b]; 1.3[g]	228	6	0; 0
Iron, Fe	mg/l	0.3[b]; 5[h]	228	217	114; 28
Mercury, Hg	mg/l	0.002	280	2	0
Manganese, Mn	mg/l	0.05[b]; 0.8[h]	228	227	215; 38
Molybdenum, Mo	mg/l	0.04[f]	228	7	2
Nickel, Ni	mg/l	0.1[f]	228	1	1
Lead, Pb	mg/l	0[e]; 0.015[g]	228	27	27; 8
Selenium, Se	mg/l	0.05	228	42	0
Silver, Ag	mg/l	0.10[b]	228	0	0
Strontium, Sr	mg/l	4[f]	228	227	64
Thallium, Tl	mg/l	0.0005[e]; 0.002	228	1	1; 1
Uranium, U	mg/l	0[e]; 0.030	232	171	171; 28
Zinc, Zn	mg/l	5[b]; 2[f]	228	57	0; 0
Trace Metals (Dissolved)					
Aluminum, Al	mg/l	<0.05[b]; >0.2[b]	271	1	0; 0
Arsenic, As	mg/l	0[e]; 0.010	271	146	146; 18
Barium, Ba	mg/l	2	271	0	0
Boron, B	mg/l	6[f]	271	70	0
Cadmium, Cd	mg/l	0.005	271	0	0
Chromium, Cr (total)	mg/l	0.1	271	0	0

Table 2.7-32: Groundwater Quality Comparison with EPA MCLs and Other Public Water Supply Standards (cont.)

Test Analyte/Parameter	Units	MCL[a] or Other Standard	Number of Samples Analyzed*	Number of Detections	Number of Detections Equal to or Above Referenced Standard
Trace Metals (Dissolved) (Continued)					
Copper, Cu	mg/l	1.0[b]; 1.3[g]	271	2	0; 0
Iron, Fe	mg/l	0.3[b]; 5[h]	271	103	44; 6
Mercury, Hg	mg/l	0.002	271	0	0
Manganese, Mn	mg/l	0.05[b]; 0.8[h]	271	266	234; 48
Molybdenum, Mo	mg/l	0.04[f]	271	2	2
Nickel, Ni	mg/l	0.1[f]	271	0	0
Lead, Pb	mg/l	0[e]; 0.015[g]	271	6	6; 0
Selenium, Se	mg/l	0.05	271	26	0
Silver, Ag	mg/l	0.10[b]	271	0	0
Uranium, U	mg/l	0[e]; 0.030	271	199	199; 37
Zinc, Zn	mg/l	5[b]; 2[f]	271	46	0; 0
Radionuclides					
Alpha Particles (Dissolved)	pCi/L	0[e]; 15	271	271	191; 191
Beta Particles and Photons (Dissolved)	mRem/yr	0[e]; 4	271	267	(i)
Radium-226 and 228 (Combined, Dissolved)	pCi/L	0[e]; 5	265	249	249; 101
Radon-222 (Total)	pCi/L	0[e]; 300[j]	251	251	249; 194

Notes:

(a) MCL - 40 CFR 141, National Primary Drinking Water Regulations, maximum contaminant level, enforceable.

(b) 40 CFR 141, National Secondary Drinking Water Regulations, non-enforceable standard, water exceeding standard may cause cosmetic and/or aesthetic effects.

(c) Drinking water advisory, non-enforceable, for persons on restricted sodium diets, from "2009 Edition of the Drinking Water Standards and Health Advisories," EPA 822-R-09-011, p. 12, U.S. Environmental Protection Agency, Washington, D.C., Fall 2009.

(d) Drinking water advisory, non-enforceable, taste threshold, from EPA 822-R-09-011, p. 12.

(e) 40 CFR 141, National Primary Drinking Water Regulations, maximum contaminant level goal, non-enforceable.

(f) Health advisory lifetime standard, non-enforceable, from EPA 822-R-09-011, pp. 8-9.

(g) 40 CFR 141, National Primary Drinking Water Regulations, action level, which, if exceeded, triggers treatment.

(h) Permit limit calculated by US EPA Region 8 drinking water toxicologist based on human-health criteria for Region 8 Underground Injection Control Class V permitting program (http://www.epa.gov/region8/water/uic/r8cvprog.html).

(i) Not compared; gross beta reported in pCi/L.

(j) Proposed maximum contaminant level.

* Number of samples includes quarterly samples from 19 wells (wells 2, 5, 7, 8, 13, 16, 18, 42, 619, 628, 631, 650, 675, 676, 677, 678, 679, 4002, 7002) collected between the third quarter of 2007 and the second quarter of 2008, one year of monthly samples from 12 wells (615, 622, 680, 681, 688, 689, 694, 695, 696, 697, 698, 3026) collected between early 2008 and early 2009, less one missed sample in March 2008 from 695, one year of monthly samples from 2 wells (705 and 706) collected between January and December 2010, 21 duplicate samples, and 7 mid-month samples (2 from 680, 3 from 681, and 1 from 688 and 689 each).

2.7.3.2.2.1 Alluvial Water Quality

As shown in Table 2.7-31, the alluvial water quality is characterized by moderate pH (7.2 - 7.6) and moderate to high TDS (2,525 - 9,325 mg/L). Table 2.7-33 summarizes the average major ion chemistry in the alluvial wells. Cation chemistry is variable, with calcium the dominant cation in 40% of wells (2 of 5) and sodium in 20% of wells (1 of 5). Two wells did not have a dominant cation (i.e., all less than 50%). Sulfate was the dominant anion in 100% of wells. Bicarbonate concentrations were low in all alluvial wells, and chloride concentrations were low in 80% of wells (4 of 5). A notable exception is Well 677, which had an average chloride concentration of 1,625 mg/L.

A comparison between the alluvial water quality and EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of gross alpha and sulfate above the standards. 80% of the wells also exceeded the uranium standard in one or more sample. With 100% of alluvial wells exceeding the gross alpha standard, radionuclide concentrations were relatively high in the alluvial wells compared to the MCL. However, the maximum concentrations in the Fall River and Chilson were significantly higher than those in the alluvium. For example, the highest average gross alpha concentration was 1,505 pCi/L in the Fall River and 4,991 pCi/L in the Chilson, compared to 63 pCi/L in the alluvium.

2.7.3.2.2.2 Fall River Water Quality

The water quality in the Fall River Formation is characterized by moderate TDS (774 to 2,250 mg/L), relatively consistent major ion chemistry, and high radionuclide concentrations. Table 2.7-35 summarizes the average major ion chemistry of the Fall River wells. Sodium is the dominant cation in 75% of wells (9 of 12). Of the remaining three wells, two exhibited calcium dominance and one well did not have a dominant cation. All of the Fall River baseline wells exhibited strong sulfate dominance, with sulfate accounting for 72% to 92% of the anion concentration (in meq/L).

A comparison between the Fall River water quality and EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of sulfate above the standard. Additional standards exceeded in one or more samples included gross alpha (83% of wells), radium-226 (67% of wells), and uranium (8% of wells).

Table 2.7-33: Major Ion Chemistry - Alluvium

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
675	21.2	25%	30.5	37%	31.8	38%	---
676	25.7	66%	9.5	24%	3.9	10%	calcium
677	23.3	16%	33.4	23%	85.5	60%	sodium
678	21.3	25%	36.3	43%	26.6	32%	---
679	22.7	67%	8.0	24%	3.3	10%	calcium
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
675	7.7	9%	1.9	2%	73.4	88%	sulfate
676	4.5	11%	0.4	1%	36.1	88%	sulfate
677	9.9	7%	45.8	31%	92.2	62%	sulfate
678	9.6	11%	1.9	2%	72.6	86%	sulfate
679	2.9	8%	0.3	1%	30.9	91%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

Table 2.7-34: Groundwater Quality Comparison with Federal Drinking Water Standards

Parameter	Arsenic, Dissolved	Gross Alpha, Dissolved	Radium-226, Dissolved	Uranium, Dissolved	Sulfate
MCL	0.010 mg/L	15 pCi/L	5 pCi/L*	0.030 mg/L	250 mg/L**
Alluvial Wells					
Hydro ID					
675	---	X	---	X	X
676	---	X	---	X	X
677	---	X	---	X	X
678	---	X	---	X	X
679	---	X	---	---	X
Percentage exceeding MCL in one or more samples:	0% (0/5)	100% (5/5)	0% (0/5)	80% (4/5)	100% (5/5)
Fall River Wells					
Hydro ID					
5	---	---	---	---	X
7	---	X	X	---	X
8	---	---	---	---	X
18	---	X	X	---	X
628	---	X	X	---	X
631	---	X	X	---	X
681	---	X	X	---	X
688	---	X	X	---	X
694	---	X	---	---	X
695	---	X	X	---	X
698	---	X	X	X	X
706	---	X	---	---	X
Percentage exceeding MCL in one or more samples:	0% (0/12)	83% (10/12)	67% (8/12)	8% (1/12)	100% (12/12)
Chilson Wells					
Hydro ID					
2	---	---	---	---	X
13	---	X	---	---	X
16	---	X	X	---	X
42	---	X	X	X	X
615	X	X	X	---	X
619	---	X	X	---	X
622	---	X	X	---	X
650	---	---	---	---	X
680	X	X	X	X	X
689	---	X	X	---	X
696	---	X	---	---	X
697	---	X	X	---	X

Table 2.7-34: Groundwater Quality Comparison with Federal Drinking Water Standards (cont.)

Parameter	Arsenic, Dissolved	Gross Alpha, Dissolved	Radium-226, Dissolved	Uranium, Dissolved	Sulfate
Chilson Wells					
Hydro ID					
705	---	---	---	---	**X**
3026	**X**	**X**	**X**	---	**X**
7002	---	**X**	**X**	---	X
Percentage exceeding MCL in one or more samples:	20% (3/15)	80% (12/15)	67% (10/15)	13% (2/15)	100% (15/15)
Unkpapa Wells					
Hydro ID					
690	---	---	---	---	**X**
693	---	---	---	---	**X**
703	---	**X**	---	---	**X**
704	---	---	---	---	**X**
Percentage exceeding MCL in one or more samples:	0% (0/4)	25% (1/4)	0% (0/4)	0% (0/4)	100% (4/4)

Notes: **X** denotes that one or more analyses exceed the MCL.

* MCL applies to radium-226 and radium-228 combined.

** Secondary drinking water standard.

Table 2.7-35: Major Ion Chemistry - Fall River Formation

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
5	6.2	19%	4.1	13%	21.9	68%	sodium
7	1.8	12%	1.2	8%	11.9	80%	sodium
8	2.7	19%	1.9	14%	9.6	67%	sodium
18	1.7	12%	1.0	7%	12.0	82%	sodium
628	2.0	11%	1.4	8%	13.9	81%	sodium
631	15.9	58%	7.5	27%	4.0	15%	calcium
681	3.1	22%	2.0	14%	9.2	64%	sodium
688	2.3	19%	1.6	13%	8.3	68%	sodium
694	1.5	10%	0.9	6%	12.3	84%	sodium
695	3.8	23%	2.2	13%	10.5	64%	sodium
698	18.4	55%	11.0	33%	3.8	11%	calcium
706	8.3	47%	3.9	22%	5.6	31%	---
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
5	2.4	7%	0.7	2%	30.1	91%	sulfate
7	3.4	22%	0.3	2%	11.6	76%	sulfate
8	3.4	23%	0.3	2%	11.0	75%	sulfate
18	3.6	25%	0.4	3%	10.7	73%	sulfate
628	3.0	16%	1.3	7%	14.7	77%	sulfate
631	3.3	11%	0.3	1%	25.8	88%	sulfate
681	3.5	25%	0.4	3%	10.1	72%	sulfate
688	2.7	23%	0.3	3%	8.9	75%	sulfate
694	3.6	26%	0.4	3%	10.1	72%	sulfate
695	3.5	22%	0.3	2%	12.1	76%	sulfate
698	2.3	8%	0.3	1%	28.5	92%	sulfate
706	3.9	21%	0.3	1%	14.1	77%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

While many of the Fall River Formation baseline wells were outside of the ore zone and yielded low to non-detectable radionuclide concentrations, the maximum radionuclide concentrations were often relatively high. For example, the highest average gross alpha concentration (dissolved) was 1,505 pCi/L in well 698.

2.7.3.2.2.3 Chilson Water Quality

The water quality in the Chilson Member of the Lakota Formation is characterized by moderate TDS (708 - 2,358 mg/L), relatively consistent major ion chemistry, and often high radionuclide concentrations. Table 2.7-36 summarizes the average major ion chemistry of the Chilson wells. Sodium is the dominant cation in 53% of wells (8 of 15). Four wells (27%) exhibited calcium dominance and three wells (20%) did not have a dominant cation. All of the Chilson baseline wells exhibited strong sulfate dominance, with sulfate accounting for 71% to 92% of the anion concentration (in meq/L).

A comparison between the Chilson water quality and EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of sulfate above the standard. Additional standards exceeded in one or more samples included dissolved arsenic (20% of wells), gross alpha (80% of wells), radium-226 (67% of wells) and uranium (13% of wells).

Many of the Chilson wells yielded relatively high average radionuclide concentrations. For example, the highest average gross alpha concentration (dissolved) was 4,991 pCi/L in well 680.

Table 2.7-36: Major Ion Chemistry - Chilson Member of the Lakota Formation

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
2	2.6	16%	1.4	9%	12.3	75%	sodium
13	3.1	24%	2.0	16%	7.6	60%	sodium
16	5.9	50%	3.8	32%	2.1	18%	calcium
42	1.7	12%	1.0	7%	11.6	81%	sodium
615	3.7	33%	1.8	16%	5.8	51%	sodium
619	16.0	55%	9.4	32%	3.8	13%	calcium
622	4.1	29%	2.4	17%	7.7	54%	sodium
650	8.3	41%	6.5	32%	5.3	26%	---
680	19.2	54%	10.2	29%	6.0	17%	calcium
689	2.3	21%	1.3	12%	7.7	68%	sodium
696	4.9	31%	3.0	19%	7.7	49%	---
697	2.6	20%	1.4	11%	9.2	70%	sodium
705	4.2	30%	2.6	18%	7.1	51%	sodium
3026	19.0	52%	9.3	26%	8.2	22%	calcium
7002	11.5	44%	7.3	28%	7.6	29%	---
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
2	4.2	25%	0.3	2%	12.4	73%	sulfate
13	3.2	23%	0.3	2%	10.0	74%	sulfate
16	3.1	24%	0.1	1%	9.4	74%	sulfate
42	3.6	25%	0.3	2%	10.3	72%	sulfate
615	2.8	25%	0.1	1%	8.2	74%	sulfate
619	2.3	8%	0.3	1%	26.9	91%	sulfate
622	3.5	25%	0.3	2%	10.2	73%	sulfate
650	1.4	6%	0.5	2%	20.6	92%	sulfate
680	5.0	15%	0.4	1%	28.2	84%	sulfate
689	3.0	27%	0.1	1%	8.1	72%	sulfate
696	4.0	27%	0.3	2%	10.7	71%	sulfate
697	3.3	26%	0.2	2%	9.4	72%	sulfate
705	2.7	19%	0.2	2%	11.1	79%	sulfate
3026	3.5	10%	0.5	1%	31.4	89%	sulfate
7002	5.2	19%	0.3	1%	22.4	80%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

2.7.3.2.2.4 Unkpapa Water Quality

Four Unkpapa wells have been sampled as part of the baseline monitoring program. Two of these wells (690 and 693) were installed and used as monitor wells for the Burdock (well 690) and Dewey (well 693) pumping tests. These wells were sampled once in 2008 during the pumping tests. The other two wells (703 and 704) were installed in 2008 to replace domestic wells near potential well field areas. The former domestic wells were replaced because they were completed in the Fall River or Chilson targeted for ISR operations. One water quality sample was collected from each of these wells during baseline monitoring.

The water quality in the Unkpapa Sandstone is characterized by high pH (9.0 to 11.4), moderate and relatively consistent TDS (1,300 to 1,400 mg/L), relatively consistent major ion chemistry, and relatively low radionuclide concentrations. Table 2.7-37 summarizes the average major ion chemistry of the Unkpapa wells. Sodium is the dominant cation in 100% of wells (4 of 4), and sulfate is the dominant anion in 100% of wells (4 of 4).

A comparison between the Unkpapa water quality and EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of sulfate above the standard. An additional standard exceeded in one or more samples included gross alpha (25% of wells).

Radionuclide concentrations were generally lower in the Unkpapa than the alluvium, Fall River or Chilson. With the exception of one well exceeding the gross alpha standard in one or more samples, radionuclide concentrations in the Unkpapa were below MCLs.

Powertech (USA) proposes to sample Unkpapa wells 690, 693, and 703 four times (including the initial samples) prior to ISR operations for parameters listed in Table 6.1-1. Water samples from the Unkpapa can no longer be obtained from well 704 because this well was cemented off in the Unkpapa in 2009 and perforated in the Chilson due to low yield from the Unkpapa. Prior to ISR operations, well 704 will be replaced in accordance with procedures described in Section 5.7.1.3.3. Additionally, Powertech (USA) will include Unkpapa wells 690, 693, and 703 in the operational groundwater monitoring program as described in Section 5.7.8.2. Quarterly samples will be analyzed for all parameters in Table 6.1-1.

Table 2.7-37: Major Ion Chemistry - Unkpapa Sandstone

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
690	2.1	11%	2.1	11%	14.9	78%	sodium
693	3.7	16%	2.9	13%	16.5	72%	sodium
703	3.6	18%	0.0	0%	16.1	82%	sodium
704	1.1	5%	1.2	6%	19.0	89%	sodium
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
690	0.8	4%	0.8	5%	16.8	91%	sulfate
693	1.3	6%	1.1	5%	18.5	88%	sulfate
703	3.0	15%	0.5	2%	17.2	83%	sulfate
704	1.5	7%	2.0	9%	18.2	84%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

2.7.3.2.3 Comparison of Historical and Recent Water Quality near the Project

An analysis was conducted to determine if the well chemistry data collected at the PA 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 (USA) data set. Nine wells were selected for analysis based on TVA and Powertech (USA) data sets being available for each well, time period, and constituent (Figure 2.7-33). All nine wells are completed into the Inyan Kara Group. Five of the wells are completed into the Chilson, three in the Fall River, and one in both the Chilson and Fall River.

Powertech (USA) 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 2.7-38 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 (USA). Table 2.7-39 shows the constituents sampled for during TVA data collection and those used in the comparison analysis either with statistics or Piper diagrams. 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 (USA) data.

The number of samples analyzed during the current monitoring program limited the sample size available for statistical analysis. Therefore the analytical 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 2.7-40). Complete groundwater quality data results are available in Appendix 2.7-G of the approved license application (Powertech (USA) results) and Appendix 2.7-J of the approved license application (TVA results).

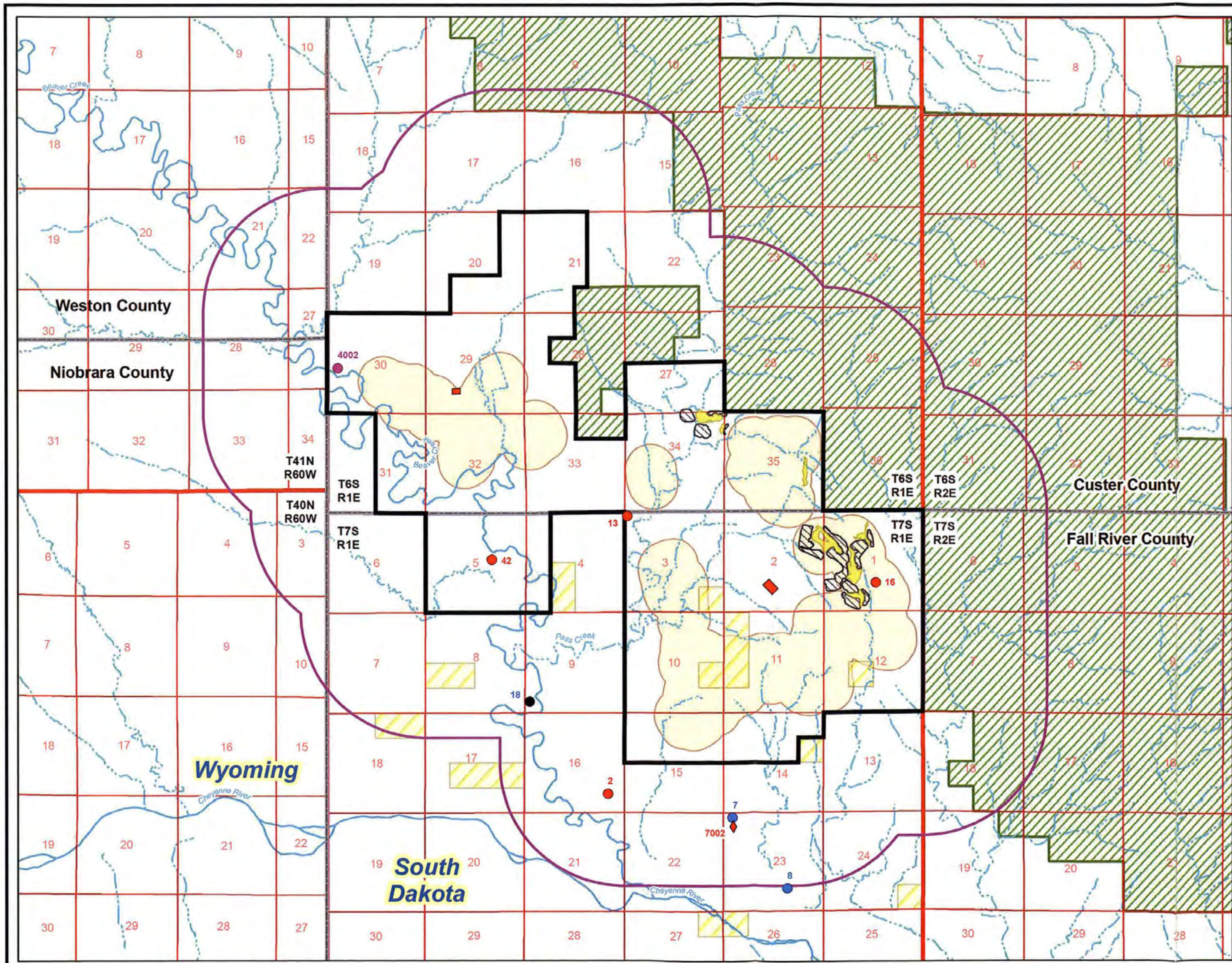


Figure 2.7-33

Wells with Historical and Recent Water Quality Data

Dewey-Burdock Project

DRAWN BY J. Mays
DATE 17-Jun-2013
FILENAME Wells-Paired.mxd

POWERTECH (USA) INC.

Table 2.7-38: TVA and Powertech (USA) Sampling History

Well No.	Aquifer	Number of TVA Samples (1979 - 1984)	Number of Powertech (USA) Samples (2006 - 2008)
2	Chilson	10	4
7	Fall River	2	5
8	Fall River	11	4
13	Chilson	11	5
16	Chilson	3	5
18	Fall River	11	5
42	Chilson	10	5
4002	Inyan Kara[1]	5	4
7002	Chilson	11	4

Note: [1] Inyan Kara indicates that screened interval includes both Chilson and Fall River.

Table 2.7-39: 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	%		

Table 2.7-39: Parameters Analyzed During TVA Water Quality Monitoring (con'd)

Test Analyte/Parameter	Units	Notes	Used in Historic/Recent Comparison
TRACE METALS			
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 5 percent in the two data sets. A plot comparing average alkalinity between TVA and Powertech (USA) data is given in Figure 2.7-34.

Conductivity was overall slightly greater (5 percent) than in previous sampling years. It decreased slightly in No.16 and was essentially the same in No. 13 and No. 7002. Figure 2.7-35 is a plot of average conductivity compared between historic TVA and current Powertech (USA) data.

Values of pH were slightly higher in Powertech (USA) samples than in TVA samples, with the exception of wells No. 7 and No. 7002 (Figure 2.7-36). Mean pH values varied from 7.44 to 7.94 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 (USA) data.

The TDS values from the two different sampling periods were also very similar. Figure 2.7-37 gives a comparison between historic TVA and current Powertech (USA) mean TDS.

Table 2.7-40: Comparison of Statistics for Selected Constituents between Historical TVA Data and Current Powertech (USA) Data

	Well	Mean			Minimum			Maximum		
		Powertech	TVA	RPD	Powertech	TVA	RPD	Powertech	TVA	RPD
Alkalinity as CaCO3, mg/L	2	211	220	4%	208	200	4%	214	242	12%
	7	171	181	6%	170	171	1%	176	191	8%
	8	169	178	5%	164	166	1%	178	194	9%
	13	159	173	8%	142	160	12%	170	196	14%
	16	153	152	1%	148	144	3%	160	157	2%
	18	180	196	9%	176	180	2%	184	238	26%
	42	178	188	5%	174	179	3%	180	204	13%
	4002	141	158	11%	138	144	4%	144	202	34%
	7002	261	261	0%	250	210	17%	280	300	7%
Specific Conductance µmhos/cm	2	1580	1548	2%	1500	1450	3%	1670	1750	5%
	7	1542	1338	14%	1440	1325	8%	1650	1350	20%
	8	1458	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	1428	1379	3%	1360	1300	5%	1470	1420	3%
	42	1408	1353	4%	1310	1200	9%	1510	1400	8%
	4002	1223	1161	5%	1130	1100	3%	1340	1195	11%
	7002	2328	2339	0%	2200	1925	13%	2480	2500	1%
pH	2	7.90	7.7	3%	7.85	7.16	9%	7.93	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	8.09	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%
Total Dissolved Solids, mg/L	2	1100	1043	5%	1100	1004	9%	1100	1113	1%
	7	990	1081	9%	960	1058	10%	1000	1104	10%
	8	975	965	1%	940	860	9%	1000	1130	12%
	13	878	886	1%	850	792	7%	890	1006	12%
	16	814	846	4%	760	796	5%	940	894	5%
	18	960	909	5%	940	520	58%	990	1118	12%
	42	950	939	1%	930	888	5%	980	1033	5%
	4002	823	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.

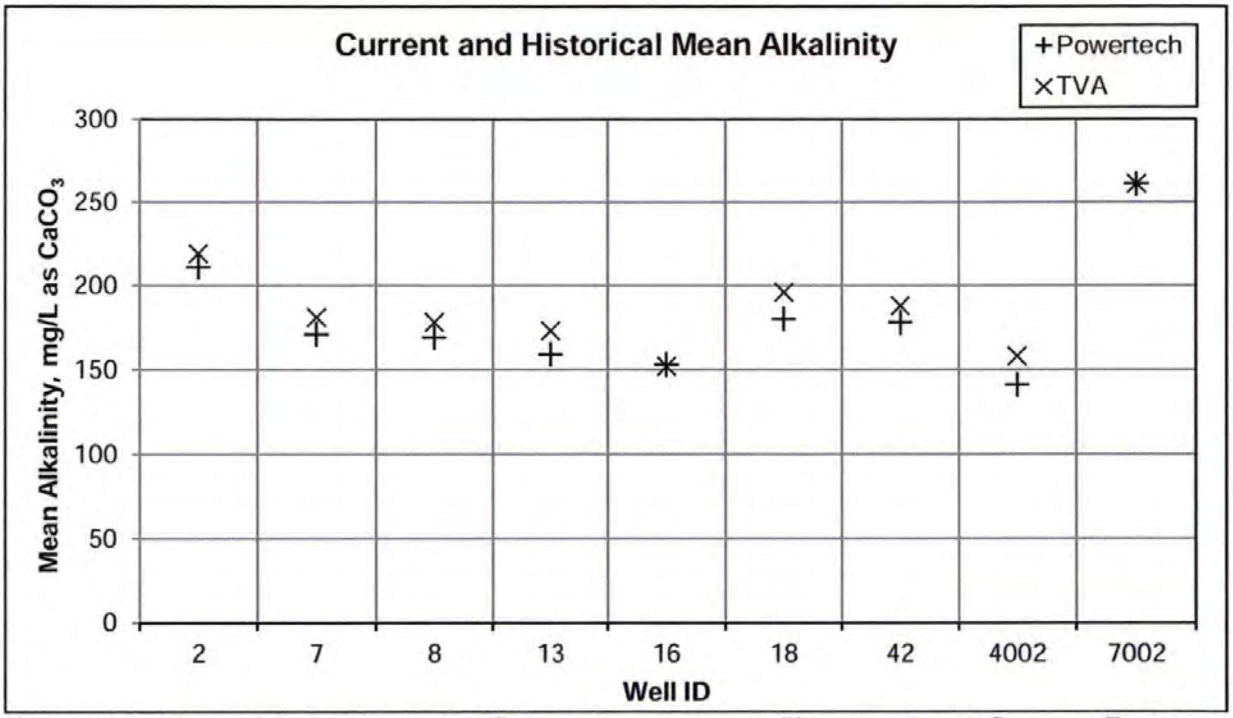


Figure 2.7-34: Mean Alkalinity Comparison between Historical and Current Data

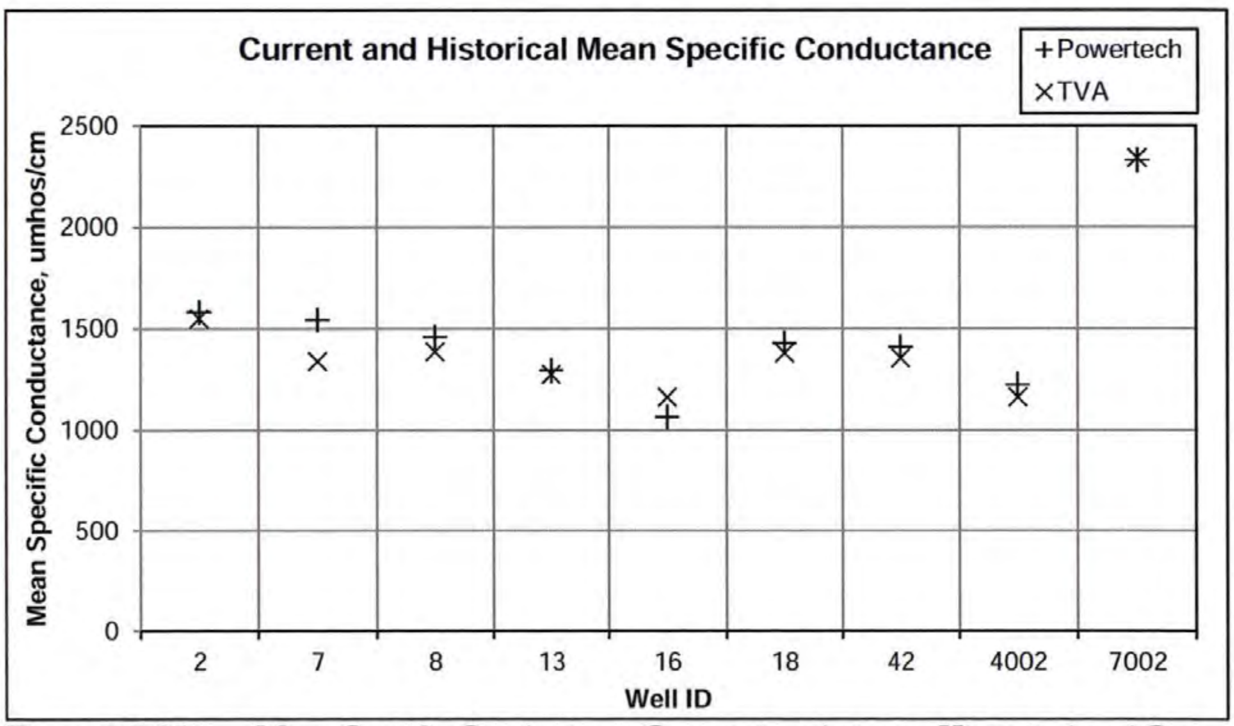


Figure 2.7-35: Mean Specific Conductance Comparison between Historical and Current Data

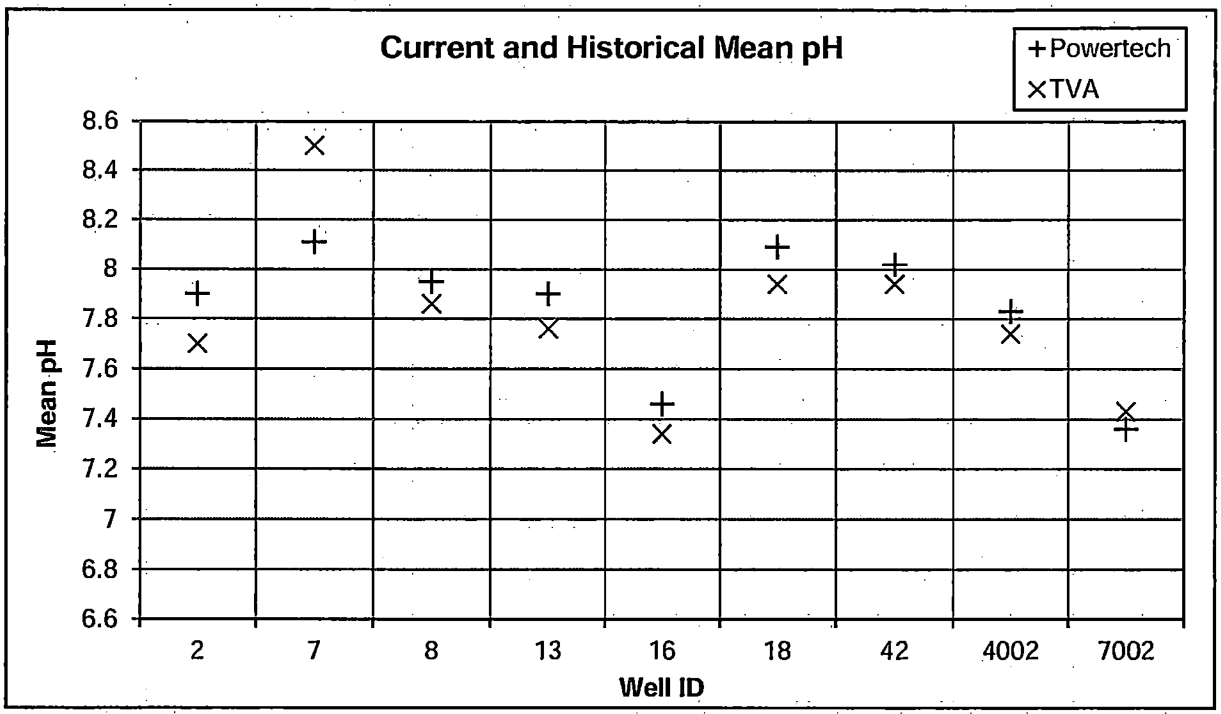


Figure 2.7-36: **Mean pH Comparison between Historical and Current Data**

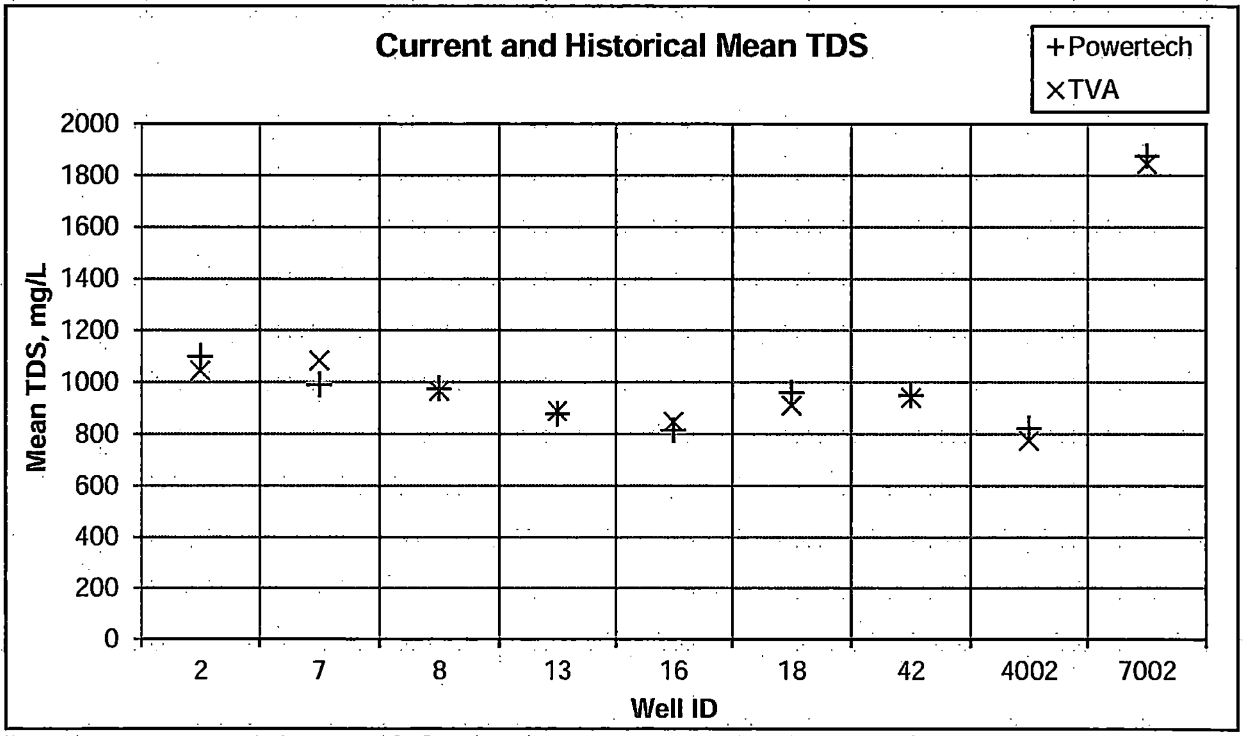


Figure 2.7-37: **Mean TDS Comparison between Historical and Current Data**

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 2.7-38 through 2.7-48). 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 Chilson display a similar distribution. For both formations, sulfate is by far the dominant anion accounting for 70 to 80 percent meq/l (Figures 2.7-47 and 2.7-48). 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 Chilson has a greater fluctuation with a group of samples having only 20 to 30 percent meq/l of sodium. Figures 2.7-47 and 2.7-48 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 2.7-38 through 2.7-46 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 inconsistent 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 PA.

Although a rigorous statistical analysis was not performed due to the small sample size of the Powertech (USA) and TVA well chemistry data, the general water quality parameters in the aquifers has shown good consistency over time. Therefore, the Powertech (USA) 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.

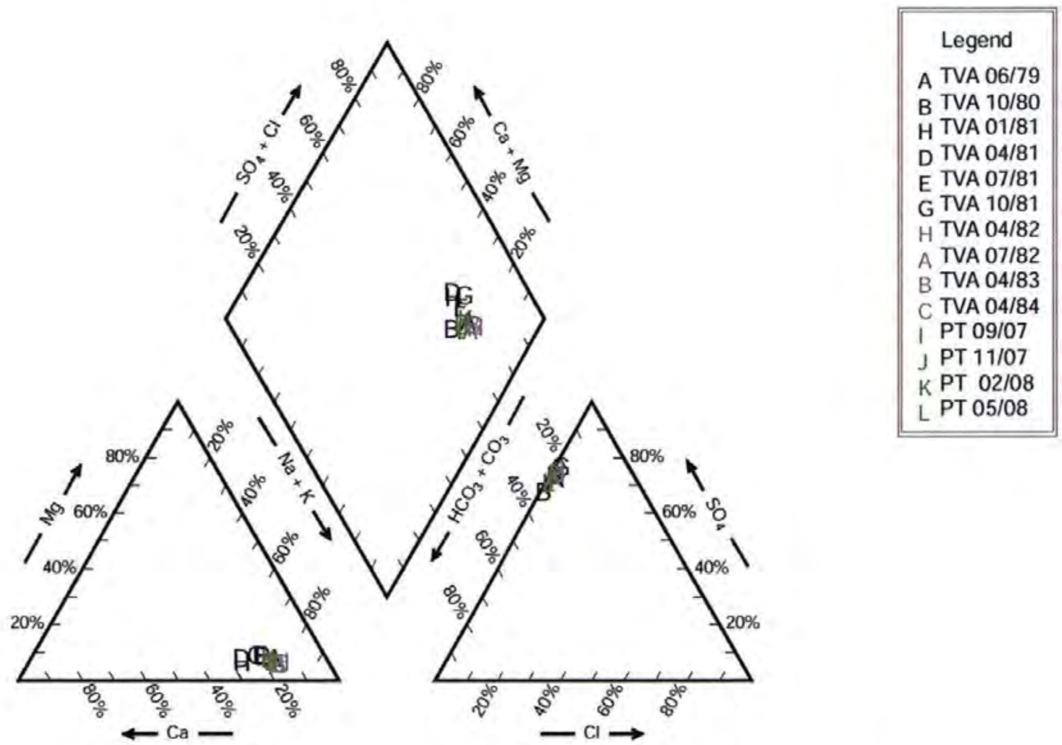


Figure 2.7-38: Piper Diagram of Historical and Current Data for Well 2

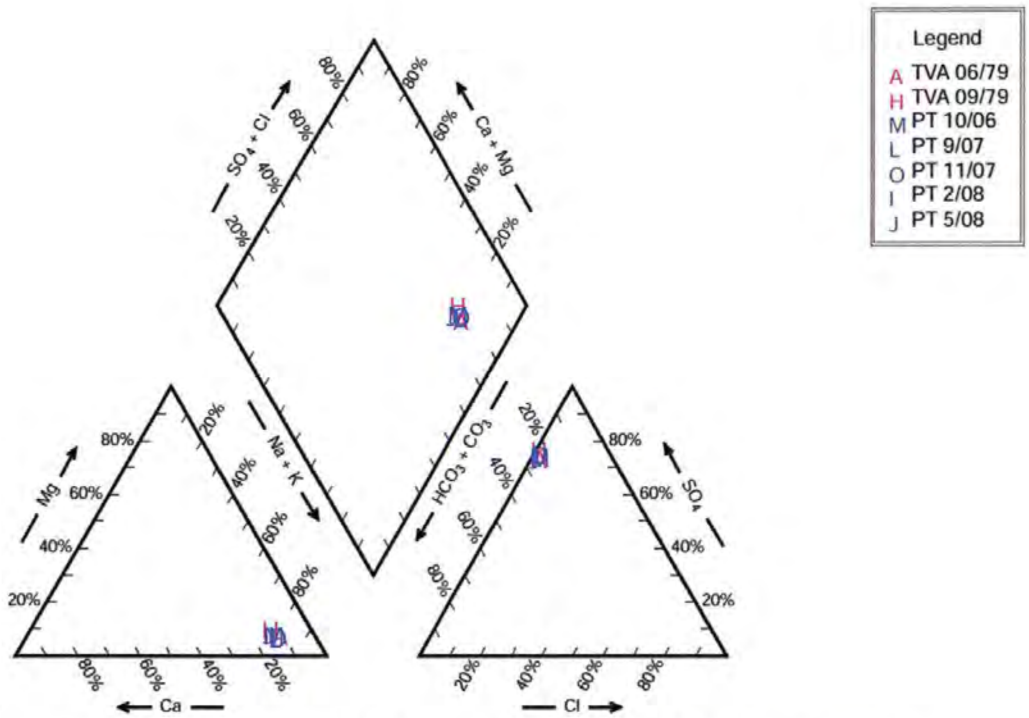


Figure 2.7-39: Piper Diagram of Historical and Current Data for Well 7

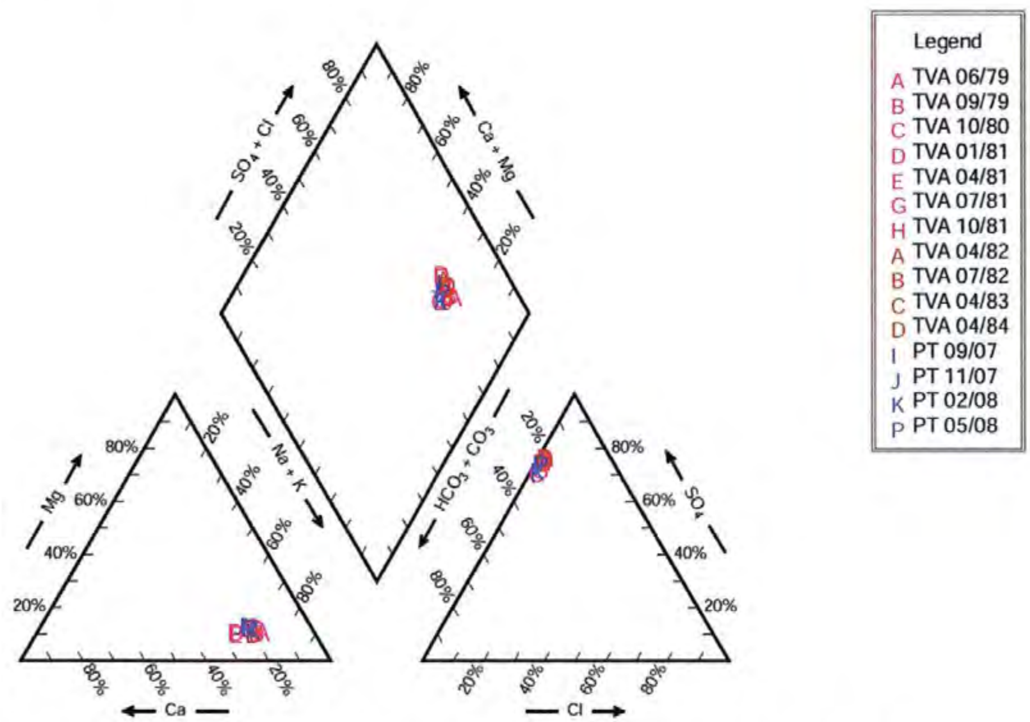


Figure 2.7-40: Piper Diagram of Historical and Current Data for Well 8

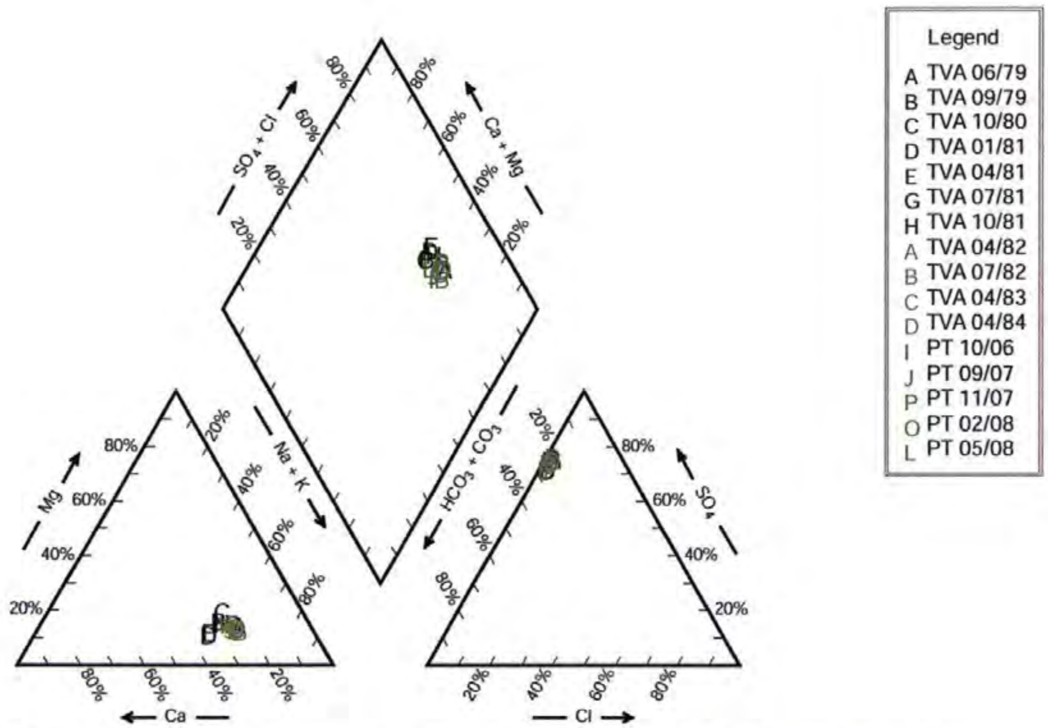


Figure 2.7-41: Piper Diagram of Historical and Current Data for Well 13

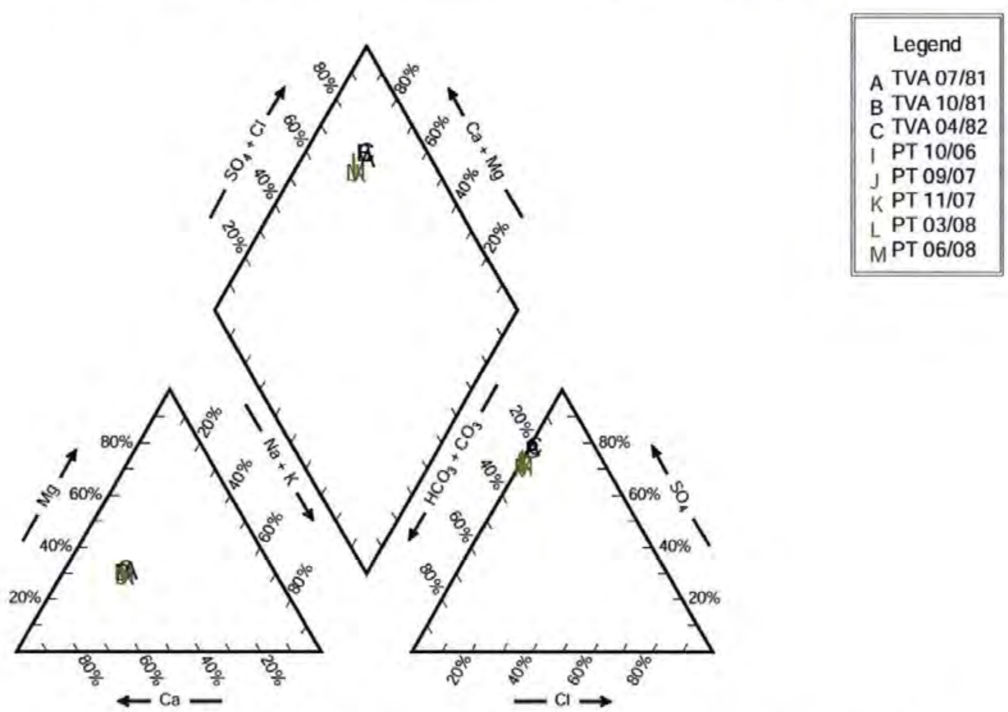


Figure 2.7-42: Piper Diagram of Historical and Current Data for Well 16

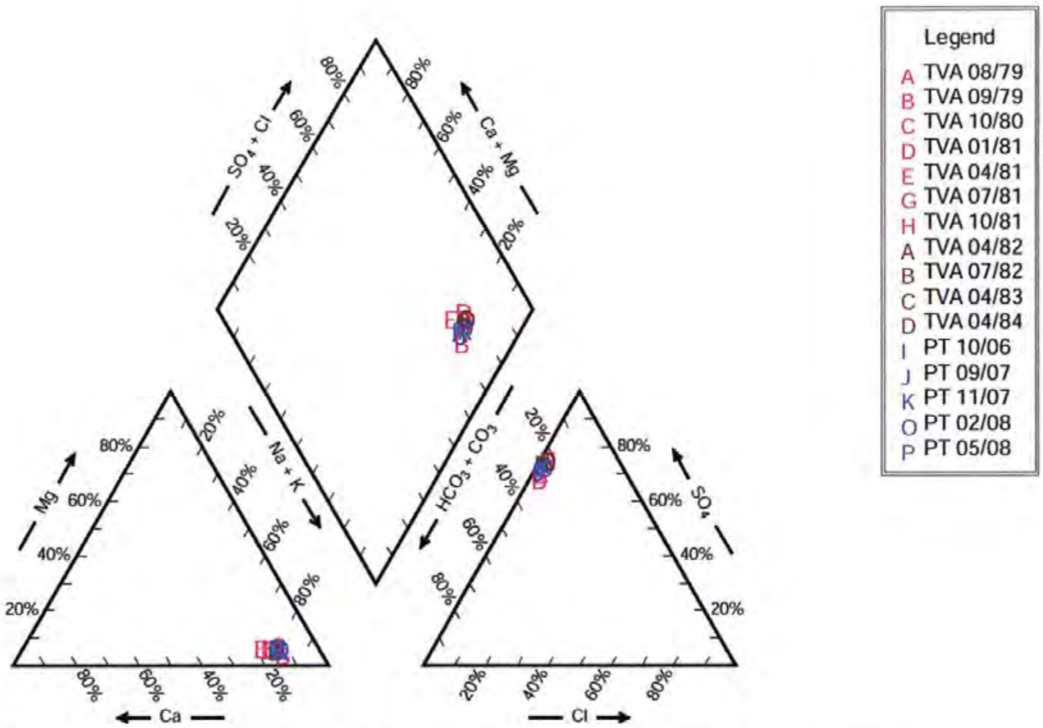


Figure 2.7-43: Piper Diagram of Historical and Current Data for Well 18

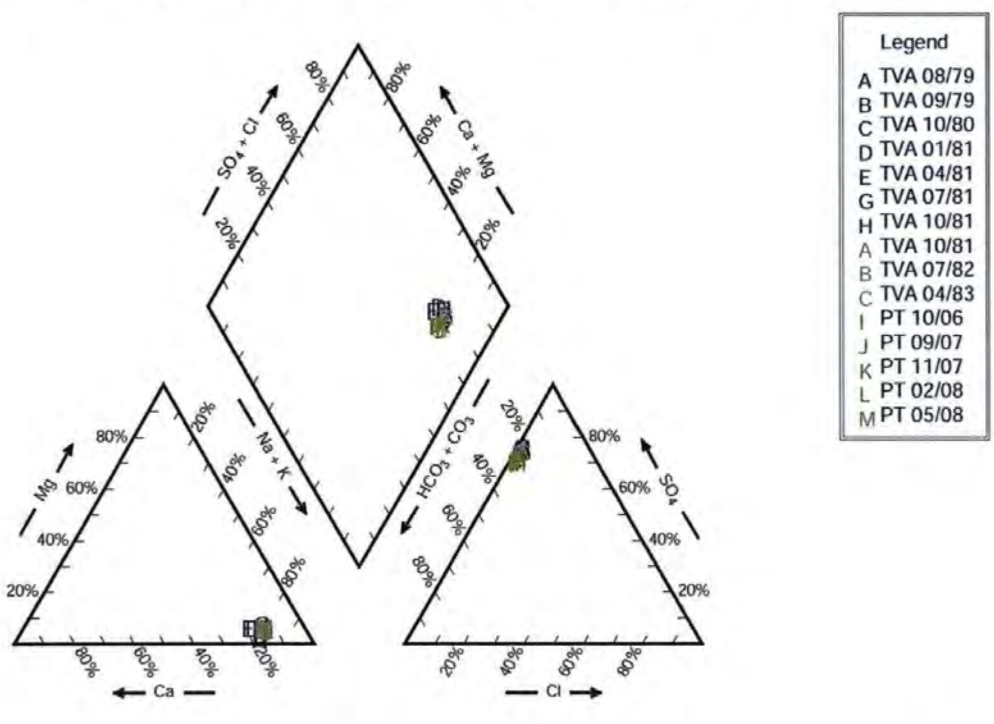


Figure 2.7-44: Piper Diagram of Historical and Current Data for Well 42

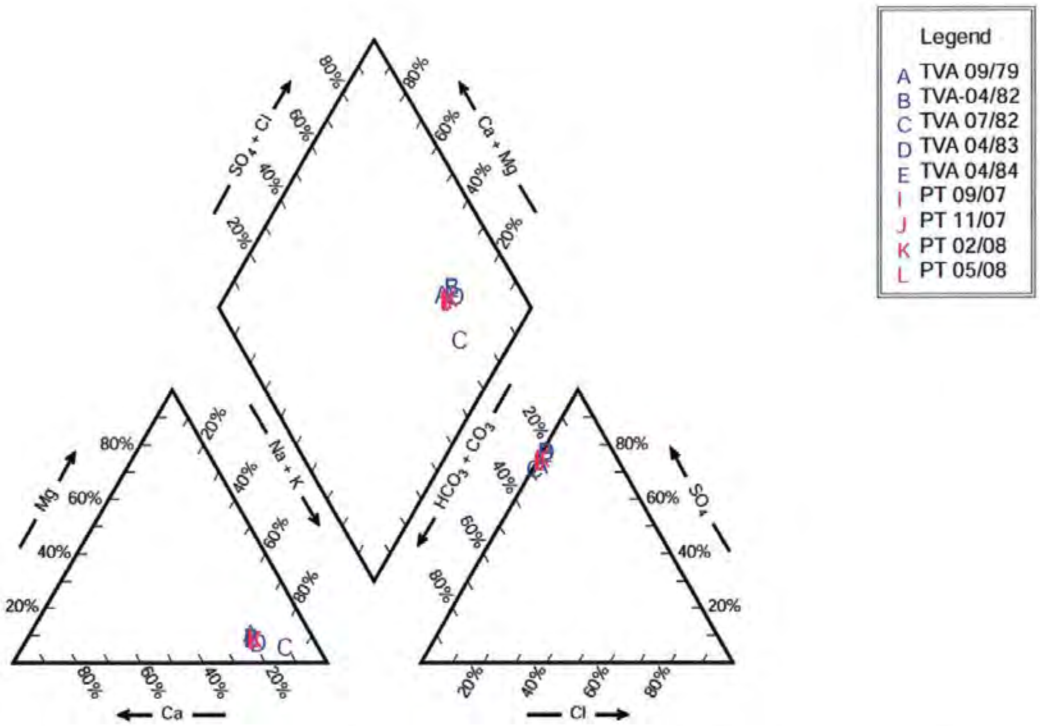


Figure 2.7-45: Piper Diagram of Historical and Current Data for Well 4002

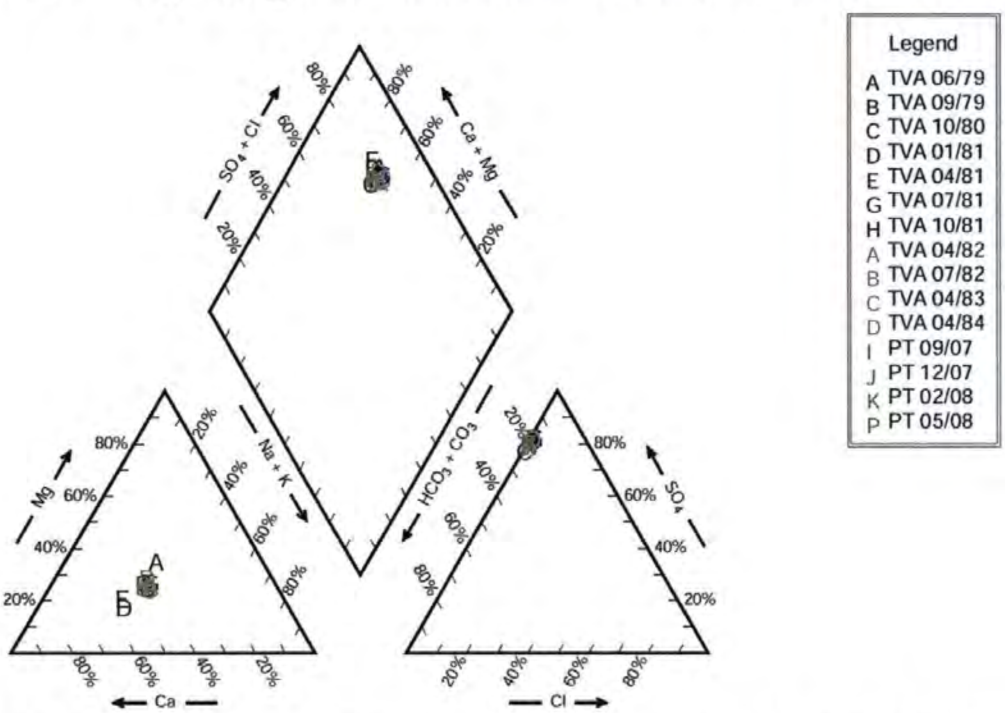


Figure 2.7-46 Piper Diagram of Historical and Current Data for Well 7002

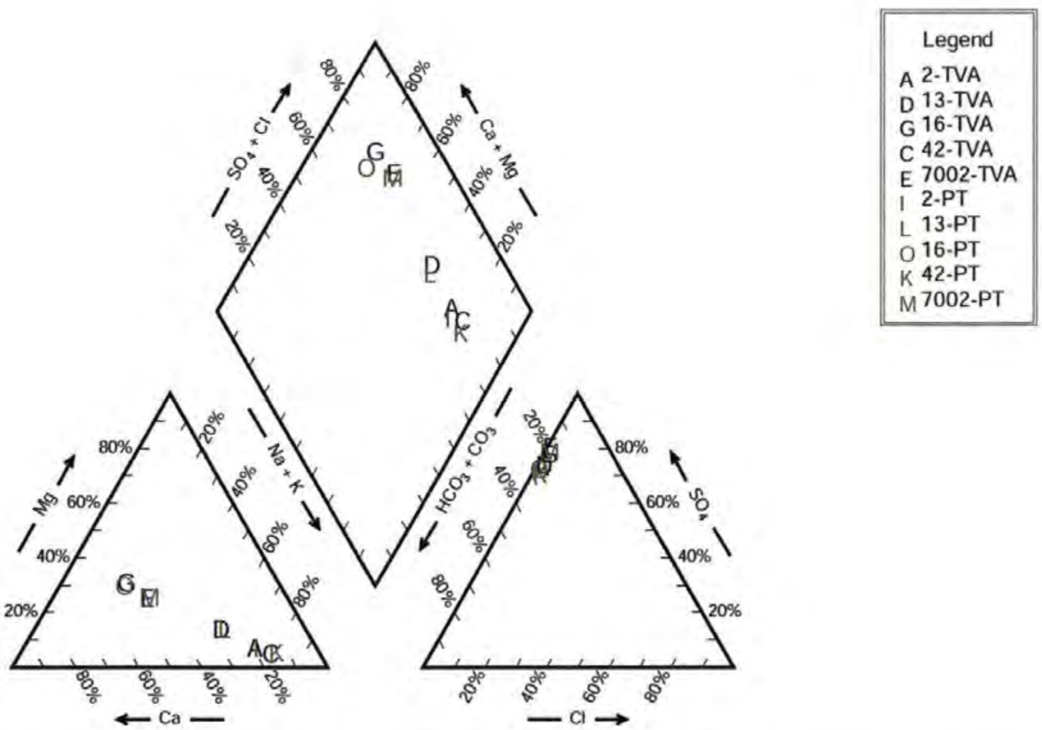


Figure 2.7-47: Piper Diagram of Historical and Current Data for Chilson Wells

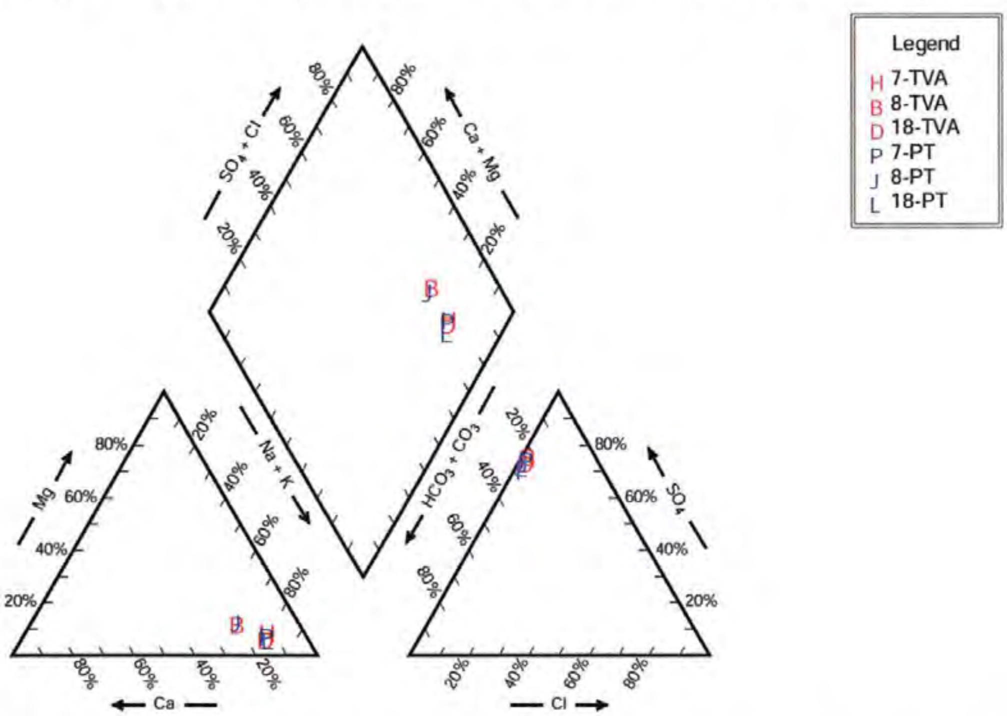


Figure 2.7-48: Piper Diagram of Historical and Current Data for Fall River Wells

2.7.4 References

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2.8 Ecological Resources

2.8.1 Introduction

This section describes the existing ecological resources within the PA. The analysis consisted of a review of existing local and regional documents, agency databases, and previous relevant reports, as well as targeted field surveys.

All vegetation sampling procedures were designed according to previous experience with similar projects and in collaboration with the South Dakota Department of Game, Fish and Parks (SDGFP).

Background information on terrestrial vertebrate wildlife species, and aquatic vertebrates and invertebrates in the vicinity of the project was obtained from several sources, including records from SDGFP, Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), and the original Draft Environmental Statement (DES) prepared by the Tennessee Valley Authority (TVA) in 1979. Site-specific data for the project and surrounding perimeter were obtained from those same sources, with current data collected during regular site visits and targeted surveys conducted from July 2007 through early August 2008.

2.8.2 Regional Setting

The PA is within the mixed grass eco-region of the Northern Great Plains (EPA 1993), near the southwestern extension of the Black Hills. The elevation within the PA ranges from approximately 3,600 feet to 3,900 feet above mean sea level, with the highest elevations along the pine breaks that overlap its eastern boundary. Topography in the PA and surrounding lands is primarily gently rolling in the western quarter, with more varied terrain in the pine breaks and dissected hills that comprise the rest of the area.

The PA is comprised of five main vegetative communities, in descending order: Ponderosa Pine Woodland, Big Sagebrush Shrubland, Greasewood Shrubland, Upland Grassland, and Cottonwood Gallery. Despite the overall ranking, Upland Grassland was present in the largest individual parcels. Interspersed among those primary habitats are smaller inclusions of Silver Sagebrush Shrubland, Agricultural Land, creek channels, and numerous ephemeral draws.

The PA is located within the Cheyenne River watershed. Two main stream channels pass through the PA: Beaver Creek (perennial) and Pass Creek (ephemeral). Both flow south into the Cheyenne River, which runs from west to east approximately 2.5 miles south of the PA boundary. A few small stock reservoirs are scattered throughout the area, though they may not retain water year-round.

Trees are present along the riparian corridors of both primary creeks, and on the higher elevation hilltops in the PA. The plains cottonwood (*Populus deltoides*) was the only tree present along the creek channels, and was more prevalent in the Pass Creek corridor. Ponderosa pine (*Pinus ponderosa*) dominates the higher elevation hilltops and breaks in the central and eastern portions of the PA, with Rocky Mountain juniper (*Juniperus scopulorum*) present as individual trees or small inclusions in some of the dry drainages.

2.8.3 Climate

The PA is characterized as semi-arid continental or steppe with a dry winter season. The area commonly experiences low precipitation levels, high evaporation rates, low relative humidity, and plentiful sunshine. Temperatures are moderate, with large diurnal and annual variations, and extremes ranging from approximately -37 degrees F in the winter to 114 degrees F in the summer. The first freeze typically occurs in mid- to late September, with the last freeze often recorded during late May.

Yearly precipitation totals average about 14 inches. Approximately one-half of the annual precipitation falls during the months of May, June, and July. As expected, most of the winter precipitation occurs as snow, with an annual average of 37 inches. Thunderstorms are relatively frequent in the PA during the summer months, averaging 40-45 days per year. Much of the annual rainfall is associated with these events.

Windy conditions are fairly common in the PA, generally averaging 9 mph. Prevailing winds come from the west-northwest during much of the year, though east-southeast winds are also common.

2.8.4 Baseline Data

Ecological baseline studies for flora and fauna were collected to fulfill the objectives specified in U.S. Nuclear Regulatory Commission (NRC) NUREG-1569, "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications*". Ecological surveys were also conducted in accordance with applicable SD Department of Environment and Natural Resources (DENR), SDGFP, and USFWS established guidelines. These agencies were consulted prior to initiating field surveys to ensure that adequate objectives, survey methodologies, and data collection techniques were employed.

Vegetation sampling was conducted by BKS Environmental Associates, Inc. (BKS) of Gillette, Wyoming. Initial surveys were conducted during July 2007, with supplemental sampling performed to adjust to subsequent changes in the PA boundary. Wildlife and aquatics sampling were conducted by ICF Jones & Stokes (formerly Thunderbird-Jones & Stokes), of Gillette, Wyoming from July 2007 through early August 2008 to meet agency requirements of one year of baseline data, and to accommodate changes to the PA boundary during that period.

The following sections were generated from the final survey reports completed by BKS and Jones & Stokes for this project.

2.8.5 Terrestrial Ecology

Powertech (USA) conducted terrestrial ecological baseline field surveys including vegetation, wetlands, wildlife. The methodology and results are discussed in the following sections.

2.8.5.1 Vegetation

2.8.5.1.1 Survey Methodology

General

All sampling procedures were designed according to previous experience with similar projects, and the methodology was submitted to Powertech (USA) for its approval. Refer to Appendix 2.8-A of the approved license application for the submitted methodology.

Mapping

Seven different plant communities were identified for the PA, i.e., Big Sagebrush Shrubland (BS), Greasewood Shrubland (GW), Ponderosa Pine Woodland (PP), Upland Grassland (UG), Cottonwood Gallery (CG), Silver Sagebrush Shrubland (SS), and Agricultural Land (AG), using 2001 color infra-red (CIR) aerial photography, which was verified by field survey. The Agricultural Land was not sampled as it was actively being used for crop production. The Silver Sagebrush Shrubland will be described as an inclusion of the Greasewood Shrubland Community.

Transect Origin Selection

The transects were randomly located in the field within each sampled vegetation community. Each transect was at least 150 feet from the previous transect. Random numbers between 1 and 360 were generated to determine cover transect direction, and compasses were utilized to orient transects to the nearest 1/8 of 360 degrees in the field. Each sample site was marked with hand-held Garmin Global Positioning System (GPS), and these points were later plotted on the final vegetation survey map (Plate 2.8-1).

Cover

A sample size of 37 50-meter point-intercept cover transects were sampled within the Ponderosa Pine Woodland and Greasewood Shrubland communities, while 27 samples were taken in the Big Sagebrush Shrubland, 26 samples for the Cottonwood Gallery and 30 samples for the Upland Grassland community for a total of 157 cover points in the PA.

In the vegetation communities, each 50-meter transect represented a single sample point. Percent cover measurements were taken from point-intercepts at 1-meter intervals along a 50-meter transect. Transects that exceeded the boundaries of the vegetation community being sampled were redirected back into its vegetation community at a 90 degree angle from the original transect direction at the point of intercept. In instances where a 90 degree angle of reflection did not place the transect within the sampled community, a 45 degree angle of reflection was used. Each point-intercept represents 2 percent towards cover measurements.

Percent cover measurements record "first-hit" point-intercepts by live foliar vegetation species, litter, rock, or bare ground. Multiple hits on vegetation were recorded, but used only for the purpose of constructing a plant species list for each plant community (Appendix 2.8-B of the approved license application).

Total Vegetation Cover

Vegetation data cover was recorded by species, using first hit data. All point intercepts of living vegetation and growth produced during the current growing season were counted toward total vegetation cover. Total vegetation cover measurements were expressed in absolute percentages for each sample point. Percent vegetation cover is the vertical projection of the general outline of plants to the ground surface. Cover summaries for each vegetation community are contained in Appendix 2.8-C of the approved license application.

Total Ground Cover

Total ground cover data was recorded by live vegetation, litter, or rock, minus bare ground. Litter includes all organic material that is dead including manure. Rock fragments were recorded when equal to or greater than two centimeters in size (i.e., sheet flow, minimum non-erodible particle size). Total ground cover measurements were expressed in absolute percentages for each sample point. Total ground cover equals the sum of cover values for percent vegetation, percent litter, and percent rock.

Shrub Density

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data can be found in Appendix 2.8-C of the approved license application.

Shrub density data was collected in conjunction with randomly selected cover transects, wherever possible. All shrubs, full, half, or sub, were counted within 50 centimeters on either side of the 50 meter cover transect (1 meter x 50 meter belt transect), yielding a 100 m^2 belt transect. Sample adequacy was not calculated for shrub density. The number of belt transects equaled the number of cover transects for a given vegetation type.

Tree Density

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data can be found in Appendix 2.8-D of the approved license application.

Tree density data was collected in the Ponderosa Pine Woodland vegetation community in conjunction with randomly selected cover transects, wherever possible. Tree density in this community was determined using the point-center quarter method. Trees within the Cottonwood Gallery or Riparian areas were directly counted on an aerial photograph. Within other vegetation communities, individual *Pinus ponderosa* (Ponderosa Pine) or other tree species found were directly counted for numbers. Sample adequacy was not calculated on the point-center quarter plots.

Species Composition

A list of plant species encountered during 2007 quantitative sampling is compiled in Appendix 2.8-B of the approved license application by vegetation community type for each of the five vegetation communities. The species list includes plant species sampled in cover transects as well as plant species observed along the belt transect. Plant names in the Rocky Mountain Vascular Plants of Wyoming (Dorn 2001, 3rd Edition) were utilized. Plant identification was confirmed by Robert Dorn, when necessary. Scientific nomenclature followed that in use at the Rocky Mountain Herbarium in Laramie, Wyoming, during 2007.

Sample Adequacy

A minimum of 20 cover transects per vegetation type was sampled in five vegetation communities. Sample adequacy was calculated and an incremental number of cover transects was sampled up the maximum of 50.

The following sample adequacy formula was utilized to determine the minimum required size of the sample population.

$$n_{min} \geq \frac{2(sz)^2}{(dx)^2}$$

Where n_{min}= minimum number of sampled line transects needed to adequately represent native vegetation types
s= sample standard deviation
z= the z statistic
d= the amount of reduction desired
x= sample mean for cover

This sample adequacy formula is used by the Wyoming Department of Environmental Quality (WDEQ). The 2 in the numerator makes this a very conservative test. The term "grassland" indicates that a community has less than or equal to 20 percent relative cover by shrub species while a "shrubland" is greater than or equal to 20 percent relative cover by shrub species according to the WDEQ.

The five vegetation communities have been identified as “grassland”, or “shrubland”. Upland Grassland is identified as grassland while the Ponderosa Pine Woodland, Big Sagebrush Shrubland, Greasewood Shrubland, and Cottonwood Gallery communities are identified as shrublands. The constant values to be used in statistical tests for cover are: “z”=1.28 and “d” = 0.1 for grasslands and shrublands. All sampled vegetation was included in the sample adequacy test (i.e., “undesirable” species were not eliminated from the equation). Also as adjustments were made to the permit boundary, the samples that fell outside of the boundary were not excluded as they were initially part of the boundary at the time of survey.

Extended Reference Area

The Extended Reference Area (EXREFA) is a native land unit used to evaluate revegetation success on portions of the same native plant community that was affected by the proposed operation. This study shows the operation will affect five plant communities, Big Sagebrush Shrubland, Cottonwood Gallery, Greasewood Shrubland, Ponderosa Pine Woodland, and Upland Grassland. All areas of these communities not affected by production activities will serve as the EXREFA.

2.8.5.1.2 Vegetation Survey Results

The PA acreage is 10,580 acres. Of these acres, Big Sagebrush Shrubland was 2,501.74 acres (23.70 percent), Greasewood Shrubland was 2,190.45 acres (20.75 percent), Ponderosa Pine Woodland was 2,183.76 acres (20.69 percent), Upland Grassland was 2,187.56 acres (20.72 percent), Agricultural Land was 780.79 acres (7.40 percent), Disturbed areas were 14.7 acres (0.14 percent), existing mine pits were 326.99 acres (3.10 percent), Cottonwood Gallery was 240.6 acres (2.28 percent), Silver Sagebrush Shrubland was 119.49 acres (1.13 percent), water was 8.94 acres (0.08 percent), and Shale Outcrop was 2.19 acres (0.02 percent). Refer to Table 2.8-1 for acreage of each vegetation community by permit acreage, and ½-mile buffer acreage.

Table 2.8-1: Acreage and Percent of Total Area for Each of the Map Units

Map Unit	Permit area	% of Area	1/2 Mile Buffer Area	% of Area
Sampled Vegetation Communities				
Big Sagebrush Shrubland	2,501.56	23.70	2,639.45	31.75
Greasewood Shrubland	2,190.45	20.75	837.66	10.07
Ponderosa Pine Woodland	2,183.76	20.69	2,036.58	24.49
Upland Grassland	2,187.56	20.72	2,027.18	24.38
Cottonwood Gallery	240.6	2.28	103.13	1.24
Described Vegetation Communities				
Agricultural Land	780.79	7.40	604.19	7.27
Disturbed	14.7	0.14	--	--
Existing Mine Permit	326.99	3.10	--	--
Silver Sagebrush Shrubland	119.49	1.13	53.65	0.65
Shale Outcrop	2.19	0.02	--	--
Water	8.94	0.08	12.6	0.15
TOTAL	**10,557.03**	**100.00**	**8,314.44**	**100.00**

General

The Extended Reference Area EXREFA will remain unaffected over the course of the proposed operation and will be used to evaluate revegetation success. The EXREFA will include portions of the same native plant communities that area affected by the proposed operation but located outside those disturbed areas and within the project boundary.

2.8.5.1.3 Big Sagebrush Shrubland

Cover

The Big Sagebrush Shrubland community comprised 2,501.56 of the 10,557.03 acres of the PA (23.70 percent). Twenty-seven cover transects were sampled for this community. Absolute total vegetation cover was 45.89 percent. Absolute bare soil and litter/rock percentages were 14.07 percent and 38.52 percent, respectively. Absolute total ground cover was 85.78 percent. *Bouteloua gracilis* (blue grama), provided the highest relative vegetation cover at 24.38 percent, while *Buchloe dactyloides* (buffalograss) provided the next highest relative vegetation cover at 20.98 percent. Refer to Table 2.8-2 for the absolute cover values.

Table 2.8-2: 2007 Absolute Cover for the Big Sagebrush Shrubland Vegetation Community

Vegetation Parameter
Absolute Total Vegetation Cover (45.89%)
Absolute Total Cover (85.78%)

Sample Adequacy

There were 27 samples taken in the Big Sagebrush Shrubland plant community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Big Sagebrush Shrubland met sample adequacy

Refer to Table 2.8-3 below for sample adequacy values.

Table 2.8-3: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Big Sagebrush Shrubland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Big Sagebrush Shrubland						
Total Vegetation Cover	22.75	6.52	26.91	27.00	2.56	99.48
Total Ground Cover	42.64	3.49	2.20	27.00	8.98	NA

Shrub Density

Big Sagebrush Shrubland supported an average of 3,661.46 shrubs per acre or 0.90 shrubs/m^2. The following full and half/sub-shrub species were found: *Artemisia tridentata* (big sagebrush), *Artemisia frigida* (fringed sagewort), and *Gutierrezia sarothrae* (broom snakeweed). Refer to Appendix 2.8-D of the approved license application for a complete Big Sagebrush Shrubland density summary.

Species Composition

Species composition for the Big Sagebrush Shrubland community was dominated by warm season perennial grasses with 46.33 percent relative vegetation cover, followed by cool season perennial grasses with 20.33 percent relative vegetation cover. Perennial shrubs had 15.82 percent relative vegetation cover, while annual grasses had 10.15 percent relative vegetation cover. Annual forbs had 1.90 percent relative vegetation cover. Perennial forbs had 1.11 percent relative vegetation cover; sub-shrubs had a total of 2.59 percent relative vegetation cover. Succulents had 1.77 percent relative vegetation cover. The cool season perennial grasses were mainly *Elymus smithii* (western wheatgrass), *Carex filifolia* (threadleaf sedge), and *Poa secunda* (Sandberg bluegrass). The warm season perennial grasses were mainly blue grama, buffalograss, and *Bouteloua curtipendula* (sideoats grama). Annual grasses were *Bromus japonicus* (Japanese brome) and *Bromus tectorum* (cheatgrass). Perennial forbs were dominated by *Calochortus nuttallii* (sego lily), *Phlox spp.* (phlox), and *Sphaeralcea coccinea* (scarlet globemallow). Annual forbs included *Alyssum desertorum* (desert alyssum) and *Lepidium densiflorum* (prairie peppergrass). Present shrubs/sub-shrubs was big sagebrush, fringed sagewort, and broom snakeweed. Also present was the succulent *Opuntia polyacantha* (plains prickly pear). Refer to Table 2.8-4 for relative Big Sagebrush Shrubland cover summary and Appendix 2.8-C of the approved license application for a complete Big Sagebrush Shrubland cover summary.

Table 2.8-4: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Big Sagebrush Shrubland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	9.33	20.33
Warm Season Perennial Grasses	21.26	46.33
Annual Grasses	4.66	10.15
Annual Forbs	0.87	1.90
Perennial Forbs	0.51	1.11
Perennial Shrubs	7.26	15.82
Perennial Sub-Shrubs	1.19	2.59
Succulents	0.81	1.77

2.8.5.1.4 Greasewood Shrubland

Cover

The Greasewood Shrubland community comprised 2,190.45 of the 10,557.03 acres of the PA (20.75 percent). Thirty-seven cover transects were sampled for this community. Absolute total vegetation cover was 37.11 percent. Absolute bare soil and litter/rock percentages were 18.70 percent and 42.54 percent, respectively. Absolute total ground cover was 81.41 percent. Western wheatgrass provided the highest relative vegetation cover at 23.31 percent. *Sarcobatus vermiculatus* (greasewood), provided the next highest cover at 22.88 percent. Refer to Table 2.8-5 for the absolute cover values.

Table 2.8-5: 2007 Absolute Cover for the Greasewood Shrubland Vegetation Community

Vegetation Parameter	Mean
Absolute Vegetation Cover (%)	37.11
Absolute Total Cover (%)	81.41

Sample Adequacy

There were 37 samples taken in the Greasewood Shrubland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Greasewood Shrubland met sample adequacy. Refer to Table 2.8-6 for sample adequacy values.

Table 2.8-6: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Greasewood Shrubland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Greasewood Shrubland						
Total Vegetation Cover	18.84	5.80	31.06	37.00	2.79	99.74
Total Ground Cover	40.70	6.74	8.99	37.00	5.19	NA

Shrub Density

Greasewood Shrubland supported an average of 2,589.42 shrubs per acre or 0.64 shrubs/m^2. The following full and half/sub-shrub species were found: greasewood, big sagebrush and *Artemisia cana* (silver sagebrush), *Ericameria nauseosa* (rubber rabbitbrush), and fringed sagewort. Refer to Appendix 2.8-D of the approved license application for a complete Greasewood Shrubland density summary

Species Composition

Species composition for the Greasewood Shrubland community was dominated by perennial shrubs with 28.70 percent relative vegetation cover, followed by cool season perennial grasses with 27.67 percent relative vegetation cover. Warm season perennial grasses had 24.31 percent relative vegetation cover. Annual grasses had 4.96 percent relative vegetation cover while annual forbs had 10.32 percent relative vegetation cover. Perennial forbs had 0.40 percent relative vegetation cover. Succulents had 3.64 percent relative vegetation cover. The cool season perennial grasses were mainly western wheatgrass, *Agropyron cristatum* (crested wheatgrass), threadleaf sedge, *Bromus inermis* (smooth brome), and *Elymus lanceolatus* (thickspike wheatgrass). Warm season perennial grasses were mainly blue grama, buffalograss, *Distichlis stricta* (inland saltgrass), and *Sporobolus airoides* (alkali sacaton). Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by scarlet globemallow, *Ambrosia psilostachya* (western ragweed), and *Convolvulus arvensis* (field bindweed). Annual forbs included *Bassia sieversiana* (summer cypress), *Plantago patagonica* (Pursh's plantain), and *Monolepis nuttalliana* (Nuttall's povertyweed). Shrubs included greasewood, big sagebrush and silver sagebrush. Plains prickly pear was also present. An area dominated by silver sagebrush was present within this community. This area was wetter than the typical greasewood community. The species composition was likely similar except for the dominance of silver sagebrush in the shrub component which is due to the increased moisture present within this area. Refer to Table 2.8-7 for relative Greasewood Shrubland cover summary and Appendix 2.8-C of the approved license application for a complete Greasewood Shrubland cover summary.

Table 2.8-7: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Greasewood Shrubland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	10.27	27.67
Warm Season Perennial Grasses	9.02	24.31
Annual Grasses	1.84	4.96
Annual Forbs	3.83	10.32
Perennial Forbs	0.15	0.40
Perennial Shrubs	10.65	28.70
Succulents	1.35	3.64

2.8.5.1.5 Ponderosa Pine Woodland

Cover

The Ponderosa Pine Woodland community comprised approximately 1,555.64 of the 7,960.77 acres of the PA (19.54 percent). Thirty-seven cover transects were sampled for this community. Absolute total vegetation cover was 34.33 percent. Absolute bare soil and litter/rock percentages were 10.54 and 53.57, respectively. Absolute total ground cover was 88.92 percent. *Pinus ponderosa* (ponderosa pine) provided the highest relative vegetation cover at 45.03 percent, while *Carex geyeri* (Geyer's sedge) provided the next highest relative vegetation cover at 13.37 percent. Refer to Table 2.8-8 for the absolute cover values.

Table 2.8-8: 2007 Absolute Cover for the Ponderosa Pine Woodland Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	34.33
Absolute Total Cover (%)	88.92

Sample Adequacy

There were 37 samples taken in the Ponderosa Pine Woodland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Ponderosa Pine Woodland met sample adequacy. Refer to Table 2.8-9 below for sample adequacy values.

Table 2.8-9: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Ponderosa Pine Woodland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Ponderosa Pine Woodland						
Total Vegetation Cover	17.19	5.25	30.56	37.00	2.82	97.67
Total Ground Cover	44.19	3.86	2.50	37.00	3.80	NA

Shrub Density

Ponderosa Pine Woodland supported an average of 1,224.27 shrubs per acre or 0.30 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, silver sagebrush, rubber rabbitbrush, *Chrysothamnus viscidflorus* (Douglas rabbitbrush), fringed sagewort, broom snakeweed, *Rosa arkansana* (prairie rose), and *Yucca glauca* (yucca or small soapweed). Refer to Appendix 2.8-D of the approved license application for a complete Ponderosa Pine Woodland density summary.

Tree Density

Ponderosa Pine Woodland supported an average of 75.88 ponderosa pine trees per acre or 0.019 trees/m^2. *Juniperus scopulorum* (Rocky Mountain juniper) was also observed within this community; however no quantitative evaluations were made for this species. Refer to Appendix 2.8-E of the approved license application for a complete tree density summary for the Ponderosa Pine Woodland community.

Species Composition

Species composition for the Ponderosa Pine Woodland community was dominated by trees with 52.58 percent relative vegetation cover, followed by warm season perennial grasses with 22.34 percent relative vegetation cover. Cool season perennial grasses had 19.34 percent relative vegetation cover. Annual grasses had 0.79 percent relative vegetation cover while annual forbs had 0.44 percent relative vegetation cover. Biennial forbs had 0.15 percent relative vegetation cover, while perennial forbs had 1.22 percent relative vegetation cover. Succulents had 0.47 percent relative vegetation cover while perennial shrubs and sub-shrubs had 2.04 percent and 0.64 percent relative vegetation cover, respectively. The trees were dominated by ponderosa pine and *Juniperus scopulorum* (Rocky Mountain juniper). The cool season perennial grasses were mainly Geyer's sedge, western wheatgrass and *Hesperostipa comata* (needleandthread). Warm season perennial grasses were mainly blue grama, sideoats grama, *Schizachyrium scoparium* (little bluestem), and *Aristida purpurea var. fendleriana* (Fendler's threeawn). Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by *Erigeron spp.* (fleabane), *Thermopsis rhombifolia* (prairie thermopsis), *Antennaria parvifolia* (small-leaf pussytoes), *Liatris punctata* (dotted blazing star), and *Vicia americana* (American vetch). Annual forbs included *Chenopodium berlandieri* (pitseed goosefoot), *Draba nemorosa* (yellow draba), and *Lappula redowski* (beggars-tick). Biennial forbs included *Melilotus officinalis* (yellow sweetclover). The shrubs and subshrubs present were big sagebrush, silver sagebrush, and fringed sagewort. Plains prickly pear was also present. Refer to Table 2.8-10 for relative Ponderosa Pine Woodland cover summary and Appendix 2.8-C of the approved license application for a complete Ponderosa Pine Woodland cover summary.

Table 2.8-10: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Ponderosa Pine Woodland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	6.64	19.34
Warm Season Perennial Grasses	7.67	22.34
Annual Grasses	0.27	0.79
Annual Forbs	0.15	0.44
Biennial Forbs	0.05	0.15
Perennial Forbs	0.42	1.22
Perennial Shrubs	0.70	2.04
Perennial Sub-Shrubs	0.22	0.64
Succulents	0.16	0.47
Trees	18.05	52.58

2.8.5.1.6 Upland Grassland

Cover

The Upland Grassland community comprised approximately 2,187.56 of the 10,557.03 acres of the PA (20.72 percent). Thirty cover transects were sampled for the Upland Grassland community. Originally there were 31 transects sampled in this community, however, upon review transect 26 was discarded due to the fact that it was not representative of the community. Absolute total vegetation cover was 46.02 percent. Absolute bare soil and litter/rock percentages were 11.07 and 41.13, respectively. Absolute total ground cover was 88.95 percent. Buffalograss provided the highest relative vegetation cover at 27.81 percent, while blue grama provided the next highest relative vegetation cover at 27.10 percent. Refer to Table 2.8-11 for the absolute cover values.

Table 2.8-11: Absolute Cover for the Upland Grassland Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	46.02
Absolute Total Cover (%)	88.47

Sample Adequacy

There were 30 samples taken in the Upland Grassland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Upland Grassland met sample adequacy. Refer to Table 2.8-12 for sample adequacy values.

Table 2.8-12: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Upland Grassland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Upland Grassland						
Total Vegetation Cover	23.00	6.88	29.32	30.00	1.29	90.15
Total Ground Cover	44.23	3.04	1.55	30.00	5.63	NA

Shrub Density

Upland Grassland supported an average of 51.01 shrubs per acre or 0.01 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, fringed sagewort, and broom snakeweed. Refer to Appendix 2.8-D of the approved license application for a complete Upland Grassland density summary.

Species Composition

Species composition for the Upland Grassland community was dominated by warm season perennial grasses with 54.91 percent relative vegetation cover, followed by cool season perennial grasses with 27.66 percent relative vegetation cover. Annual grasses had 9.00 percent relative vegetation cover, while annual forbs had 3.35 percent relative vegetation cover. Perennial forbs had 0.43 percent relative vegetation cover. Subshrubs had a total 0.15 percent relative vegetation cover. Succulents had 4.50 percent relative vegetation cover. The cool season perennial grasses were dominated by western wheatgrass, threadleaf sedge, and crested wheatgrass. Warm season grasses were dominated by blue grama and buffalograss. Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs included scarlet globemallow. Annual forbs included desert alyssum, prairie peppergrass, and *Thlaspi arvense* (field pennycress). Fringed sagewort was the only sub-shrub present. Also present was plains prickly pear. Refer Table 2.8-13 for relative Upland Grassland cover summary and to Appendix 2.8-C of the approved license application for a Upland Grassland complete cover summary.

Table 2.8-13: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Upland Grassland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	12.73	27.66
Warm Season Perennial Grasses	25.27	54.91
Annual Grasses	4.14	9.00
Annual Forbs	1.54	3.35
Perennial Forbs	0.20	0.43
Perennial Sub-Shrubs	0.07	0.15
Succulents	2.07	4.50

2.8.5.1.7 Cottonwood Gallery

Cover

The Cottonwood Gallery community comprised approximately 240.60 of the 10,557.03 acres of the PA (2.28 percent). Twenty-six cover transects were sampled for the Cottonwood Gallery community. Absolute total vegetation cover was 62.61 percent. Absolute bare soil and litter/rock percentages were 1.19 and 17.50, respectively. Absolute total ground cover was 97.62 percent. Smooth brome provided the highest relative vegetation cover at 29.12 percent, while western wheatgrass provided the next highest relative vegetation cover at 26.29 percent. Refer to Table 2.8-14 for the absolute cover values.

Table 2.8-14: 2007 Absolute Cover for the Cottonwood Gallery Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	62.61
Absolute Total Cover (%)	97.62

Sample Adequacy

There were 26 samples taken in the Cottonwood Gallery community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Cottonwood Gallery met sample adequacy. Refer to Table 2.8-15 for sample adequacy values.

Table 2.8-15: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Cottonwood Gallery

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Cottonwood Gallery						
Total Vegetation Cover	31.31	7.65	19.56	26.00	2.95	99.84
Total Ground Cover	48.81	2.08	0.60	26.00	16.92	NA

Shrub Density

Cottonwood Gallery supported an average of 567.60 shrubs per acre or 0.14 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, silver sagebrush, rubber rabbitbrush, greasewood, and *Symphoricarpos occidentalis* (western snowberry). Refer to

Appendix 2.8-D of the approved license application for a complete Cottonwood Gallery density summary.

Tree Density

Tree species within this community were counted on an aerial photograph. Upon counting the number of plains cottonwoods within the community was 295.

Species Composition

Species composition for the Cottonwood Gallery community was dominated by cool season perennial grasses with 55.41 percent relative cover, followed by trees with 21.37 percent relative cover. Warm season perennial grasses had 0.37 percent relative cover. Annual forbs had 18.06 percent relative cover while annual grasses had 1.23 percent relative cover. Perennial forbs had 2.33 percent relative cover. Shrubs had a total 1.23 percent relative cover. The cool season perennial grasses were dominated by smooth brome and western wheatgrass. The warm season perennial grasses included inland saltgrass. Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by *Cirsium arvense* (Canada thistle) and *Achillea millefolium* (common yarrow). Annual forbs included summer cypress and *Chenopodium album* (lambsquarters goosefoot). Present shrubs were silver sagebrush, greasewood, and *Symphoricarpos occidentalis* (western snowberry). *Populus deltoides* (plains cottonwood) was the only tree present. Refer to Table 2.8-16 below for relative Cottonwood Gallery cover summary and to Appendix 2.8-C of the approved license application for a Cottonwood Gallery complete cover summary.

Table 2.8-16: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Cottonwood Gallery Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	34.69	55.41
Warm Season Perennial Grasses	0.23	0.37
Annual Grasses	0.77	1.23
Annual Forbs	11.31	18.06
Perennial Forbs	1.46	2.33
Perennial Shrubs	0.77	1.23
Trees	13.38	21.37

2.8.5.1.8 Vegetation Survey Discussion

The 10,580 acre PA consists of five vegetation communities: Big Sagebrush Shrubland, Greasewood Shrubland, Ponderosa Pine Woodland, Upland Grassland, and Cottonwood Gallery. Each community was investigated for baseline vegetation information in support of a NRC Source Materials License and SD DENR Regular Mine Permit Application.

No threatened or endangered species were encountered within the PA. The presence of the state designated weed Canada thistle was present within the Cottonwood Gallery vegetation community. The presence of the Fall River County designated weed field bindweed was present within the Greasewood Shrubland vegetation community.

2.8.5.2 Wetlands

2.8.5.2.1 Wetland Survey Methodology

The wetland surveys were conducted in accordance with the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region. All WoUS and OWUS were assessed during the surveys. The routine wetland delineation approach with onsite inspection was utilized, and the survey was conducted by pedestrian reconnaissance and review of existing maps of the PA. Identification of potential wetlands was based on visual assessment of vegetation and hydrology indicators, as well as intrusive soil sampling to determine the presence of wetland criteria indicators. Wetland Determination Data Forms-Great Plains Region (DRAFT), were utilized for each observation point. Hydrology and soils were evaluated whenever a plant community type met hydrophytic vegetation parameters based on the Dominance Test and Prevalence Index (as defined by the Great Plains Regional Supplement), or whenever indicators suggested the potential presence of a seasonal wetland area under normal circumstances.

Plate 2.8-2 presents the results of the wetland surveys.

Natural Resources Conservation Service (NRCS) soils mapping for Custer and Fall River Counties, South Dakota, (2007) and BKS soil mapping of the PA were reviewed for general soils information.

Potential wetlands (WoUS) and OWUS were initially identified via review of area maps to include the following:

- 1977 USFWS NWI mapping for the Dewey, Burdock and Twenty-one Quads

- Custer Quad Digital Elevation Model
- Burdock Quad Digital Elevation Model

Wetland indicator categories were identified for each dominant plant species noted through use of the National List of Vascular Plant Species that Occur in Wetlands, 1996 National Summary. Region 4 (North Plains) indicator categories were utilized for the PA.

Field sample locations and resulting wetland boundaries were recorded with a hand-held Garmin GPS map 60Cx Global Positioning System (GPS) unit in NAD 1983 UTM Zone 13. BKS provided drafting services for the project.

2.8.5.2.2 Wetland Survey Results

The PA was generally characterized by Big Sagebrush Shrubland, Greasewood Shrubland, and Ponderosa Pine Woodland with pockets of Upland Grassland and Agricultural land, mine pit, Silver Sagebrush Shrubland, Shale Outcrop, or Pass Creek. Beaver Creek had Agricultural land to the south and Greasewood Shrubland and Big Sagebrush Shrubland to the north. Agricultural land comprised 399.83 acres, Greasewood Shrubland comprised 2,252.15 acres and Big Sagebrush Shrubland comprised 2,738.85 acres. Beaver Creek had water present continuously in the drainage and wetland species near the banks. The upper banks were comprised mainly of *Artemisia tridentata* (big sagebrush), *Sarcobatus vermiculatus* (Greasewood), and *Elymus smithii* (Western wheatgrass). The wetland indicator status of these plants are UPL (upland), UPL, and FACU (facultative upland) respectively. The Pass Creek comprised of the Cottonwood Gallery vegetation community comprised mainly of *Bromus inermis* (smooth brome), western wheatgrass, and *Populus deltoides* (cottonwood trees). The wetland indicator statuses of these plants are UPL, FACU, and FAC (facultative) respectively. Please refer to Section 2.8.5.1 for further information regarding the vegetation within the PA.

The PA generally occurs on uplands, with inclusions of two main drainages, Beaver Creek and Pass Creek and several depressed areas. Beaver Creek and Pass Creek were evaluated using pedestrian reconnaissance, while the remaining small drainages were evaluated based on existing mapping. Wetlands were identified throughout the Beaver Creek drainage; however Pass Creek only had wetlands present near an old open flowing well close to the project boundary. Wetlands were also identified in the majority of the old mine pits as well as depressed areas throughout the PA. The wetland classification along Beaver Creek was Riverine Lower Perennial Emergent (R2EM) and Palustrine Emergent (PEM) WoUS in Pass Creek and other small drainages. The mine pits were primarily designated as Palustrine Unconsolidated Bottom (PUB) OWUS and depressions were typically PEM or PUB designations.

The project may affect a total of 35.114 acres of R2EM, R4SB7 (Riverine Intermittent Streambed vegetated), and PEM stream channel, Palustrine Aquatic Bed Intermittently Flooded Diked (PABJh), Palustrine Unconsolidated Shore Temporarily Flooded (PUSA), PEM, PUB, PUS, and PEMC (seasonally flooded) isolated ponds, and open water (OW). The acreage of OW consists of approximately 9.451 acres.

The area had previously been mined for uranium through several open pit mines; some of the mines had been filled in with water. One livestock watering tank was identified on the survey.

Soils information for the PA was obtained by NRCS Web Soil Survey for Custer and Fall River Counties, South Dakota, (2007).

There are two main drainage basins located in the PA; each of the drainages had different soil types. Beaver Creek had Haverson loam, 0-2 percent slopes throughout the drainage. Pass Creek had Barnum silt loam in the south half of the drainage and Barnum-Winetti complex, 0-6 percent slopes. The old mine pits were also classified as Barnum silt loam and Barnum-Winetti complex.

None of the soil map units were found on the hydric soils list for Fall River County or Custer County, South Dakota.

Table 2.8-17 is a summary list of the wetlands in the PA along with several details about each wetland, including location, delineation designation, geomorphic setting, comments, and jurisdictional recommendations. Table 2.8-18 provides of summary of the 2007 wetland delineation results.

Table 2.8-17: Summary of Wetlands within the Project Area

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W1	Sec 32 T6S R1E	R1 P1	Wetland	PEMC	0.005	Depression in tributary	--	Non-jurisdictional
W2	Sec 32, T6S R1E	No photos	Wetland	R2EM	0.017	Tributary to Beaver Creek, wetland channel	--	Jurisdictional
W3	Sec 32, T6S R1E	R1 P12 R1 P13	Non-wetland	--	--	Tributary to Beaver Creek	--	--
W4	Sec. 32, T6S R1E	R1 P2 R1 P3 R1 P4	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W5	Sec 32, T6S R1E	R1 P5	Non- wetland	--	--	Drainage	Bank of Beaver Creek	--
W6	Sec. 32, T6S R1E	R1 P16	Non-wetland	--	--	Upland tributary	--	--
W7	Sec. 32, T6S R1E	R1 P17 R1 P18	Wetland	R4SB7	0.002	Upland tributary, wetland channel	--	Non-jurisdictional
W8	Sec. 31, T6S R1E	R1 P19 R1 P20	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W9	Sec. 32, T6S R1E	R1 P23 R1 P24	Wetland	PABJh	0.26	Depression w/ berm	Previously mapped as PABFh	Non-jurisdictional
W10	Sec. 32, T6S R1E	R2 P1 R2 P2	Wetland	PUSA	0.03	Depression	Previously mapped as PEMF	Non-jurisdictional
W11	Sec. 32 T6S R1E	R2 P3 R2 P4	Non-wetland	--	--	Drainage by berm	Previously mapped as PEMF	--
W12	Sec. 32 T6S R1E	R2 P5 R2 P6	Non-wetland	--	--	Drainage	Previously mapped as PEMF	--
W13	Sec. 32 T6S R1E	No photos	Wetland	R4US	0.036	Drainage, wetland channel	Beaver Creek	Jurisdictional
W14	Sec. 32 T6S R1E	R2 P7 R2 P8 R2 P9	Wetland	R4US	0.012	Isolated Drainage, wetland channel	Tributary	Non-jurisdictional
W15	Sec. 30 T6S R1E	R2 P12 R2 P13	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W16	Sec. 31 T6S R1E	R2 P18 R2 P19	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional

Table 2.8-17: Summary of Wetlands within the Project Area (cont)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W17	Sec. 31 T6S R1E	R2 P22 R2 P23	Non-Wetland	--	--	Ditch around Agricultural area	Previously mapped as PEMA	--
W18	Sec. 31 T6S R1E	R3 P1 R3 P2	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W19	Sec. 31 T6S R1E	R3 P3 R3 P4	Non-wetland	--	--	Low area	Previously mapped as PEMF	--
W20	Sec. 9 T7S R1E	R3 P8 R3 P9	Wetland	PEM	0.503	Drainage, wetland channel	Pass Creek	Non-jurisdictional
W21	Sec. 9 T7S R1E	R3 P10 R3 P11 R3 P12	Wetland					
W22	Sec. 9 T7S R1E	R3 P13 R3 P14	Wetland					
W23	Sec. 10 T7S R1E	R3 P17 R3 P18	Wetland					
W25	Sec. 34 T6S R1E	R4 P1 R4 P2	Non-wetland	--	--	Drainage	Pass Creek	--
W26	Sec. 34 T6S R1E	R4 P3 R4 P4	Non-wetland	--	--	Drainage	Pass Creek	--
W27	Sec. 34 T6S R1E	R4 P11 R4 P12	Non-wetland	--	--	Drainage	Pass Creek	--
W28	Sec. 34 T6S R1E	R4 P13 R4 P14	Non-wetland	--	--	Drainage	Pass Creek	--
W29	Sec. 3 T7S R1E	R4 P17 R4 P18	Non-wetland	--	--	Drainage	Pass Creek	--
W30	Sec. 10 T7S R1E	R4 P19 R4 P20	Non-wetland	--	--	Depression	--	--
W31	Sec. 10 T7S R1E	R4 P21 R4 P22	Wetland	PUB	1.801	Depression	--	Non-jurisdictional
W32	Sec. 10 T7S R1E	R4 P24 R4 P25	Wetland	PUB	1.475	Depression	--	Non- jurisdictional
W33	Sec. 14 T7S R1E	R5 P1 R5 P2	Wetland	PEM	1.417	Pond	--	Non- jurisdictional
W34	Sec. 14 T7S R1E	R5 P9 R5 P10	Non-wetland	--	--	Drainage	--	--

Table 2.8-17: Summary of Wetlands within the Project Area (cont)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W35	Sec. 14 T7S R1E	R5 P11 R5 P12	Wetland	PUB	1.972	Depression	--	Non-jurisdictional
W36	Sec. 10 T7S R1E	R5 P20 R5 P21	Wetland	PEM	0.253	Outfall	Drainage	Non-jurisdictional
W37	Sec. 34 T6S R1E	R6 P6 R6 P7 R6 P8 R6 P9 R6 P10	Non-wetland	OW	7.635	Old Mine Pit	--	--
W38	Sec. 2 T7S R1E	R6 P13 R6 P14	Wetland	PUS	1.099	Depression	--	Non-jurisdictional
W39	Sec. 2 T7S R1E	R6 P16 R6 P17	Wetland	PUS	0.308	Depression w/ manmade berm	--	Non-jurisdictional
W40	Sec. 1 T7S R1E	R6 P18	Wetland	PEM	0.213	Pond	--	Non-jurisdictional
W41	Sec. 1 T7S R1E	R6 P19 R6 P20	Wetland	PUB	0.008	Old Mine Pit	--	Non-jurisdictional
W42	Sec. 1 T7S R1E	R6 P22 R6 P23 R6 P24	Wetland	PUB	0.167	Old Mine Pit	--	Non-jurisdictional
W44	Sec. 2 T7S R1E	R7 P24 R8 P1 R8 P2	Wetland	PEM	0.378	Depression near drainage	--	Non-jurisdictional
W45	Sec. 1 T7S R1E	R8 P4 R8 P5	Wetland	PEM	0.035	Depression	--	Non-jurisdictional
Wpt 3	Sec. 32 T6S R1E	R1 P6 R1 P7	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 4	Sec. 32 T6S R1E	R1 P8 R1 P9	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 22	Sec. 30 T6S R1E	R2 P14 R2 P15	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional

Table 2.8-17: Summary of Wetlands within the Project Area (cont)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
Wpt 26	Sec. 31 T6S R1E	R2 P24	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 27	Sec. 31 T6S R1E	R3 P5	Non-wetland	--	--	Depression	Previously mapped as PEMFh, no longer present	--
Wpt 29	Sec. 30 T6S R1E	R3 P6 R3 P7	Non-wetland	--	--	Depression	Previously mapped as PEMC and PEMFx, no longer present	--
Wpt. 35	Sec. 3 T7S R1E	R3 P23 R3 P24	Non-wetland	--	--	Drainage	Cottonwood Drainage	--
Wpt. 56	Sec. 3 T7S R1E	R5 P3 R5 P4	Non-wetland	--	--	Depression	Previously mapped as PEMAf- not present	--
Wpt. 57	Sec. 14 T7S R1E	R5 P5	Non-wetland	--	--	Depression	--	--
Wpt. 58	Sec. 14 T7S R1E	R5 P8	Wetland	PEM	1.417	Pond	Same as W33	Non- jurisdictional
Wpt. 60 and Wpt. 61	Sec. 15 T7S R1E	R5 P13 R5 P14 R5 P15	Non-wetland	--	--	Depression	Salt Crust present	--
Wpt. 62	Sec. 10 T7S R1E	R5 P16 R5 P17	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present	
Wpt. 68	Sec. 10 T7S R1E	R5 P18 R5 P19	Wetland	PEM	0.253	Outfall	Same as W36	Non-jurisdictional
Wpt. 74	Sec. 11 T7S R1E	R6 P1 R6 P2	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present	
Wpt. 78	Sec. 12 T7S R1E	R6 P5	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present. Nor the PEMCh just north of the point.	

Table 2.8-17: Summary of Wetlands within the Project Area (cont.)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
Wpt. 83	Sec. 2 T7S R1E	R6 P15	Wetland	PUS	0.308	Depression w/ manmade berm	Same as W39	Non-jurisdictional
Wpt. 88 and Wpt. 89	Sec. 1 T7S R1E	R7 P1 R7 P2	Non-wetland	--	--	Old Mine Pit	Dominated by rabbit brush and *Hordeum jubatum*	--
Wpt. 92	Sec. 1 T7S R1E	R7 P5 R7 P6 R7 P7	Non-wetland	OW	0.452	Old Mine Pit	Mine Pit filled with water	--
Wpt. 94	Sec. 1 T7S R1E	R7 P9	Non-wetland	--	--	Old Mine Pit	Mine pit is dry, no vegetation	--
Wpt. 97	Sec. 1 T7S R1E	R7 P14	Non-wetland	--	--	Depression	Previously mapped PEMCh not present	--
Wpt 103	Sec. 2 T7S R1E	R7 P20	Wetland	PEM and OW	2.364	Old Mine Pit	--	Non-jurisdictional
Wpt 104	Sec. 2 T7S R1E	R7 P21 R7 P22 R7 P23	Wetland	PUS	1.299	Depression	--	Non-jurisdictional

Table 2.8-18: Summary of 2007 Wetland Delineation Results

Summary		
Number of Features	**Name**	**Acres**
2	Wetland Channel (PEM)	0.756
2	Wetland Channel (R2EM)	13.393
1	Wetland Channel (R4SB7)	0.002
2	Wetland Channel (R4US)	0.048
4	PEM Isolated Ponds	2.043
1	PEMC Isolated Pond	0.005
1	PABJh Isolated Ponds	0.260
1	PUSA Isolated Ponds	0.030
3	PUB Isolated Depression	5.248
3	PUS Isolated Depression	2.706
5	Mine Pits PUB, PEM, OW	10.626
	Total	**35.114**
	Wetland Channel (PEM)	1,842.05 Linear Feet (0.35 mi)
	Wetland Channel (R2EM)	34,079.65 Linear Feet (6.45 mi)

Results:

Beaver Creek

Beaver Creek is located in the northwest of the PA in Sections 30, 31, and 32 in T6S, R1E. The entire stretch of Beaver Creek within the project boundary is designated as a R2EM wetland, for a total of 13.376 acres. Seven data forms were filled out for the variety of lengths in the drainage as well as four photo waypoints. The most common vegetation that was identified along the drainage was *Spartina pectinata* (prairie cordgrass), *Juncus balticus* (Baltic rush), and *Schoenoplectus pungens* (common threesquare). These plants have an indicator status of FACW (facultative wet), FACW, and OBL (obligate) respectively.

Pass Creek

Pass Creek is centrally located within the PA in T7S, R1E in Sections 3, 9, and 10, and T6S, R1E in Section 34. Pass Creek only had wetlands present in Section 9, primarily due to an old open flowing well on the other side of the road outside the project boundary. The wetland totaled 0.503 acres of PEM, a total of four datasheets were filled out. The common vegetation found within the wetland was prairie cordgrass and common threesquare. The remaining drainage was walked and delineated, however no other wetlands were present. Five non-wetland datasheets were filled out and photo points were taken. Refer to Table 2.8-17, Summary of Wetlands within the PA for more details.

Previously Mapped Wetlands Confirmed as a Non-Wetland

There were several National Wetlands Inventory 1977 previously mapped wetlands that were confirmed as non-wetland or not present during the 2007 field survey. The areas generally lacked hydrophytic vegetation, hydric soils, and hydrology. Most areas had geomorphic position but often lacked another secondary indicator. Datasheets were filled out to confirm no presence of these wetlands and can be found in Table 2.8-17, Summary of Wetlands within the PA for more details. Previously mapped wetlands that are no longer present do not appear on the map (Plate 2.8-2).

Old Mine Pits

There are seven old uranium open pits present within the PA. Four of the mine pits were classified as non-wetland primarily due to lack of hydrophytic vegetation and/or hydrology presence. Two mine pits located in T7S, R1E in Section 1 were classified as PUB wetlands. The only mine pit in Section 2 was classified as both a PEM and Open Water (OW). The PEM is located along the bank of the pit and OW throughout the rest of the pit. The mine pit in Section 34 T6S R1E was classified as OW and totaled 7.635 acres another small mine pit located at waypoint 92 is Section 1 T7S R1E was classified as OW at 0.452 acres. There were approximately 1.172 acres of wetlands and 9.451 acres of open water within old mine pits in the PA. Refer to Table 2.8-17, Summary of Wetlands within the PA for more details.

Depressional Areas and Ponded Areas Identified as Wetlands

All the depressional areas identified as wetlands in 2007 were also previously identified during the 1977 NWI mapping. All of these wetlands are recommended to be non-jurisdictional based on the isolated nature of the wetlands. The wetlands were primarily classified as PEM, PEMC, PABJh, PUS, PUSA and PUB wetlands based primarily on the hydrology conditions of each waypoint. There were approximately 10.292 acres of wetland depressions and ponds present within the PA. Refer to Table 2.8-17, Summary of Wetlands within the PA for more details.

Expanded Boundary Analysis

Surveys for wetlands were conducted inside the buffer boundary and not inside the expanded boundary.

Beaver Creek Update

Beaver Creek is likely to have wetlands throughout the entire PA as it is a major drainage and had a good flow of water when the surveys were conducted in 2007. The boundary change took out 1.956 acres of R2EM wetlands along Beaver Creek in the NW1/4 of Section 31 T6S R1E. The boundary change also added 4.81 acres of R2EM wetlands along Beaver Creek in the SE1/4 of Section 31 T6S R1E and E1/2 of Section 5, the SW1/4 of Section 4 of T7S R1E. The total acreage addition to the wetlands along Beaver Creek was 2.86 acres of R2EM.

Small PEM and PUB isolated wetlands may be found SW of the Beaver Creek Drainage is Section 5, T7S R1E; however accessibility to the area was not present to confirm. There are two depressions that can be seen on the map and based on the 2007 surveys of the PA the likelihood of the depressions being classified as a wetland is rare.

Pass Creek Update

In 2007, Pass Creek had 0.503 acres of PEM wetlands surveyed along its stretch; however due to the recent boundary change there are now only 0.05 acres of wetlands present on Pass Creek. The boundary change moved the boundary east of W22, and now excludes the three wetland points of W20, W21, and W22. The wetlands present on Pass Creek are primarily due to an old open flowing well on the other side of the road outside the project boundary.

In 2007, Pass Creek was surveyed from the southern project boundary to the old mine pit and no wetlands were identified except near the spring. No surveys were conducted on Pass Creek in 2008 as the map indicated that the area is likely dry.

Old Mine Pits

No changes to the acreages on the 2007 identified old mine pits wetland occurrences.

Depressional Areas and Ponded Areas Identified as Wetlands

No changes to the acreages on the 2007 depressional areas and ponded areas identified as wetlands. As noted above there may be some isolated PUB or PEM depressional areas SW of Beaver Creek, but accessibility to the area was not present during the 2008 surveys. However, it is unlikely that the areas indicated contain wetlands as the 2007 surveys proved that many of the potential wetlands indicated on the map and NWI no longer existed.

2.8.5.3 References

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2.8.5.4 Wildlife

2.8.5.4.1 General Setting

This section provides a general discussion of the affected environment for vertebrate terrestrial wildlife and aquatic species (vertebrates and macro-invertebrates). Background information for terrestrial and aquatic fauna in the vicinity of the project was obtained from several sources, including records from SDGFP, BLM, USFWS, USFS, and the TVA DES for similar operations overlapping the PA. Site-specific data for the project and surrounding perimeter were obtained from those same sources, with current data collected during regular site visits and targeted surveys conducted for this project.

Survey protocols and timing were developed collaboratively with SDGFP to meet species-specific requirements. The survey area included the PA and one-mile perimeter for threatened and endangered (T&E) species, bald eagle winter roosts, all nesting raptors, upland game bird leks, and big game. Surveys conducted only in the PA included other vertebrate species of concern tracked by the South Dakota Natural Heritage Program (SDNHP), as well as bats, small mammals, lagomorphs, prairie dog (*Cynomys* spp.) colonies, breeding birds, predators, and herptiles (reptiles and amphibians). Aquatic sampling occurred at water gauge stations located in Beaver Creek upstream of the PA, and in Beaver Creek and the Cheyenne River downstream of the area. In addition to these targeted efforts, incidental observations of all vertebrate wildlife species seen within the PA were recorded during each site visit during the year-long baseline survey period. Surveys for black-footed ferrets (*Mustela nigripes*) were not required for this project due to a block clearance issued by the USFWS that includes the entire PA and vicinity. All surveys were conducted by qualified biologists using standard field equipment and appropriate field guides. Most observations were recorded from vantage points during pedestrian or vehicular surveys to avoid disturbing wildlife; exceptions included small mammal trapping and aquatic species sampling. Raptor nests, prairie dog colonies, and other features or observation points of special interest were mapped in the field using a hand-held Global Positioning System (GPS) receiver to record the Universal Transverse Mercator (UTM, NAD27) coordinates.

2.8.5.4.2 Big Game

No crucial big game habitats or migration corridors are recognized by the SDGFP in the PA or surrounding one-mile perimeter. Crucial range is defined as any particular seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level.

Pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) are the only two big game species that regularly occur in the PA, and both are considered year-round residents. Elk (*Cervus elaphus*) and white-tailed deer (*O. virginianus*) are also present in the survey area, but only in small herds. The latter two species can also be seen in the survey area year-round, but may be more common during different times of the year.

The pronghorn is the most common big game species in the project survey area, though no species is prevalent. The pronghorn is a browse species and sagebrush-obligate, using shrubs for both forage and cover (Fitzgerald et al. 1994). Pronghorn herds were most often observed in sagebrush stands just beyond the north-central boundary of the PA during winter 2007-2008. Conversely, herds were widely distributed throughout grassland habitats in the northwestern and southeastern portions of the survey area during spring, summer, and early fall 2008. In June, after the ground and water pools had dried up, water availability became a limiting factor and pronghorn began to move to, and concentrate around, more dependable water sources such as Beaver Creek and livestock tanks, and to draws with more succulent forage.

Mule deer use nearly all habitats, but prefer sagebrush-grassland, rough breaks, and riparian bottomland (Jones et al. 1983). Browse is an important component of the mule deer's diet throughout the year, comprising as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). In the project survey area, mule deer were observed as individuals or in small herds in ponderosa pine and cottonwood riparian habitats along Beaver and Pass Creeks, and in the pine breaks along the eastern edge of the PA. They are considered year-round residents in the survey area.

By nature, elk are shy animals that are less accepting of human disturbance than pronghorn (Fitzgerald et al. 1994) or deer. Elk in the project survey area share their range with pronghorn and domestic cattle from spring through fall. Because elk prefer grass to shrubs, the resident herd competes more directly with domestic cattle and wild horses than with pronghorn in the spring and summer months. A herd of six bull elk was observed in the survey area in ponderosa pine habitat on one occasion (June 2008) during the baseline survey period, but local residents report that elk are frequently seen in the pine stands, especially during fall and winter.

White-tailed deer are typically associated with forests, woodlands, and treed galleries along streams (Fitzgerald et al. 1994). Small numbers of white-tailed deer were observed in the project survey area during the baseline survey period, predominantly in the cottonwood corridor along Pass Creek in the central portion of the PA. Most sightings of white-tailed deer were actually in the cottonwood corridor along the Cheyenne River, approximately 2-2.5 miles south of the PA. This species is considered an uncommon year-round resident in the survey area itself.

2.8.5.4.3 Other Mammals

A variety of small and medium-sized mammalian species have the potential to occur in the project survey area, although not all were observed in the PA itself during the baseline wildlife surveys. These potential species include a variety of predators and furbearers such as the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), badger (*Taxidea taxus*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*).

Numerous prey species, including rodents (e.g., mice, rats, voles, gophers, ground squirrels, chipmunks, prairie dogs, etc.), jackrabbits (*Lepus* spp.), and cottontails (*Sylvilagus* spp.) can also be found in the project survey area. These species are cyclically common and widespread throughout the region, and are important food sources for raptors and other predators. Each of these prey species, with the exception of chipmunks and rats, were either directly observed during the field surveys, or were known to exist through burrow formation or scat. Jackrabbit sightings were uncommon and cottontail sightings were below normal, suggesting these species are currently in a local downward trend. Observations of small mammals occurred most often near Beaver and Pass Creeks, in the northwestern and central portions of the survey area, respectively.

One black-tailed prairie dog (*Cynomys ludovicianus*) colony is located in the northwestern corner of the PA, and two others are present in the southwestern portion of the one-mile perimeter. Local ranchers use shooting and other control methods to reduce and/or eradicate prairie dogs from the PA (private surface) and surrounding private lands.

Other mammal species such as the striped skunk (*Mephitis mephitis*), porcupine (*Erethizon dorsatum*), and various weasels (*Mustela* spp.) inhabit sage-steppe communities, but no sightings or confirmed scat were recorded for these species during the surveys. Infrequent, incidental bat sightings (species unknown) occurred during nocturnal amphibian surveys and spotlighting efforts at targeted ponds in the PA during the baseline period. A northern river otter (*Lontra canadensis*) carcass was unexpectedly discovered at one of the fisheries sampling points along Beaver Creek in April 2008. The otter may have come up the creek during the flooding that occurred in early April, though the cause of death was not apparent. The carcass was gone by the July sampling period, presumably washed back downstream with the next flood event. Otters are tracked by the SDNHP.

Small mammal trapping was conducted during fall 2007 as part of the baseline survey requirements for the project. Trapping occurred in nine transects spread among six habitat types: Upland Grassland, Ponderosa Pine, Greasewood, Cottonwood Gallery, Clay Breaks, and Pine/Sage Edge. Grassland habitats occupy the largest parcels throughout the area, and held four transects; the remaining habitats held one transect each. Each transect included a combination of 20 live traps, 10 snap traps, and 5 pitfall traps. All traps were baited daily, with cotton balls placed in the live and pitfall traps for nesting material. Each transect was run for three consecutive days and nights (per SDGFP). The deer mouse (*Peromyscus maniculatus*) dominated the captures, with only seven individuals of other species recorded (Table 2.8-19). Deer mice are known for their ubiquitous presence and generalized habitat use, and these survey results are similar to those from other recent trapping efforts in northwest South Dakota.

Table 2.8-19: Small Mammal Abundance[1] during Trapping in September 2007

Species	Total
Deer mouse (*Peromyscus maniculatus*)	152
Olive-backed pocket mouse (*Perognathus fasciatus*)	3
Western harvest mouse (*Reithrodontomys megalotis*)	3
Northern grasshopper mouse (*Onychomys leucogaster*)	1
Totals	**159**

Lagomorph (hares and rabbits) surveys are also a common component of baseline wildlife inventories. Spotlight lagomorph counts were conducted on two consecutive nights in fall 2007. Cottontail abundance was twice that of jackrabbits, though neither count was especially high (Table 2.8-20). Results from lagomorph surveys conducted in northeast Wyoming annually since 1984 indicate that the regional lagomorph population is experiencing a downward trend in its regular cyclic pattern. Although no data is available from the PA prior to 2007, its proximity to the annual survey area in Wyoming suggests that the population trend is similar in southwestern South Dakota.

Table 2.8-20: Total Lagomorphs Observed During Spotlight Surveys and Abundance Indices in September 2007

	Species		
	White-tailed jackrabbit	**Cottontail**	**Totals**
Total Count	**12**	**28**	**40**
Lagomorphs/Survey Mile	**1.5**	**3.4**	**4.9**

[1] Survey route totaled 8.2 miles.
[2] Number given is highest count per species from two survey nights.

2.8.5.4.4 Raptors

Raptor species observed during the project baseline wildlife surveys included the bald eagle, red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), turkey vulture

(*Cathartes aura*), Cooper's hawk (*Accipiter cooperii*), rough-legged hawk (*Buteo lagopus*), merlin (*Falco columbarius*), great horned owl (*Bubo virginianus*), and long-eared owl (*Asio otus*). Other raptor species could also occur in the survey area, particularly as seasonal migrants, but were not seen during the 2007 and 2008 inventories.

Raptor sightings were recorded frequently throughout the project survey area during 2007 and 2008 in ponderosa pine, cottonwood riparian, and grassland habitats. Observations were most concentrated in proximity to Beaver Creek and Pass Creek, perhaps because of prey availability due to the presence of water and better vegetative cover along those drainages. Raptors were observed hunting, perching on nest trees, power poles, and topographic features, nest tending, incubating, and exhibiting nest defense. The bald eagle, red-tailed hawk, American kestrel, and northern harrier were the most commonly seen raptor species in the area. Raptor sightings for those species were recorded with regularity during all four seasons during the baseline survey period, though some of those species may leave the area under harsher winter conditions.

Biologists watched for active raptor nests and breeding behavior (territory defense, courtship flights, prey deliveries, etc.) during all site visits within the breeding season. Additional nest searches were conducted concurrent with other surveys completed during the non-breeding season. Nests were monitored from a distance using binoculars and a spotting scope early in the nesting season to avoid impacting active nests. All active nests were monitored throughout the breeding season to determine their success and production level.

Five confirmed, intact (i.e., material present) raptor nests and one potential nest site were documented in the PA during the 2007-2008 baseline survey period; two additional nests were recorded in the one-mile survey perimeter (see Plate 2.8-3). All eight nests are listed in Table 2.8-21, including their locations, and their status and productivity in 2008. Three raptor species tracked by the SDNHP nested in the PA. The bald eagle and long-eared owl (*Asio otus*) successfully nested within the PA. A merlin (*Falco columbarius*) was recorded at a potential nest site in the pine breaks east of the project boundary. The bird exhibited defensive behavior near the nest site, but no young or signs of active use (e.g., droppings, prey remains, egg shells, etc.) were recorded there.

Table 2.8-21: Raptor Nest Locations and Activity in and Within 1 Mile of the Project Area during Baseline Wildlife Surveys from mid-July 2007 through early August 2008

Species[1,2]	¼ Section	Township/Range	Habitat	Status	Location
LEOW	**SESW 35**	**6 South/1 East**	**Ponderosa Pine**	**1+ owl fledged**	**Permit area**
RTHA (2 nests)	SENE 29	6 South/1 East	Ponderosa Pine	1 hawk fledged	Permit area
RTHA	SESW34	6 South/1 East	Cottonwood-riparian	2 hawks fledged	Permit area
BAEA	**Mid-SW 30**	**6 South/1 East**	**Cottonwood-riparian**	**1 eagle fledged**	**Permit area**
MERL	**NWSW 36**	**6 South/1 East**	**Ponderosa Pine**	**Nest defense but no confirmed young**	**1-mile perimeter**
GHOW	SWNE 5	7 South/1 East	Lone, live cottonwood tree	Status unknown[3]	Permit area
Unk Buteo	NWSE 27	41 North/60 West (Wyoming)	Lone, dead cottonwood tree	Inactive	1-mile perimeter

[1] **Bold** species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

[2] Species Codes:
BAEA = Bald eagle
GHOW = Great horned owl
LEOW = Long-eared owl
MERL = Merlin
RTHA = Red-tailed hawk
Unk Buteo = Unknown *Buteo* (soaring hawks) species

[3] One adult GHOW was observed in the nest tree, but no chicks, feathers, droppings, or prey items were observed in or on the nest, or on the ground under the nest.

2.8.5.4.5 Upland Game Birds

The wild turkey (*Meleagris gallopavo*) and mourning dove (*Zenaida macroura*) were the only upland game bird species observed in the project survey area during baseline inventories conducted from July 2007 to August 2008. Both species are relatively common and occur in a variety of woodland and open habitats in the PA.

Three grouse species could potentially occur in the PA (PA and one-mile perimeter): the greater sage-grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and ruffed grouse (*Bonasa umbellus*). The greater sage-grouse is a species of great concern throughout the west, and is considered a "landscape species" due to its use of wide expanses of sagebrush as primary habitat during each phase of its life cycle. Searches for grouse leks were completed between April 7 and May 12, 2008. Surveys were conducted between first light and approximately one hour after sunrise. Biologists searched for displaying grouse by driving through the PA and one-mile perimeter, and making frequent stops at vantage points to scan and listen for strutting birds. Although sage-grouse were historically recorded in the general vicinity (TVA DES 1979), no leks have been documented by agency biologists within 6 miles of the PA in recent years. No grouse were observed during the entire year-long baseline survey period for this project. Potential habitat for sage-grouse is present, but only in small stands of sage surrounded by grasslands and pine breaks; such habitat is not conducive to supporting a population of sage-grouse.

2.8.5.4.6 Other Birds

Lists of avian species tracked by the SDNHP were obtained from Mr. S. Michals (SDGFP) in July 2007 and the SDGFP website in September 2008. Biologists watched for all vertebrate species of concern during each site visit to the PA during the year-long baseline survey period. All observations were recorded, including notes on species, number of individuals, age and sex (when possible), location, habitat, and activity. Three species of special interest (i.e., tracked by the SDNHP) were observed while conducting other surveys during the baseline inventory period: the Cooper's hawk (*Accipiter cooperii*), golden eagle (*Aquila chrysaetos*), and Clark's nutcracker (*Nucifraga columbiana*). All three species were briefly observed flying over the PA, but no known nesting or other targeted use was recorded by these species.

In addition to those incidental observations, targeted surveys for breeding birds (primarily passerines) were conducted in the same habitats and along the same general transects within the PA as the small mammal trapping. Four transects were surveyed in Upland Grassland, and one each in the remaining five habitat types. Breeding bird surveys were conducted using belt transects measuring 100 m wide by 1,000 m long. Transects were surveyed by slowly walking through the center of each line and stopping at least every 50 m to watch and listen for birds. Individuals observed while walking were also recorded, with efforts made to avoid double counting birds. Each transect was surveyed on three consecutive mornings in June 2008. To reduce bias, surveys started in a different habitat type each morning. Surveys began between dawn and sunrise, and were completed within four hours. All birds were identified to species. Flyovers and birds seen and heard beyond the transect boundaries were recorded as incidentals, but were not included in the analysis. Surveys were not conducted during inclement weather (precipitation, moderate to heavy winds, etc.).

Weather conditions during all surveys were mostly calm and clear, with a light breeze and approximately 25 percent high, thin cloud cover. Thirty-six species were observed within the breeding bird transects during spring 2008, with two additional unknown species logged (Table 2.8-22). The western meadowlark (*Sturnella neglecta*) was the most common species, followed by the mourning dove. The dove was the only species recorded in all six habitat types. The long-billed curlew (*Numenius americanus*) was the only species of the 36 observed that is tracked by the SDNHP. As expected, several species were associated with specific habitat types. For example, the curlew was only seen in the grassland transects (Table 2.8-22). Likewise, several species typically associated with trees were only observed in or immediately adjacent to the Cottonwood Gallery or Ponderosa Pine transects: the chipping sparrow (*Spizella passerina*), mountain bluebird (*Sialia currucoides*), black-capped chickadee (*Poecile atricapillus*), and yellow-rumped warbler (*Dendroica coronata*), among others. Similar associations were noted between other species and habitats.

Table 2.8-22: Breeding Bird Species Richness and Relative Abundance in Six Habitat Types in June 2008

	Average Number of Birds per Habitat Type[1]						
Species[2]	**BB**	**COT GAL**	**G**	**GW**	**P-SB Edge**	**PP**	**AVG #/PLOT**
Western meadowlark (*Sturnella neglecta*)	3.0	1.7	2.9	7.0	2.0	---	2.8
Mourning dove (*Zenaida macroura*)	5.0	1.7	1.9	0.7	0.3	2.0	1.9
Long-billed curlew (*Numenius americanus*)	---	---	1.9	---	---	---	0.9
Chipping sparrow (*Spizella passerina*)	---	---	---	0.3	4.0	1.6	0.6
Lark sparrow (*Chondestes grammacus*)	3.7	---	---	---	1.7	---	0.6
Grasshopper sparrow (*Ammodramus savannarum*)	---	---	0.1	4.3	---	---	0.5
Northern flicker (*Colaptes auratus*)	---	4.3	---	0.3	---	---	0.5
Mountain bluebird (*Sialia currucoides*)	---	---	---	---	2.3	2.0	0.5
Brewer's blackbird (*Euphagus cyanocephalus*)	---	3.7	---	---	---	---	0.4
Spotted towhee (*Pipilo maculatus*)	---	1.3	---	0.3	0.7	1.0	0.4
American kestrel (*Falco sparverius*)	0.3	2.3	0.2	---	---	---	0.4
Brown-headed cowbird (*Molothrus ater*)	---	0.3	---	---	2.0	1.0	0.4
House wren (*Troglodytes aedon*)	---	2.7	---	---	---	---	0.3
Yellow warbler (*Dendroica petechia*)	---	2.0	---	---	---	---	0.2
Say's phoebe (*Sayornis saya*)	---	0.3	---	---	1.3	---	0.2
Bullock's oriole (*Icterus bullockii*)	---	1.7	---	---	---	---	0.2
Unknown flycatcher	---	---	---	---	---	1.7	0.2
Eastern kingbird (*Tyrannus tyrannus*)	---	1.3	---	---	---	---	0.1
Red-tailed hawk (*Buteo jamaicensis*)	---	0.3	0.1	0.3	---	---	0.1
Black-capped chickadee (*Poecile atricapillus*)	---	0.3	---	---	---	0.7	0.1
Yellow-rumped warbler (*Dendroica coronata*)	---	0.3	---	---	---	0.7	0.1

Table 2.8-22: Breeding Bird Species Richness and Relative Abundance in Six Habitat Types in June 2008 (cont.)

	Average Number of Birds per Habitat Type[1]						
Species[2]	**BB**	**COT GAL**	**G**	**GW**	**P-SB Edge**	**PP**	**AVG #/PLOT**
European starling (*Sturnus vulgaris*)	---	1.0	---	---	---	---	0.1
Great horned owl (*Bubo virginianus*)	---	1.0	---	---	---	---	0.1
Vesper sparrow (*Pooecetes gramineus*)	---	---	0.3	---	---	---	0.1
American crow (*Corvus brachyrhynchos*)	---	---	0.1	---	---	0.3	0.1
Red-headed woodpecker (*Melanerpes erythrocephalus*)	---	0.7	---	---	---	---	0.1
Rock wren (*Salpinctes obsoletus*)	0.7	---	---	---	---	---	0.1
Western kingbird (*Tyrannus verticalis*)	I	0.7	---	---	---	---	0.1
American robin (*Turdus migratorius*)	---	0.3	---	---	---	---	<0.1
Common nighthawk (*Chordeiles minor*)	---	I	---	---	---	0.3	<0.1
Indigo bunting (*Passerina cyanea*)	---	0.3	---	---	---	---	<0.1
Killdeer (*Charadrius vociferous*)	---	---	0.1	---	---	---	<0.1
Lazuli bunting (*Passerina amoena*)	---	0.3	---	---	---	---	<0.1
Western wood peewee (*Contopus sordidulus*)	---	---	---	---	0.3	---	<0.1
Yellow-breasted chat (*Icteria virens*)	---	0.3	---	---	---	---	<0.1
Red-winged blackbird (*Agelaius phoeniceus*)	---	---	I	---	---	---	I
Turkey vulture (*Carthartes aura*)	I	I	---	---	---	---	I
Average # Birds/Transect	12.3	29.0	7.7	13.3	15.3	10.7	12.4
TOTAL SPECIES	5	23	10	7	10	10	36

BB = Bentonite breaks
COT GAL = Cottonwood Gallery
G = Grassland
GW = Greasewood
P-SB = Pine-sagebrush
PP = Ponderosa pine
I = Incidental flyover during breeding bird survey (not counted in totals)

[2] **Bold** species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

2.8.5.4.7 Waterfowl, Shorebirds

Under natural conditions, the PA provides limited seasonal habitat for waterfowl and shorebirds. As described previously, natural aquatic habitats in the PA occur mainly in Beaver Creek and Pass Creek, with a few scattered stock reservoirs also present. Because of the limited precipitation in the area, such habitats are available primarily during the spring migration period, with less reliable nesting and brood-rearing habitat in the area.

Although specific surveys for waterfowl and shorebirds were not required for the project, biologists recorded all birds seen during the year-long survey period. Eight species associated specifically with water and/or wetlands were observed during the baseline inventories: the American white pelican (*Pelecanus erythrorhynchos*), great blue heron (*Ardea herodias*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), American wigeon (*Anas americana*), killdeer (*Charadrius vociferus*), long-billed curlew, and upland sandpiper (*Bartramia longicauda*). The pelican, heron, and curlew are tracked by the SDNHP.

2.8.5.4.8 Reptiles and Amphibians

The aquatic resources present within the PA and surrounding perimeter have been thoroughly described in the General Setting and Waterfowl and Shorebird sections, above. Water is a limiting factor throughout the survey area and surrounding lands, with only one perennial stream passing through the western extent of the PA and all other natural flow categorized as intermittent or ephemeral. Even the perennial Beaver Creek experiences extended periods of low volume and flow in most years. The creeks are meandering streams with extended reaches of muddy soil substrates and intermittent riparian vegetation. Aquatic species are not locally common inhabitants of the PA. The lack of deep-water habitat and multiple perennial water sources limits the presence of fish, and decreases the potential for other aquatic species to exist.

Three aquatic or semi-aquatic amphibian species and one aquatic reptile were recorded during the 2007 and 2008 surveys in the PA: the boreal chorus frog (*Pseudacris triseriata*), Woodhouse's toad (*Bufo woodhousei*), great plains toad (*B. cognatus*), and western painted turtle (*Chrysemys picta*). All four species were heard and/or seen in Beaver Creek as it flows through the western portion of the PA, or near stock reservoirs. All four species are common to the PA, and the region as a whole. One additional aquatic reptile was recorded in the perimeter surrounding the PA, the western spiny softshell (*Trionyx spiniferus*). That observation also occurred in Beaver Creek, during the July 2008 fisheries sampling session.

Lizards (species unknown) were often observed sunning themselves on rocks and on sandy soil in the summer months during all except the early morning hours. These sightings were widespread throughout the survey area, with observations increasing as the summer progressed and the days got hotter. The shed remains of a snake skin were found in the north central portion of the survey perimeter in early May, 2007. The skin was at the base of a rock outcrop and looked as though it may have belonged to a bullsnake (*Pituophis cantenifer*).

2.8.5.5 Threatened, Endangered, or Candidate Species

2.8.5.5.1 Federally Listed Species

No federally listed vertebrate species were documented in the project survey area (current PA and one-mile perimeter) during the year-long survey period. As of February 1, 2024, the USFWS lists the Northern Long-eared Bat (endangered), Rufa Red Knot (threatened), and Tricolored Bat (proposed endangered) as potentially present in the project survey area. Bats were previously observed within the survey area, but the species of bats were not identified.

2.8.5.5.2 State Listed Species

The State of South Dakota lists 26 vertebrate species as threatened or endangered. The current list of these state species is available on the SDGFP website: https://gfp.sd.gov/threatened-endangered/. The bald eagle was previously included on the state-level T&E species list, but has been removed.

2.8.5.5.3 Species Tracked by SDNHP

As described in previous sections, current lists of other vertebrate species of interest or concern tracked by the SDNHP were obtained from SDGFP through personal contacts (July 2007) and from the agency's website (February 2024).

Six vertebrate sensitive species or species of local concern other than the bald eagle were documented within the PA during the baseline survey period: the long-billed curlew, great blue heron, golden eagle, Cooper's hawk, American white pelican, and long-eared owl. The long-eared owl and curlew are known or are suspected to have nested in the permit area, based on evidence (young present) or persistent defensive behavior, respectively. The heron, golden eagle, Cooper's hawk, and pelican were merely observed flying over the area; those four species were recorded only once each.

These six species of special interest are considered as secure populations within their respective overall ranges, though one or more could be less common in parts of a given range, especially in the periphery. Likewise, all six are considered to be either rare and local throughout their statewide ranges, or locally abundant in restricted portions of those ranges.

Four additional vertebrate species of concern were documented at least once each in the one-mile perimeter: the northern river otter, merlin, Clark's nutcracker, and plains topminnow (*Fundulus sciadicus*). The otter and birds were described in preceding sections of this document. The topminnow was captured during fisheries sampling efforts in Beaver Creek, beyond all permit boundary outlines, in July 2008. Additional information about those survey efforts and results is presented in Section 2.8.5.5 (Aquatic Resources), below.

2.8.5.6 Aquatic Resources

2.8.5.6.1 Aquatic Species and Habitats

2.8.5.6.1.1 Aquatic Species and Habitat-Survey Methods

Because Beaver Creek is the only perennial stream in the PA, and is the receiving water for drainage from the portions of the PA identified for proposed future ISL activities, it was the focus of aquatic habitat monitoring efforts conducted for this project. Some sampling was also conducted in the Cheyenne River downstream of the PA to obtain additional site data. Beaver Creek is listed as impaired under Section 303(d) of the federal Clean Water Act for the following constituents: oil, specific conductivity, temperature, total dissolved solids, and total suspended solids (EPA 2008).

Baseline monitoring stations were located at sites that were previously established as water quality monitoring locations on Beaver Creek and the Cheyenne River. Using these sites allows a comparison with past and ongoing water quality records. One site (BVC04) is located upstream and the other (BVC01) is downstream of the proposed ISL activities (refer to Figure 2.9-11 for site locations). Fish sampling for species, abundance, and radiological testing was conducted at both Beaver Creek sites, and at a site on the Cheyenne River downstream of the Beaver Creek confluence (site CHR05).

Baseline sampling of aquatic habitat, benthic macro-invertebrates, and fish was conducted according to protocols developed by the South Dakota Department of Environment and Natural Resources (SDDENR 2002) and the SDPFG (S. Michals, personal communication 2008). Aquatic data collected at the two Beaver Creek sites during the baseline sampling included: stream habitat description; aquatic benthic macro-invertebrate community composition; the variety, condition, and relative abundance of fish species; and radiological analysis of fish collected. As indicated, fish sampling also occurred at CHR05, though SDGFP did not require the other aquatic sampling efforts to be conducted at that location.

Based on conversations with area landowners and the SDGFP, there are no known fish populations in any impoundments within the project area or in any impoundments outside of the project area but immediately downstream from proposed activities within the project area. Field verification of the presence or absence of fish was not made for the relatively small and often dry impoundments within and immediately downstream from the project area.

Powertech (USA) reviewed and discussed the fish sampling plan with SDGFP. SDGFP expressed far greater interest in the potential impacts to flowing water (i.e., Beaver Creek and the Cheyenne River) rather than ephemeral streams such as Pass Creek, ephemeral impoundments, or mine pits. Therefore, an alternative fish sampling program that did not include sampling impoundments was developed in cooperation with SDGFP due to the ephemeral nature of most streams and impoundments within the project area and the absence of known fish populations in impoundments within the project area. Results of the fish sampling are summarized in Table 2.8-23.

Habitat, invertebrate, and fish sampling was conducted during spring (April) and summer (July) conditions in 2008 to provide a baseline for semi-annual monitoring described in NRC Guide 4.14 (NRC 1990). This timing was selected to capture seasonal differences, including high and base flow conditions. However, the late spring and early summer of 2008 were unusually wet and, as a result, the flow during both seasonal events was similar. Consequently, neither sampling effort represented the low summer flow conditions that have typically occurred at these sites in recent years (M. Hollenbeck, personal communication 2008).

The habitat description and invertebrate collection efforts followed the SDDENR protocol (SDDENR 2002). Eleven cross-section transects were established at equidistant intervals from the downstream end of each sample site. The longitudinal distance of each survey reach was established as the distance equal to 30 average channel widths as determined by 10 preliminary width measurements.

Fish sampling was accomplished by blocking and seining a 100-meter survey reach downstream of each sample site, according to SDGFP guidelines (S. Michals, personal communication 2008). Due to obstacles in the stream, it was not feasible to seine an entire reach in one sweep, so three separate sweeps were made at a given sample site and fish were collected on shore at three locations within each 100-meter reach. All fish captured were identified, counted, measured, and weighed. Individuals that were less than 100 millimeters (mm) in length were combined for a composite weight by species.

Numerous fish were collected for radiological testing during each of the spring and summer flow sampling events. The initial target at each sample site was six individual fish, preferably from six different species (i.e., 6 fish per sample site, 18 total fish), though fewer fish were retained if the target was not achieved. Many of the specimens collected in April 2008 contained no detectable uranium. In an effort to improve the protocol to better represent conditions in sampled fish populations, up to five individuals of each of six species (i.e., 30 fish per sample site, 90 total fish) were collected in July (when available in the catch) and processed for radiology.

Live fish were bagged, frozen, and kept frozen until they were analyzed for the following:

- Uranium (mg/kg)
- Uranium (µCi/kg)
- Thorium-230 (µCi/kg)
- Radium-226 (µCi/kg)
- Lead-210 (µCi/kg)
- Polonium-210 (µCi/kg)

These analytes are specified in NRC Guide 4.14. Analysis was conducted by Energy Laboratories Inc., in Casper, Wyoming. Lab results are included in Appendix 2.8-H of the approved license application, and are summarized in Table 2.8-23.

Table 2.8-23: Baseline Radiological Analysis of Whole Fish

Site	Species	Number	Length[a] mm	Sample Weight [b] (g)	U				Po-210			Pb-210			Th-230			Ra-226		
					Conc.[c] mg/kg	RL (LLD) mg/kg	Conc.[c] uCi/kg	RL (LLD) uCi/kg	Conc. uCi/Kg	Precision (±) uCi/Kg	RL (LLD)	Conc. uCi/Kg	Precision (±) uCi/Kg	RL (LLD)	Conc. uCi/Kg	Precision (±) uCi/Kg	RL (LLD)	Conc. uCi/Kg	Preci-ion (±) uCi/Kg	RL (LLD)
BVC01 April	GRS	1	120	22.96	<MDC	0.02	<MDC	2.0E-05	0.0E+00	6.0E-05	6.0E-05	0.0E+00	2.0E-04	5.0E-05	0.0E+00	2.0E-05	1.0E-05	3.0E-04	9.0E-05	1.0E-04
	PLK	1	48	1.77	<MDC	0.3	<MDC	2.0E-04	0.0E+00	8.0E-04	5.0E-04	2.0E-02	2.0E-02	5.0E-04	2.0E-04	3.0E-04	1.0E-04	-4.0E-04	4.0E-04	9.0E-04
	LND	1	48	0.64	<MDC	0.9	<MDC	6.0E-04	2.0E-03	3.0E-03	1.0E-03	0.0E+00	7.0E-03	1.0E-03	1.0E-03	1.0E-03	3.0E-04	-2.0E-03	1.0E-03	3.0E.-03
	FHM	1	30-60	4	<MDC	0.1	<MDC	1.0E-04	4.0E-04	5.0E-04	2.0E-04	0.0E+00	1.0E-03	2.0E-04	0.0E+00	7.0E-05	5.0E-05	-1.0E-04	2.0E-04	5.0E-04
BVC04 April	PLK	1	40-60	0.72	<MDC	0.8	<MDC	5.0E-04	0.0E+00	1.0E-03	1.0E-03	0.0E+00	8.0E-03	1.0E-03	0.0E+00	4.0E-04	3.0E-04	-1.0E-03	1.0E-03	2.0E-03
	RIC	1	111	18.79	<MDC	0.03	<MDC	2.0E-05	4.0E-04	2.0E-04	5.0E-05	0.0E+00	3.0E-04	5.0E-05	2.0E-05	3.0E-05	1.0E-05	-2.0E-05	6.0E-05	1.0E-04
	GRS	1	50	2.16	<MDC	0.3	<MDC	2.0E-04	6.0E-04	7.0E-04	4.0E-04	0.0E+00	3.0E-03	4.0E-04	8.0E-04	6.0E-04	4.0E-04	-3.0E-04	4.0E-04	9.0E-04
	FHM	1	30-70	~1.2	<MDC	0.02	<MDC	1.0E-05	0.0E+00	2.0E-05	5.0E-05	0.0E+00	9.0E-05	5.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-04	3.0E-05	3.0E-05
	CHC	1	215	72	0.05	0.05	3.0E-05	3.0E-05	9.0E-04	3.0E-04	8.0E-05	0.0E+00	5.0E-04	8.0E-05	2.0E-05	3.0E-05	2.0E-05	-8.0E-05	6.0E-05	1.0E-04
CHR05 April	RIC	1	97	13.73	<MDC	0.04	<MDC	3.0E-05	8.0E-04	3.0E-04	7.0E-05	0.0E+00	4.0E-04	7.0E-05	0.0E+00	5.0E-05	1.0E-05	-9.0E-05	5.0E-05	1.0E-04
	GRS	1	98	13.67	<MDC	0.04	<MDC	3.0E-05	8.0E-05	1.0E-04	7.0E-05	0.0E+00	4.0E-04	7.0E-05	1.0E-05	5.0E-05	1.0E-05	-6.0E-05	7.0E-05	1.0E-04
	SRS	1	169	55.05	<MDC	0.02	<MDC	1.0E-05	2.0E-04	1.0E-04	5.0E-05	0.0E+00	1.0E-04	5.0E-05	2.0E-05	2.0E-05	1.0E-05	-1.0E-05	2.0E-05	3.0E-05
	CRC	1	30-70	2.92	<MDC	0.2	<MDC	1.0E-04	0.0E+00	3.0E-04	3.0E-04	0.0E+00	2.0E-03	3.0E-04	0.0E+00	2.0E-04	7.0E-05	-2.0E-04	3.0E-04	6.0E-04
	PLK	1	32-74	1.51	<MDC	0.4	<MDC	3.0E-04	0.0E+00	1.0E-03	6.0E-04	0.0E+00	3.0E-03	6.0E-04	1.0E-03	8.0E-04	1.0E-04	-5.0E-04	5.0E-04	1.0E-03
	SAS	1	30-60	1.51	<MDC	0.4	<MDC	3.0E-04	0.0E+00	5.0E-04	6.0E-04	0.0E+00	3.0E-03	6.0E-04	1.0E-03	7.0E-04	1.0E-04	-3.0E-04	6.0E-04	1.0E-03

Table 2.8-23: Baseline Radiological Analysis of Whole Fish (cont.)

Site	Species	Number	Length[a] mm	Sample Weight [b] (g)	U Conc.[c] mg/kg	U RL (LLD) mg/kg	U Conc.[c] uCi/kg	U RL (LLD) uCi/kg	Po-210 Conc. uCi/Kg	Po-210 Precision (±) uCi/Kg	Po-210 RL (LLD)	Pb-210 Conc. uCi/Kg	Pb-210 Precision (±) uCi/Kg	Pb-210 RL (LLD)	Th-230 Conc. uCi/Kg	Th-230 Precision (±) uCi/Kg	Th-230 RL (LLD)	Ra-226 Conc. uCi/Kg	Ra-226 Preci-ion (±) uCi/Kg	Ra-226 RL (LLD)
BVC01 July	FHM	5	42-67	~8	0.026	0.0050	1.8E-05	3.4E-06	4.0E-04	2.3E-04	9.3E-05	1.4E-03	3.6E-03	6.0E-03	-1.2E-05	6.2E-05	1.9E-05	-2.2E-04	1.2E-04	2.9E-04
	PLT	5	48-71	12	0.021	0.0050	1.4E-05	3.4E-06	3.5E-04	2.8E-04	1.1E-04	-2.0E-03	4.2E-03	7.1 E-03	1.0E-04	1.0E-04	2.2E-05	-2.0E-04	1.1E-04	2.7E-04
	PLK	5	57-71	9	0.035	0.0050	2.4E-05	3.4E-06	4.7E-04	3.1E-04	1.1E-04	1.2E-03	4.2E-03	7.1E-03	5.7E-06	1.0E-04	2.2E-05	-2.0E-04	1.lE-04	2.8E-04
	SAS	5	46-62	7	0.031	0.0050	2.1E-05	3.4E-06	2.3E-04	2.6E-04	1.6E-04	3.8E-03	6.1E-03	1.0E-02	9.8E-05	1.6E-04	3.2E-05	-3.0E-04	1.6E-04	4.0E-04
	CAP	1	171	73	0.0098	0.0050	6.7E-06	3.4E-06	7.8E-04	1.9E-04	5.0E-05	7.6E-05	5.0E-04	8.4E-04	-7.4E-07	9.2E-06	2.6E-06	-2.3E-05	1.6E-05	3.6E-05
BVC04 July	SAS	5	45-58	~6.7	0.024	0.0050	1.6E-05	3.4E-06	5.4E-04	5.4E-04	1.1E-04	6.4E-04	4.4E-03	7.3E-03	2.7E-05	1.0E-04	2.3E-05	-7.7E-05	1.3E-04	2.5E-04
	SRS	1	136	130	0.0072	0.0050	4.9E-06	3.4E-06	1.7E-04	1.0E-04	5.0E-05	l.2E-04	1.2E-03	2.0E-03	1.9E-06	2.3E-05	6,3E-06	-3.7E-05	3.2E-05	6.9E-05
	FHM	5	42-61	~3.7	0.031	0.0050	2. 1E-05	3.4E-06	1.8E-04	3. 1E-04	1.2E-04	7.9E-04	4.7E-03	7.9E-03	-1.2E-05	6.9E-05	2.5E.05	-1.2E-04	1.6E-04	3.2E-04
	PLK	5	48-68	~7.2	0.019	0.0050	1.3E-05	3.4E-06	8.5E-05	1.3E-04	1.2E-04	3.2E-03	4.7E-03	7.8E-03	9.4E-05	9.1E-05	2.4E-05	-2.1E-04	1.1E-04	2.8E-04
	CAP	1	260	237	0.014	0.0050	9.4E-06	3.4E-06	1.6E-04	7.1E-05	4.0E-06	9.2E-05	1.5E-04	2.6E-04	2.3E-06	3.7E-06	8.0E-07	-4.8E-06	4.2E-06	9.1E-06
CHR05 July	SAS	5	42-60	~1.5	0.04	0.0050	2.7E-05	3.4E-06	4.9E-04	3.2E-04	1.4E-04	4.5E-03	5.3E-03	8.8E-03	1.4E-04	1.1E-04	2.7E-05	-2.8E-04	1.5E-04	3.8E-04
	FHM	5	38-60	~0.7	0.024	0.0050	1.6E-05	3.4E-06	4.2E-04	2.8E-04	1.1E-04	1.5E-03	4.3E-03	7.2E-03	1.3E-05	4.5E-05	2.2E-05	-2.1 E-04	1.3E-04	3.0E-04
	PLK	4	46-68	~7.4	0.017	0.0050	1.2E-05	3.4E-06	4.7E-04	3.5E-04	1.7E-04	-1.8E-03	6.5E-03	1.lE-02	1.6E-05	8.9E-05	3.4E-05	-2.2E-04	1.9E-04	4. 1E-04
	SRS	2	146-160	78	0.0066	0.0050	4.4E-06	3.4E-06	5.0E-04	1.3E-04	1.3E-05	2.3E-04	4.9E-04	8.1 E-04	3.2E-06	5.3E-06	2.5E-06	-8.7E-05	1.8E-05	3.4E-05
	CAP	1	135	31	0.01	0.0050	6.9E-06	3.4E-06	7.4E-04	2.2E-04	3.1E-05	1.5E-04	1.2E-03	2.0E-03	1.7E-05	2.7E-05	6.1E-06	-6.4E-05	4.4E-05	1.0E-04
	CHC	3	181-290	265	0.017	0.0050	1.2E-05	3.4E-06	1.6E-04	5.2E-05	3.5E-06	3.2E-05	1.4E-04	2.3E-04	9.0E-06	2.6E-05	7.0E-07	-1.6E-06	4.4E-06	8.4E-06
	RIC	4	381-415	5150	0.031	0.0050	2.1E-05	3.4E-06	6.6E-07	3.2E-06	2.7E-06	1.1E-05	1.0E-04	1.7E-04	-1.3E-05	2.3E-05	5.3E-07	8.0E-06	5.4E-06	7.3E-06

Notes:

GRS = Green Sunfish, PLK = Plains Killifish; LND = Longnosed Dace; RIC = River Carpsucker; FHM = Fathead Minnow; CHC = Channel Catfish; SRS = Shorthead Redhorse Sucker; CRC = Creek Chub; SAS = Sand Shiner. U = Uranium; Po = Polonium; Pb = Lead; Th = Thorium; Ra = Radium. [a]Lengths reported as a range when multiple specimens were combined as a composite sample, or when the individual processed for radiology was not recorded separately. [b]Approximate sample weights from field average weights for the species measured in the field. [c]MDC = minimum detectable concentration = RL (reporting limit) in this case.

2.8.5.6.1.2 Aquatic Species and Habitat-Survey Results

2.8.5.6.1.2.1 Habitat

Compiled habitat data forms may be found in Appendix 2.8-I of the approved license application. Summaries of results by site are described below.

Site BVC04

Site BVC04 is located downstream of the Old Highway 85 bridge over Beaver Creek in Weston County, WY (refer to Figure 2.9-11 for site locations). This site was selected as the background site as it is upstream of all projects. At BVC04, Beaver Creek is a low gradient prairie stream that is deeply incised in places, is subject to large fluctuations in flow, and shows significant evidence of active erosion (bank slumping, bare soil) and sediment deposition on stream banks and in slow moving pools.

<u>April</u>

The preliminary average channel width at BVC04 was 7.35 meters. Sample transects were located 18.5 meters apart, with a total surveyed reach length of 185 meters. During the April habitat survey, water temperature varied from 7.0° C to 16.0° C, indicating that stream temperature is highly variable during the day. In general, riparian vegetation is limited to herbaceous and short shrubs, with only occasional trees. With the exception of the bridge, there was no shade present in the center of the channel. As a result, the creek is subject to substantial solar heating during the day. Water was clear during the survey, although specific conductivity was high (5,109 µS/cm), indicating a high concentration of dissolved solids typical of prairie streams in this region. Discharge at BVC04 was 7.31 cfs on April 14.

Within the BVC04 survey reach, habitat included two large pools, two glides, and 3 riffles. The total length of riffles was 54.6 m.

Beaver Creek carries a heavy sediment load during high flow, resulting in a deep layer (up to 2 feet) of fine silt deposited in pools. Silt dominates the sediment composition of the reach, although sand, gravel and cobbles dominate the substrate of the faster moving riffle and glide areas. The cumulative and proportional particle distribution of sediment in the BVC04 reach during the April survey is shown in Figure 2.8-4. This distribution indicates a predominance of silt and sand, with gravel in the riffle areas. Large wood in the reach was located in riffle and glide areas and was generally comprised of small (0.1 to 0.25 m diameter) pieces in the portion of the channel between the wetted channel and the bank full elevation.

Beaver Creek is significantly incised. Bank slumpage was observed at eight transects and erosion at ten of the eleven transects in this reach. The wetted stream width during the survey was 4.2 to 10.7 meters; bank-full width ranged from 5.3 to 11.3 meters; and the width at the top of bank was 10.7 to 17.1 meters. Bank height was up to 2.0 meters. Riparian land use is rangeland with no riparian buffer, cattle have access to the stream, especially in the vicinity of the bridge. Woody vegetation has probably been sparse along Beaver Creek stream banks for many years, which may have contributed to channel down-cutting and erosion, and a general lack of large woody debris and cover in the channel. Examples of channel dimensions in pool, riffle, and run habitat types of the upstream (BVC04) site are shown in Figures 2.8-5, 2.8-6, and 2.8-7, below.

As mentioned previously, pools contained a large volume of silt. This silt reduces the depth and volume of the pools, reducing the quality and quantity of available fish habitat. Due to pool filling and lack of cover, pool quality is poor.

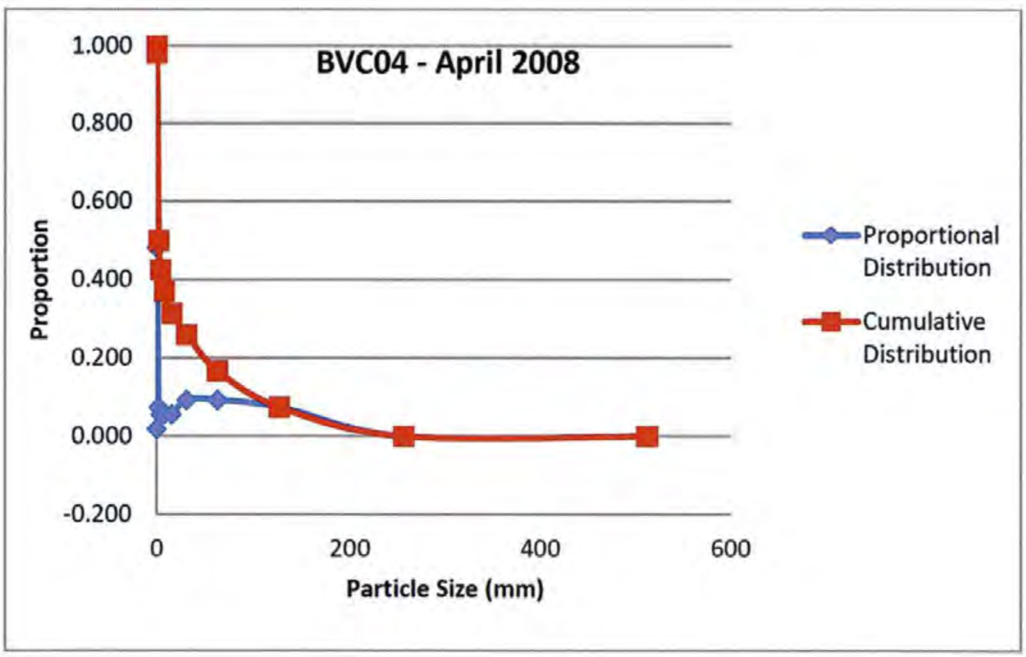

Figure 2.8-4: Cumulative and Proportional Sediment Particle Distribution at Site BVC04, Transects 1 through 11 Combined, April 2008

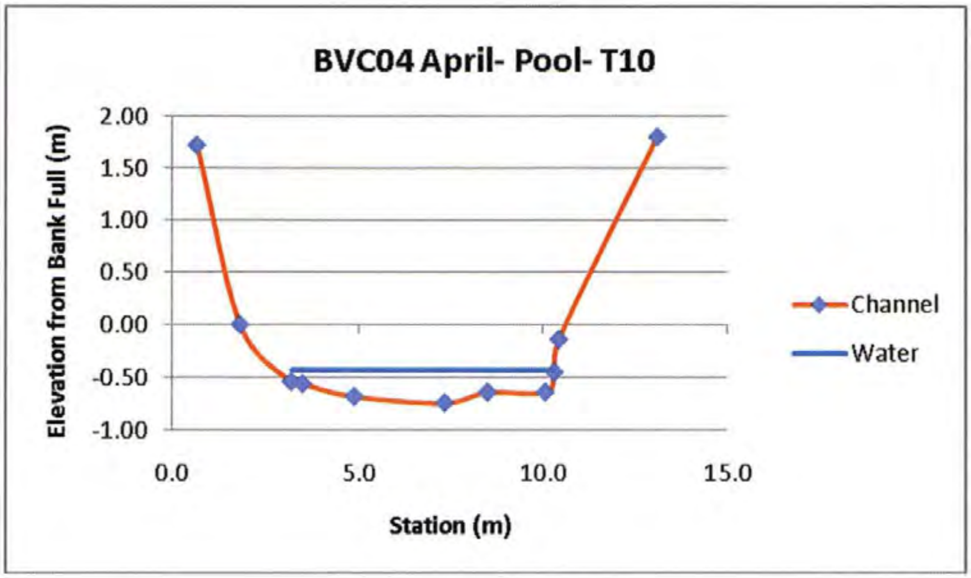

Figure 2.8-5: Channel Dimensions in Pool Habitat, Transect 10

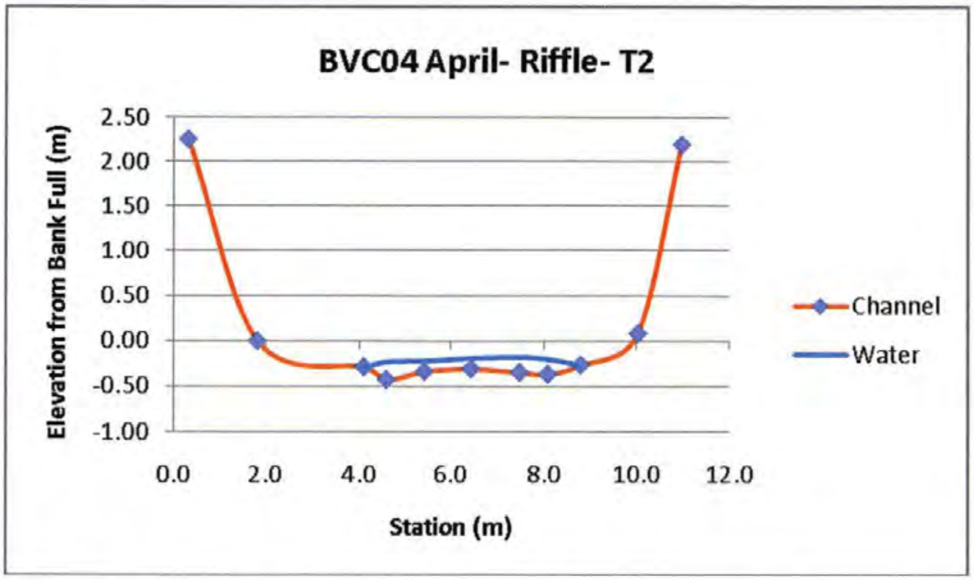

Figure 2.8-6: Channel Dimensions in Riffle Habitat, Transect 2

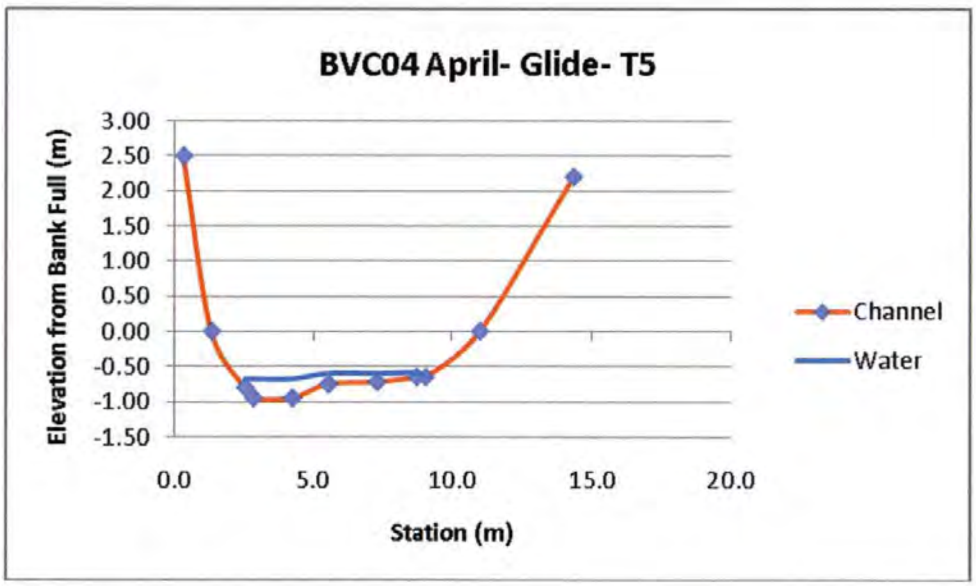

Figure 2.8-7: Channel Dimensions in Glide Habitat, Transect 5

<u>July</u>

In July 2008, the channel dimensions were essentially the same as measured during April, with some localized changes. Between the April and July field visits Beaver Creek experienced high flows that appeared to have resulted in somewhat less fine sediment in the pools, and transport of woody debris out of the survey reach. Stream discharge in July was 12.3 cfs, approximately 5 cfs higher than in April. The average wetted width measured was 6.9 meters in April and 7.5 meters in July.

The July air temperature reached 25° to 35° C and water temperatures were quite warm at 23° C to 24° C. As during April, riparian vegetation was limited to herbaceous and short shrubs, with only occasional trees. Shade along the banks was greater in July, since trees were generally bare in April and fully leafed-out in July. However, most of the stream channel itself was unshaded during both site visits indicating a high degree of solar warming is typical in Beaver Creek.

Within the BVC04 survey reach, habitat included 1 pool, 3 glides, and 3 riffles. The total length of riffles was 59.9, although two riffle segments ran to either side of an island. If these two are considered together, the riffle length measured 43.9 m.

As described under spring conditions, fine silt dominated the sediment composition of the reach and filled the larger part of the pools in at this site. Sand, gravel and cobbles dominate the substrate of the faster moving riffle and glides. The cumulative and proportional particle distribution of sediment for the BVC04 reach during the summer survey is shown in Figure 2.8-8 demonstrating a slightly higher proportion of gravel in the overall substrate composition than in April.

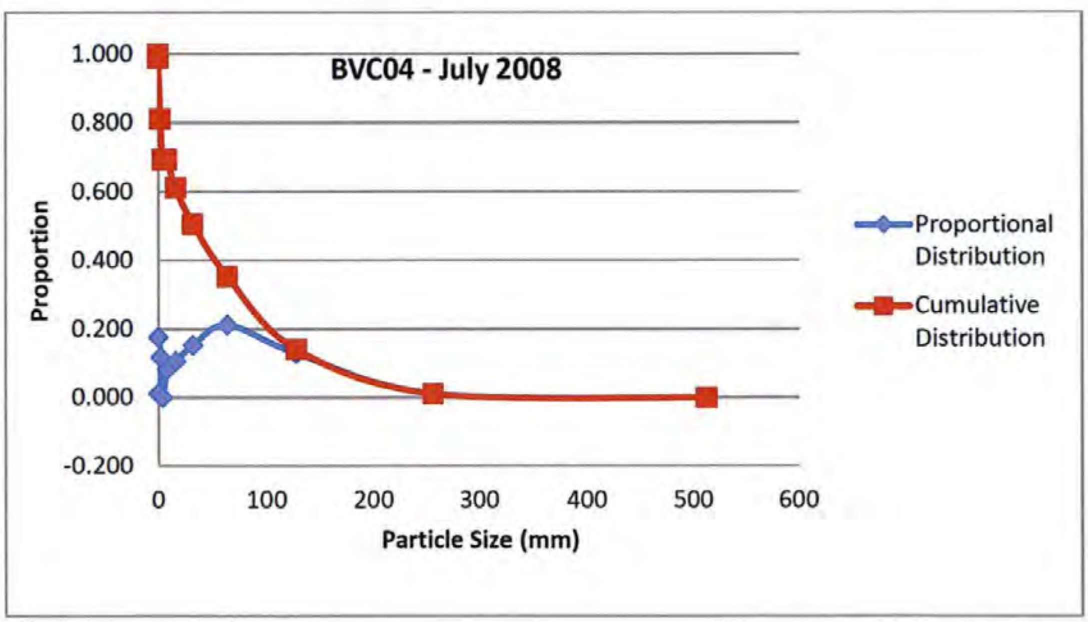

Figure 2.8-8: Cumulative Sediment Particle Distribution at Site BVC04, Transects 1 through 11 Combined during July

Large wood in the reach was essentially absent in July. Small pieces that had been present in April apparently were washed out of the survey reach during the peak flows that occurred in June.

The wetted stream width during the summer survey was 4.3 to 10.1 meters; bank-full width ranged from 6.0 to 11.2 meters; and the width at the top of bank was 15.0 to 21.0 meters. Bank height was 2.1 to 3.9 meters.

As mentioned previously, pools contained a large volume of silt. This silt reduces the depth and volume of the pools, reducing the quality and quantity of available fish habitat. Due to pool filling and lack of cover, pool quality is poor.

Site BVC01

Site BVC01 is located upstream of the Argentine Road bridge over Beaver Creek in Fall River County, SD. This site was selected as the test site as it is downstream of most proposed operations and all proposed land application sites.

At BVC01, Beaver Creek is still a low gradient, incised prairie stream as it is at BVC04. However, the stream gradient is slightly higher and banks are generally lower. Riparian habitat along BVC01 is more actively managed for cattle grazing than BVC04 and there are fewer trees and shrubs and more grass at BVC01 than at BVC04. Fine sediment was present in pools. However, there appeared to be less fine sediment in July indicating that high flows transported sediment out of this reach.

April

The preliminary average channel width at BVC01 was 7.35 meters. Sample transects were located 22 meters apart, with a total surveyed reach length of 220 meters.

During the April habitat and fish surveys, water temperature varied from 11.8° C to 16.9° C, indicating that stream temperature at this site is also variable during the day. As was the case at site BVC04, riparian vegetation at BVC01 was limited to herbaceous and short shrubs, with only a single boxelder tree in the survey reach. With the exception of the bridge, there was no shade present in the center of the channel and the creek is subject to substantial solar heating during the day.

Water was clear during the survey, although specific conductivity was high (7,186 µS/cm); somewhat higher than observed at BVC04. Discharge at BVC01 was 5.08 cfs on April 14, 2008.

Within the BVC01 survey reach, habitat included 3 pools, 2 glides, and 3 riffles. The total length of riffles was 28 meters.

Overall, gravel dominated the sediment composition of the BVC01 reach. The cumulative and proportional particle distribution of sediment for the BVC01 reach during the April survey is shown in Figure 2.8-9. This distribution indicates a predominance of gravel with some fine sediment. The fine sediment was primarily confined to pool areas.

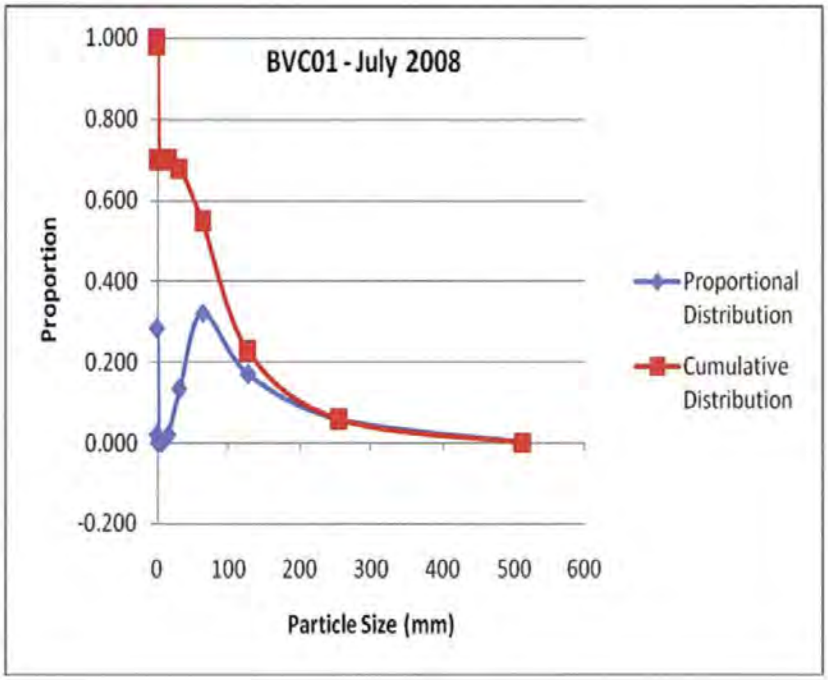

Figure 2.8-9: Cumulative and Proportional Sediment Particle Distribution at Site BVC01, Transects 1 through 11 Combined, April 2008

Beaver Creek is significantly incised along the BVC01 reach, although bank height was generally lower than at the upstream (BVC04) site. Bank slumpage was observed at nine transects and erosion at seven of the eleven transects in this reach. The wetted stream width during the April survey was 3.5 to 7.8 meters; bank-full width ranged from 6.5 to 10.2 meters; and the width at the top of bank was 12.0 to 17.4 meters. Bank height was 1.3 to 2.0 meters. Riparian land use is rangeland with no riparian buffer, cattle have access to the stream, especially in the vicinity of the bridge and transect 1. Woody vegetation is nearly absent from the vicinity of BVC01 and no woody debris was observed in the BVC01 survey reach.

Examples of channel dimensions in pool, riffle, and run habitat types are shown in Figures 2.8-10, 2.8-11, and 2.8-12 below.

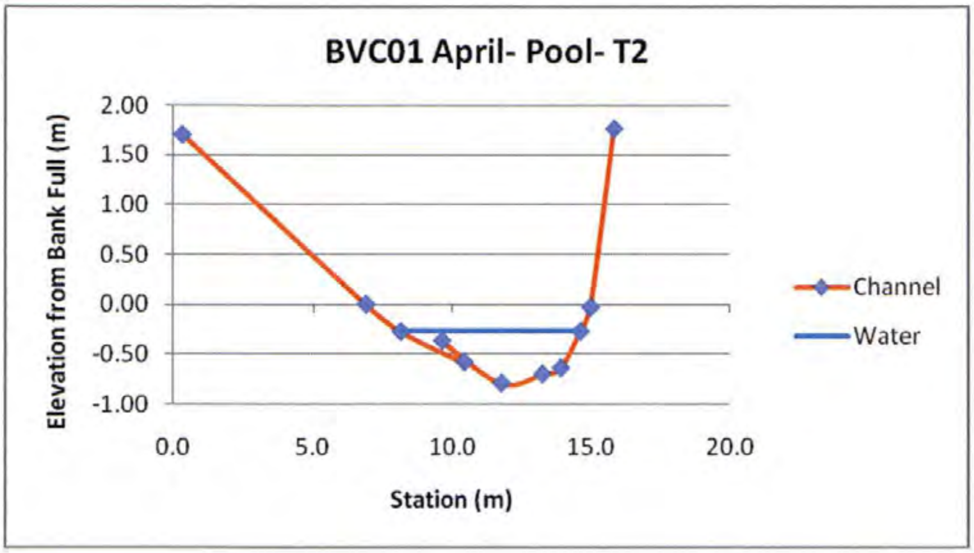

Figure 2.8-10: Channel Dimensions in Pool Habitat, Transect 2

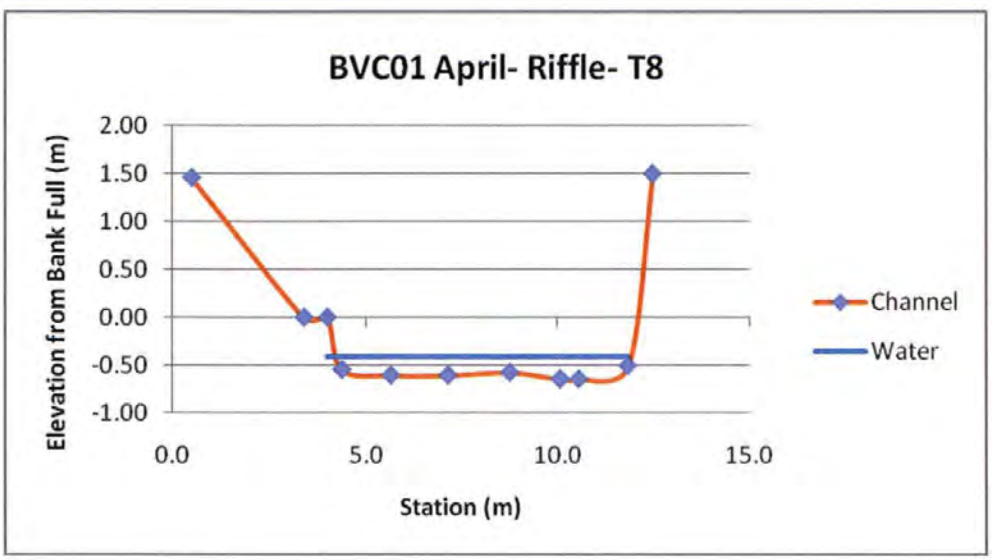

Figure 2.8-11: Channel Dimensions in Riffle Habitat, Transect 8

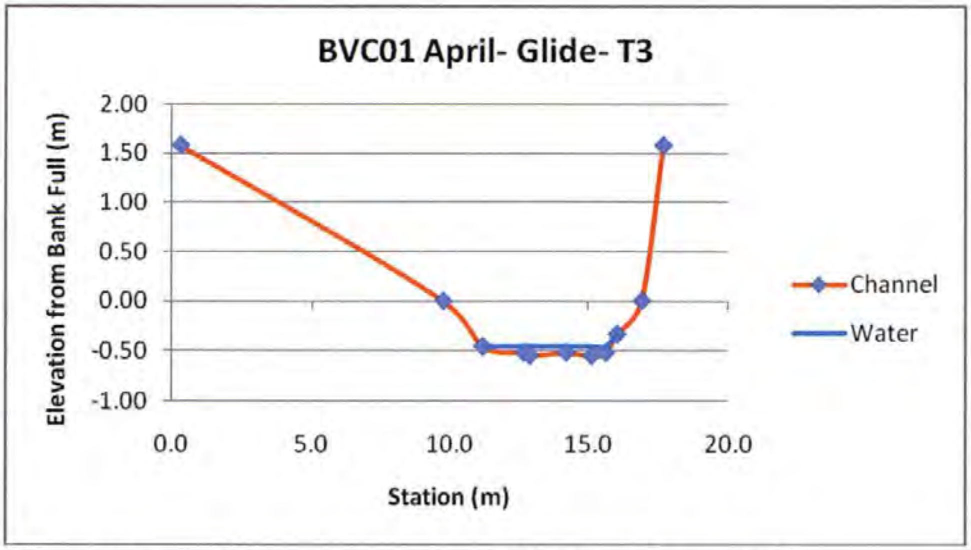

Figure 2.8-12: Channel Dimensions in Glide Habitat, Transect 3

Pools in reach BVC01 were not as deep or long as those in BVC04 and therefore were less conducive to fine sediment deposition. Due to shallow pool depth and lack of cover, pool quality was poor.

<u>July</u>

In July, 2008, the channel dimensions were essentially the same as measured during April, with some localized changes. The high flows that Beaver Creek experienced between the April and July field visits appeared to have resulted in somewhat less fine sediment in the pools. Stream discharge in July was 7.5 cfs, approximately 48 percent higher than in April. In both April and July, discharge was higher at the upstream site (BVC04) than at the downstream site (BVC01). The average wetted width 6.2 meters in April and 7.5 meters in July.

In July the air temperature at BVC01 a water temperatures of 24° C was recorded at 9:20 AM. Although trees were generally bare in April and fully leafed-out in July, the one tree in the riparian buffer was too far from the stream to provide shade to the wetted portion of the channel.

Within the BVC01 survey reach, habitat included 2 pools, 1 glide, and 2 riffles during July. The total length of riffles was 70.8 meters. This represented a change from what was observed in April that was due to increased flow and probably some redistribution of gravel substrate in the channel during high flows.

In contrast to April conditions, very little silt was observed within BVC01 during July. Where fine sediment was present it was restricted to slow moving water in pools and along banks. The cumulative and proportional particle distribution of sediment for the BVC01 reach during the summer survey is shown in Figure 2.8-13, demonstrating the dominance of gravel in the particle size distribution.

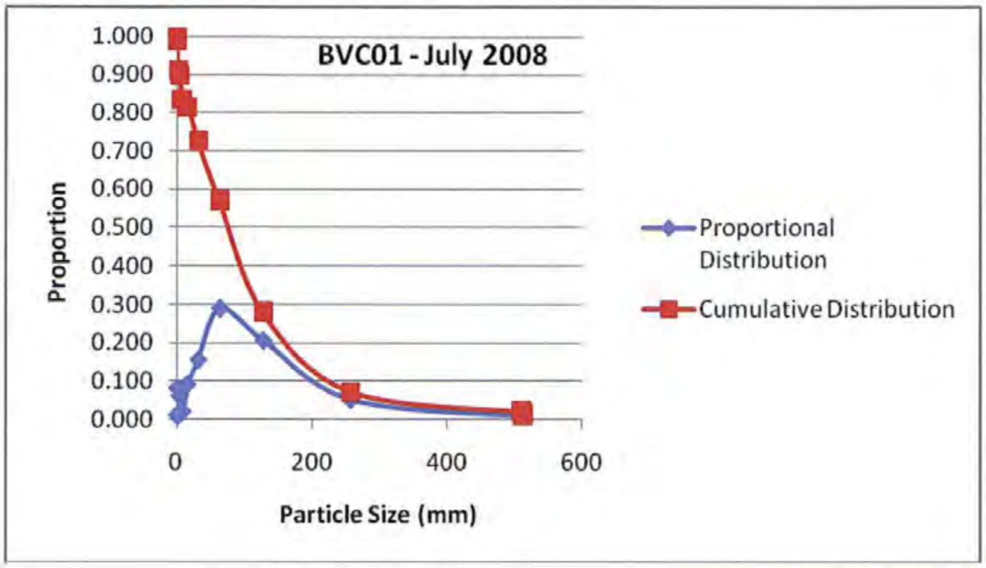

Figure 2.8-13: Cumulative Sediment Particle Distribution at Site BVC01, Transects 1 through 11 Combined during July

Large wood in the reach was essentially absent in July as in April.

The wetted stream width during the summer survey was 4.1 to 8.2 m; bank-full width ranged from 6.8 to 11.3 m; and the width at the top of bank was 12.6 to 18.9 m. Bank height was 1.5 to 2.8 m.

As mentioned previously, pools were considered poor due to lack of depth and cover. Emergent rushes (*Juncus* spp.) and submerged stonewort (*Chara* spp.) were observed growing along the banks in pools during the July survey providing some cover for small fish and substrate for aquatic invertebrates.

2.8.5.6.1.2.2 Habitat/Species Relationships

Benthic Invertebrates

Benthic invertebrates can be useful indicators of habitat quality, providing an index of quality that is integrated over time. Different taxa of aquatic invertebrates (primarily insects, crustaceans, and mollusks) exhibit different habitat requirements, feeding strategies, and tolerances to environmental perturbation. Therefore, there are several metrics of benthic invertebrate community composition that are indicative of aquatic habitat quality. Several of the most indicative and most commonly described of these metrics are summarized in Table 2.8-24.

The invertebrate communities sampled indicate poor habitat conditions in Beaver Creek. The counts of each taxa are shown in Table 2.8-25, and a synopsis of the Community composition metrics is shown in Table 2.8-26. The total number of invertebrates and the taxonomic richness (number of species) were both very low at both Beaver Creek sites. Ephemeroptera (mayflies) and plecoptera (stoneflies) were absent from both sites, indicating an impaired condition. Most taxa collected were moderately tolerant taxa. One individual of a sensitive taxa, *Lepidostoma*, and one individual of a very tolerant taxa, *Culiciodes*, were collected at the downstream site (BVC01) in April. All other taxa collected are considered moderately tolerant.

Table 2.8-24: Benthic Invertebrate Community Composition Metrics and Predicted Direction of Response to Perturbation

Category	Metric	Definition	Predicted response to increasing perturbation
Richness measures	Total taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
	Ephemeroptera taxa	Number of mayfly taxa (usually genus or species level)	Decrease
	Plecoptera taxa	Number of stonefly taxa (usually genus or species level)	Decrease
	Trichoptera taxa	Number of caddisfly taxa (usually genus or species level)	Decrease
Composition measures	% EPT	Percent composite of mayfly, stonefly, and caddisfly taxa	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/Intolerance measures	No. of Intolerant taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
	% Tolerant organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase
Feeding measures	% Filterers	Percent of the macrobenthos that filter fine organic particulate matter from the water column or sediment.	Variable
	% Grazers and Scrapers	Percent of the macrobenthos that scrape or graze upon periphyton	Decrease
Habitat measures	Number of clinger taxa	Number of taxa of clinging insects	Decrease
	% Clingers	Percent of insects having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease

Source:Barbour et al. 1999

Table 2.8-25: Benthic Macroinvertebrate Counts for Composite Samples Collected April and July 2008

	Site and Date			
	BVC01	BVC04	BVC01	BVC04
Taxa	14-Apr-08	14-Apr-08	9-Jul-08	9-Jul-08
Phylum:Mollusca Class:Gastropoda Order: Bassommatophora Family: Physidae	2		2	1
Phylum: Arthropoda Class: Insecta Order: Diptera Family: Ceratopogonidae Genus: *Culiciodes*	1			
Family: Chironomidae Subfamily: Orthocladiinae	14	33		2
Subfamily: Chironomnae		11		1
Subfamily: Tanypodinae			4	23
Family: Siluliidae Genus: *Simulium*	2			1
Order: Trichoptera Family: Hydropsychidae Genus: *Cheumatopsyche*				76
Family: Lepidostomadtidae Genus: *Lepidostoma*	1			
Family: Limnephilidae Genus: *Limnephilus*	3	2		
Order: Coleoptera Family: Elmidae			1	3

Table 2.8-26: Community Composition Metrics for Benthic Macro-invertebrates Collected at the Beaver Creek Sites

							Abundance			
			Functional Feeding Group		Habitat/ Behavior		BVC01	BVC04	BVC01	BVC04
Measures	**Taxa**	**Tolerance**	**Primary**	**Secondary**	**Primary**	**Secondary**	**April**	**April**	**July**	**July**
Taxa	Physidae	8	SC				2		2	1
	Culicoides	10	PR	GC	bu		1			
	Orthocladiinae	5	GC		bu		14	33		2
	Chironominae	6	GC					11		1
	Tanypodinae	7	PR		bu				4	23
	Simulium	6	FC				2			1
	Cheumatopsyche	5	FC							76
	Lepidostoma	1	SH				1			
	Limnephilus	5	SH		sp		3	2		
	Elmidae (early instar)	4	GC		cn	bu			1	3
Abundance	Abundance						23	46	7	107
Richness	Total Taxa						6	3	3	7
	EPT Taxa						3	1	0	1
	Ephemeroptera Taxa						0	0	0	0
	Plecoptera Taxa						0	0	0	0
	Trichoptera Taxa						3	1	0	1
Composition	% EPT Taxa						17.4%	4.3%	0.0%	71.0%
	% Ephemeroptera						0%	0%	0%	0%
Tolerance	Number of Intolerant Taxa						1	0	0	0
	% Tolerant Macrobenthos						13.0%	0.0%	28.6%	0.9%
	% Dominant Taxa						60.9%	71.7%	0.0%	1.9%
Feeding	% Filterers						8.7%	0.0%	0.0%	72.0%
	% Grazers & Scrapers						69.6%	95.7%	42.9%	6.5%
Habitat	Number of Clinger Taxa						0	0	0	0
	% Clingers						0%	0%	20%	3%
Notes:	SC=Scraper, PR = Predator, GC = Gatherer collector, FC = Filterer/collector, SH = Shredder									
	bu = burrower, sp = sprawler, cn = clinger									
	Tolerance scores on scale of 1-10 with 1 being most sensitive, and 10 most tolerant of environmental stressors									

The downstream site, BVC01, had very low abundance, particularly in the July samples. During the month of June 2008, very high flows occurred in Beaver Creek. It is likely that the high flows mobilized a large volume of sediment and probably resulted in considerable scouring of the sediment, particularly at this site. The reduced macro-benthos present in July may have been due, at least in part, to the high flows that occurred in June.

During a year with more moderate flows, the macro-benthos would likely show an increase in abundance and taxonomic richness throughout the growing season, while a year with drought conditions might have no flow in the riffles where the greatest diversity of benthic invertebrates is typically seen.

High pH, conductivity, temperatures and a high volume of fine sediment all may contribute to the de-pauperate invertebrate communities observed in Beaver Creek.

2.8.5.6.1.2.3 Fish

A total of 12 fish species were collected from the three sampling locations: BVC04 – Beaver Creek upstream of the PA; BVC01 – Beaver Creek downstream of the PA; and CHR05 – Cheyenne River downstream of the confluence of Beaver Creek. The species, trophic category, and habitat notes are summarized in Table 2.8-27. The abundance (presented as catch per unit effort or fish per meter of stream length), and average sizes of fish are shown in Table 2.8-28. Fish collection data forms are presented in Appendix 2.8-J of the approved license application.

Table 2.8-27: Fish Species and Trophic Categories

Species Code	Common Name	Latin Name	Trophic Category	Notes
SAS	Sand shiner	*Notropis stramineus*	Omnivore	
CRC	Creek chub	*Semotilus atromaculatus*	Primarily carnivorous omnivore	
PLM	Plains Minnow	*Hybognathus placitus*	Primarily herbiverous	Generally in slower water and side channels of turbid streams. Eats benthic algae & other plant material.
CAP	Common carp	*Cyprinus carpio*	Omnivore	Introduced species. Bottom feeder.
LND	Longnosed dace	*Rhynichthys cataractae*	Primarily carnivorous omnivore	Primarily in riffles
FHM	Fathead minnow	*Pimephales promelas*	Primarily herbiverous	Widely cultivated for bait, and extensively used in toxicological studies
RIC	River Carpsucker	*Carpoides carpio*	Bottom feeding omnivore	
SHR	Shorthead Redhorse Sucker	*Moxostoma macrolepidotum*	Bottom feeding carnivore	
CHC	Channel Catfish	*Ictalurus punctatus*	Bottom feeding omnivore	Species most likely to be eaten by humans.
PLT	**Plains topminnow**	*Fundulus sciadicus*	**Surface feeding carnivore**	
PLK	Plains Killifish	*Fundulus zebrinus*	Surface feeding carnivore	
GRS	Green sunfish	*Lepomis cyanellus*	Carnivore	Palatable but generally too small for human consumption

Bold species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

Table 2.8-28: Summary of Fish Size and Abundance

Location	Date	Common Name	CPUE (fish/m)	Average total length (mm)	Average weight (g)
CHR05 – Cheyenne River at Marietta	4/15/08	Green sunfish	0.01	98	20
		Sand shiner	0.53	48	4.6
		Creek chub	1.00	47	0.9
		River Carpsucker	0.01	97	13
		Shorthead Redhorse Sucker	0.14	145	115
		Plains topminnow	**0.01**	**51**	**<1**
		Plains killifish	0.48	49	1.5
CHR05 – Cheyenne River at Marietta	7/09/08	Common carp	0.01	135	31
		Longnosed dace	0.01	74	4
		Fathead minnow	0.10	47	0.7
		Sand Shiner	0.45	49	1.5
		Shorthead Redhorse Sucker	0.14	153	39
		River Carpsucker	0.04	407	1,038
		Channel catfish	0.03	222	88
		Plains killifish	0.07	58	1.9
BVC01 – Beaver Creek at Argentine Road	4/16/08	Fathead minnow	0.64	48	1.3
		Plains killifish	0.02	45	4
		Longnosed dace	0.01	48	<1
		Green sunfish	0.01	120	25
BVC01 – Beaver Creek at Argentine Road	7/10/08	Common carp	0.01	171	73
		Sand Shiner	0.10	50	1.1
		Fathead minnow	0.33	50	1.5
		Longnosed dace	0.01	59	2
		Plains minnow	0.01	73	1
		Plains topminnow	**0.06**	**56**	**2**
		Plains killifish		60	1.8
BVC04 – Beaver Creek at old Hwy 85 Bridge	4/16/08	Common carp	0.03	75	9.3
		Fathead minnow	0.84	45	1.1
		Channel catfish	0.01	215	72
		Plains killifish	0.10	44	1.4
		Green sunfish	0.04	66	7.5
BVC04 – Beaver Creek at old Hwy 85 Bridge	7/10/08	Common carp	0.01	260	230
		Sand Shiner	0.26	52	1.3
		Fathead minnow	0.47	50	1.4
		Longnosed dace	0.02	63.5	2.5
		Shorthead redhorse sucker	0.01	136	130
		Plains killifish	0.09	55	1.4

Notes: 1CPUE = Catch per unit effort.

Bold species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

2.8.5.6.1.2.3.1 Locally Significant Fish Species

Recreational anglers fish Beaver Creek, although the Cheyenne River and Angostura Reservoir provide greater fishing opportunities in the area. Channel catfish is the species most likely to be caught and eaten from Beaver Creek.

Hampton (1998) calculated the relative weight index (Wr) for channel catfish in the Cheyenne River to assess the condition of this species in the Cheyenne River. Hampton (1998) reported a curvilinear relationship between weight and length (Ws=63.75 +5,780/L where Ws= standard weight, and L= total length). Comparing the weight/length ratio of channel catfish collected in this study to the standard weight (Ws) described above, the relative weight (Wr=100*W/Ws) can be used as an indicator of fish condition. Generally, relative weights greater than 100 indicate better than average condition and those less than 100 indicate poorer than average condition. The weight of the largest (290 mm) channel catfish collected from the Cheyenne River had a very high relative weight (Wr = 198) while the other catfish collected from the Cheyenne River had low relative weights (Wr = 51 and 52), and the one channel catfish collected from Beaver Creek (at BVC04) had a moderately low relative weight (Wr=79). Although the average Wr for the Cheyenne River channel catfish (100.8) indicates good agreement with Hampton's (1998) modeled relationship, the weight/length ratio of individual fish varied considerably. A larger sample size would be needed to draw any conclusions about the relative condition of fish from these sites.

Relative weights are shown in Table 2.8-29 below.

Table 2.8-29: Relative weight index for channel catfish collected at Beaver Creek and Cheyenne River

Site	Date	Length	Weight	Standard Weight (Ws)	Relative Weight (Wr)
BVC04	Apr-08	215	72	90.6	79.4
CHR05	Jul-08	290	166	83.6	198.4
CHR05	Jul-08	186	50	94.8	52.7
CHR05	Jul-08	181	49	95.6	51.2
CHR05 Average					100.8

2.8.5.6.1.2.3.2 Threatened and Endangered Aquatic Species

No threatened or endangered aquatic species are known to inhabit Beaver Creek, particularly within 1.0 mile of the permit boundary.

2.8.5.6.1.2.4 Radiological Testing

The channel catfish was the only species collected in April that contained detectable uranium (0.05 mg/kg, and 3 X 10^{-5}µCi/kg) (Table 2.8-23). This species was collected from the downstream Beaver Creek site (BVC04). In July, channel catfish were collected from the Cheyenne River site (CHR05). The channel catfish is the only species collected in the PA that is typically caught for human consumption.

Uranium was detected in all of the fish collected in July 2008 due, in large part, to increased sample sizes (Table 2.8-23). As indicated, April samples showed little, if any, detectable uranium, however, the detection limits were higher during that sampling effort due to matrix interference. Therefore, it is not possible to determine if there was an actual seasonal difference in fish tissue uranium concentration. Uranium concentrations and uranium radioactivity were generally low and similar across sample sites when compared by species. Radioactivity from Polonium-210, Thorium-230, and Radium-226 was detectable, but low in most samples. Lead-210 was only detected in one specimen (plains killifish [*Fundulus zebrinus*]) collected in April at the downstream Beaver Creek site (BVC01). Although this measurement was relatively high (0.02 µCi ±0.02 µCi), it should be noted that, due to matrix interference, the precision was limited on this sample. Lead-210 was not detected in any of the other samples.

2.8.5.7 References

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2.9 Baseline Radiologic Characteristics

2.9.1 Introduction

This section provides baseline radiological data for surface soils (0-5 and 0-15 cm), subsurface soils to a depth of 1 meter, vegetation, locally grazed cattle and a pig, direct radiation, radon-222 in air; and radon-222 flux rates representative of the project property. The work was performed by Environmental Restoration Group (ERG) between August 2007 and July 2008, with additional food sampling in April 2011.

Field investigations, sample collection, and other quality-related work performed were conducted in accordance with applicable ERG standard operating procedures (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 PA.
- 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 PA.
- 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 Air Monitoring Stations (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 High Pressurized Ion Chamber (PIC) and thermoluminescent detectors (TLDs).
- Collecting samples of locally grazed livestock including beef and a pig.

Table 2.9-1 summarizes the scope of the field investigation. 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 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 2.9, however, adopts the unit picocuries per gram (pCi/g) for this parameter, as this unit is used more generally and consistently by the uranium industry and public.

Table 2.9-1: 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 plus commitment to collect 15 additional samples in the Dewey area. 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 onsite (AMS-01 through AMS-07) and one located approximately 1.9 miles west of the southwest corner of the permit area (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 onsite (AMS-01 through AMS-07) and one located approximately 1.9 miles west of the southwest corner of the permit area (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 and one sample each from one additional cow and one pig. Commitment to sample one additional cow and two additional pigs prior to ISR operations.	Radium-226, thorium-230, natural uranium, lead-210 and polonium-210
J. Soil Sampling in Local Vegetable Gardens	Commitment to sample vegetable garden soil and apply plant-to-soil concentration factors to estimate radionuclide concentrations in vegetables prior to ISR operations.	Natural uranium, thorium-230, radium-226, lead-210 and polonium-210.

2.9.1.1 References

Code of Federal Regulations, 10 CFR 40, *"Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content"*.

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2.9.2 Gamma Survey

2.9.2.1 Methods

2.9.2.1.1 Baseline GPS-Based Gamma Surveys

Survey Methodology

A GPS-based gamma survey was conducted over the main and surface mine areas of the project in September 2007 and July 2008. The initial GPS-based gamma survey was performed in the Main Permit Area and Surface Mine Area using 500-meter and 100-meter transect spacing, respectively, from September 13-27, 2007. The boundary of the Main Permit Area was later extended to the southwest. Refer to Figure 2.9-6 for the locations of the Main Permit Area and Surface Mine Area. The 500-meter survey lines were extended south to this new boundary by mobilizing to the site and conducting the survey on July 14, 2008. Work continued from July 17-19, 2008, where additional data within the Land Application Areas were obtained to comply with the desire to have data on 100-meter transect spacing therein. Transects at a spacing of 100 meters were added within the previously determined 500-meter transects within the Land Application Areas only. Land Application Areas are depicted on Figure 3.1-1. Figures 2.9-3 and 2.9-4 indicate the locations of the gamma-ray surveys.

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 main project area 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.

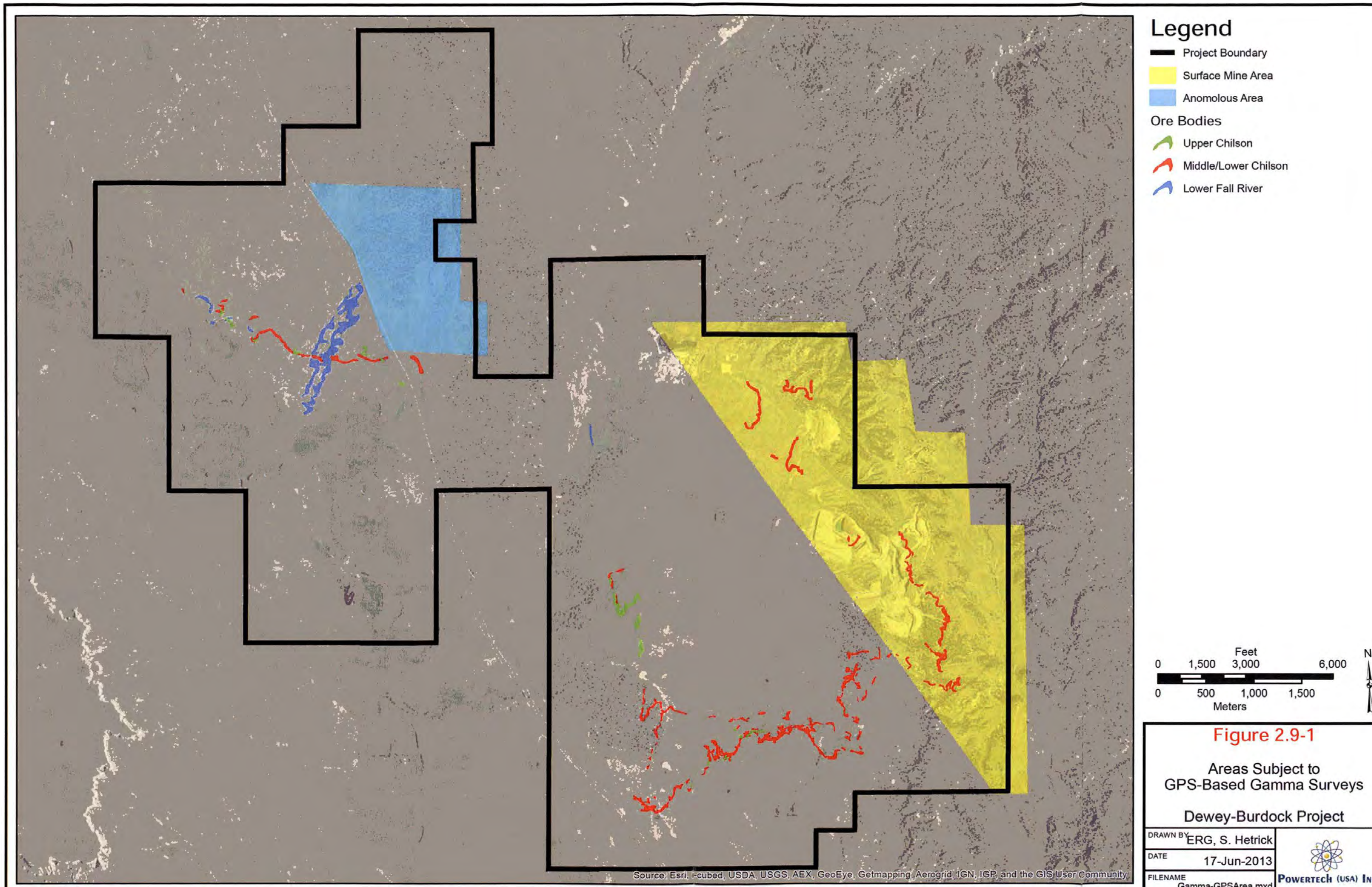
A second GPS-based gamma survey was conducted over the land application areas from July 17-19, 2008, using the Ludlum gamma-ray detection system described above with the same response characteristics as used in the initial survey. The scanning speed and detection height were unchanged from the initial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

The areas subject to GPS-based gamma surveys are shown on Figure 2.9-1.

<u>Combining Data from Two Surveys</u>

The use of a correlation to predict the Ra-226 in soil requires that all data, including the gamma survey and correlation data, be collected under similar soil moisture conditions. All data were gathered in fair weather during the late summers of 2007 and 2008 under similar soil moisture conditions. No effect on the gamma ray count rate-soil Ra-266 correlation is expected nor was one observed.

Another consideration when combining data from two surveys is whether the data from 2007 and 2008 may be combined because of possible different background count rates. A search for overlapping 2007/2008 areas was completed, concentrating on overlap areas considered free of anomalies. Ten areas of overlapping data (within 3 feet) were identified and corresponding count rates were recorded and compared, as shown in Table 2.9-1a. The results confirm that the survey instruments produced count rates that were similar, with a mean ratio of the two count rates of 1.01 and a maximum difference of any two data points of 15 percent. An Anderson-Darling test was done to see if the differences of the paired data were of a normal distribution. The results of the Anderson-Darling test for normality yielded a p-value of 0.093 (cannot reject normal distribution hypothesis). Then a paired t-test was performed to determine whether the differences were significantly different from 0. The results of the paired t-test were a p-value of 0.787 (cannot reject zero-difference hypothesis), an average difference of 84 cpm, and a 95% confidence interval on the average difference of (-603 cpm, 772 cpm). In summary, the two data sets are not statistically different from one another and combining the data sets has no impact on the statistics when summarizing the gamma count rate in and around the project area.



Legend
Project Boundary
Surface Mine Area
Anomolous Area
Ore Bodies
Upper Chilson
Middle/Lower Chilson
Lower Fall River
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500
Meters
N
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Figure 2.9-1
Areas Subject to GPS-Based Gamma Surveys
Dewey-Burdock Project
DRAWN BY ERG, S. Hetrick
DATE 17-Jun-2013
FILENAME Gamma-GPSArea.mxd
POWERTECH (USA) INC.

Table 2.9-1a: Data Pairs from 2007 and 2008 Gamma Surveys

Location	2007 Count Rate (cpm)	2008 Count Rate (cpm)	Ratio 2007:2008
1	12,721	14,985	0.85
2	12,060	11,309	1.07
3	12,186	11,299	1.08
4	11,958	11,562	1.03
5	15,016	15,074	1.00
6	13,358	13,752	0.97
7	13,829	13,970	0.99
8	12,685	12,207	1.04
9	15,788	14,633	1.08
10	12,979	12,945	1.00
		Mean	1.01

A significant effort was made to match the instrument responses to background radiation and radiation sources prior to deployment for the 2007 survey. In preparing for the 2008 survey, the instrument performances were again matched to one another and to the performances of the instruments used in 2007. Since the instrument responses in background areas were the same for the 2007 and 2008 surveys, Powertech (USA) concludes that the background radiation was very similar for the two surveys and that merging the data was appropriate.

A statistical evaluation of the total data set and sets of data corresponding to defined areas is presented in the Baseline Radiological Report (Appendix 2.9-A of the approved license application), including tests for normality and log transforms. All frequency distributions were found to be nonparametric, and conventional approaches were used to describe these distributions. Powertech (USA) does not believe that a test of variance of the three defined areas would add meaningful information to the discussion regarding the Main Permit Area, the anomalous north area, and the Surface Mine Area since the anomalous north area and the Surface Mine Area are clearly different from the remainder of the Main Permit Area based on historical use and geological features.

Technical Justification for Transect Spacing

Regulatory Guide 4.14 recommends a total of 80 direct radiation measurements at 150 m (492 ft) intervals up to a distance of 1,500 m (4,921 ft) in eight directions from the center or 5 or more direct radiation measurements at the locations used for collection of particulate samples once prior to site construction. As an alternative to the Regulatory Guide 4.14 guidance, Powertech (USA) co-located TLDs with the air particulate samplers and collected additional direct radiation measurements (gamma-ray surveys) using ATVs as discussed below. The number of direct gamma measurements collected by Powertech (USA) (157,057) greatly exceeds the number recommended in Regulatory Guide 4.14 (80).

The gamma transect spacing was intentionally small when surveying suspected radiologically anomalous areas. A larger spacing (500 m) was used for areas not anticipated to be impacted by naturally occurring radioactive materials (NORM), and a smaller spacing (100 m) was used for known or potential NORM impacted areas. While this work was done prior to recently published data by Whicker, et al. (2008), Powertech (USA) believes that the methods are similar to and consistent with that publication. Whicker et al. did not recommend transect spacing. They reported typical transect spacing that they used for certain situations (including surveys for cleanup). Powertech (USA) does not believe that the authors intended to establish a standard method. The measure of success for the gamma survey is determined by asking the questions: did the survey adequately determine the mean and variance of the exposure rates for areas within the site, and did it identify areas with highly varying exposure rates commonly referred to as anomalous areas? Powertech (USA) believes that the answer to both questions is yes.

The technical justification for the 500-meter transect spacing is based on the assumption that mineralized ore outcrops were not anticipated in areas where this transect spacing was used. Therefore, non-impacted areas were expected to be made up of large areas of different soil types or large fields having a unique history of fertilizer applications, if any. The characteristic sizes of these areas were expected to be large compared to 500 meters.

Data from the surveys were evaluated at the end of each day to determine whether the gamma count rates were consistent with the assumptions. Data anomalies were investigated and, where appropriate, the transect spacing and areal extent of the survey were changed to bound the anomaly. During the survey, an exposure-rate anomaly near a flowing artesian well was discovered and additional measurements were made to delineate the area. The data also showed that a region at the north end of the site had a slightly higher average exposure rate. However, an evaluation in the field indicated that the variance was not high and that this anomalous region was due to different geology. Also the gamma survey boundary was extended in the Surface Mine Area so that an anomaly on the original survey boundary could be bounded. These daily evaluations of the data and changes to the survey density were made to correct for small departures from the conditions that were assumed when developing the plans.

Considering Variations in Background Count Rates during Cleanup Operations

10 CFR Part 40, Appendix A, Criterion 6(6) decommissioning regulations limit the radionuclide concentrations in soil. Compliance with the cleanup criteria is based on laboratory analysis of soil samples. While it is true that gamma-ray action levels are used to identify anomalies, the accuracy of the action levels is known to be limited, due to changes in background count rates, vertical distribution and aerial extent of radionuclides, soil moisture, and other factors. Experience has shown that results of gamma surveys cannot be reliably interpreted if done when there is excessive soil moisture. This limitation in itself reduces the variation in background count rates during cleanup operations. Action levels are conservatively set and periodically revaluated during cleanup, especially when known changes may influence gamma-ray emissions. The confidence lines of correlations such as in those shown in Figures 5-1 and 5-2 in Appendix 2.9-A of the approved license application are useful in establishing conservative gamma-ray action levels. Normally the application of these conservatively chosen action levels results in cleanup to near background levels, in accordance with NRC's ALARA policy.

2.9.2.1.2 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 micoRoentgens per hour (μR/h) 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 (USA) 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 in, 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 in. 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 2.9-2.

2.9.2.1.3 Gamma/Radium-226 Correlation

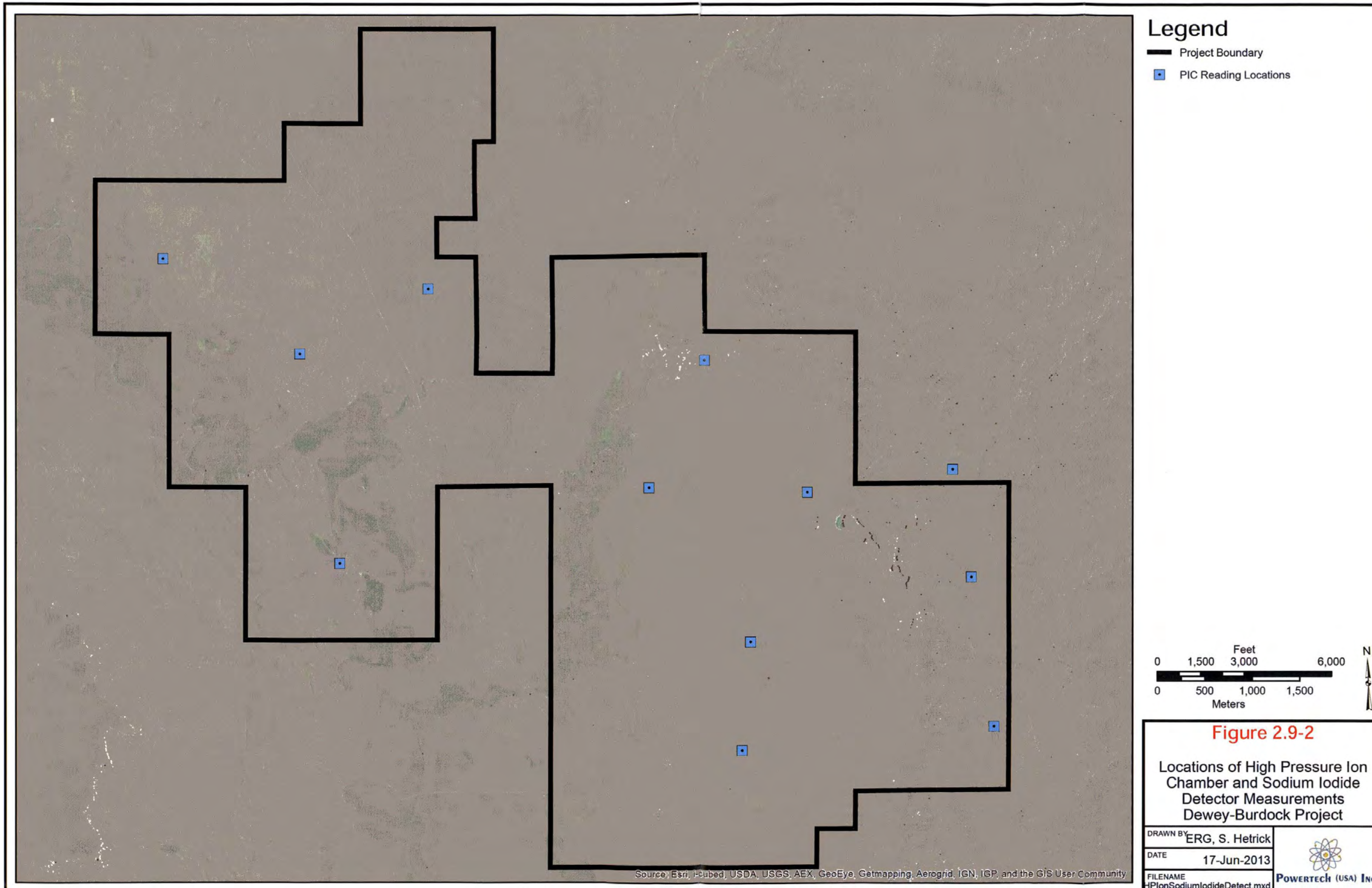
To estimate site-wide radium-226 concentrations at each of the GPS-based gamma survey points, a correlation was established by performing a regression between the surface soil analytical results for radium-226 in the 80 surface (0 to 15 cm) soil samples and one-minute integrated direct radiation measurements 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 was used to map the predicted site-wide radium-226 concentrations. The input parameters to ArcView GIS were gross gamma-ray count rates, in counts per minute (cpm), measured using matched sodium iodide detectors and recorded during the GPS-based survey. The results obtained from ArcView GIS were the predicted Ra-226 concentrations, in pCi/g, calculated using Equation 2.2 given in Section 2.9.2.2.3:

$$\textit{Ra-226 Concentration} = 1.9*10^{-4} \times \textit{Gamma-Ray Count Rate} - 1.04$$

2.9.2.1.4 Data Quality Assurances/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 2.9-A of the approved license application. Appendix 2.9-A of the approved license application includes a description of the criteria (including the basis for the criteria) used to evaluate the acceptability of the daily function tests.



Legend
Project Boundary
PIC Reading Locations
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500
Meters
N
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Figure 2.9-2
Locations of High Pressure Ion Chamber and Sodium Iodide Detector Measurements Dewey-Burdock Project
DRAWN BY ERG, S. Hetrick
DATE 17-Jun-2013
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2.9.2.2 Gamma Survey Results

2.9.2.2.1 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 gamma data from the Main Permit Area, Surface Mine Area, and both land application areas (Dewey and Burdock) were analyzed separately with the statistical software package Minitab, version 15.1.1.0. Output graphs from Minitab are provided in Appendix 2.9-L of the approved license application.

The observed gamma-ray count rates are presented as colors representing ranges of counts in Figure 2.9-3. 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 main project area.

None of the data sets: the entire permit area, and gamma data obtained in the main permit and surface mine areas are normally, 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 interquartile 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).

Several tools were used to identify potential outliers, including histograms, distribution tests, and probability plots. Support for the use of box plots and IQRs to screen outliers is found in Chapter 12 of *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (EPA, 2009). In any case, it is important to clarify that potential outliers were identified for informational purposes (e.g., to determine whether the data sets could be described by various distributions without the potential outliers included). The potential outliers defined using the IQR method were not removed or discounted in the statistical analysis of the GPS gamma data.

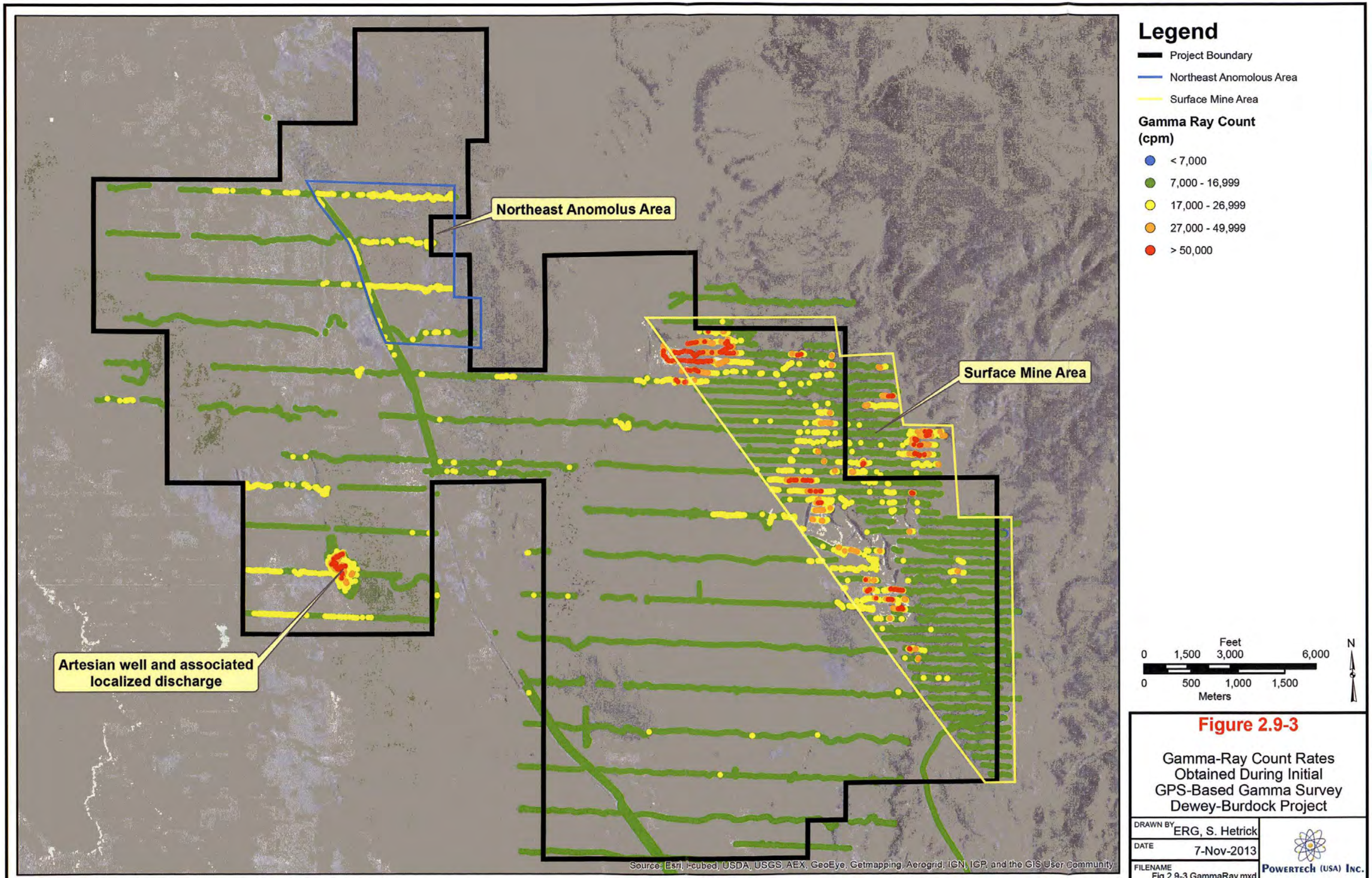


Figure 2.9-3

Gamma-Ray Count Rates Obtained During Initial GPS-Based Gamma Survey Dewey-Burdock Project

The summary statistics of the GPS-based gamma-ray survey are listed in Table 2.9-2. The median of the gamma-ray count rates for the overall data set was 12,687 counts per minute (cpm). Field personnel collected 157,075 readings ranging from 5,550 to 460,485 cpm.

Table 2.9-2: 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 Permit Area**	**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.

Main Project Area

As shown in Table 2.9-2, the median gamma-ray count rate for the main project area data set was 12,664 cpm for 75,345 observations. The count rates ranged from 5,883 to 171,243 cpm. Low outliers in the main project area 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 main project area. The area is identified as an anomalous area on Figure 2.9-1.

Approximately 0.2 and 3 percent of the gamma-ray count rates observed in the main project area are comprised of low and high outliers, respectively.

The majority of high outliers are located in the north section of the main project area. 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

As indicated above, 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 permit area. 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 project land application areas are listed in Table 2.9-3. The gamma-ray count rates obtained in the main permit area are listed in the table to facilitate comparison between the land application areas and the larger area in which they occur. The data are shown as ranges of count rates on Figure 2.9-4.

Gamma-ray count rates in the land application areas are similar to those obtained in the larger main permit area. 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 2.9-3: Statistical Summary of Gamma-Ray Count Rates in Land Application Areas

	Gamma-Ray Count Rate (cpm)		
		Land Application Area	
Estimator/Endpoint	**Main Permit Area**	**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

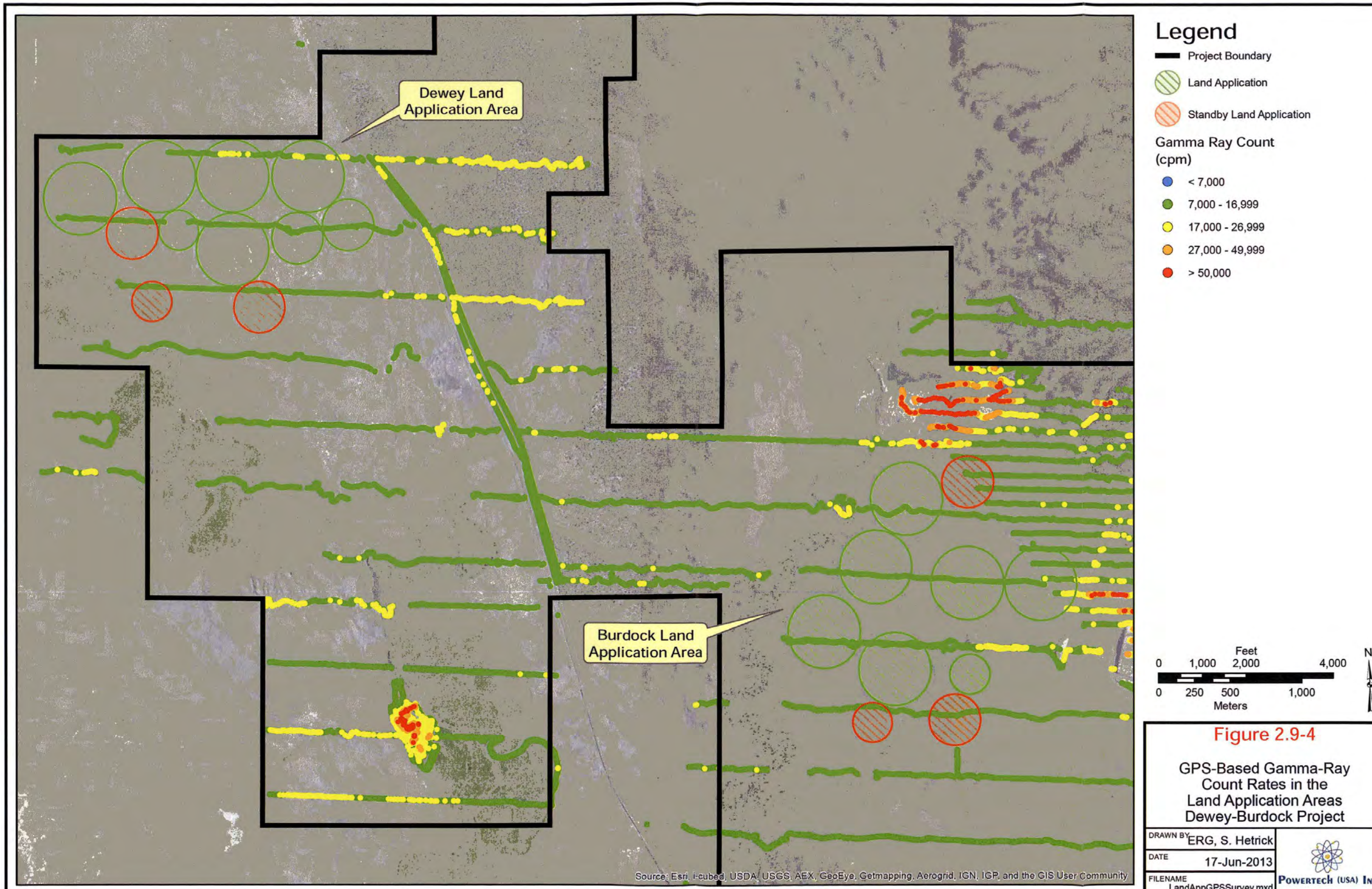


Figure 2.9-4

GPS-Based Gamma-Ray Count Rates in the Land Application Areas Dewey-Burdock Project

2.9.2.2.2 Results of Cross-Calibration of Sodium Iodide Detectors and 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 2.9-5. The correlations are similar for the individual sodium iodide detectors and not discussed further.

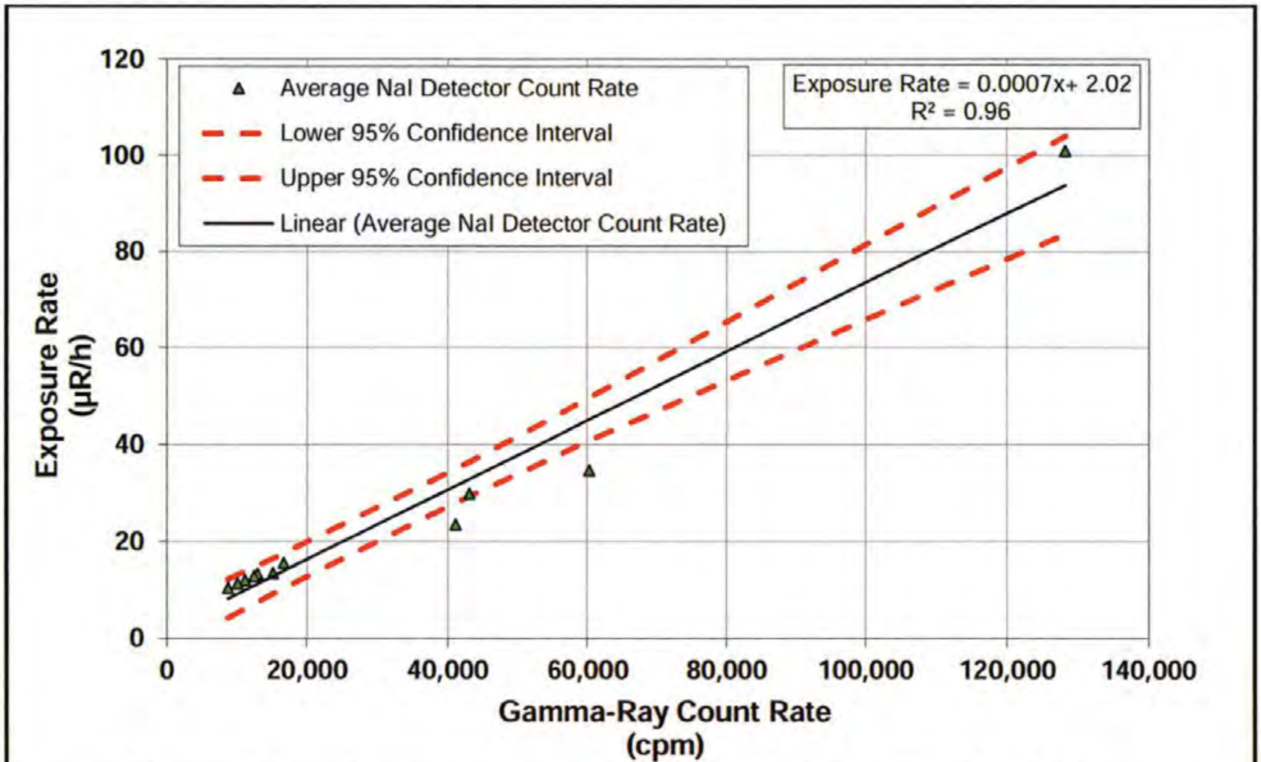
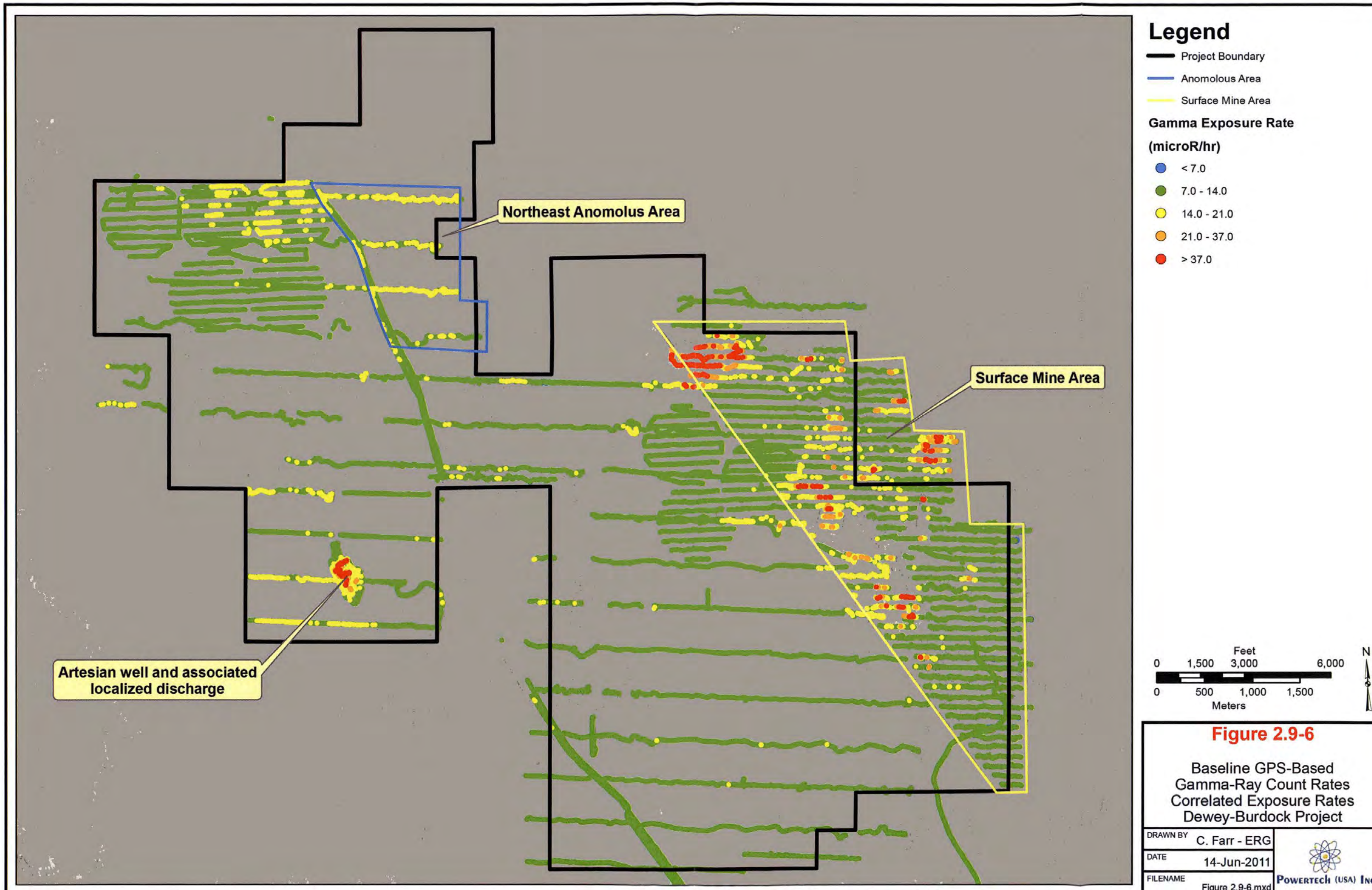


Figure 2.9-5: Linear Regression of Gamma Count Rate Data and PIC Measurements, Including the 95% Confidence Interval

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 a minimum count rate cutoff of 5,500 cpm and the maximum observed gamma count rate of 460,485 cpm. The predicted site-wide exposure rates are shown on Figure 2.9-6. ArcView GIS was used to map gamma survey data. The



Legend
Project Boundary
Anomolous Area
Surface Mine Area
Gamma Exposure Rate
(microR/hr)
< 7.0
7.0 - 14.0
14.0 - 21.0
21.0 - 37.0
> 37.0
Northeast Anomolus Area
Surface Mine Area
Artesian well and associated localized discharge
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500
Meters
N
Figure 2.9-6
Baseline GPS-Based Gamma-Ray Count Rates Correlated Exposure Rates Dewey-Burdock Project
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DATE 14-Jun-2011
FILENAME Figure 2.9-6.mxd
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input parameters to ArcView GIS were gross gamma-ray count rates, in counts per minute (cpm), measured using matched sodium iodide detectors and recorded during the GPS-based survey. The results obtained from ArcView GIS were the predicted exposure rates, in μR/hr, calculated using the equation given above. Figure 2.9-6 is intended for informational purposes only, to qualitatively evaluate the relative spatial distribution of exposure rates across the project area. No interpolation or other method to spatially predict gamma exposure rate within the project area was used.

The error estimates associated with the data on Figure 2.9-6 are based on the linear regression correlation of the gamma count rate data and PIC measurements. The 95 percent confidence interval of the regression line is shown in Figure 2.9-5. For predicted exposure rates near the median gamma count rate, the upper and lower 95 percent confidence limits are within 35% of the predicted value.

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

Linear regression modeling was used to provide a correlation between the concentration of Ra-226 in soil and the gamma count rate. This is standard industry practice. For decades the uranium industry decommissioning programs have relied on gamma count rate/Ra-226 correlations to identify land areas with Ra-226 contaminated soils requiring removal.

Two linear regression models were developed. The equations and descriptive statistics for each model are shown in Table 2.9-4. Equation 2.1 was developed using all soil data, while Equation 2.2 was developed using the same data but with five outliers excluded. The R^2 value for Equation 2.1 is higher than Equation 2.2. While the higher R^2 value often indicates a better fit, in this case Equation 2.2 better represents the concentrations of Ra-226 in soil as described below.

Plots of residuals (actual data minus predicted values from the equations) for both equations show increasing deviation with increasing gamma count rate. This is demonstrated in Figures 2.9-6a and 2.9-6b. This increasing deviation violates the assumption of constant variance that is used in linear regression. Therefore, the use of R^2 as a measure of the adequacy of a model is not appropriate.

Equation 2.2 (the linear regression model with five outliers excluded) was selected based on an evaluation of results of data analysis that compare the two linear regression models using two distinct equations, which indicated that the selected equation produced the best fit of data. Instead of using the R^2 value, the model predictions were directly compared to the data by examining the median and quartiles. The median and quartiles predicted by Equation 2.2 are very close to the median and quartiles of the data and are much closer than the median and quartiles of Equation 2.1. Therefore, Equation 2.2 was used to predict concentrations of Ra-226 in soil.

Table 2.9-4: Predicted Radium-226 Concentrations from Two Linear Regression Models Compared to Actual Data

Linear Regression Model Equation	Soil Data	R^2	Gamma Count Rate (All) (cpm)	Predicted Ra-226 Soil Concentration (pCi/g)
2.1) [Ra-226] = -0.87 + 0.0002*GCR	All	0.75	Median (12,687)	1.7
			1st Quartile (11,395)	1.4
			3rd Quartile (14,437)	2.0
2.2) [Ra-226] = -1.04 + 0.000187*GCR	5 outliers removed	0.43	Median (12,687)	1.4
			1st Quartile (11,395)	1.1
			3rd Quartile (14,437)	1.7
Actual Soil Data	All	NA	Median	1.3
			1st Quartile	1.1
			3rd Quartile	1.7
GCR = gamma count rate				

2.9.2.2.4 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 2.9-6, predicted exposure rates ranging from 21 to greater than 37 μR/hr occur in the open pit mine areas, near the artesian well 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 permit area range from 7 to 21 μR/hr.

2.9.2.2.5 Soil Ra-226 Concentration Mapping

Predicted radium-226 concentrations in soil are shown in Figure 2.9-7. 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.

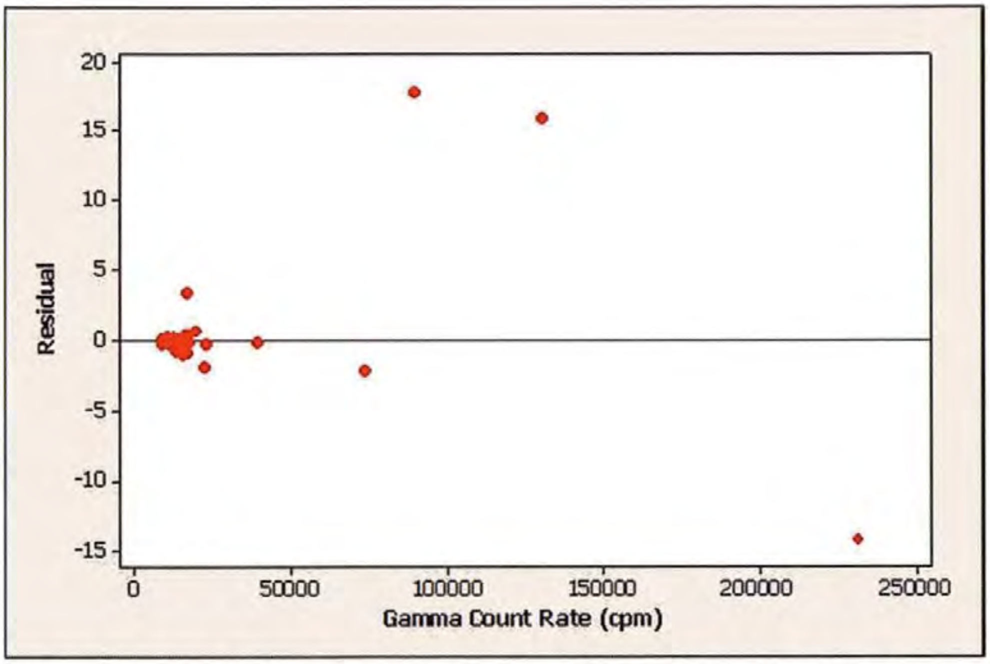

Figure 2.9-6a: Plot of Residuals versus Gamma Count Rate for the Linear Regression Equation 2.1

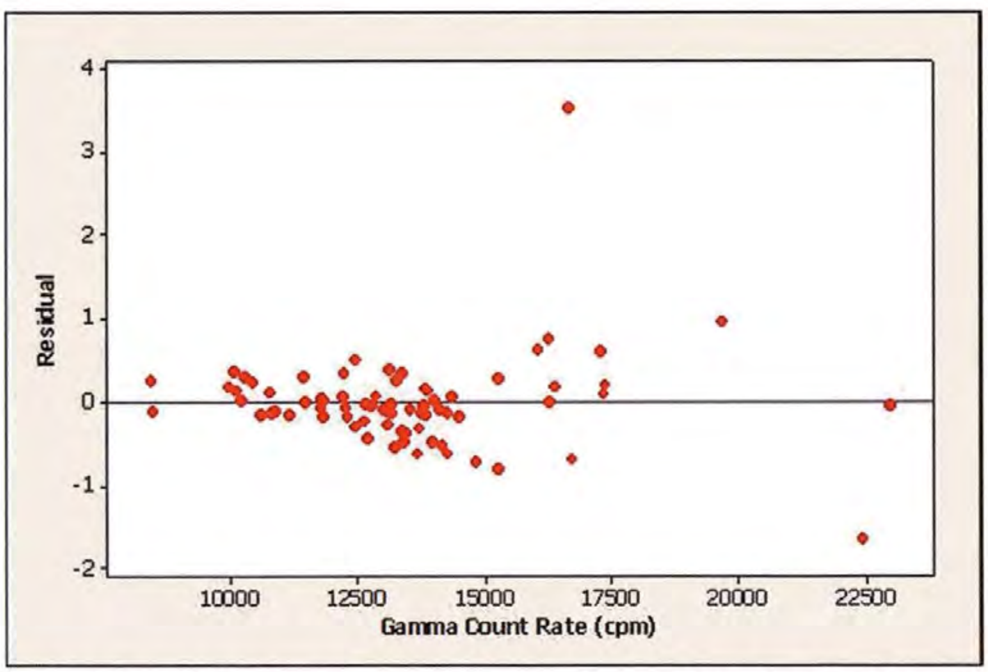

Figure 2.9-6b: Plot of Residuals versus Gamma Count Rate for the Linear Regression Equation 2.2

Figure 2.9-7 is intended for information purposes only, to qualitatively evaluate the relative spatial distribution of Ra-226 concentrations in soil across the project area. No interpolation or other method to spatially predict Ra-226 concentrations within the project area was used.

The error associated with the predicted values in Figure 2.9-7 is coupled with the error of the regression line. A 95% confidence interval for the regression line used to predict radium-226 concentration is shown in Figure 5-2 of Appendix 2.9-A of the approved license application. The 95% confidence interval across the range of typical gamma count rates spans approximately 2 pCi/g. Provided future gamma count rates are collected using similar instrumentation and during a similar seasonal period as the existing data, little seasonal variability would be introduced. If soil moisture conditions are much different when collecting future gamma count rate data, new correlations to radium-226 concentrations in soil will be established for the specific condition.

Figure 2.9-7 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.

2.9.3 Soil Sampling

2.9.3.1 Methods

2.9.3.1.1 Surface and Subsurface Soil Sampling

Two salient guidances were applied to the radiological characterization of the project site. The first is NUREG-1569 "Standard Review Plan (SRP) for In Situ Leach Uranium Extraction License Applications" (NRC 2003). NUREG-1569 identifies guidance in NRC Regulatory Guide 4.14 (Revision 1), "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC 1980) as the acceptable criteria for pre-operational radiological baseline evaluations.

The general soil sampling strategy is described below, but the following key points are emphasized.

1) The Dewey-Burdock project area was treated as one "milling site," not as two separate "milling sites." For pre-operational baseline characterization, Powertech (USA) contends that this is appropriate, since one continuous license area is proposed and the locations of well fields, processing facilities, and land application areas within that license area are arbitrary when evaluating the average pre-operational radiological conditions.

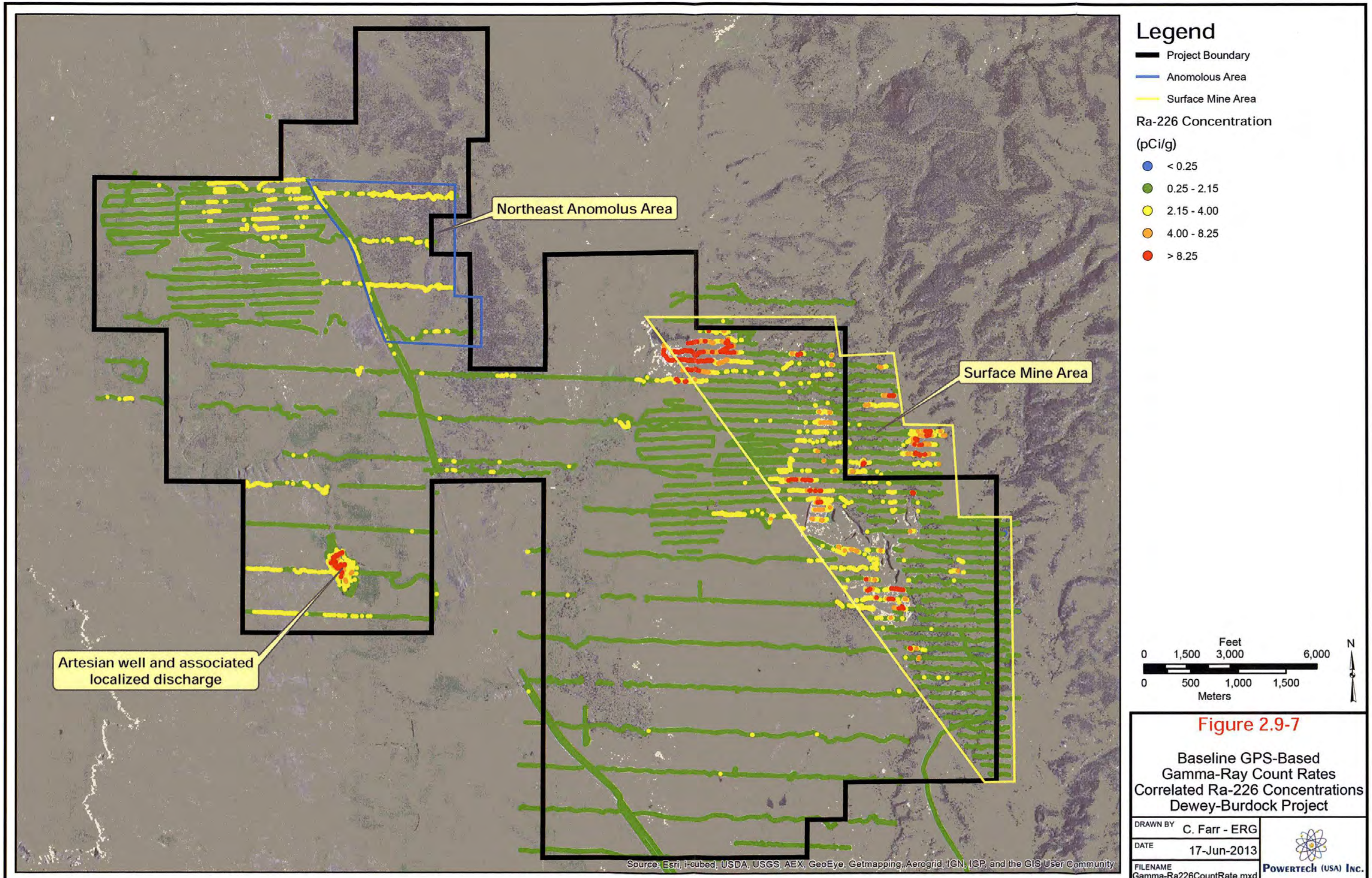

Figure 2.9-7

Baseline GPS-Based Gamma-Ray Count Rates Correlated Ra-226 Concentrations Dewey-Burdock Project

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2) The radial pattern sample point distribution recommended in Regulatory Guide 4.14 was not used due to the configuration of proposed ISR facilities. Most soil sample locations were based on a combination of random and biased sampling. Random sampling was intended to evaluate the central tendency (mean or median) of the radionuclide concentrations in soil, while the biased sampling was focused on defining the range of radionuclide concentrations in soil, within the project area. The gamma survey data were used to help locate the bias sampling locations. An exception to this method was that soil samples were collected at air particulate monitoring locations, consistent with Regulatory Guide 4.14.

3) Initially, the total number of biased and random samples was 80. Regulatory Guide 4.14 recommends 40 radially spaced samples from a depth interval of 0-5 cm, while NUREG-1569 recommends an additional 40 soil samples from a depth interval of 0-15 cm co-located with the 0-5 cm sample locations. In addition to the 40 radially spaced soil samples, Regulatory Guide 4.14 recommends soil sampling (0-5 cm depth interval) from the air particulate monitoring locations. An additional 17 random soil sample locations were later added in the proposed land application areas.

4) The approach was to focus the baseline soil investigation on the 0-15 cm depth intervals and limit soil sampling of the 0-5 cm depth interval to the air particulate monitoring locations, while keeping the total number of samples greater than or equal to those recommended by Regulatory Guide 4.14 and NUREG-1569 the same, which is 80 samples. The rationale for this approach includes the following items:

   a. The 0-5 cm depth interval is more sensitive to aerial deposition of radionuclides than the 0-15 cm depth interval, and it therefore makes sense to sample the more sensitive depth interval where air particulate monitoring is taking place.

   b. The 0-5 cm depth interval sampling at air particulate monitoring stations will be part of the operational monitoring program, thus operational monitoring data can be compared to baseline monitoring data at consistent depth intervals.

   c. The radium-226 soil cleanup standard contained in 10 CFR 40, Appendix A is defined as 5 pCi/g above background for a depth interval of 0-15 cm.

   d. An emphasis on the depth interval applicable to the radium-226 cleanup standard was used since this standard requires a well-defined pre-operational characterization of background radiological conditions in soil from a depth of 0-15 cm.

5) Consistent with Regulatory Guide 4.14 recommendations, all soil samples were analyzed for radium-226, while 10% of the soil samples were also analyzed for natural uranium, thorium-230 and lead-210. All soil samples collected at the air particulate monitoring locations were analyzed for natural uranium, thorium-230, radium-226, and lead-210.

The box plot in Figure 2.9-7a demonstrates that the median Ra-226 concentrations in the 0-5 cm and 0-15 cm soil depth interval are similar. Collecting additional 0-5 cm depth interval soil samples and analyzing for Ra-226 would not provide additional information.

In the case of surface soil radiological characterization, sample placement prescribed by RG 4.14 may lead to insufficient characterization of the site. 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 meters out to 1500 meters 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 to 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 to 5 cm. NUREG-1569 suggest the collection of samples at 0 to 15 cm. To avoid any ambiguity in the interpretation of these guidance documents, Powertech (USA) chose to collect 80 samples at 0 to 15 cm and supplementing the sampling effort with Global Positioning System (GPS)-based gamma radiation surveys. 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.

The following discussion provides justification for the number of samples collected in the Dewey and Burdock portions of the project area. Powertech (USA) acknowledges that there was a difference in sample density between the Dewey and Burdock portions of the project area and commits to collecting additional soil samples in the Dewey area prior to ISR operations.

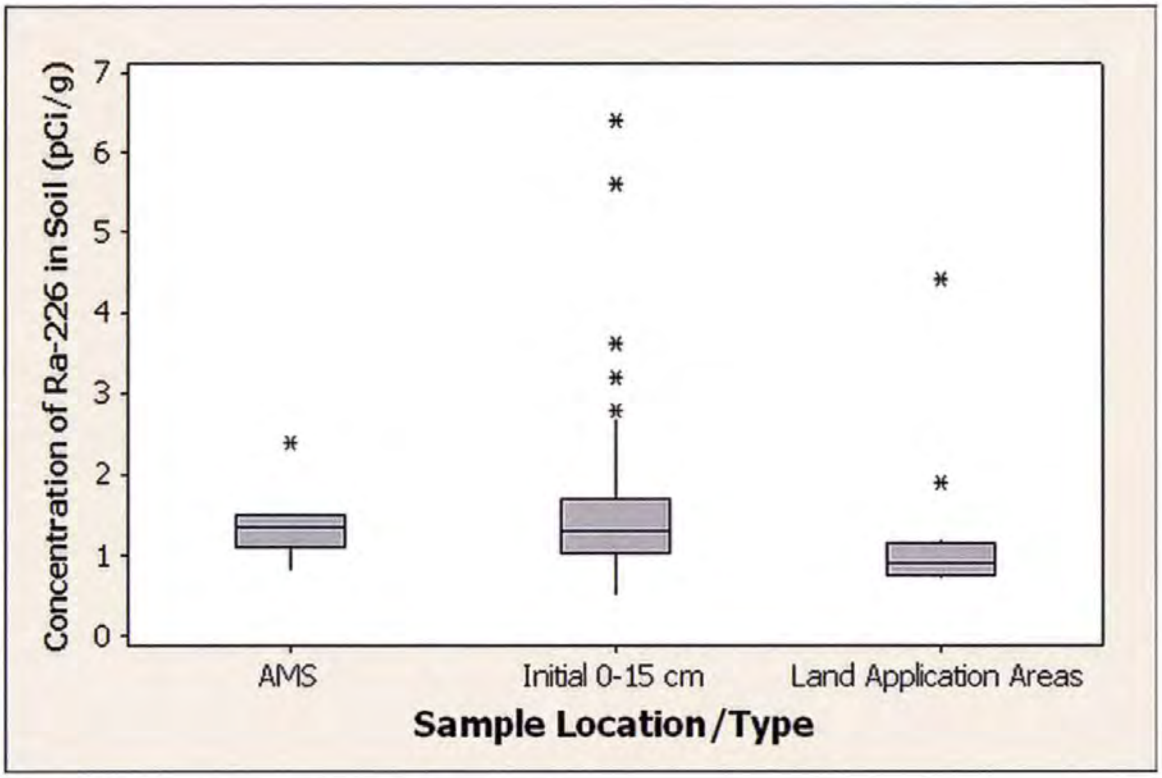

Figure 2.9-7a: Box and Whisker Plot of Ra-226 Concentrations in Surface Soil at Depths of 0-5 cm (AMS), 0-15 cm (Initial 0-15 cm), and 0-15 cm (Land Application Areas)

Dewey Area

Table 2.9-4a describes the samples collected in the Dewey portion of the project area. These samples include random and biased locations within the general Dewey area as well as the Dewey land application area. The sample locations were focused on the roll-front areas, land application areas and in an area exhibiting higher gamma readings in the north and northeast part of the Dewey area. Sample locations have been plotted on Figure 2.9-9 to show their relationship to proposed process-related features.

Table 2.9-4a: Dewey Area Soil Samples

Sample ID	Depth (cm)	Analytes
MPA-R01	0-15	Radium-226
NEA-R01	0-15	Full List
NEA-R02	0-15	Radium-226
NEA-R03	0-15	Radium-226
NEA-R04	0-15	Radium-226
NEA-R05	0-15	Radium-226
RFA-B01	0-15, 15-30, 30-100	Full List
RFA-B03	0-15	Radium-226
RFA-B06	0-15	Radium-226
RFA-B10	0-15	Radium-226
RFA-B13	0-15, 15-30, 30-100	Radium-226
RFA-B14	0-15cm	Radium-226
RFA-B17	0-15, 15-30, 30-100	Radium-226
RFA-B18	0-15	Radium-226
RFA-B23	0-15	Radim-226
RFA-B25	0-15	Full List
RFA-B28	0-15	Radium-226
RFA-B30	0-15, 15-30, 30-100	Radium-226
RFA-B41	0-15	Radium-226
RFA-B43	0-15	Radium-226
RFA-B45	0-15	Radium-226
LAN-001	0-15, 15-30, 30-100	Full List
LAN-002	0-15, 15-30, 30-100	Full List
LAN-003	0-15, 15-30, 30-100	Full List
LAN-004	0-15, 15-30, 30-100	Full List
LAN-005	0-15, 15-30, 30-100	Full List
LAN-006	0-15, 15-30, 30-100	Full List
LAN-007	0-15, 15-30, 30-100	Full List
LAN-008	0-15, 15-25 , Refusal at 25	Full List
LAN-009	0-15, 15-30, 30-100	Full List
LAN-010	0-15, 15-30, 30-100	Full List

Note: "Full List" includes natural uranium, radium-226, thorium-230 and lead-210.

Burdock Area

Table 2.9-4b describes the samples collected in the Burdock portion of the project area. These samples include random and biased locations within the Burdock area. The sample locations were focused on the roll-front areas and land application areas. Sample locations have been plotted on Figure 2.9-9 to show their relationship to proposed process-related features.

Since the pre-operational soil sampling strategy treated the entire project area as one "mill site" as discussed above, Powertech (USA) proposes to evaluate adequate sample numbers for the entire project area, not sub-areas. Nevertheless, Powertech (USA) acknowledges that there was a difference in sample densities between the Dewey and Burdock portions of the project area and commits to additional soil sampling in the Dewey area as described below.

Powertech (USA) chose to use methods contained in NUREG/CR-5849, "Manual for Conducting Radiological Surveys in Support of License Termination" (NRC, 1992) to evaluate the sample number adequacy. The land application area sample results (sample ID designations LAS and LAN) were not used in the evaluation, since they were not part of the initial 80 soil samples. NUREG/CR-5849 describes a method to determine an adequate sample size (N), where t is the t-statistic, r is the relative fractional error, and cv is the coefficient of variation.

$$N > \left(\frac{t}{r}cv\right)^2$$

A 95% confidence level with the degrees of freedom approaching infinity yields a t-statistic of 1.645. Figure 2.9-7b shows the plot of this equation for a relative fraction error of 10 and 20 percent for various values of coefficient of variation.

The mean and standard deviation of the radium-226 concentrations in the 55 samples collected in the Main Permit Area are 1.51 and 0.77 pCi/g, respectively. The coefficient of variation for the samples is 0.77/1.51=0.5. Inspection of the plot in Figure 2.9-7b indicates that about 20 and 70 samples are sufficient to estimate the mean radium-226 concentration to within 20 and 10 percent, respectively. The collection of 55 samples is acceptably within this range. The addition of 17 land application samples exceeds this range. Based on this evaluation, Powertech (USA) concluded that an adequate number of soil samples were collected to describe the mean radium-226 concentration in the entire project area to within 10 percent.

Table 2.9-4b: Burdock Area Soil Samples

Sample ID	Depth (cm)	Analytes
MPA-R02	0-15	Radium-226
MPA-R03	0-15	Full List
MPA-R04	0-15	Radium-226
MPA-R05	0-15	Radium-226
MPA-B01	0-15	Radium-226
MPA-B02	0-15	Radium-226
MPA-B03	0-15	Radium-226
RFA-B02	0-15, 15-30, 30-100	Radium-226
RFA-B04	0-15	Radium-226
RFA-B07	0-15	Radium-226
RFA-B08	0-15	Radium-226
RFA-B09	0-15	Radium-226
RFA-B11	0-15	Full List
RFA-B12	0-15	Radium-226
RFA-B15	0-15, 15-30, 30-100	Radium-226
RFA-B16	0-15	Radium-226
RFA-B19	0-15	Radium-226
RFA-B20	0-15	Full List
RFA-B21	0-15, 15-30, 30-100	Radium-226
RFA-B22	0-15	Radium-226
RFA-B24	0-15	Radium-226
RFA-B26	0-15	Radium-226
RFA-B27	0-15	Radium-226
RFA-B29	0-15	Radium-226
RFA-B31	0-15	Radium-226
RFA-B33	0-15	Radium-226
RFA-B34	0-15	Radium-226
RFA-B35	0-15	Radium-226
RFA-B36	0-15, 15-30, 30-100	Radium-226
RFA-B37	0-15, 15-30, 30-100	Radium-226
RFA-B38	0-15	Radium-226
RFA-B39	0-15	Radium-226
RFA-B40	0-15	Full List
RFA-B44	0-15	Radium-226
LAS-001	0-15, 15-30, 30-100	Full List
LAS-002	0-15, 15-30, 30-100	Full List
LAS-003	0-15, 15-30, 30-100	Full List
LAS-004	0-15, 15-30, 30-100	Full List
LAS-005	0-15, 15-30, 30-100	Full List
LAS-006	0-15, 15-30, 30-100	Full List
LAS-007	0-15, 15-30, 30-100	Full List

Note: "Full List" includes natural uranium, radium-226, thorium-230 and lead-210.

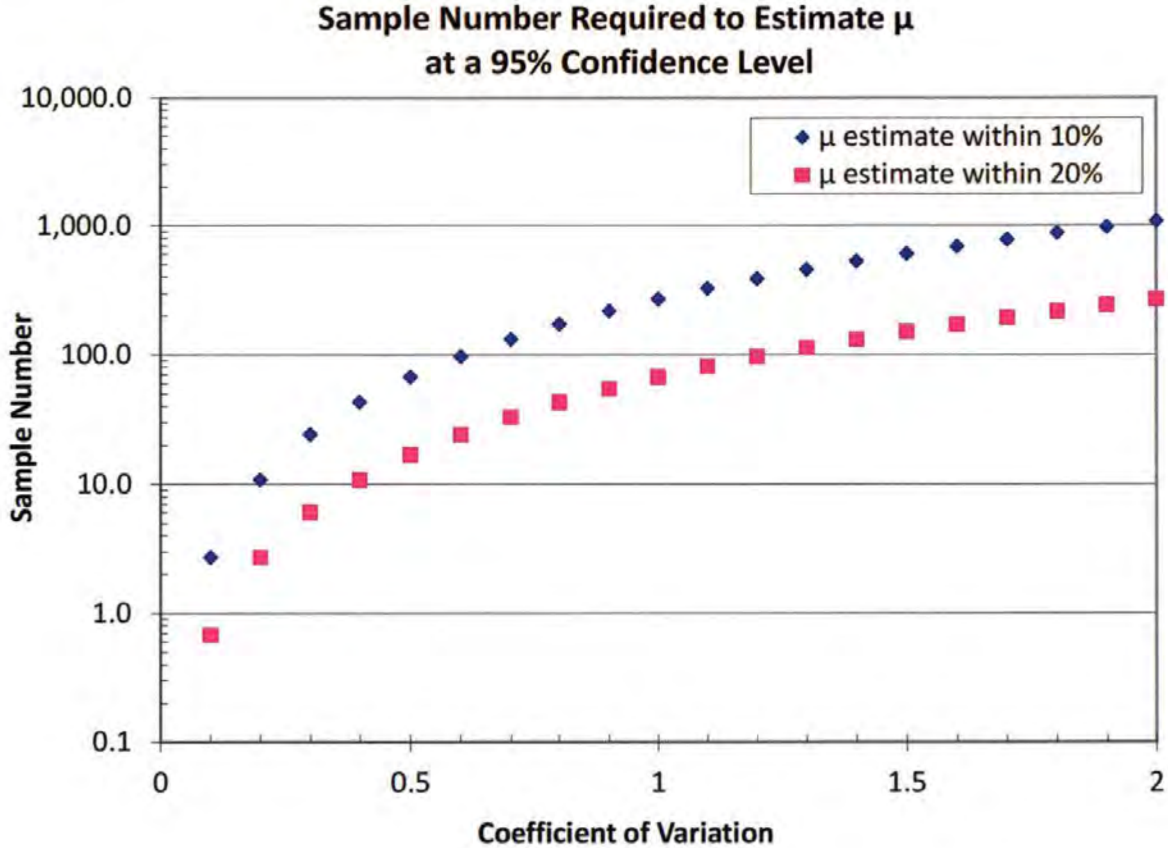

Figure 2.9-7b: Adequate Sample Size as a Function of the Coefficient of Variation

Commitment to Collect Additional Soil Samples

Powertech (USA) acknowledges a difference in sample density (number of samples per unit area) between the Burdock and Dewey areas. The Burdock area has a higher sample density, which the NRC staff has stated is probably sufficient for the pre-operational baseline sampling program. Powertech (USA) commits to collecting 15 more surface soil samples (0-15 cm) in the Dewey area. The proposed locations of these additional samples are shown in Figure 2.9-7c. The samples will be analyzed for parameters consistent with the recommendations of Regulatory Guide 4.14, including the suggested LLDs. This additional sampling will result in equal sample densities for the Dewey and Burdock portions of the project area.

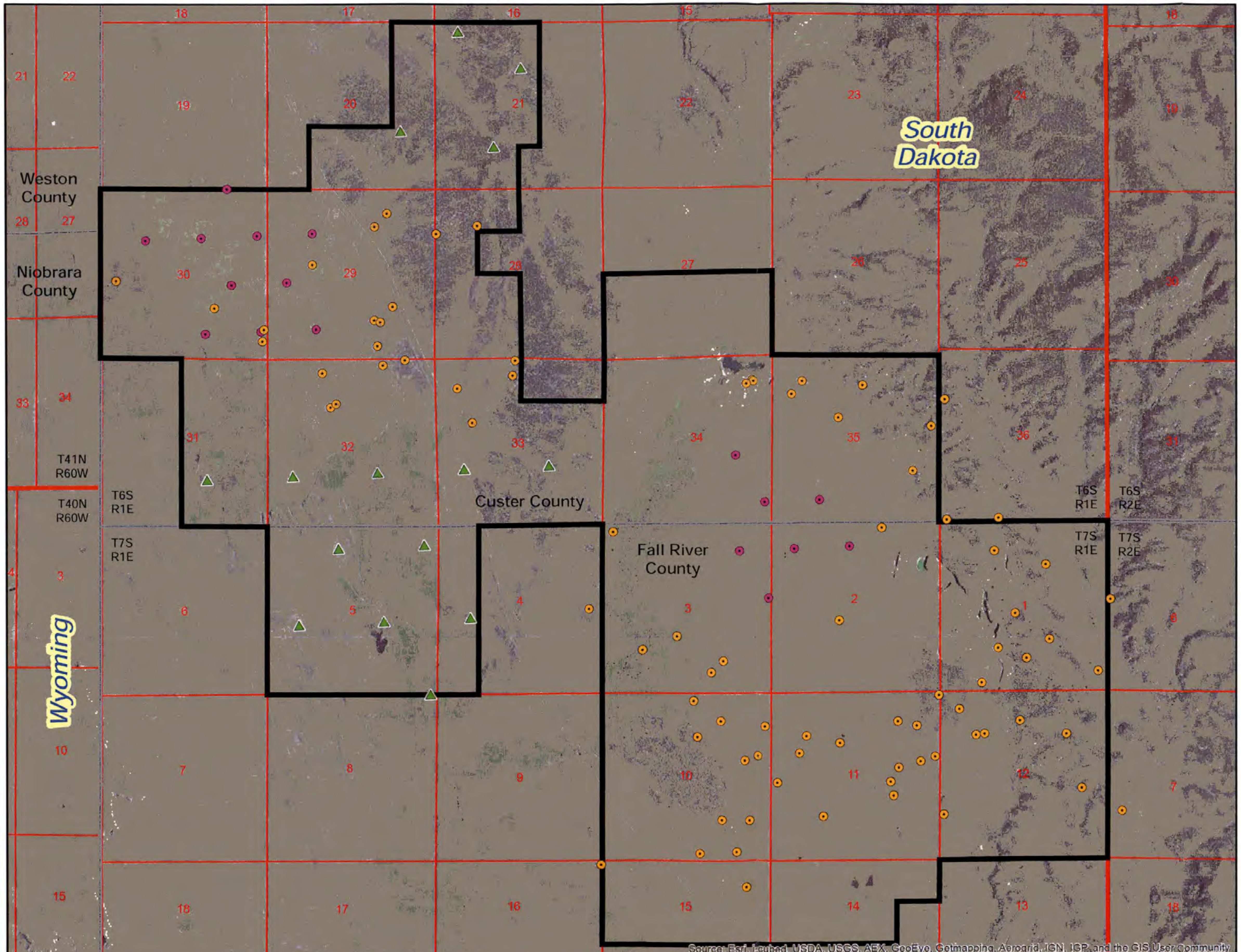

Figure 2.9-7c

Additional Dewey Area Surface Soil Sample Locations

Dewey-Burdock Project

DRAWN BY	C. Farr - ERG
DATE	17-Jun-2013
FILENAME	DeweySurfSoilSamp.mxd

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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 2.9-8 (this figure also shows the locations of the radon flux and track etch detector measurements, discussed below) and 80 additional locations shown in Figure 2.9-9. Biased samples were collected at 5 of the 80 locations; the remainder was placed randomly, using Visual Sampling Plan (VSP), Version 5.0. For the Main Permit Area and Surface Mine Area, the input to VSP consisted of shape files of the license boundary and Surface Mine Area and the number of samples (75) for the Main Permit Area and Surface Mine Area. Refer to Figure 2.9-6 for the locations of the Main Permit Area and the Surface Mine Area. For the Land Application Areas, the input to VSP consisted of shape files of the Land Application Areas and the number of samples (17) for the Land Application Areas. Land Application Areas are shown on Figure 3.1-1. The results obtained from VSP consisted of coordinates for soil samples in the Main Permit Area and Land Application Areas. These locations are shown on Figures 2.9-9 and 2.9-10. 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 to 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 to 15, 15 to 30, and 30 to 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 two 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. Clarification from the contract laboratory, Energy Laboratories, Inc., on the testing method used for Ra-226 soil sample analyses, is provided in Appendix 2.9-G of the approved license application. The type of gamma analysis performed on the soil samples to determine the Ra-226 concentrations was closed-can gamma analysis in a 3-in can filled with 150 to 200 grams of soil. The soil is dried, ground, split, canned and taped in accordance with EPA Method 901.1. The Ra-226 concentrations were determined by measuring the 609 keV peak from bismuth-214.

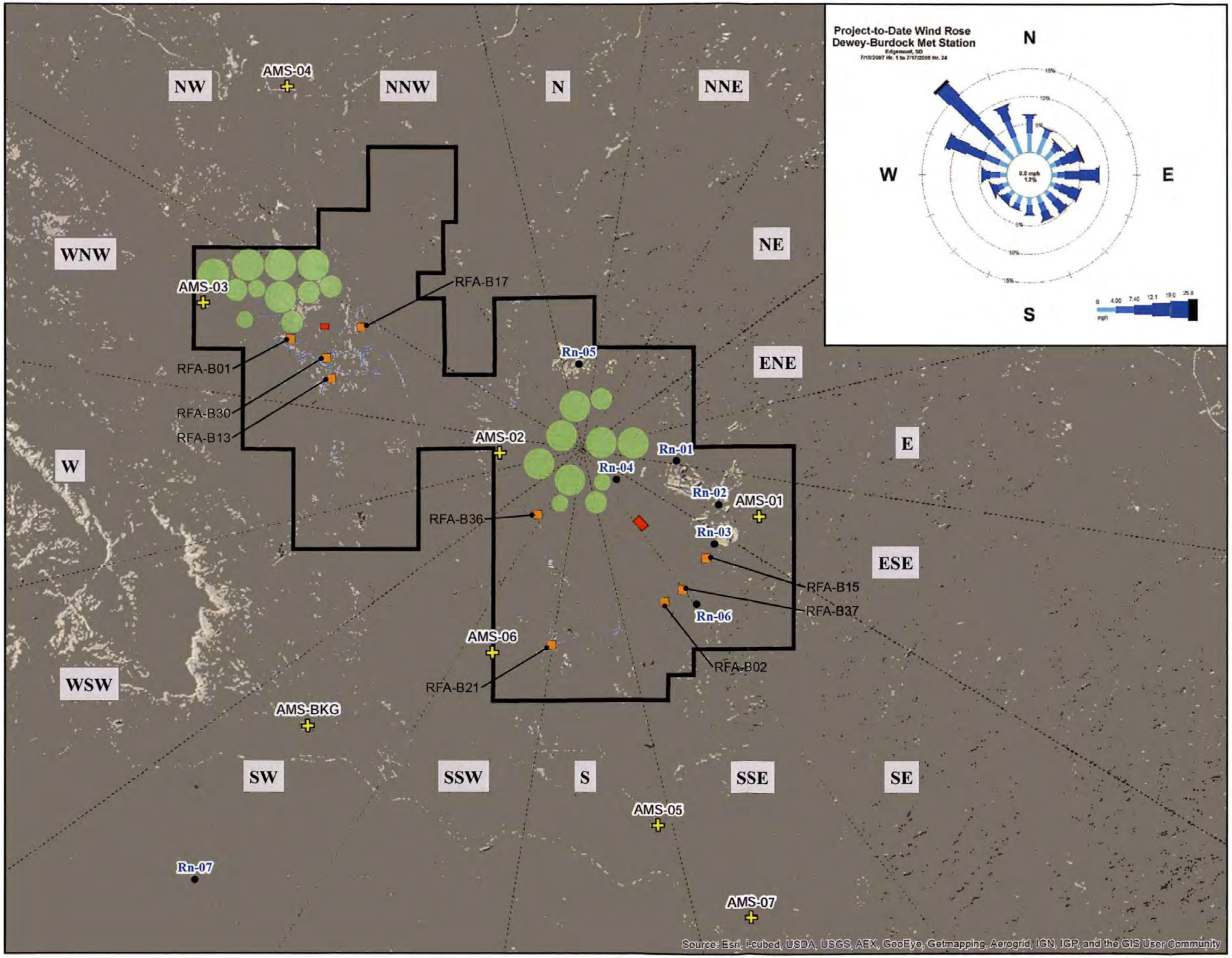

Figure 2.9-8

Air Monitoring Station, Ambient Radon, and Radon Flux Measurement Locations Dewey-Burdock Project

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DATE 17-Jun-2013

FILENAME AirMonRadonFlux.mxd

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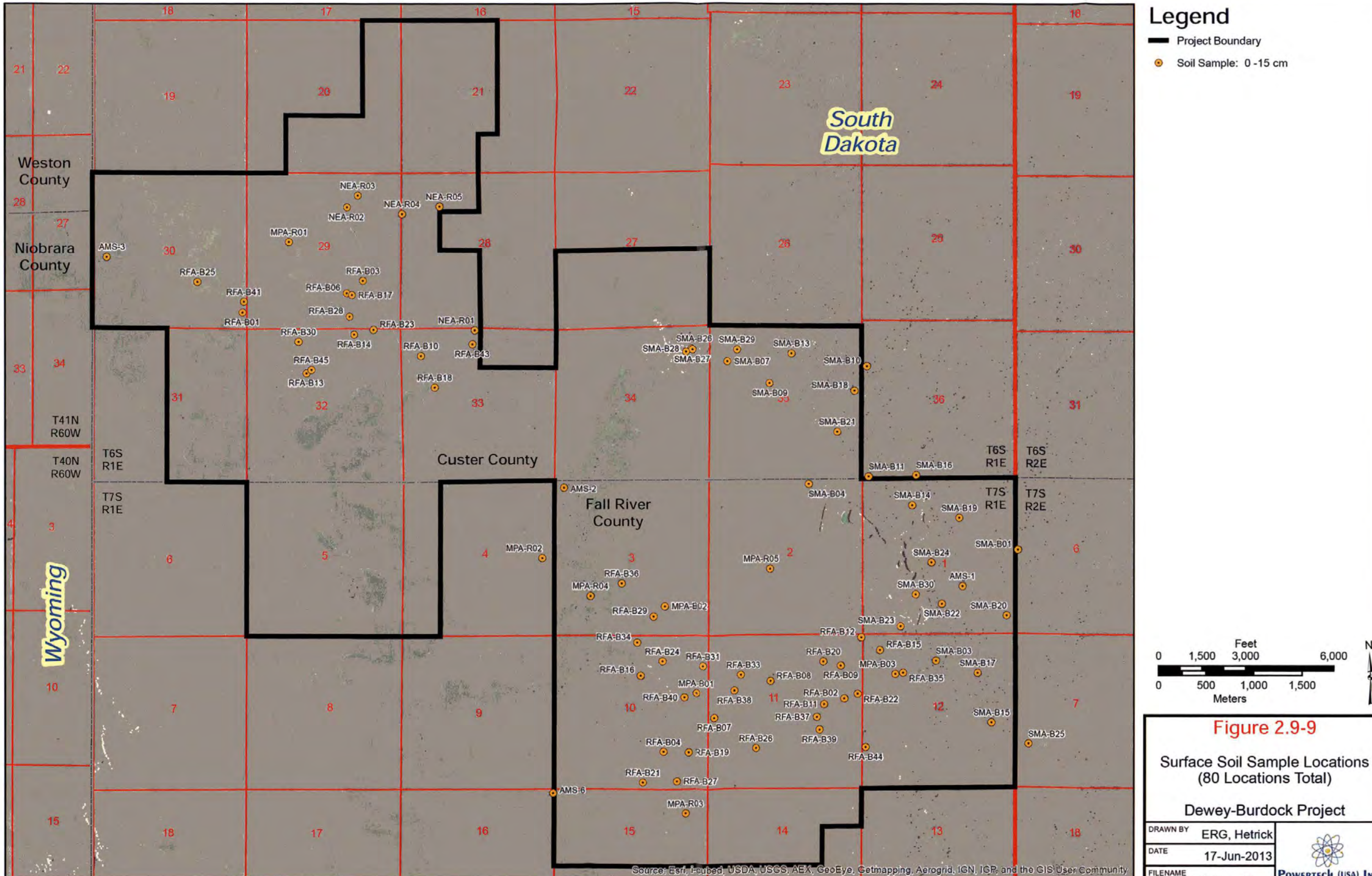

Figure 2.9-9

Surface Soil Sample Locations (80 Locations Total)

Dewey-Burdock Project

DRAWN BY	ERG, Hetrick
DATE	17-Jun-2013
FILENAME	SurfSoilSamp80.mxd

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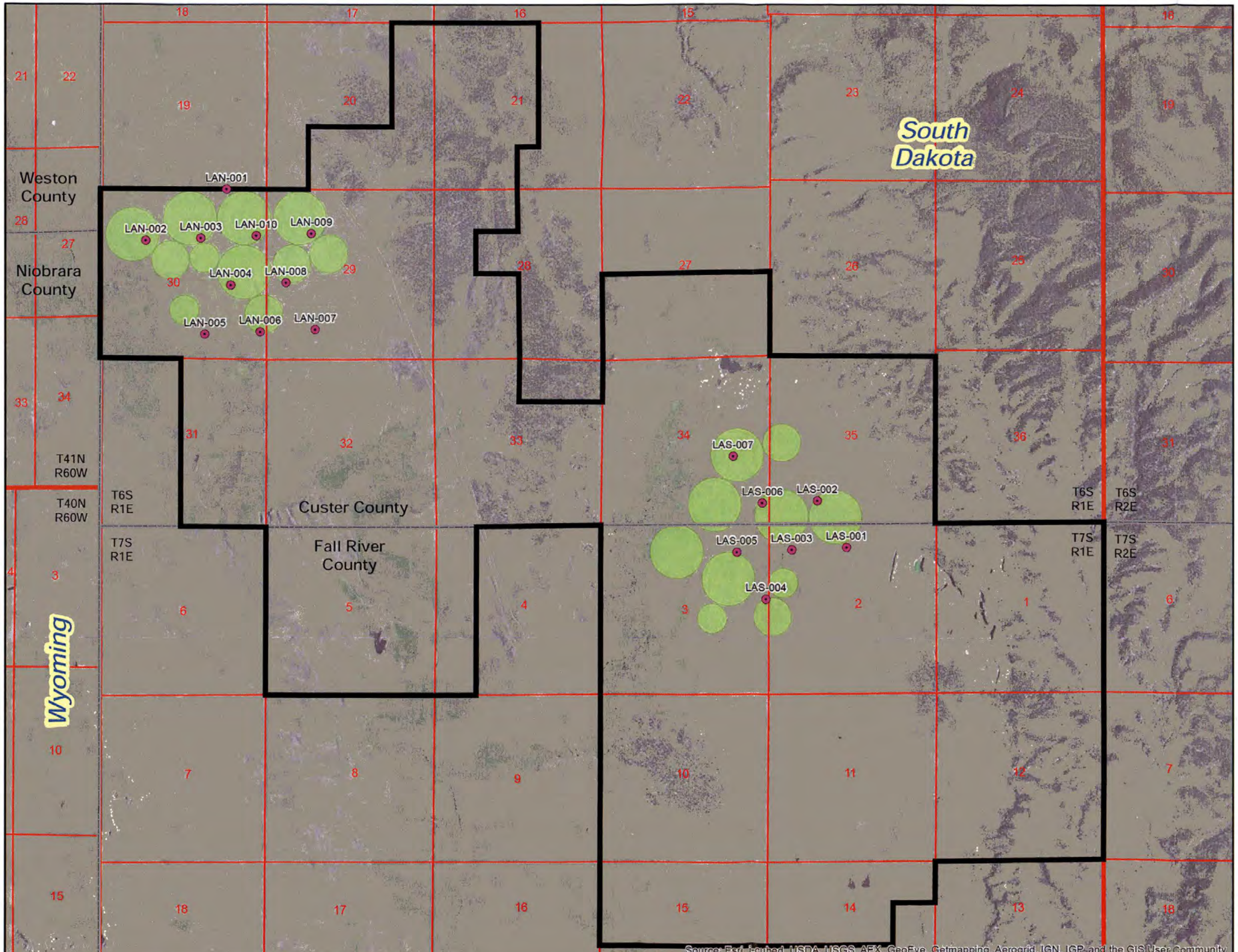

Figure 2.9-10

Soil Sample Locations in Land Application Areas

Dewey-Burdock Project

DRAWN BY ERG, Hetrick
DATE 17-Jun-2013
FILENAME LandApp-SoilSamp.mxd
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- 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. Consistent with Regulatory Guide 4.14, a laboratory performance evaluation for uranium in a soil matrix using EPA Method 6020A is provided as Appendix 2.9-F of the approved license application. The performance evaluation was performed by RTC Corp. (A2LA Accreditation No. 2122.01) for the accreditation provided by the American Association for Laboratory Accreditation (A2LA). The performance evaluation is for the period July 30 through September 12, 2008, which is the time period during which the soil samples from the land application areas were analyzed. The initial 80 soil samples were analyzed in late 2007. The evaluation indicates that Method 6020A is used by the laboratory for analysis of uranium in soil and that it provides an acceptably accurate measurement of uranium in a soil matrix.
- Lead-210: EPA Method 909, *Determination of Lead in Drinking Water* (EPA, 1982). This method was selected by the contract laboratory, Energy Laboratories, Inc., as the preferred test method. A copy of EPA Method 909 (EPA, 1982), is provided as Appendix 2.9-E of the approved license application. Although EPA Method 909 was developed by EPA personnel and can be found on the EPA test method website (http://www.epa.gov/ne/info/testmethods), EPA Method 909 is not an EPA-approved procedure. Powertech (USA) understands that EPA does not have an approved procedure for lead-210 in water or soil.
- EPA Method 3050B, *Acid Digestion of Sediments, Sludges, and Soils*, was used to convert the soil into an aqueous matrix (EPA, 1996). This procedure is provided as Appendix 2.9-D of the approved license application.

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 to 15, 15 to 30, and 30 to 100 cm. Refusal was encountered at 10 inches 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 2.9-10. The samples were analyzed for radium-226, natural uranium, thorium-230, and lead-210.

2.9.3.2 Soil Sampling Results

Table 2.9-5 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 2.9-A of the approved license application.

Table 2.9-5: Radionuclide Concentrations in All Soil Samples

Sample ID	Date Collected	Depth (cm)	Gamma 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)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (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	1.9E-08	1 E-07	1 E-07	1 E-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	2.0E-08	1 E-07	1 E-07	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-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	1.8E-08	1 E-07	1 E-07	1 E-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	1.8E-08	1 E-07	1 E-07	1 E-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	1.8E-08	1 E-07	1 E-07	1 E-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	1.8E-08	1 E-07	1 E-07	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-07
MPA-B01	9/25/2007	0-15	13824	-	-	-	-	-	1.4E-06	3.0E-07	-	-	-	1 E-07
MPA-B02	9/25/2007	0-15	14176	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
MPA-B03	9/25/2007	0-15	13006	-	-	-	-	-	1.3E-06	3.0E-07	-	-	-	1 E-07
MPA-R01	9/24/2007	0-15	13749	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
MPA-R02	9/24/2007	0-15	16059	-	-	-	-	-	2.6E-06	3.0E-07	-	-	-	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-07
MPA-R04	9/24/2007	0-15	10810	-	-	-	-	-	-	-	-	-	-	1 E-07
MPA-R04-Dup	9/24/2007	0-15	-	-	-	-	-	-	-	-	-	-	-	1 E-07
MPA-R05	9/24/2007	0-15	11850	-	-	-	-	-	-	-	-	-	-	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-07
NEA-R02	9/24/2007	0-15	13176	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07
NEA-R03	9/24/2007	0-15	16393	-	-	-	-	-	2.2E-06	3.0E-07	-	-	-	1 E-07
NEA-R04	9/24/2007	0-15	17356	-	-	-	-	-	2.3E-06	3.0E-07	-	-	-	1 E-07
NEA-R04-Dup	9/24/2007	0-15	-	-	-	-	-	-	2.5E-06	3.0E-07	-	-	-	1 E-07
NEA-R05	9/24/2007	0-15	17269	-	-	-	-	-	2.8E-06	3.0E-07	-	-	-	1 E-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	2 E-08	1 E-07	1 E-07	1 E-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	1.7E-07	1 E-07	1 E-07	1 E-07
RFA-B02A	9/26/2007	0-15	13360	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B03	9/25/2007	0-15	14253	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B04	9/25/2007	0-15	13963	-	-	-	-	-	1.5E-06	3.0E-07	-	-	-	1 E-07
RFA-B06	9/25/2007	0-15	13819	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B07	9/25/2007	0-15	12700	-	-	-	-	-	1.7E-06	2.0E-07	-	-	-	1 E-07

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

Sample ID	Date Collected	Depth (cm)	Gamma 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)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
RFA-B08	9/25/2007	0-15	13433	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B08-Dup	9/25/2007	0-15	13528	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B09	9/25/2007	0-15	14825	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B10	9/25/2007	0-15	13366	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-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	2 E-8	1 E-07	1 E-07	1 E-07
RFA-B12	9/25/2007	0-15	13135	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B13A	9/26/2007	0-15	13987	-	-	-	-	-	1.8E-06	3.0E-07	-	-	-	1 E-07
RFA-B14	9/25/2007	0-15	13872	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B15A	9/26/2007	0-15	13535	-	-	-	-	-	1.4E-06	3.0E-07	-	-	-	1 E-07
RFA-B16	9/25/2007	0-15	13675	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B17A	9/26/2007	0-15	16283	-	-	-	-	-	2.0E-06	3.0E-07	-	-	-	1 E-07
RFA-B18	9/25/2007	0-15	13835	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B19	9/25/2007	0-15	13689	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-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	1.9E-8	1 E-07	1 E-07	1 E-07
RFA-B21A	9/26/2007	0-15	16641	-	-	-	-	-	5.6E-06	4.0E-07	-	-	-	1 E-07
RFA-B22	9/25/2007	0-15	14087	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
RFA-B23	9/25/2007	0-15	19674	-	-	-	-	-	3.6E-06	4.0E-07	-	-	-	1 E-07
RFA-B24	9/25/2007	0-15	12766	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-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	1.9E-8	1 E-07	1 E-07	1 E-07
RFA-B26	9/25/2007	0-15	11791	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B27	9/25/2007	0-15	13794	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
RFA-B28	9/25/2007	0-15	15246	-	-	-	-	-	2.4E-06	3.0E-07	-	-	-	1 E-07
RFA-B28-Dup	9/25/2007	0-15	-	-	-	-	-	-	1.8E-06	3.0E-07	-	-	-	1 E-07
RFA-B29	9/25/2007	0-15	14345	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B30A	9/26/2007	0-15	12461	-	-	-	-	-	1.8E-06	2.0E-07	-	-	-	1 E-07
RFA-B31	9/25/2007	0-15	12221	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07
RFA-B33	9/25/2007	0-15	13221	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B34	9/25/2007	0-15	13408	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B35	9/25/2007	0-15	12290	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B36A	9/25/2007	0-15	12465	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B37A	9/26/2007	0-15	11170	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

Sample ID	Date Collected	Depth (cm)	Gamma 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)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
RFA-B38	9/25/2007	0-15	11852	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B39	9/25/2007	0-15	11478	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-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	1.7E-08	1 E-07	1 E-07	1 E-07
RFA-B41	9/25/2007	0-15	11806	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B43	9/25/2007	0-15	13264	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
RFA-B44	9/25/2007	0-15	11436	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
RFA-B45	9/25/2007	0-15	12242	-	-	-	-	-	1.6E-06	3.0E-07	-	-	-	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-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	1.8E-08	1 E-07	1 E-07	1 E-07
SMA-B03	9/24/2007	0-15	22410	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
SMA-B04	9/24/2007	0-15	15263	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
SMA-B07	9/24/2007	0-15	22925	-	-	-	-	-	3.2E-06	3.0E-07	-	-	-	1 E-07
SMA-B09	9/24/2007	0-15	12879	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
SMA-B09-Dup	9/24/2007	0-15	-	-	-	-	-	-	1.7E-06	2.0E-07	-	-	-	1 E-07
SMA-B10	9/25/2007	0-15	13184	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
SMA-B11	9/24/2007	0-15	17346	-	-	-	-	-	2.3E-06	3.0E-07	-	-	-	1 E-07
SMA-B13	9/25/2007	0-15	13252	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07
SMA-B14	9/24/2007	0-15	14483	-	-	-	-	-	1.4E-06	3.0E-07	-	-	-	1 E-07
SMA-B14-Dup	9/24/2007	0-15	-	-	-	-	-	-	1.6E-06	2.0E-07	-	-	-	1 E-07
SMA-B15	9/24/2007	0-15	8474	-	-	-	-	-	8.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B16	9/24/2007	0-15	10235	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B17	9/24/2007	0-15	10139	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
SMA-B18	9/25/2007	0-15	8511	-	-	-	-	-	5.0E-07	1.0E-07	-	-	-	1 E-07
SMA-B18-Dup	9/25/2007	0-15	-	-	-	-	-	-	4.0E-07	1.0E-07	-	-	-	1 E-07
SMA-B19	9/24/2007	0-15	10074	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
SMA-B20	9/27/2007	0-15	10897	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B21	9/24/2007	0-15	16712	-	-	-	-	-	1.4E-06	2.0E-07	-	-	-	1 E-07
SMA-B22	9/24/2007	0-15	10618	-	-	-	-	-	8.0E-07	2.0E-07	-	-	-	1 E-07
SMA-B23	9/24/2007	0-15	16233	-	-	-	-	-	2.7E-06	3.0E-07	-	-	-	1 E-07
SMA-B23-Dup	9/24/2007	0-15	-	-	-	-	-	-	2.8E-06	3.0E-07	-	-	-	1 E-07
SMA-B24	9/24/2007	0-15	12662	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

Sample ID	Date Collected	Depth (cm)	Gamma 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)	U-nat LLD (µCi/g)	Pb-210 LLD (µCi/g	Th-230 LLD (µCi/g)	Ra-226 LLD (µCi/g)
SMA-B25	9/24/2007	0-15	9991	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
SMA-B26	9/28/2007	0-15	73243	-	-	-	-	-	1.1E-05	5.0E-07	-	-	-	1 E-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	1.7E-08	1 E-07	1 E-07	1 E-07
SMA-B28	9/29/2007	0-15	39061	-	-	-	-	-	6.4E-06	4.0E-07	-	-	-	1 E-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	1.7E-08	1 E-07	1 E-07	1 E-07
SMA-B30	9/28/2007	0-15	89139	-	-	-	-	-	3.4E-05	9.0E-07	-	-	-	1 E-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	7E-09	3.8 E-06	1 E-07	4 E-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	7E-09	3.7 E-06	1 E-07	5 E-08
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	7E-09	3.6 E-06	1 E-07	5 E-08
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	7E-09	2.4 E-06	1 E-07	8 E-08
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	7E-09	2.4 E-06	1 E-07	8 E-08
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	7E-09	2.3 E-06	1 E-07	8 E-08
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	7E-09	2.4 E-06	1 E-07	8 E-08
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	7E-09	2.4 E-06	1 E-07	8 E-08
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	7E-09	2.3 E-06	1 E-07	9 E-08
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	7E-09	2.3 E-06	1 E-07	8 E-08
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	7E-09	2.0 E-06	1 E-07	1 E-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	7E-09	1.9 E-06	1 E-07	1 E-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	7E-09	1.9 E-06	1 E-07	1 E-07
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	7E-09	1.9 E-06	1 E-07	1 E-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	7E-09	1.9 E-06	1 E-07	1 E-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	1E-08	1.9 E-06	1 E-07	1 E-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	7E-09	1.9 E-06	1 E-07	1 E-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	7E-09	2.5E-06	1 E-07	9 E-08
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	1.8E-08	1 E-07	1 E-07	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-07
RFA-B02B	9/26/2007	15-30	-	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B13B	9/26/2007	15-30	-	-	-	-	-	-	1.8E-06	2.0E-07	-	-	-	1 E-07
RFA-B15B	9/26/2007	15-30	-	-	-	-	-	-	1.5E-06	2.0E-07	-	-	-	1 E-07
RFA-B17B	9/26/2007	15-30	-	-	-	-	-	-	2.2E-06	3.0E-07	-	-	-	1 E-07
RFA-B21B	9/26/2007	15-30	-	-	-	-	-	-	1.3E-06	2.0E-07	-	-	-	1 E-07

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (cont'd)

Sample ID	Date Collected	Depth (cm)	Gamma 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)	U-nat LLD (μCi/g)	Pb-210 LLD (μCi/g	Th-230 LLD (μCi/g)	Ra-226 LLD (μCi/g)
RFA-B30B	9/26/2007	15-30	-	-	-	-	-	-	2.1E-06	3.0E-07	-	-	-	1 E-07
RFA-B36B	9/26/2007	15-30	-	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-07
RFA-B37B	9/26/2007	15-30	-	-	-	-	-	-	7.0E-07	2.0E-07	-	-	-	1 E-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	7E-09	3.8E-06	1 E-07	4 E-08
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	7E-09	3.8E-06	1 E-07	6 E-08
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	7E-09	3.8E-06	1 E-07	5E-08
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	7E-09	2.3E-06	1 E-07	8E-08
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	7E-09	2.3E-06	1 E-07	8E-08
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	7E-09	2.4E-06	1 E-07	2E-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	7E-09	2.3E-06	1 E-07	8E-08
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	7E-09	2.4E-06	1 E-07	8E-08
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	7E-09	2.3E-06	1 E-07	8E-08
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	7E-09	2.3E-06	1 E-07	8E-08
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	7E-09	2.0E-06	1 E-07	1E-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	7E-09	2.0E-06	1 E-07	1E-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	7E-09	1.9E-06	1 E-07	1E-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	7E-09	1.9E-06	1 E-07	1E-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	7E-09	2.0E-06	1 E-07	1E-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	7E-09	1.9E-06	1 E-07	1E-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	7E-09	1.9E-06	1 E-07	1E-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	7E-09	2.5E-06	1 E-07	1E-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	1.9E-08	1 E-07	1 E-07	1 E-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	1.9E-08	1 E-07	1 E-07	1 E-07
RFA-B02C	9/26/2007	30-100	-	-	-	-	-	-	9.0E-07	2.0E-07	-	-	-	1 E-07
RFA-B13C	9/26/2007	30-100	-	-	-	-	-	-	1.6E-06	2.0E-07	-	-	-	1 E-07
RFA-B15C	9/26/2007	30-100	-	-	-	-	-	-	1.5E-06	3.0E-07	-	-	-	1 E-07
RFA-B17C	9/26/2007	30-100	-	-	-	-	-	-	2.5E-06	3.0E-07	-	-	-	1 E-07
RFA-B21C	9/26/2007	30-100	-	-	-	-	-	-	1.2E-06	2.0E-07	-	-	-	1 E-07
RFA-B30C	9/26/2007	30-100	-	-	-	-	-	-	1.7E-06	3.0E-07	-	-	-	1 E-07

Table 2.9-5: Radionuclide Concentrations in All Soil Samples (concluded)

Sample ID	Date Collected	Depth (cm)	Gamma 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)	U-nat LLD (μCi/g)	Pb-210 LLD (μCi/g	Th-230 LLD (μCi/g)	Ra-226 LLD (μCi/g)
RFA-B36C	9/26/2007	30-100	-	-	-	-	-	-	1.0E-06	2.0E-07	-	-	-	1 E-07
RFA-B37C	9/26/2007	30-100	-	-	-	-	-	-	1.1E-06	2.0E-07	-	-	-	1 E-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	7E-09	3.7E-06	1 E-07	4 E-08
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	7E-09	3.6E-06	1 E-07	6 E-08
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	7E-09	3.7E-06	1 E-07	5 E-08
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	7E-09	2.3E-06	1 E-07	8 E-08
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	7E-09	2.4E-06	1 E-07	8 E-08
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	7E-09	2.3E-06	1 E-07	8 E-08
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	7E-09	2.4E-06	1 E-07	8 E-08
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	7E-09	2.3E-06	1 E-07	8 E-08
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	7E-09	2.3E-06	1 E-07	8 E-08
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	7E-09	2.3E-06	1 E-07	1 E-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	7E-09	1.9E-06	1 E-07	1 E-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	7E-09	1.9E-06	1 E-07	1 E-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	7E-09	1.9E-06	1 E-07	1 E-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	7E-09	1.9E-06	1 E-07	1 E-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	7E-09	1.9E-06	1 E-07	1 E-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	7E-09	2.6E-06	1 E-07	1 E-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	7E-09	2.6E-06	1 E-07	1 E-07

Notes:
All errors reported are ± 2σ

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

- AMS: air monitoring station (sometimes designated as HV for high-volume air samplers)
- SMA: surface mine area
- MPA: main permit area
- NEA: northeast area
- RFA: roll front area
- LAN: land application area north (Dewey)
- LAS: land application south (Burdock)

2.9.3.2.1 Surface Soil Sampling Results

The Ra-226 soil sampling results for the first set of 80 locations, the Surface Mine Area and the Main Permit Area, were analyzed with the statistical software package Minitab, version 15.1.1.0. Output from Minitab for the statistical analyses of baseline Ra-226 soil sampling results is provided in Appendix 2.9-M of the approved license application. The Ra-226 soil sampling results from the north section of the Main Permit Area and the Land Application Areas were not analyzed statistically.

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 permit areas 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 permit area 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 Permit Area

Fifty-five surface soil samples were collected in the main permit area. 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 permit area 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 Permit Area

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 permit area. 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 permit area 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 permit area, with statistical significance.

Radium-226 Concentrations in the 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

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 permit area also differ from the main permit area.

Several methods were considered to evaluate outliers, including histograms, distribution tests, and probability plots, prior to the decision to use IQRs. The set of the data from the Main Permit Area was initially found to be non-parametric (i.e., does not follow a normal, lognormal or other commonly used distribution that can be described with parameters). The IQR was used to help identify any potential outliers non-parametrically. The usefulness of using box plots to non-parametrically screen for data outliers is discussed in Chapter 12 of *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (EPA, 2009). As described on pg. 12-5 of this guidance, "Box plots…provide an alternate method to perform outlier screening, one not dependent on normality of the underlying measurement population. Instead of looking for points inconsistent with a linear pattern on a probability plot, the box plot flags as possible outliers values that are located in either or both of the *extreme tails* of the sample."

The five potential outlier locations in the data from the Surface Mine Area were biased, based on an evaluation of the gamma survey results, and were intended to capture the upper limit of radium-226 soil concentrations in the area. Because the sample locations were intentionally biased toward higher radium-226 concentrations, it is not surprising that they would be outliers compared to the remaining data set. The box plot analysis (see Figure 3 in Appendix 2.9-M of the approved license application) identified five samples within the Surface Mine Area as being outliers. At the request of the NRC staff, ASTM Standard E178-08, Standard Practice for Dealing with Outlying Observations (ASTM, 2002), was also used to evaluate whether the outliers identified using the box plot analysis are also outliers using the methods described within. Prior to presenting the test data contained in ASTM E178-08, three important points should be mentioned:

1) ASTM E178-08 discusses rejecting observations based on judgment provided a physical reason is known or discovered for the outlier. Statistical test for these outliers may be used

but is not required to support a judgment that a physical reason actually exists for the outlier.

2) The criteria for outliers within ASTM E178-08 are based on an assumed underlying normal distribution.
3) When data are not normally or approximately normally distributed, the probabilities associated with the tests will be different (ASTM E178-08).

In the case of the five outliers in the Surface Mine Area, physical properties (the proximity of the historical open-pit uranium mines) for the higher values were known. This physical property was the reason samples were collected at these locations. Table 2.9-5a provides the statistical analysis based on methods described in Section 6 of ASTM E178-08.

Table 2.9-5a supports the decision to consider the sample results as outliers based on judgment and the outlier screening using box plots. Consistent with ASTM E178-09, these observations were recognized as likely being from a different population than the other sample values and were not used in describing the central tendency of the data or other data analysis.

Table 2.9-5a: Outlier Test for Surface Soil Samples Collected in Surface Mine Area

Potential Outlier Sample ID	Sample Ra-226 Concentration (pCi/g)	N	Mean Ra-226 Concentration (pCi/g)	Standard Deviation (pCi/g)	‡Test Statistic	†Critical Value (upper 1%)	Outlier (Yes/No)
SMA-B27	40.00	25	5.90	11.00	3.10	3.009	Yes
SMA-B30	34.00	24	4.84	8.65	3.37	2.987	Yes
SMA-B29	29.00	23	3.20	6.08	4.24	2.963	Yes
SMA-B26	11.00	22	2.02	2.36	3.81	2.939	Yes
SMA-B28	6.40	21	1.60	1.28	3.75	2.912	Yes

† Critical values obtained from Table 1 of ASTM E178-08
‡ Test Statistic $T_n = (x_n - \bar{x})/s$

Potential outliers in the data obtained in the Main Permit Area were not attributed to any known or discovered physical property. The samples were identified as potential outliers using box plots. Table 2.9-5b provides the statistical analysis for outliers for these three samples based on methods described in Section 6 of ASTM E178-08. Two of the three samples identified as outliers using box plots were also identified as outliers using the ASTM method. The outlier data in the case of the Main Permit Area are probably extreme manifestations of the random variability inherent in the data and should be retained and processed in the same manner as the other observations in the sample (ASTM E178-08). These data were only excluded from the other data processing when attempting to fit a parametric distribution to the data, in this case a lognormal distribution. These data were included when describing the median radium-226 concentration (1.3 pCi/g) for the Main Permit Area and excluded when calculating the geometric mean (1.3 pCi/g) for the same area. The estimate of the central tendency of the data using non-parametric (outliers were included in estimate) and parametric (outliers were excluded in estimate) estimates are the same.

Table 2.9-5b: Outlier Test for Surface Soil Samples Collected in Main Permit Area

Potential Outlier Sample ID	Sample Ra-226 Concentration (pCi/g)	N	Mean Ra-226 Concentration (pCi/g)	Standard Deviation (pCi/g)	‡Test Statistic	†Critical Value (upper 1%)	Outlier (Yes/No)
RFA-B21A	5.60	55	1.51	0.77	5.31	3.376	Yes
RFA-B23	3.60	54	1.44	0.54	4.00	3.368	Yes
NEA-R05	2.80	53	1.40	0.45	3.11	3.361	No

† Critical values obtained from Table 1 of ASTM E178-08
‡ Test Statistic $T_n = (x_n - \bar{x})/s$

With outliers removed, both the surface mine and main permit 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 project area surface soils. Exceptional areas include those in and around the artesian well discharge and open pit mines. At this time, radium-226 concentrations are not well characterized in the northern anomalous area in the main permit 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 2.9-5 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 LLDs (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. The median lead-210 concentration for surface soils (0-5 cm and 0-15 cm depths), excluding land application samples (LAN and LAS), was 1.5 E-6 µCi/g. In these areas, the lead-210 LLD was 1.0 E-7 µCi/g, which is consistent with the Regulatory Guide 4.14 LLD for lead-210 in soil. The median lead-210 soil concentration for surface soil in the land application areas was 1.1 E-6 µCi/g. In the land application areas, the LLD ranged from 1.9 E-6 to 3.8 E-6 µCi/g. Since the median lead-210 concentrations were similar between the two data sets, Powertech (USA) considers the reported lead-210 soil concentrations within the land application areas as representative of background regardless of the reported sample-specific LLD values.

2.9.3.2.2 Subsurface Soil Sample Results

Table 2.9-5 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.

2.9.3.2.3 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 2.9-6, which lists the errors and lower limits of detection (LLDs) for each duplicate pair. Table 2.9-6 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 minimal detectable concentration (MDC), respectively, as established in a Quality Assurance Project Plan (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).

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.

Table 2.9-6: Quality Control Analysis for Soil Samples

Sample ID	Depth (cm)	Relative Percent Difference (%)				Replicate Error Ratio		
		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.

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.

2.9.3.3 Conclusions

Main Project and Surface Mine Areas

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

2.9.4 Sediment Sampling

In June and August of 2008, baseline sediment sampling was conducted at the 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 project boundary. Impoundment sediment samples were collected in the same impoundments at which surface water chemistry was sampled. Figure 2.9-11 and Table 2.9-7 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 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.

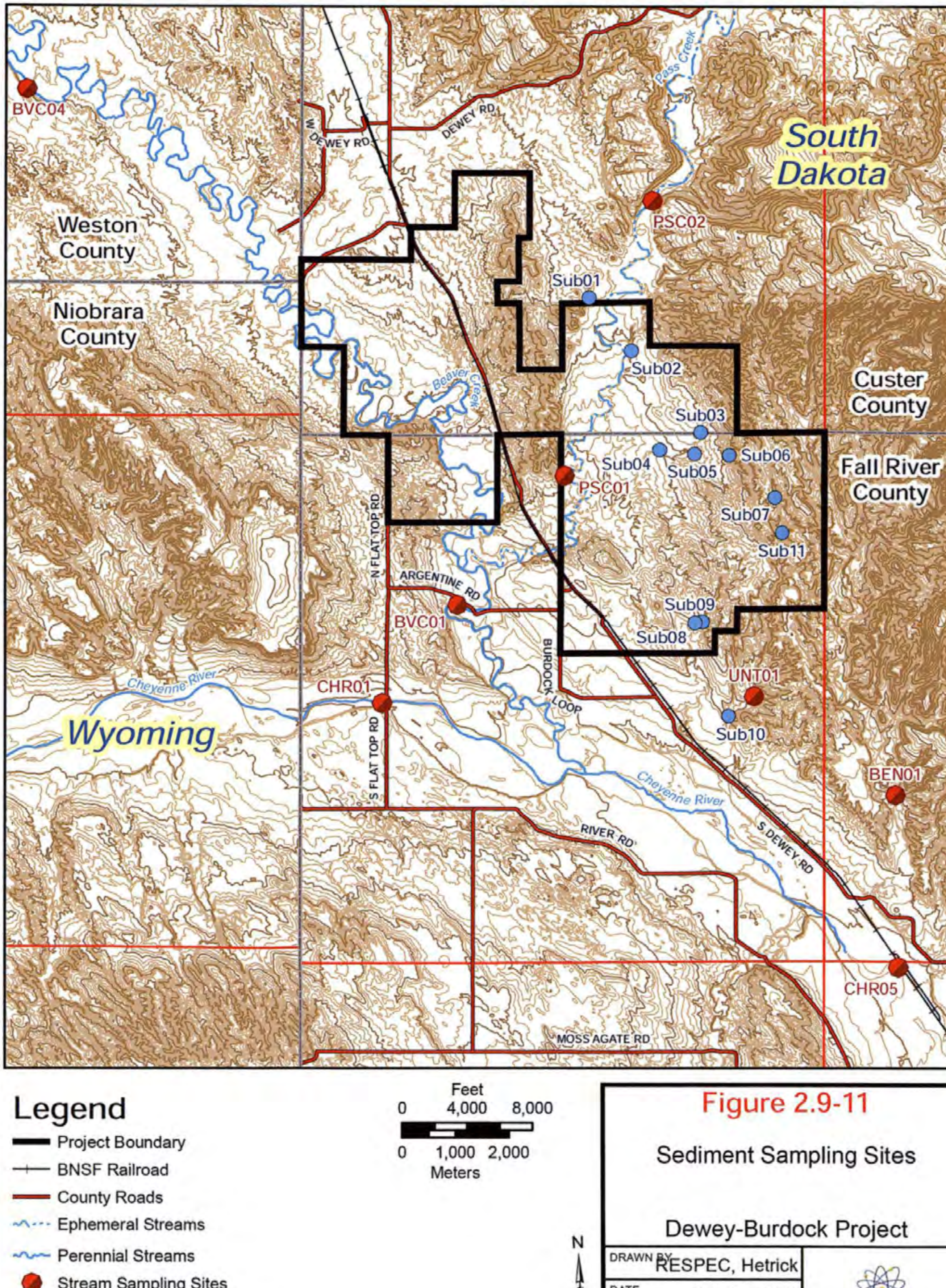


Figure 2.9-11

Sediment Sampling Sites

Dewey-Burdock Project

DRAWN BY	RESPEC, Hetrick
DATE	18-Jun-2013
FILENAME	SedimentSites.mxd

POWERTECH (USA) INC.

Table 2.9-7: 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	

2.9.4.1 Methods

2.9.4.1.1 Stream Sediment 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.

2.9.4.1.2 *Surface Water Impoundment 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 2.9-12). A subset of 11 of the total 48 impoundments within a 2 km radius of the 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.

Figure 2.9-12: Surface Water Impoundments

2.9.4.2 Sediment Sampling Results

2.9.4.2.1 Stream Sediment Sample Results

Analytical results for the sediment sampling completed as part of the baseline monitoring program are provided in Appendix 2.9-H of the approved license application. A summary of radionuclide concentrations in sediment samples is provided in Appendix 2.9-K of the approved license application. The summary tables include the error and LLDs associated with each concentration in accordance with the recommendations in RG 4.14, Section 7.0. Beaver Creek sediment sample results from the historical TVA survey (TVA DES, 1980) are provided in Table 2.9-9. LLDs for radionuclide results presented in Table 2.9-9, if recorded by the laboratory during analysis, are no longer available. A FOIA request was filed with TVA, including sediment laboratory reports, but no additional information was received regarding the baseline work performed in the 1970s.

Table 2.9-9: Historical Radionuclide Concentrations in Beaver Creek Sediment Samples

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

Source: TVA DES, 1980

2.9.4.3 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 (PSC01) 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).

2.9.5 Ambient Gamma and Radon Monitoring

2.9.5.1 Methods

2.9.5.1.1 Ambient Gamma Dose Rate Monitoring

Ambient exposure rates were determined for three periods, using TLDs supplied and analyzed by Landauer, Inc. The monitoring periods were: August 15, 2007 to February 4, 2008, February 4 to May 17, 2008, and May 17 to July 17, 2008. The 29-day period between July 17 and August 15 that would complete the year was not monitored.

The TLDs were deployed at each of the eight AMS locations. The criteria used to establish the AMS locations is discussed in Section 2.9.6. The AMS locations meet the siting criteria recommended in Regulatory Guide 4.14. On this basis the TLD monitoring locations also meet the siting criteria recommended in Regulatory Guild 4.14. 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 disturbance. Two additional TLDs were lost from subsequent deployments, presumably as a result of cattle in the area.

2.9.5.1.2 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 2.9-8.

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.

2.9.5.2 Results

2.9.5.2.1 Ambient Gamma Dose Rate Monitoring

The ambient gamma dose rate monitoring results are listed in Table 2.9-10. All reported dose equivalents were converted to an adjusted dose rate by dividing by the time between the shipment of the dosimeters to the site and the time that the dosimeters were processed by the vendor. In order to obtain an estimate of the annual dose equivalent rate, the average daily dose rate for the 29-day period (July 17, 2008-August 15, 2008) which was not monitored was assumed equal to the May 17, 2008 to July 17, 2008 period. This is reasonable since terrestrial dose rates for a location primarily depend on soil moisture and snow and vegetation cover. For locations where TLDs were missing, no attempt was made to obtain an annual projected dose equivalent. The results for the TLDs reported in millirem per year (mrem/yr) ambient dose equivalents are as follows:

- AMS-04: 112 mrem/yr
- AMS-05: 91 mrem/yr
- AMS-07: 109 mrem/yr
- AMS-BKG: 123 mrem/yr

The TLD results compare favorably with the baseline direct gamma-ray survey data for the site reported in Section 2.9.2.1.1 when expressed in exposure rate units (μR/h) as reported in Section 2.9.2.2.2, where the average exposure rate was reported as 10.9 microRoentgen/h (μR/h). Since a Roentgen is approximately equal to a rem, 10.9 μR/h can be expressed as 96 mrem/yr. This is very close to the 109 mrem/y average for the four monitoring locations.

The range of exposure rates (91 to 123 mrem/yr) and average (109 mrem/yr) are 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 from 60 to 160 mrem/yr.

The analytical reports are provided as Appendix 2.9-C of the approved license application. Included at the beginning of Appendix 2.9-C of the approved license application is an index sheet listing the TLD reports by sample location and monitoring period.

TLDs at the stations AMS-01, AMS-02, AMS-03, and AMS-06 were eaten or otherwise removed by cattle or humans for one or more of the monitoring periods. For example, Table 2.9-10 shows that the TLD monitoring period for AMS-01 was 164 days. The documentation for the monitoring periods for each AMS is included in Appendix 2.9-C of the approved license application. Rather than computing an annual average dose equivalent rate for these stations, Powertech (USA) relied on the extensive set of exposure rate data predicted from the GPS-based gamma surveys. The gamma-ray count rates were converted to exposure rates by developing a correlation with data from a pressurized ionization chamber (PIC). As described above, the annual gamma dose rate for the project area (96 mrem) agrees well with the 109 mrem annual measured dose equivalent rate from the TLD data at the four monitoring stations where the data sets are complete. These stations are located to the north, southwest, and south of the project area, not near the historical surface mining area or other known elevated exposure rate anomalies.

Table 2.9-10: Ambient Gamma Dose Rates

Location	Starting Date	End Date	Dose (mrem)	Adjusted Dose Rate (mrem/day)[b]	Projected Annual Doses (mrem)
AMS-01	8/15/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	37.2[a]	0.260	
	5/17/08	7/17/08	57.7[a]	0.412	
AMS-02	8/16/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	-	NC	
	5/17/08	7/17/08	54.0	0.386	
AMS-03	8/15/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	38.6	0.270	
	5/17/08	7/17/08		NC	
AMS-04	8/15/07	2/4/08	62.4	0.297	112
	2/4/08	5/17/08	36.1	0.252	
	5/17/08	7/17/08	54.3	0.388	
AMS-05	8/15/07	2/4/08	50.6	0.241	91
	2/4/08	5/17/08	36.7	0.257	
	5/17/08	7/17/08	36.4	0.260	
AMS-06	8/15/07	2/4/08	-	NC	NC
	2/4/08	5/17/08	36.9	0.258	
	5/17/08	7/17/08	51.1	0.365	
AMS-07	8/15/07	2/4/08	73.7	0.351	109
	2/4/08	5/17/08	35.5	0.248	
	5/17/08	7/17/08	36.1	0.258	
AMS-BKG	8/15/07	2/4/08	68.8[a]	0.328	123
	2/4/08	5/17/08	40.5[a]	0.283	
	5/17/08	7/17/08	58.5[a]	0.418	

Notes:

a. Result is average of measurement plus duplicate.
b. Dose rate adjusted by dividing the reported dose by the time from vendor shipment of dosimeters to site and the time dosimeters were processed.

NC = Not Calculated due to missing data

2.9.5.2.2 Ambient Radon-222 Monitoring

The ambient radon monitoring results are listed in Table 2.9-11. 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 2.9-11: 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 2.9-11: Radon Concentrations in Air (cont'd)

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 2.9-11: Radon Concentrations in Air (concl.)

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.

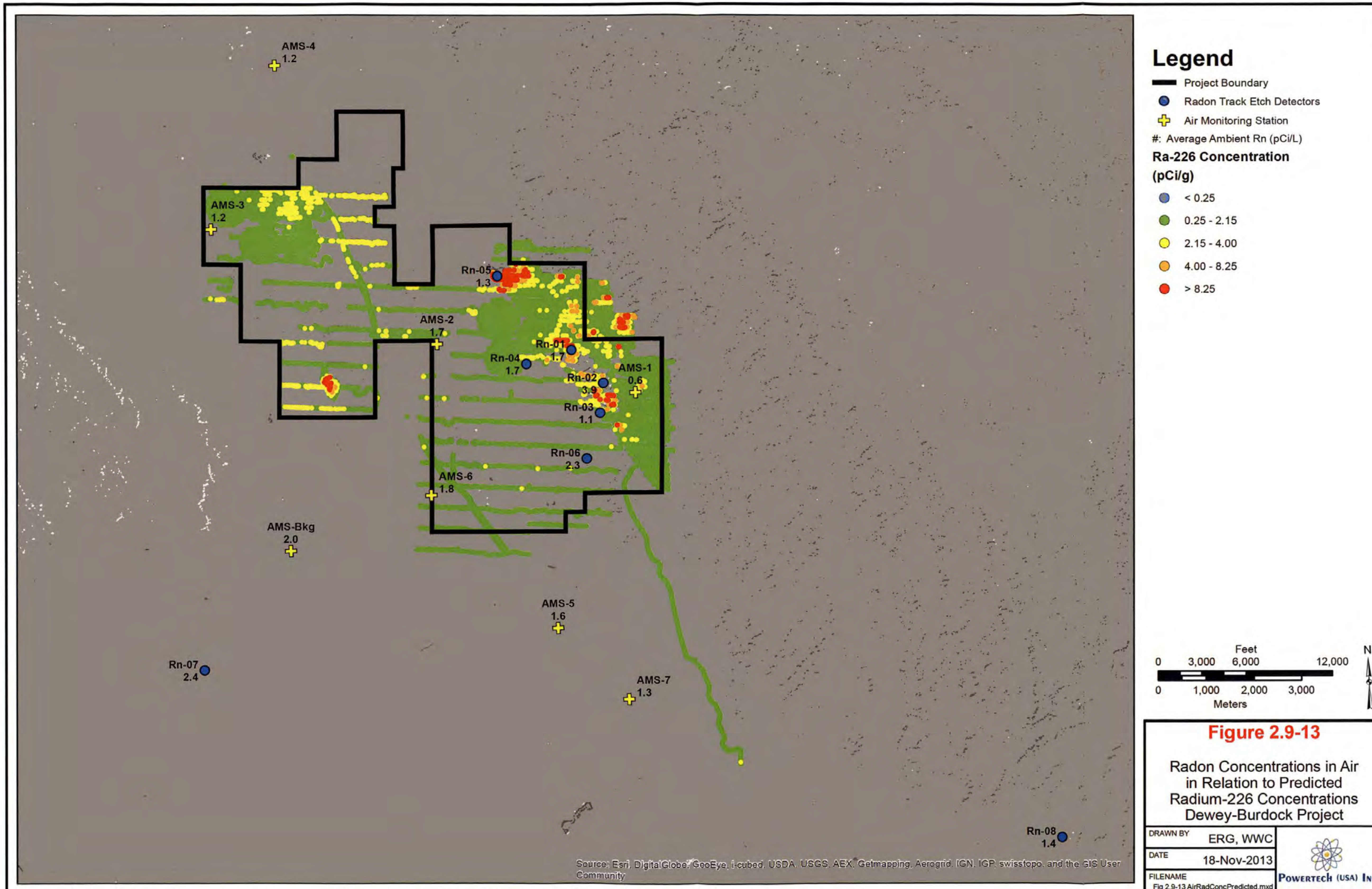
Figure 2.9-13 presents the ambient radon concentrations in relation to the radium-226 concentrations predicted from the gamma-ray count rate data. One expects higher radon concentrations in the mined areas. However, there is only one case where this is true: the Q1 observation at Rn-02, located adjacent 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 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.


Legend
Project Boundary
Radon Track Etch Detectors
Air Monitoring Station
#: Average Ambient Rn (pCi/L)
Ra-226 Concentration (pCi/g)
< 0.25
0.25 - 2.15
2.15 - 4.00
4.00 - 8.25
> 8.25
AMS-4 1.2
AMS-3 1.2
AMS-2 1.7
AMS-1 0.6
AMS-6 1.8
AMS-Bkg 2.0
AMS-5 1.6
AMS-7 1.3
Rn-05 1.3
Rn-01 1.7
Rn-04 1.7
Rn-02 3.9
Rn-03 1.1
Rn-06 2.3
Rn-07 2.4
Rn-08 1.4
Feet
0 3,000 6,000 12,000
0 1,000 2,000 3,000
Meters
N
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Figure 2.9-13
Radon Concentrations in Air in Relation to Predicted Radium-226 Concentrations Dewey-Burdock Project
DRAWN BY ERG, WWC
DATE 18-Nov-2013
FILENAME Fig 2.9-13 AirRadConcPredicted.mxd
POWERTECH (USA) INC.

2.9.5.3 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).

2.9.6 Air Particulate Monitoring

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

2.9.6.1 Methods

Eight Hi-Q Model HVP-4200AFC high volume air samplers were established within and surrounding the permit area. The samplers operated continuously for 366 days from August 2007 to August 2008 except for minor down time due to filter changes, power outages, and other disruptions of the power supply. This was consistent with the recommendations in RG 4.14 and requirements in 10 CFR 40, Appendix A, Criterion 7. The locations of the air samplers are shown on Figures 2.9-8 and 2.9-13.

The criteria used to establish air particulate sampling locations include the following factors:

1) Average meteorological conditions such as wind speed, wind direction and atmospheric stability
2) Prevailing wind direction
3) Site boundaries nearest to proposed facility processing areas, land application areas, and well fields
4) Direction of nearest occupiable structure
5) Locations of estimated maximum concentrations of radioactive materials
6) Locations of existing features near or within the license boundary, but unrelated to proposed site activities, that may impact background radiological conditions (e.g., railroads and historical surface mines)
7) Location of nearest multiple resident area or town

Factors 1-5 are identical to the air particulate sampler siting criteria contained in Regulatory Guide 4.14. Factors 6 and 7 were added to account for site-specific conditions. Table 2.9-11a compares the air monitoring station locations suggested by Regulatory Guide 4.14 to those established for the site. The locations of the air monitoring stations are shown on Figure 2.9-8. Figure 2.9-14 shows the Dewey-Burdock wind direction distribution.

Table 2.9-11a: Regulatory Guide 4.14 Recommended Versus Pre-operational Air Monitoring Locations

Regulatory Guide 4.14 Recommendation	Dewey-Burdock Pre-operational Monitoring Locations
Three locations at or near the site boundary	Initially, AMS-01 was positioned to evaluate particulate emissions potentially resulting from disturbed areas associated with historical open-pit uranium mines to the west and northwest of this location. AMS-01 is also near the eastern boundary of the project area, approximately 3.2 km east-southeast of the proposed Burdock land application areas. Figure 2.9-8 shows the location of AMS-01 relative to the Burdock land application areas. This figure also shows the predominant wind directions and the wind rose. The land application areas are the only expected source of potential routine airborne particulate emissions in the form of long-lived radionuclides. Winds from the northwest occur nearly 20% of the time as shown in Figure 2.9-14. Additionally, the strongest winds are from the northwest as shown on the updated wind rose. AMS-01 is positioned near the eastern boundary of the project area and downwind from the only potential source of routine airborne particulate radionuclide emissions. Using the factors listed above, AMS-01 meets the criteria to establish an air particulate sampling location at this boundary location.
	AMS-02 is near the project boundary in the center of the project area. It is approximately 3.5 km east-southeast of the proposed Satellite Facility and 2.5 km northwest of the proposed CPP. Winds from the southeast (including east-southeast and south-southeast) occur approximately 15% of the time as shown in Figure 2.9-14. Winds from the northwest (including north-northwest and west–northwest) occur approximately 40% of the time. Additionally, the strongest winds are from the northwest as shown on the wind rose. AMS-02 is positioned in downwind direction from the proposed Satellite Facility and CPP. This is an ideal location to monitor potential airborne particulate radionuclide emissions from all potential facility-related sources.
	AMS-03 is near the northwest project boundary. It is approximately 2 km west of the proposed Satellite Facility and very near the Dewey land application areas. Winds from the east occur approximately 8% of the time, which is the fourth highest frequency when compared to other sectors from the 16 compass directions (refer to Figure 2.9-14). Given the proximity of AMS-03 to the proposed Satellite Facility and the Dewey land application areas and the significant contribution of winds from the east and east-southeast, AMS-03 is ideally located to evaluate potential environmental impacts of airborne particulate radionuclide emissions.

Table 2.9-11a: Regulatory Guide 4.14 Recommended Versus Pre-operational Air Monitoring Locations (cont.)

Regulatory Guide 4.14 Recommendation	Dewey-Burdock Pre-operational Monitoring Locations
If within 10 km of the site, an air sampler should be at or near the structure with the highest predicted airborne radionuclide concentration due to milling operations and at or near at least one structure in any area where predicted doses exceed 5% of the standards in 40 CFR Part 190.	Location AMS-02 is located within 10 km of the site, is adjacent to occupiable structures and is downwind of the CPP and Satellite Facility and land application areas. AMS-02 has the highest predicted airborne radionuclide concentrations during ISR operations for locations with occupiable structures in and around the project area, as determined by MILDOS-AREA.
A remote location that represents background conditions at the mill site.	AMS-BKG is approximately 7 km south of the proposed Satellite Facility and 6 km east-southeast of the proposed CPP. AMS-BKG is in one of the least prevalent wind directions from both the proposed Satellite Facility and the CPP. It is expected that this location would be unaffected by the proposed uranium recovery operations.

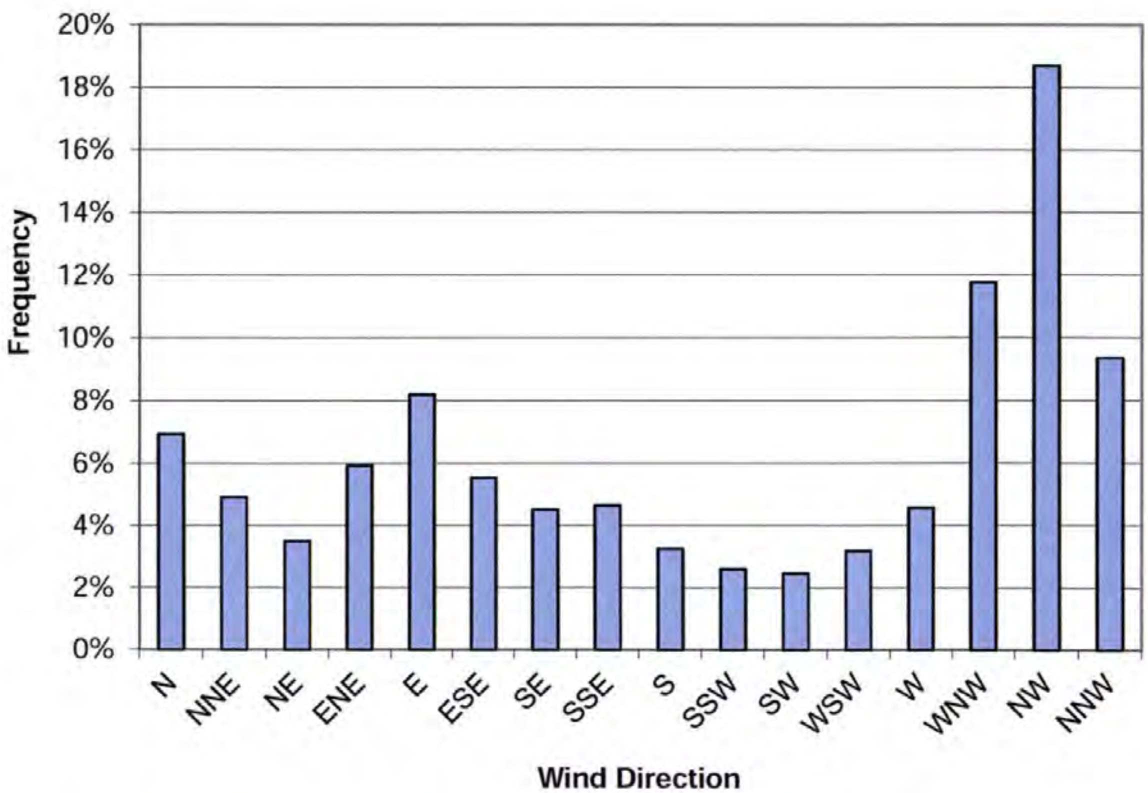


Figure 2.9-14: Dewey-Burdock Wind Direction Distribution

Table 2.9-11b shows the sum of predicted particulate radionuclide concentrations in air for all of the AMS locations and the southeast corner of the project boundary. The southeast corner of the project boundary was included in this evaluation in response to an NRC staff question regarding the absence of a pre-operational air particulate sampler at this location, which is in the downwind direction from the CPP. The predicted airborne radionuclide concentrations were obtained from the MILDOS-AREA output contained in Appendix 7.3-A of the approved license application. As shown in Table 2.9-11b, AMS-02 has the highest predicted airborne radionuclide concentrations of the air monitoring locations followed by AMS-03 and AMS-01. Based on the April 7-8, 2011 meeting with NRC staff, Powertech (USA) understands that NRC staff do not disagree that AMS-02 and AMS-03 are acceptable boundary locations according to Regulatory Guide 4.14 recommendations. Additionally, the predicted air concentrations at AMS-01 are similar to the predicted airborne radionuclide concentrations at AMS-03 and are larger than the predicted airborne radionuclide concentrations at the southeast corner of the project boundary. Based on the provided information and supported by the updated annual wind rose shown in Figure 2.9-8, AMS-01 also meets the siting criteria contained in Regulatory Guide 4.14.

Four stations were initially sited consistent with factor 6 listed above. These included Stations AMS-01, AMS-05, AMS-06 and AMS-07. AMS-04 was placed in the town of Dewey because this is the closest area to the license boundary that contains multiple residences. As discussed above, AMS-01 also meets the siting criteria contained in Regulatory Guide 4.14 for a site boundary monitoring location.

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 13 to October 2, 2007
- Period 2: October 2, 2007 to January 4, 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

Table 2.9-11b: Predicted Airborne Radionuclide Concentrations at Dewey-Burdock AMS Locations

Location	U-nat (µCi/ml)	Th-230 (µCi/ml)	Ra-226 (µCi/ml)	Pb-210 (µCi/ml)	Total Concentration (µCi/ml)
AMS-02	1.18E-15	3.95E-16	2.37E-16	3.94E-17	1.86E-15
AMS-03	5.14E-16	1.71E-16	1.03E-16	1.71E-17	8.05E-16
AMS-01	4.67E-16	1.56E-16	9.35E-17	1.56E-17	7.32E-16
AMS-06	2.15E-16	7.18E-17	4.31E-17	7.17E-18	3.37E-16
AMS-04	1.46E-16	4.88E-17	2.93E-17	4.87E-18	2.29E-16
AMS-05	1.34E-16	4.45E-17	2.67E-17	4.44E-18	2.09E-16
AMS-07	1.03E-16	3.44E-17	2.06E-17	3.43E-18	1.62E-16
AMS-BKG	8.83E-17	2.95E-17	1.77E-17	2.94E-18	1.38E-16
Southeast Boundary	3.42E-16	1.14E-16	6.84E-17	1.14E-17	5.35E-16

µCi/ml = microCuries per milliliter

Based on the use of modern, automatic flow control air samplers, the recommendation in Regulatory Guide 4.14 to change filters weekly is obsolete. When Regulatory Guide 4.14 was issued, automatic flow control air samplers were not available, resulting in the need for weekly filter changes. Use of automatic flow control air samplers and visual observations and flows recorded during each filter change confirmed that bi-weekly filter changes were sufficiently frequent to prevent any reduction in performance due to dust loading.

The approximately bi-weekly filter collection schedule was chosen based on the following:

1) As part of the baseline monitoring program, Powertech (USA) utilized brushless, automatic flow control hi-vol air samplers. Each air sampler was equipped with a variable speed motor, controlled by a programmable logic controller (PLC). The PLC received input from a mass air flow sensor placed in the air flow path downstream of the filter paper. Any changes in the pre-set flow rate due to dust loading, barometric pressure or temperature were detected by the air flow sensor and the PLC compensated by adjusting the motor speed to maintain the pre-set flow rate.

2) Each air sampler was equipped with an air flow totalizer, which was recorded and reset during each filter change.

3) Given the rural South Dakota site location and the features of the samplers described above, it was unlikely that total suspended particulate concentrations in air would interfere with air flow rates over a two-week period.

Air Particulate Sampler Calibration Methods

The model number of the high-volume, air particulate samplers used during baseline monitoring for the Dewey-Burdock Project was HVP-4200AFC. The unit is manufactured by Hi-Q Environmental Products Company, San Diego, CA. The procedures to operate and maintain this equipment are described in the manufacturer's operations and maintenance manual (Hi-Q, 2006), which is included as Appendix 2.9-B of the approved license application. The samplers were purchased new from the manufacturer and deployed on or near August 13, 2007. Although the operations and maintenance manual states that the units were calibrated before leaving the factory and there was no need to calibrate before use, a calibration check was performed after initial installation using the procedures described in the operations and maintenance manual. The operations and maintenance manual also states that all air flow devices should be recalibrated at least once a year against a traceable standard. Since air monitoring was discontinued on August 13, 2008, one year after installation, recalibration was not deemed necessary.

The air particulate samplers were equipped with air flow totalizers, which were recorded and reset during each filter change. Qualitative checks of air particulate sampler operation were also performed during each filter change. No anomalous flow volumes or conditions were observed.

Sample Analysis and Calculation of Results

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.

Uranium in air particulate was reported by the laboratory in milligrams per filter composite. The results for uranium were converted to microcuries per milliliter using the specific activity for natural uranium provided in Footnote 3 to 10 CFR Part 20, Appendix B and the following equation:

$$[U_{nat}] = \frac{U_{nat}Result\ (mg) \times SA_{unat}(Ci/g) * 1x10^6\ \mu Ci/Ci}{1000\ mg/g * V\ (ml)}$$

Where:

$[U_{nat}]$ = Air concentration of natural uranium (μCi/ml)

SA_{unat} = Specific activity of natural uranium (6.77 E-7 Ci/g)
U_{nat} Result = Laboratory result for natural uranium in filter composite (mg)

V = Volume of air sampled (ml)

For the parameters other than natural uranium, the data were converted to units of microcuries 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 2.9-12 as percentages of the respective effluent limits. The most conservative effluent limits were applied to thorium-230 ($2*10^{-14}$ 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.

2.9.6.2 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 2.9-12 and summarized as averages and ranges in Table 2.9-13.

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

- Natural uranium concentrations ranged from $-3.0*10^{-17}$ to $1.5*10^{-14}$ µCi/ml and averaged $1.4*10^{-15}$ µCi/ml.
- Thorium-230 concentrations ranged from $-1.5*10^{-18}$ 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 $5.3*10^{-17}$ µCi/ml and averaged $1.6*10^{-18}$ µCi/ml.
- Lead-210 concentrations ranged from $6.0*10^{-15}$ to $4.1*10^{-14}$ µCi/ml and averaged $1.5*10^{-14}$ µCi/ml.

Table 2.9-12: Radionuclide Concentrations in Air

Location	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-01	1	7.10E-15	1.70E-17	2.80E-17	5.30E-17	4.30E-17	2.40E-14	6.20E-16	0.24%	0.00%	0.01%	4.00%	7.10E-15	4.20E-18	4.80E-17	2.10E-17
	2	0.00E+00	1.60E-18	1.10E-17	7.20E-18	9.10E-18	4.10E-14	6.90E-16	0.00%	0.00%	0.00%	6.78%	1.60E-16	1.60E-18	1.60E-18	7.90E-18
	3	-1.30E-17	3.40E-18	1.00E-17	1.80E-17	1.70E-17	2.10E-14	3.50E-16	0.00%	0.00%	0.00%	3.54%	1.70E-18	1.70E-18	1.20E-17	2.10E-16
	4	2.40E-17	1.30E-17	9.80E-18	1.40E-17	9.70E-18	2.10E-14	4.90E-16	0.00%	0.00%	0.00%	3.51%	1.50E-18	1.50E-18	8.30E-18	4.20E-16
	5	-1.70E-17	6.50E-18	2.50E-17	-3.10E-17	2.70E-17	1.00E-14	6.50E-16	0.00%	0.00%	0.00%	1.74%	4.30E-18	4.30E-18	5.60E-17	6.70E-16
AMS-02	1	7.00E-15	4.10E-18	2.80E-17	-8.30E-18	2.90E-17	1.10E-14	4.50E-16	0.23%	0.00%	0.00%	1.85%	7.00E-15	4.10E-18	3.70E-17	2.10E-17
	2	0.00E+00	1.60E-17	1.10E-17	-2.30E-18	7.00E-18	2.00E-14	4.70E-16	0.00%	0.00%	0.00%	3.26%	1.50E-16	1.50E-18	1.50E-18	7.60E-18
	3	-2.00E-17	4.70E-18	1.10E-17	-8.60E-18	1.30E-17	8.90E-15	2.50E-16	0.00%	0.00%	0.00%	1.49%	1.60E-18	1.60E-18	1.10E-17	1.90E-16
	4	4.20E-18	0.00E+00	7.40E-18	-4.20E-18	7.40E-18	8.20E-15	4.20E-16	0.00%	0.00%	0.00%	1.37%	1.40E-18	1.40E-18	7.60E-18	3.90E-16
	5	-1.30E-17	0.00E+00	8.00E-18	-4.90E-17	2.30E-17	1.50E-14	6.50E-16	0.00%	0.00%	0.00%	2.44%	4.00E-18	4.00E-18	5.30E-17	6.20E-16
AMS-03	1	5.00E-15	-1.50E-18	2.00E-17	-5.90E-18	2.10E-17	1.20E-14	3.70E-16	0.17%	0.00%	0.00%	1.97%	5.00E-15	3.00E-18	2.70E-17	1.50E-17
	2	0.00E+00	9.30E-18	1.00E-17	5.40E-18	8.90E-18	1.30E-14	3.90E-16	0.00%	0.00%	0.00%	2.16%	1.60E-16	1.60E-18	1.60E-18	7.80E-18
	3	-3.00E-17	9.30E-18	1.20E-17	-1.40E-17	1.30E-17	9.20E-15	2.50E-16	0.00%	0.00%	0.00%	1.53%	1.50E-18	1.50E-18	1.20E-17	1.90E-16
	4	1.80E-17	8.90E-18	9.00E-18	9.60E-18	9.50E-18	8.00E-15	4.40E-16	0.00%	0.00%	0.00%	1.34%	1.50E-18	1.50E-18	8.90E-18	4.10E-16
	5	-1.60E-17	1.90E-17	9.70E-18	-3.20E-18	3.10E-17	1.20E-14	6.50E-16	0.00%	0.00%	0.00%	1.99%	4.20E-18	4.20E-18	5.00E-17	6.60E-16
AMS-04	1	5.00E-15	5.90E-18	2.50E-17	4.60E-17	2.90E-17	1.10E-14	3.70E-16	0.17%	0.00%	0.01%	1.89%	5.00E-15	3.00E-18	3.00E-17	1.50E-17
	2	0.00E+00	9.40E-18	1.10E-17	2.30E-18	8.30E-18	2.20E-14	5.10E-16	0.00%	0.00%	0.00%	3.66%	1.60E-16	1.60E-18	1.60E-18	7.80E-18
	3	-2.60E-17	2.50E-18	1.10E-17	-2.80E-17	1.20E-17	8.50E-15	2.60E-16	0.00%	0.00%	0.00%	1.42%	1.70E-18	1.70E-18	9.90E-18	2.00E-16
	4	1.90E-17	6.60E-18	9.00E-18	1.20E-17	9.50E-18	1.00E-14	4.60E-16	0.00%	0.00%	0.00%	1.74%	1.50E-18	1.50E-18	8.10E-18	4.10E-16
	5	-1.00E-18	2.70E-17	9.70E-18	-5.20E-18	3.30E-17	1.30E-14	6.70E-16	0.00%	0.00%	0.00%	2.23%	4.20E-18	4.20E-18	5.50E-17	6.60E-16

Table 2.9-12: Radionuclide Concentrations in Air (cont.)

Location	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	5.90E-15	2.60E-17	2.50E-17	-4.50E-17	2.40E-17	1.10E-14	5.30E-16	0.20%	0.00%	0.00%	1.82%	5.90E-15	3.50E-18	4.50E-17	1.70E-17
	2	0.00E+00	2.00E-17	1.40E-17	4.70E-17	1.30E-17	2.50E-14	2.60E-16	0.00%	0.00%	0.01%	4.09%	1.60E-16	1.50E-18	1.50E-18	7.70E-18
	3	1.00E-18	4.70E-18	1.10E-17	1.10E-17	1.50E-17	1.00E-14	4.40E-16	0.00%	0.00%	0.00%	1.66%	1.60E-18	1.60E-18	1.10E-17	1.90E-16
	4	2.50E-17	1.30E-17	9.20E-18	1.30E-17	9.00E-18	1.00E-14	6.30E-16	0.00%	0.00%	0.00%	1.74%	1.40E-18	1.40E-18	7.70E-18	3.90E-16
	5	2.40E-17	5.60E-17	9.50E-18	2.20E-17	3.40E-17	1.10E-14	0.00E+00	0.00%	0.00%	0.00%	1.85%	4.10E-18	4.10E-18	4.90E-17	6.40E-16
AMS-06	1	5.0E-15	1.5E-18	2.0E-17	-3.9E-17	1.8E-17	1.4E-14	4.0E-16	0.17%	0.00%	0.00%	2.28%	5.0E-15	3.0E-18	3.1E-17	1.5E-17
	2	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	3.0E-18	1.5E-18	7.3E-18
	3	-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%	0.99%	1.6E-18	3.0E-18	1.1E-17	1.9E-16
	4	1.5E-17	4.9E-18	9.1E-18	-4.9E-18	7.4E-18	9.5E-15	4.3E-16	0.00%	0.00%	0.00%	1.58%	1.4E-18	3.0E-18	8.3E-18	3.9E-16
	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	3.0E-18	4.9E-17	6.2E-16
AMS-07	1	1.5E-14	2.0E-17	2.1E-17	-4.3E-18	2.5E-17	1.8E-14	4.4E-16	0.51%	0.00%	0.00%	3.03%	4.8E-15	2.8E-18	3.4E-17	1.4E-17
	2	0.0E+00	1.3E-17	1.2E-17	2.9E-17	1.0E-17	2.8E-14	5.3E-16	0.00%	0.00%	0.00%	4.62%	1.4E-16	1.4E-18	1.4E-18	6.9E-18
	3	-1.1E-17	6.3E-18	9.0E-18	-1.3E-17	1.1E-17	7.2E-15	2.2E-16	0.00%	0.00%	0.00%	1.19%	1.4E-18	1.4E-18	9.1E-18	1.7E-16
	4	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
	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	5.7E-15	3.0E-17	2.6E-17	5.0E-18	3.1E-17	1.4E-14	4.2E-16	0.19%	0.00%	0.00%	2.26%	5.7E-15	3.3E-18	4.0E-17	1.7E-17
	2	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
	3	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	2.0E-16
	4	1.5E-17	1.4E-18	8.6E-18	2.1E-18	8.0E-18	1.3E-14	4.6E-16	0.00%	0.00%	0.00%	2.13%	1.4E-18	1.4E-18	8.5E-18	4.0E-16
	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	6.3E-16

Notes: 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. No blank corrections were performed on uranium results for the first monitoring period since sample results were reported as non-detects.

Table 2.9-13: 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)			
	Average	σ	Min	Max	Average	σ	Min	Max	Average	σ	Min	Max	Average	σ	Min	Max
AMS-01	1.4E-15	3.2E-15	-1.7E-17	7.1E-15	8.2E-18	6.4E-18	1.6E-18	1.7E-17	1.2E-17	3.0E-17	-3.1E-17	5.3E-17	2.3E-14	1.4E-17	9.1E-18	4.3E-17
AMS-02	1.4E-15	3.1E-15	-2.0E-17	7.0E-15	4.9E-18	6.5E-18	0.0E+00	1.6E-17	-1.4E-17	1.9E-17	-4.9E-17	-2.3E-18	1.3E-14	9.7E-18	7.0E-18	2.9E-17
AMS-03	1.0E-15	2.2E-15	-3.0E-17	5.0E-15	9.0E-18	7.2E-18	-1.5E-18	1.9E-17	-1.6E-18	9.3E-18	-1.4E-17	9.6E-18	1.1E-14	9.2E-18	8.9E-18	3.1E-17
AMS-04	1.0E-15	2.2E-15	-2.6E-17	5.0E-15	1.0E-17	9.8E-18	2.5E-18	2.7E-17	5.3E-18	2.7E-17	-2.8E-17	4.6E-17	1.3E-14	1.1E-17	8.3E-18	3.3E-17
AMS-05	1.2E-15	2.6E-15	0.0E+00	5.9E-15	2.4E-17	1.9E-17	4.7E-18	5.6E-17	9.6E-18	3.4E-17	-4.5E-17	4.7E-17	1.3E-14	1.0E-17	9.0E-18	3.4E-17
AMS-06	1.0E-15	2.3E-15	-1.4E-17	5.0E-15	9.9E-18	7.2E-18	1.5E-18	2.0E-17	-2.6E-18	2.3E-17	-3.9E-17	2.3E-17	1.4E-14	9.9E-18	7.4E-18	3.3E-17
AMS-07	3.1E-15	6.9E-15	-1.1E-17	1.5E-14	1.3E-17	5.7E-18	6.3E-18	2.0E-17	4.9E-18	1.7E-17	-1.3E-17	2.9E-17	1.6E-14	1.0E-17	7.5E-18	3.0E-17
AMS-BKG	1.1E-15	2.5E-15	-8.1E-18	5.7E-15	1.5E-17	1.4E-17	-7.8E-19	3.0E-17	-6.3E-19	1.1E-17	-1.7E-17	1.2E-17	1.3E-14	9.8E-18	8.0E-18	3.1E-17
Overall	1.4E-15		-3.0E-17	1.5E-14	1.2E-17		1.5E-18	5.6E-17	1.6E-18		-4.9E-17	5.3E-17	1.45E-14		7.0E-18	4.3E-17

There are no clear patterns in the data, in terms of radionuclide concentrations, when evaluating them spatially or temporally. Average natural uranium concentrations at each location were on the order of 10^{-15} 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 on the order of 10^{-14} μCi/ml over the course of monitoring.

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 0.5 percent of its effluent concentration.
- Thorium-230 concentrations were 0.0 percent of its effluent concentration.
- Radium-226 concentrations were -0.0 to 0.01 percent of its effluent concentration.
- Lead-210 concentrations were 1.0 to 6.8 percent of its effluent concentration.

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 than their respective 10 CFR 20 effluent concentration limits. The LLDs reported in Periods 1 and 2 by the laboratory for uranium exceeded the recommendation in NRC Regulatory Guide 4.14.

Justification is provided below for U-nat LLD values for monitoring periods 1 and 2 that do not satisfy Regulatory Guide 4.14 guidance. U-nat LLD values met the Regulatory Guide 4.14 guidance for all other monitoring periods, and LLDs for all other radionuclide concentrations in air met the Regulatory Guide 4.14 guidance for all monitoring periods.

U-nat LLD values greater than the Regulatory Guide 4.14 guidance can be justified by the use of the data, both currently and in the future. Currently the data are used to establish the pre-operational baseline condition of the airborne radionuclide concentrations in and around the project area. NUREG/CR-4007 states that "any measurement process must be capable of detecting the relevant radionuclides at levels well below those of concern to the public health and safety" (NRC, 1984). Regulatory Guide 4.14 states that one of its recommended siting criteria is to place an air particulate monitoring station at or near a structure with the highest predicted airborne radionuclide concentration due to milling operations and at or near at least one structure in any area where predicted doses exceed 5 percent of the standards in 40 CFR Part 190. A dose level of

5 percent of the standards in 40 CFR Part 190 is interpreted as being "well below those of concern to the public health and safety." On this basis, an LLD for air particulate monitoring low enough to measure an airborne radionuclide concentration that would result in at least 5 percent of the standards in 40 CFR 190 is justified.

The dose standards in 40 CFR 190 are an annual dose equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public as result of planned discharges of radioactive materials, radon and radon decay products excepted. For inhalation of natural uranium, the annual dose equivalent of 25 mrem to other organs of the body (the bone surface in the case of natural uranium) is the most restrictive limit. Equations 2.3 and 2.4 were used to determine the concentration of natural uranium in air that would result in an annual dose equivalent of 1.25 mrem (5 percent of the standard) to a member of the public. The inhalation dose conversion factor (DCF) from Federal Guidance 11 (EPA, 1988) for Class D U-234 with the target organ of the bone surface was used, since it is the most restrictive of the three lung clearance classes for the three uranium isotopes contained in natural uranium.

$$C_{U-nat} = 1.25\ (mrem)\ x\ \frac{1}{DCF\ x\ BR\ x\ T x\ FO} \qquad \text{(Equation 2.3)}$$

Where

$C_{u\text{-}nat}$ = Natural uranium concentration (μCi/ml)

DCF = Inhalation dose conversion factor for U-234 contained in Federal Guidance Report 11 (EPA, 1988). Value equals 40,330 mrem/μCi.

BR = Breathing rate of 8.4×10^9 ml/year (Data Collection Handbook, ANL, 1993)

T = Time period of 1 year

FO = Shielding Factor for Inhalation Pathway = 0.45 as calculated using Equation 2.4 (Data Collection Handbook, ANL, 1993)

$$FO = (TF_1 x\ 1) + (TF_2 x\ 0.4) + (TF_3 x\ 0) \qquad \text{(Equation 2.4)}$$

Where

TF_1 = Fraction of time spent on site, outdoors (0.25) (Data Collection Handbook, ANL, 1993)

TF_2 = Fraction of time spent on site, indoors (0.5) (Data Collection Handbook, ANL, 1993)

TF_3 = Fraction of time spent off site (0.25) (Data Collection Handbook, ANL, 1993)

The result of this calculation shows that by using realistic assumptions, the natural uranium concentration in air needed to approach 5 percent of the most restrictive 40 CFR 190 standard is 8.2 x 10^{-15} µCi/ml. The highest LLD for air concentrations of natural uranium was 7.1 x 10^{-15} µCi/ml. This LLD is sensitive enough to evaluate the recommended siting criteria for air particulate monitoring at a location at or above 5 percent of the 40 CFR 190 standards. In addition, this dose level (1.25 mrem) is lower than the dose (5 mrem) resulting from the LLD recommendations for stack effluent samples contained in Section 5.0 of Regulatory Guide 4.14.

The LLDs for each of the radionuclides are listed in Table 2.9-12.

2.9.6.3 Conclusions

With the exception of natural uranium, the values determined above are similar to U.S. background concentrations 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 B. The regional concentrations reported in this reference document are: ranium-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).

2.9.7 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 2.9-8. The locations coincide with the nine soil samples collected from 0 to 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 U.S. Environmental Protection Agency (EPA) Test Method 115, Monitoring for Radon-222 Emissions. Results are documented in Table 2.9-14. 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.

2.9.7.1 Conclusions

The flux rates determined at the PA 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.

Table 2.9-14: 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	

2.9.8 Surface Water and Groundwater Sampling

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. For the baseline study for the NRC permit, 19 groundwater wells (14 existing and 5 newly drilled) were selected as making up a representative sampling group for the area (Figure 2.7-30, Table 2.7-28). The wells selected for sampling include eight domestic wells, six stock watering wells, and five monitor wells. The subset includes wells within the Fall River Formation (6), Chilson Member of the Lakota Formation (7), Inyan Kara Group (Fall River and Chilson) (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from the 3rd quarter 2007 through the 2nd quarter 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 14 wells were sampled monthly beginning in early 2008 and continuing through early 2009 (Figure 2.7-31, Table 2.7-29). Of these 14 wells, six wells are in the Dewey area, six wells are near Burdock, and two wells are north of the project area.

Comprehensive information on well locations and all water quality parameters is provided in sections of the project related specifically to groundwater (Section 2.7.3.2).

2.9.8.1 Methods

Surface water sample collection and analysis methods are discussed in Section 2.7.3.1.3. Groundwater sample collection and analysis methods are described in Section 2.7.3.2.2 and summarized below.

Surface water and groundwater samples collected as part of the baseline monitoring program were analyzed for constituents listed in Table 2.7-22. The constituents met the recommendations of Regulatory Guide 4.14 and NUREG-1569 Table 2.7.3-1. Metals were analyzed for dissolved fractions, while radionuclides were typically analyzed for the dissolved and suspended fractions. In some samples analysis was also completed for total metals and total radionuclides.

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 free-flowing 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, 5, 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, 5, 18, 42, 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 were periodically recorded. If parameters had not stabilized after purging 3 volumes, wells were allowed to continue to purge until parameters had stabilized, or until the purged volume was >> 3 well volumes.

Pumped wells were purged in such a manor as to induce flow from the formation into the well so that a sample of fresh formation water was collected.

- 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 3 volumes. Table 2.9-15 gives requirements for parameter stabilization. After 3 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 3 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 were recorded periodically during the purge.

Table 2.9-15: Stability Criteria for Collecting Ground Water 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 involved labeling each sample bottle with site ID, date, and time of sampling, triple rinsing with sample water, then filling and capping.
- 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.

2.9.8.2 Surface Water and Groundwater Sampling Radiological Results

Surface and groundwater quality sampling results are provided in the following appendices of the approved license application:

- Appendix 2.7-C   Surface Water Quality Summary Tables
- Appendix 2.7-F   Surface Water Analytical Results
- Appendix 2.7-G   Groundwater Quality Summary Tables
- Appendix 2.7-H   Groundwater Analytical Results
- Appendix 2.9-I   Radionuclide Concentrations in Surface Water
- Appendix 2.9-J   Radionuclide Concentrations in Groundwater

The tables in Appendices 2.9-I (surface water) and 2.9-J (groundwater) include the value, precision and MDC format, where available (see discussion below), and other information to meet the format detailed in Table 2.9.3-1 of NUREG-1569. Where the earlier reporting format was used by the laboratory and where a result was reported as non-detect, a less than sign and the reporting limit are provided in the summary tables.

Analytical data provided by the contracting laboratory during the early part of Powertech (USA)'s baseline study were reported in a "not detected (ND) at reporting limit (RL)" format. During the course of the baseline study, the contracting laboratory, Energy Laboratories, Inc., implemented the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) process. Analytical data derived from the MARLAP process are reported in a "value, precision and minimum detectable concentration (MDC)" format. Energy Laboratories, Inc. has advised Powertech (USA) that it is not possible to reprocess earlier ND/RL data into the value/precision/MDC format (value/error/LLD format) referenced in Regulatory Guide 4.14. As a result, both reporting formats, the earlier ND/RL and the later value/precision/MDC format, appear in Powertech (USA)'s water quality radiological summary tables and laboratory analytical data packages. Following is a description of how the MDC is used in place of the LLD in the summary tables.

The lower limit of detection (LLD) is defined in MARLAP (2004) as the following: "(1) The smallest concentration of radioactive material in a sample that will yield a net count, above the measurement process (MP) blank, that will be detected with at least 95 percent probability with no greater than a 5 percent probability of falsely concluding that a blank observation represents a real signal (NRC, 1984). (2) An estimated detection limit that is related to the characteristics of the counting instrument (EPA, 1980)."

The calculation referenced in several NRC documents for LLD is generally in the form:

$$LLD = \frac{4.66 \times \sigma_b}{2.22 \times E \times M \times R \times I}$$

Where:

LLD	=	Lower limit of detection as an a priori determination
σ_b	=	Standard deviation of the instrument background count rate (counts/min)
M	=	The sample weight (g) or volume (L)
E	=	Instrument efficiency for alpha or beta
R	=	Yield for the individual radionuclide as determined by tracer or carrier
I	=	Ingrowth factor
2.22	=	Conversion for dpm to pCi

Following is an evaluation of the surface and groundwater sampling radiological results.

<u>Surface Water</u>

Following is a description of the surface water sampling radiological results for select stream sampling sites (BVC01, PSC01 and UNT01) and impoundment sampling sites based on questions from NRC staff. Complete surface water quality and radionuclide summary tables are provided in Appendices 2.7-C and 2.9-I of the approved license application, respectively. Laboratory analytical reports are provided in Appendix 2.7-F of the approved license application. For a summary of the sampling conducted at the stream and impoundment sampling sites, refer to Section 2.7.3.1.

As part of the baseline monitoring program, surface water station BVC01 was visited monthly from July 2007 to June 2008. Water samples were collected from the site each month except February 2008, when the site was ice covered. The following summarizes the samples and results.

- Ra-226, dissolved: Nine samples were analyzed. The results show the concentrations were less than the MDC in seven of the samples. The highest concentration was 2 ± 0.4 pCi/L.
- Ra-226, suspended: Nine samples were analyzed for Ra-226, suspended. Only two samples measured concentrations above the MDC. The highest concentration was 3.1 ± 1.6 pCi/L.
- Th-230, dissolved: Nine samples were analyzed only one measured a concentration above the MDC: 0.3 ± 0.3 pCi/L.
- Th-230, suspended: Five of the nine samples analyzed were equal to or less than the MDC. The highest concentration of 3.4 ± 1.1 pCi/L was measured in May 2008.
- Uranium, dissolved: Nine samples were analyzed. The average concentration for the samples was 0.0124 mg/L, with the highest concentration of 0.0269 mg/L measured in March 2008.
- Uranium, total: All 11 samples were analyzed for total uranium. The average concentration for the samples was 0.0121 mg/L.

Passive samplers were installed at sites PSC01 and UNT01 as part of the baseline monitoring program described in Section 2.7.3.1.1. The samplers were set up to automatically collect a sample in the event of an ephemeral flow event. During baseline monitoring two samples were collected from site PSC01 and one sample was collected from site UNT01. Of the three samples, only one of the PSC01 samples (July 2008) was analyzed for Pb-210 and Po-210. The laboratory results for dissolved and suspended Pb-210 were 2.2 ± 4.5 pCi/L and 0.9 ± 7.0 pCi/L. The results for dissolved and suspended Po-210 were 0.7 ± 0.70 pCi/L and 0.3 ± 0.33 pCi/L. All results were below the laboratory minimum detectable concentration (MDC).

An evaluation of water quality for all of the stream monitoring sites was completed for Pb-210 and Po-210 concentrations. The following summarizes the results:

- Pb-210, dissolved: 17 of the 24 samples were below the laboratory MDC. The highest concentration, 26 ± 2.6 pCi/L, was measured at site BVC04 in December 2007.
- Pb-210, suspended: 20 of the 24 samples were below the laboratory MDC. Site CHR05 measured the highest concentration of 22 ± 3.6 pCi/L in January 2008.
- Po-210, dissolved: 14 of the 24 samples were below the laboratory MDC. The highest concentration, 3 ± 1.7 pCi/L, was measured at site BVC04 in October 2007.
- Po-210, suspended: 13 of the 24 samples were below the laboratory MDC. Site CHR01 measured the highest concentration of 4.1 ± 3.2 pCi/L in May 2008.

As part of the baseline monitoring program 11 impoundments (Sub01 through Sub11) were visited on a quarterly basis between July 2007 and June 2008. When water was available, water samples were collected from each impoundment and analyzed for the constituents listed in Table 2.7-22. The following summarizes the sampling conducted and radionuclide analytical results for the nine impoundments (SUB01, SUB03, SUB04, SUB05, SUB06, SUB08, SUB09, SUB10, and SUB11).

Sub01

Sub01 was visited in September 2007, November 2007, March 2008, and June 2008. In September 2007 and November 2007 the impoundment was dry and no samples were collected, thus explaining the two missing quarterly samples. Quarterly samples collected in March and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Since Po-210 and Pb-210 were on the semiannual analysis schedule rather than quarterly per recommendations in Regulatory Guide 4.14, the constituents were not analyzed in the March 2008 water sample. Both Po-210 and Pb-210 were analyzed in the water sample collected in June 2008. Since Sub01 is not located downstream from proposed activities or within the project area (as described in Section 5.7.8.1), no operational monitoring is proposed at this impoundment.

Sub03

Sub03 was visited in September 2007, November 2007, February 2008, March 2008, and June 2008. The impoundment was dry in September 2007, February 2008, and March 2008 and no samples were collected, thus explaining the two missing quarterly samples. Quarterly samples collected in November 2007 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Sub03 will be included in the operational monitoring program.

Sub04

Sub04 was visited in September 2007, November 2007, February 2008, March 2008, and June 2008. The impoundment was dry in September 2007, February 2008, and March 2008 and no samples were collected at those times. Quarterly samples collected in November 2007 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. During operations Sub04 will be included in the operational monitoring program.

Sub05

Sub05 is a detention pond below the Darrow surface mines and was visited quarterly. During each monitoring site visit the impoundment was dry and no samples were collected. As described in Section 5.7.8.1, Sub05 will be included in the operational monitoring program.

Sub06

The surface water quality summary tables have been corrected to show that Ra-226 (dissolved) was analyzed during all four quarters.

Sub08

The revised surface water quality and radionuclide summary tables in Appendix 2.7-C of the approved license application and Appendix 2.9-I of the approved license application show that Ra-226 (dissolved) was analyzed during all four quarters.

Sub09

Sub09 was visited in September 2007, November 2007, March 2008, and June 2008. The impoundment was dry in September 2007 and November 2007 and no samples were collected at those times. Quarterly samples collected in March 2008 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Since Po-210 and Pb-210 were on the semiannual analysis schedule rather than quarterly per recommendations in Regulatory Guide 4.14, the constituents were not analyzed in the March 2008 water sample. Both Po-210 and Pb-210 were analyzed in the water sample collected in June 2008. Sub09 will be included in the operational monitoring program.

Sub10

Sub10 was visited in September 2007, November 2007, March 2008, and June 2008. The impoundment was dry in September 2007 and November 2007 and no samples were collected at those times. Quarterly samples collected in March 2008 and June 2008 were analyzed for Ra-226, Th-230 and uranium, as recommended by Regulatory Guide 4.14. Since Po-210 and Pb-210 were on the semiannual analysis schedule rather than quarterly per recommendations in Regulatory Guide 4.14, the constituents were not analyzed in the March 2008 water sample. Both Po-210 and Pb-210 were analyzed in the water sample collected in June 2008. Sub10 will be monitored as part of the operational surface water monitoring program.

Sub11

The surface water quality and radionuclide summary tables in Appendix 2.7-C of the approved license application and Appendix 2.9-I of the approved license application show that Ra-226 (dissolved) was analyzed during all four quarters.

Groundwater

Results to date for radiological groundwater parameters are shown in Appendix 2.9-J of the approved license application.

Relationships between Dissolved, Suspended and Total Fractions

Surface water and groundwater samples collected as part of the baseline monitoring program were analyzed for constituents listed in Table 2.7-21. Metals were analyzed for dissolved fractions, while radionuclides were typically analyzed for the dissolved and suspended fractions. In some samples analysis was also completed for the total metals and total radionuclides.

Relationships between dissolved and suspended radionuclide concentrations were evaluated for both the groundwater and surface water. Based on a comparison of all radionuclide concentrations in groundwater provided in Appendix 2.9-J of the approved license application, the dissolved and suspended radionuclide fractions in groundwater were generally similarly small. However, some differences are apparent. For example, approximately half (51%) of the Pb-210 analyses were higher for the dissolved fraction versus suspended (36% - the remaining 13% were equal). Higher dissolved fractions were most apparent in Ra-226 and uranium. During the baseline monitoring 244 groundwater samples were analyzed for both dissolved and suspended Ra-226. The results show that the majority (91%) of the samples measured higher dissolved than suspended Ra-226. The maximum dissolved Ra-226 measured was 1,440 pCi/L, while the maximum suspended Ra-226 concentration was 15.3 pCi/L. Similarly, dissolved uranium was measured at higher concentrations than the suspended fraction (nearly 70%).

Relationships for the surface water radionuclide concentrations (Appendix 2.9-I of the approved license application) indicated that suspended fractions are slightly higher for all constituents, with the exception of uranium. The results show that the majority (83.5%) of the samples measured higher dissolved uranium. Overall, the concentrations of radionuclides in surface water are generally near or below the applicable detection limits.

2.9.8.3 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 that are not acceptable for human consumption. The aquifer does not presently, and will not in the future, serve as a source of drinking water.

2.9.9 Vegetation Sampling

Three rounds of vegetation sampling were conducted on the Dewey-Burdock Project. One vegetation sample was collected in August, 2007; and April and July, 2008 at each AMS, the locations of which are shown on Figures 2.9-8.

Grass is the primary animal forage vegetation within the project area. Therefore, consistent with Regulatory Guide 4.14, grasses were the only type of forage vegetation sampled during background radiological characterization.

Vegetation samples were collected from representative grazing areas in sectors near the air monitoring stations (AMS). These stations were placed in areas predicted to have the highest airborne concentrations due to ISR operations. This is consistent with Table 1 in Regulatory Guide 4.14, which indicates that radiological sampling will be conducted in grazing areas having the highest predicted air particulate concentrations during milling operations.

2.9.9.1 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. 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).

2.9.9.2 Vegetation Sampling Results

Table 2.9-18 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.

Table 2.9-18: 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 2.9-18: 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 2.9-18: Baseline Radionuclide Concentrations in Vegetation (cont'd)

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 2.9-18: Baseline Radionuclide Concentrations in Vegetation (cont.)

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 s do not include "D"-qualified results.

- 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.

2.9.9.3 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 to 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 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.

2.9.10 Food Sampling

To determine baseline radionuclide concentrations in local food, Powertech (USA) initially 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 2.9-19. Errors are reported as $\pm 2\sigma$.

Powertech (USA)'s original assessment of land use for food sources resulted only in the identification of cattle grazed within 3.3 km of the project area. Powertech (USA) has since conducted additional investigations and determined that in addition to cattle there are "free range" pigs and vegetable gardens within 3.3 km of the project area. While chickens are also present with 3.3 km of the project area, they are fed grains not originating from the project area and are not considered grazing animals. Therefore, Powertech (USA) does not propose to sample chickens. Figure 2.9-15 has been prepared to show the updated assessment of land use for food sources within 3.3 km of the project area.

Note that Figure 2.9-15 does not depict game animals, since game animals observed in the vicinity of the project area have extensive ranges that are not confined to a particular area within the scale of Figure 2.9-15. Powertech (USA) interpreted RG 4.14 as requiring animal tissue sample analysis for livestock only, particularly in light of recently approved NRC license applications (e.g., Moore

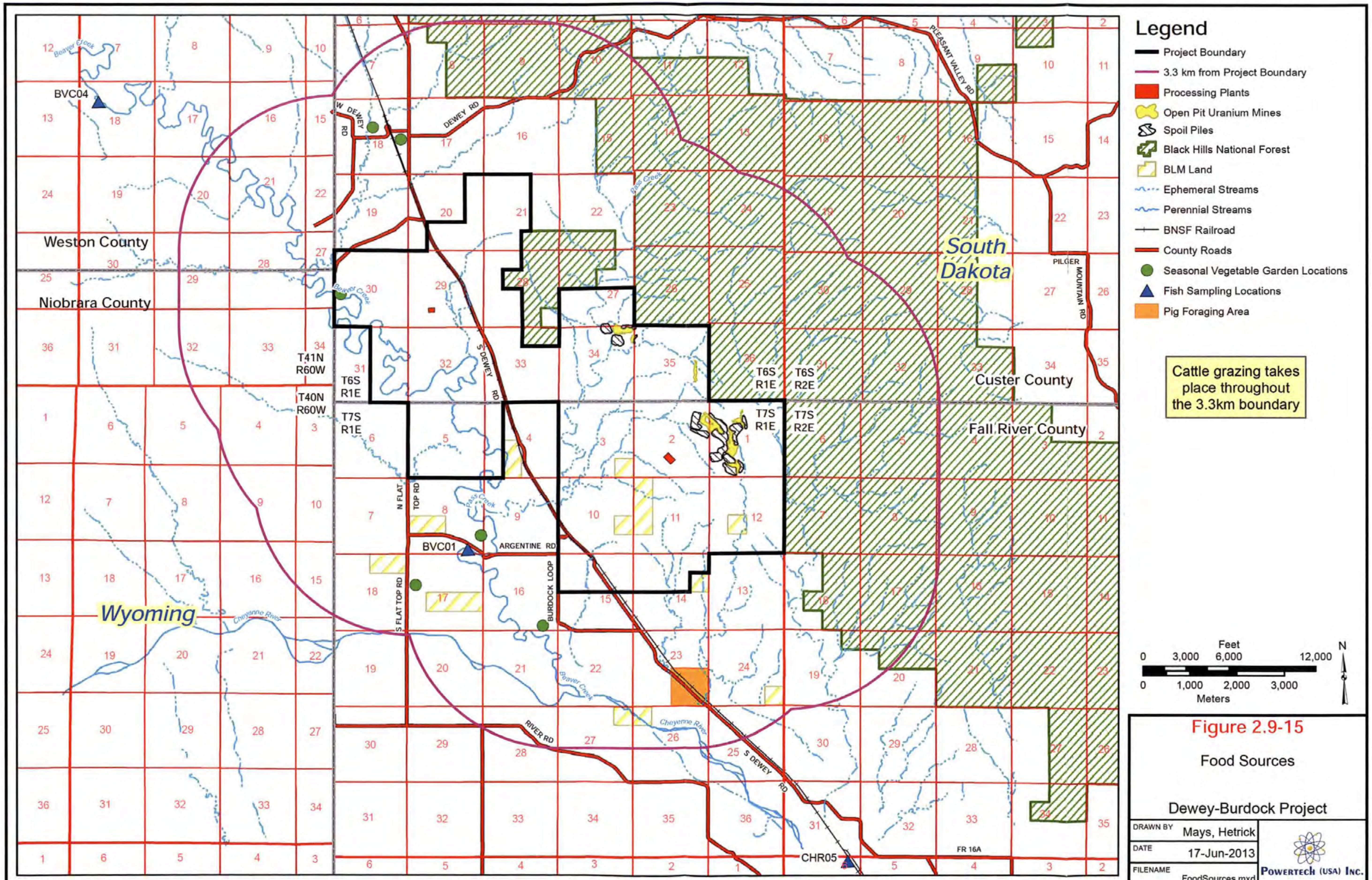


Figure 2.9-15

Food Sources

Dewey-Burdock Project

Ranch ISR Project, SUA-1596) that have not provided game animal tissue sample analyses. As additional justification for not sampling wildlife tissue, the migratory nature and relatively large home range of game animals observed in the area in relation to the size of the project area make it difficult to relate radionuclide concentrations to a particular site.

Section 1.1.3 of Regulatory Guide 4.14 states:

"At least three samples should be collected at time of harvest or slaughter or removal of animals from grazing for each type of crop (including vegetable gardens) or livestock raised within three kilometers of the mill site."

Powertech (USA)'s original interpretation of Regulatory Guide 4.14 was to collect three samples from each type of animal. Therefore, three samples were originally collected from one locally grazed cow. Pursuant to NRC staff interpretation that one sample each should be collected from three different specimens of each type of livestock, the following actions have been performed or will be performed prior to ISR operations:

- Samples from one additional cow have been analyzed for the recommended analytes in Regulatory Guide 4.14.
- Powertech (USA) commits to sampling one additional cow prior to ISR operations, bringing the total to three.
- Samples from one free ranging, locally grazed pig have been analyzed for the recommended analytes in Regulatory Guide 4.14.
- Powertech (USA) commits to sampling two additional pigs prior to ISR operations, bringing the total to three.

The results of all food samples available to date are shown in Table 2.9-19.

Table 2.9-19 and Appendix 2.9-A of the approved license application, Table 10-1 are in a format consistent with Regulatory Guide 4.14, Section 7.5 with the exception of data reported for natural uranium (U-nat), which cannot be reported in this format due to the quantification method used. U-nat concentrations in tissue were evaluated using EPA Method SW6020, which uses ICP-MS and is not a radiochemical method. The data were reported in units of mg/kg and subsequently converted to units of activity by using the specific activity for natural uranium of 6.77×10^{-4} µCi/mg. Error estimates are not evaluated on an individual sample basis using EPA Method SW6020, which is why no error estimates are presented in Table 2.9-19 and Appendix 2.9-A of the approved license application, Table 10-1 for individual samples. EPA Method SW6020 discusses controlling analytical error by evaluating laboratory control samples such as Matrix

Table 2.9-19: Baseline Radionuclide Concentrations in Local Food

Sample ID	Radionuclide	Parameter	Result
DBAT-01 (Meat sample from locally grazed cow, June 2008)	U-nat (µCi/kg)	Concentration	< 7.0E-06
		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 (Meat sample from locally grazed cow, June 2008)	U-nat (µCi/kg)	Concentration	< 7.0E-06
		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 (Liver sample from locally grazed cow, June 2008)	U-nat (µCi/kg)	Concentration	< 7.0E-06
		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

Table 2.9-19: Baseline Radionuclide Concentrations in Local Food (cont.)

Sample ID	Radionuclide	Parameter	Result
Pork (April 2011)	U-nat (µCi/kg)	Concentration	8.1E-06
		Error ± 2σ	-
		LLD	2.0E-07
	Ra-226 (µCi/kg)	Concentration	7.9E-07
		Error ± 2σ	1.6E-07
		LLD	1.4E-07
	Th-230 (µCi/kg)	Concentration	-1.7E-05
		Error ± 2σ	4.4E-06
		LLD	7.2E-06
	Pb-210 (µCi/kg)	Concentration	-3.4E-07
		Error ± 2σ	1.0E-06
		LLD	1.7E-06
Beef (April 2011)	U-nat (µCi/kg)	Concentration	2.3E-06
		Error ± 2σ	-
		LLD	2.0E-07
	Ra-226 (µCi/kg)	Concentration	6.0E-07
		Error ± 2σ	1.5E-07
		LLD	1.4E-07
	Th-230 (µCi/kg)	Concentration	1.8E-06
		Error ± 2σ	2.6E-06
		LLD	4.9E-06
	Pb-210 (µCi/kg)	Concentration	1.1E-06
		Error ± 2σ	6.3E-07
		LLD	4.4E-07

Note: U-nat analyzed using ICP-MS; therefore, error estimate is not available.

Spikes (MS) and Matrix Spike Duplicates (MSD) and establishing control limits for accuracy and precision. The data reported in the above mentioned tables met Energy Laboratories Inc. internal quality control measures.

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 initial samples.

The current use of the data in Table 2.9-19 and Appendix 2.9-A of the approved license application, Table 10-1 is to provide a pre-operational baseline concentration of radionuclides in animal tissue. NUREG/CR-4007 (NRC, 1984) states that any measurement process must be capable of detecting the relevant radionuclides at levels well below those of concern to the public health and safety. Powertech (USA) is not aware of regulatory limits for radionuclides in food items to evaluate the appropriate sensitivity of the analytical methods used. For justification purposes herein, it was assumed that 10 percent of the total effective dose equivalent public dose limit of 100 mrem per year in 10 CFR 20 would be an appropriate comparison for food items.

Equation 2.5 was used to determine the concentration in food products, in this case beef or pork, that would result in a dose equivalent of 10 percent of the public dose limit standard in 10 CFR 20. Table 2.9-20 shows the results of the radionuclide concentrations in beef that meet this criteria and the dose conversion factors used.

$$C_i = \frac{10\ mrem/yr}{IxDCF_i} \qquad \text{(Equation 2.5)}$$

Where:

C_i = Concentration of radionuclide (i) in beef that would result in dose equivalent of 1.25 mrem/y (μCi/kg)

10 mrem = 10% of 10 CFR 20 public dose limit of 100 mrem/year (CEDE)

DCFi = Dose Conversion Factor for ingestion of radionuclide (i) (mrem/μCi) [Federal Guidance Report 11 (EPA, 1988)]

I = Beef intake rate for adult (27 kg/y) [Data Collection Handbook (ANL, 1993)]

Table 2.9-20: Effective Dose Conversion Factors Used in and Results for Equation 2.5

Radionuclide	DCF (mrem/μCi)	Concentration (μCi/kg)
Natural uranium*	283	1.3×10^{-3}
Thorium-230	548	6.8×10^{-4}
Radium-226	1,325	2.8×10^{-4}
Lead-210	5,365	6.9×10^{-5}
Polonium-210	1,902	1.9×10^{-4}

* DCF for Uranium-234 was used since it is the most restrictive of the three uranium isotopes in natural uranium

Based on the justification above, LLDs for beef or pork tissue should be below the concentrations presented in Table 2.9-20. A comparison of the baseline monitoring program results in Table 2.9-19 indicates that all but one LLD for beef tissue (Pb-210 in DBAT-02) was well below the concentration values in Table 2.9-20. Powertech (USA) has submitted an additional beef sample for laboratory analysis and commits to sampling a third locally grazed cow prior to ISR operations. The goal will be to meet the LLDs contained in Regulatory Guide 4.14, but in no case will reported LLDs be greater than values contained in Table 2.9-20.

The meat LLDs in Table 2.9-19 and Appendix 2.9-A of the approved license application, Table 10-1 are substantially different from each other because of differences in matrix interference, sample size, and low radionuclide concentrations within the sample matrix. The potential for this result is acknowledged in NUREG/CR-4007, which states that "the critical (decision) level and detection limit (LLD) really do vary with the nature of the sample" and that "proper assessment of these quantities demands relevant information on each sample, unless the variations among samples are quite trivial" (NRC, 1984).

Powertech (USA) original assessment of land use for food sources did not identify any vegetable gardens within 3.3 km of the project area. Powertech (USA) has since determined that vegetable gardens are present in the town of Dewey and at one location within the project area as shown on Figure 2.9-15. Due to the large sample size (> 10 lbs) typically required to satisfy RG 4.14 suggested LLDs for vegetation and the relatively small size of the vegetable gardens, Powertech (USA) is implementing the following alternate approach to sampling vegetables from local gardens.

Prior to operations, Powertech (USA) will sample vegetable garden soil rather than the vegetables themselves and then apply plant-to-soil concentration factors to estimate the radionuclide concentrations in vegetables. Methods and parameters contained in NUREG/CR-5512 (NRC, 1992a) will be used to estimate radionuclide concentrations in root and leafy vegetables based on soil radionuclide concentrations. Equation 2.6, obtained from Section 5 (Equation 5.5) of NUREG/CR-5512, will be used to calculate vegetable concentration factors as follows:

$$C_{svhj} = 1000(ML_v + B_{JV})W_v \ \{AC_{sj}, t_{gv}\}/C_{sj} \qquad \text{(Equation 2.6)}$$

Where:

C_{svhj}	=	concentration factor for radionuclide j in plant v at harvest from an initial unit concentration of parent radionuclide i in soil (pCi/kg wet-weight plant per pCi/g dry-weight soil)
B_{JV}	=	concentration factor for uptake of radionuclide j from the soil in plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
ML_v	=	plant soil mass-loading factor for resuspension of soil to plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
W_v	=	dry to wet-weight conversion factor (unitless)

$\{AC_{sj}, t_{gv}\}$ = decay operator notation used to develop the concentration of radionuclide j in soil at the end of the crop growing period t_{gv} (pCi/g dry-weight)

C_{sj} = concentration of radionuclide j in soil during the growing period (pCi/g dry-weight)

$C_{sj}(0)$ = initial concentration of radionuclide j in soil during the growing period (pCi/g dry-weight)

t_{gv} = growing period for food crop (d)

1000 = unit conversion factor (g/kg)

The radionuclides recommended for analysis in vegetation in RG 4.14 are natural uranium, thorium-230, radium-226, lead-210, and polonium-210. These radionuclides, with the exception of polonium-210, have long half-lives when compared to the growing season; therefore, the decay correction during the growing season can be ignored for these parameters. For polonium-210, the initial soil concentration and soil concentration during the growing season will be assumed identical. This assumption will allow simplification of Equation 2.6 to Equation 2.7.

$$C_{svhj} = 1000\left(ML_v + B_{JV}\right)W_v \qquad \text{(Equation 2.7)}$$

Table 2.9-21 presents the parameters that will be used to estimate wet-weight vegetable concentrations from dry-weight soil concentrations.

Table 2.9-21: Parameters Used to Estimate Wet-Weight Vegetable Concentrations from Dry-Weight Soil Concentrations

Parameter	Parameter Description	Plant Type	Radionuclide	Value	Unit
MLv	Mass loading factor	Root Vegetables	Parameter is not radionuclide specific.	0.1	pCi/kg dry-weight plant per pCi/g dry-weight soil
		Leafy Vegetables			
		Fruits			
BJV	Concentration factor for root uptake	Root vegetables	Natural uranium	0.014	pCi/kg dry-weight plant per pCi/g dry-weight soil
			Thorium-230	0.00012	
			Radium-226	0.0032	
			Lead-210	0.0032	
			Polonium-210	0.009	
		Leafy Vegetables	Natural uranium	0.017	
			Thorium-230	0.0025	
			Radium-226	0.075	
			Lead-210	0.0058	
			Polonium-210	0.0025	
		Fruits	Natural uranium	0.004	
			Thorium-230	0.000085	
			Radium-226	0.0061	
			Lead-210	0.009	
			Polonium-210	0.0004	
Wv	Dry weight to wet weight conversion factor	Root Vegetables	Not radionuclide specific	0.2	Unitless
		Leafy Vegetables		0.25	
		Fruits		0.18	

2.9.11 References

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ASTM, 2002, ASTM E178-08, Standard Practice for Dealing with Outlying Observations, ASTM International, November 2002, Updated 2008.

Code of Federal Regulations, 10 CFR 40, *"Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content".*

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3.0 Description of Facility

3.1 In Situ Leach Process and Equipment

The ISL process involves the oxidation and solubilization of uranium from its reduced state using a leaching solution (lixiviant). The leach solution consists of ground water with an oxidant, such as gaseous oxygen, added to oxidize the uranium to a soluble valence and gaseous carbon dioxide to complex and solubilize the uranium. At the PA, Powertech (USA) will add gaseous oxygen and gaseous carbon dioxide to the recirculated ground water from the ore zone aquifer. Once solubilized, the uranium bearing ground water will be pumped by submersible pumps in the production wells in the well field to the surface where it is ionically bonded onto IX resins. After the uranium is removed, the groundwater will be recirculated and reinjected via the injection wells in the well field. When the IX resin is loaded with uranium, the loaded resin is moved to an IX elution (stripping) column where the uranium is eluted (stripped) off the resin by a salt water solution. The resulting barren resin is then recycled to recover more uranium. The salt water eluate solution is pumped to a precipitation process where the uranium is precipitated as a yellow solid uranium oxide. The precipitated uranium oxide is then filtered, washed, dried and packaged in sealed containers for shipment for further processing.

Typically, an ISL well field consists of a set of contiguous geometric shaped patterns of injection and production wells. Powertech (USA) will mostly utilize square or rectangular patterns, sometimes hexagons or triangles to cover the economically recoverable portions of the uranium deposit. This provides for uniform distribution of leach fluid (lixiviant) to efficiently contact the economically recoverable portions of the uranium orebody. The injection wells will be located at the corners of the geometric patterns and the production wells will be in the center of the geometric patterns. Powertech (USA) will withdraw 0.5 to 3 percent more ground water than is reinjected to maintain a flow of outside baseline quality groundwater into the production well field and to prevent the flow of leach fluid to the monitor well ring surrounding the orebody. The excess produced water (bleed) creates and maintains a cone of depression in the pressure surface of the aquifer so that the native ground water is continually flowing to the center of the production zone. This bleed also helps Powertech (USA) control and limit the increase in the sulfate and chloride concentration in the leach solution.

At the surface, the pregnant lixiviant flows through IX columns, where the uranium is transferred to resin. The resin will be trucked or piped to a CPP for further refinement into yellowcake - the final product for the first stage of the uranium fuel cycle.

The barren lixiviant is re-fortified with oxygen and carbon dioxide and re-circulated through the orebody to leach uranium.

Powertech (USA) proposes to use a lixiviant consisting of varying concentrations of oxygen (O_2) and carbon dioxide (CO_2) added to the native groundwater to promote the dissolution of uranium as a uranyl carbonate anionic complex. The expected or typical lixiviant concentrations and compositions are shown in Table 3.1-1. This lixiviant formulation will minimize ground water quality potential impacts during uranium recovery and enable restoration goals to be achieved in a timely manner (NUREG-1569, 2003).

Table 3.1-1: Typical Lixiviant Concentrations and Compositions

Constituent	Units	Concentration Range	
		Minimum	Maximum
Calcium	mg/L	≤20	500
Sodium	mg/L	≤400	6000
Magnesium	mg/L	≤3	100
Potassium	mg/L	≤15	300
Chloride	mg/L	≤200	5000
Carbonate	mg/L	≤0.5	5000
Bicarbonate	mg/L	≤400	5000
Sulfate	mg/L	≤400	5000
Uranium	mg/L	≤0.01	500
Vanadium	mg/L	≤0.01	100
pH	Std units	≤6.5	10.5
Total Dissolved Solids, TDS	mg/L	≤1650	12000

Notes:
Table adapted from USNRC (2008) Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities-Draft Report for Comment. NUREG-1910. July 2008.

Figures 3.1-1 and 3.1-2 depict the proposed facilities in the land application and deep disposal well liquid waste disposal options, respectively. Sections 3.1.6 and 4.2.2 describe the liquid waste disposal options. Figure 3.1-3 presents a map view of the project ore bodies proposed for uranium recovery and shows all lower Fall River ore bodies in "blue," all ore bodies within the upper Chilson Member of the Lakota Formation in "green" and middle/lower Chilson ore bodies in "red." No potential well fields are located within 1,600 feet of the project boundary in order to establish an operational buffer between the well fields and the project boundary. In addition, no well fields are proposed for unsaturated Fall River ore bodies in the eastern portion of the project area. Figures 3.1-1, 3.1-2, and 3.1-3 show the location of all operations/infrastructure within the license boundary. All well fields and infrastructure associated with the Dewey-Burdock Project will be

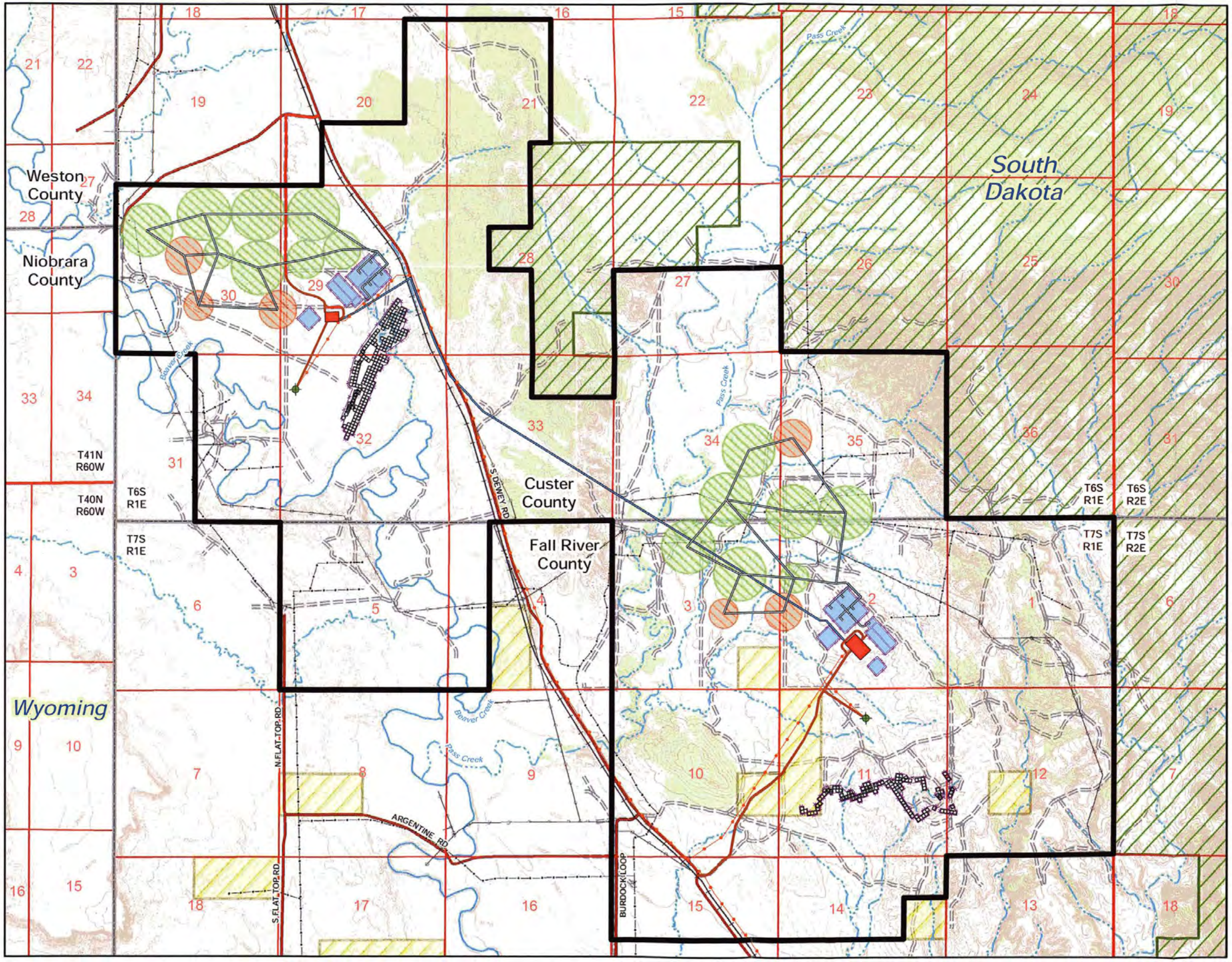

Figure 3.1-1

Proposed Facilities and Potential Initial Well Field Areas, Land Application Option Dewey-Burdock Project

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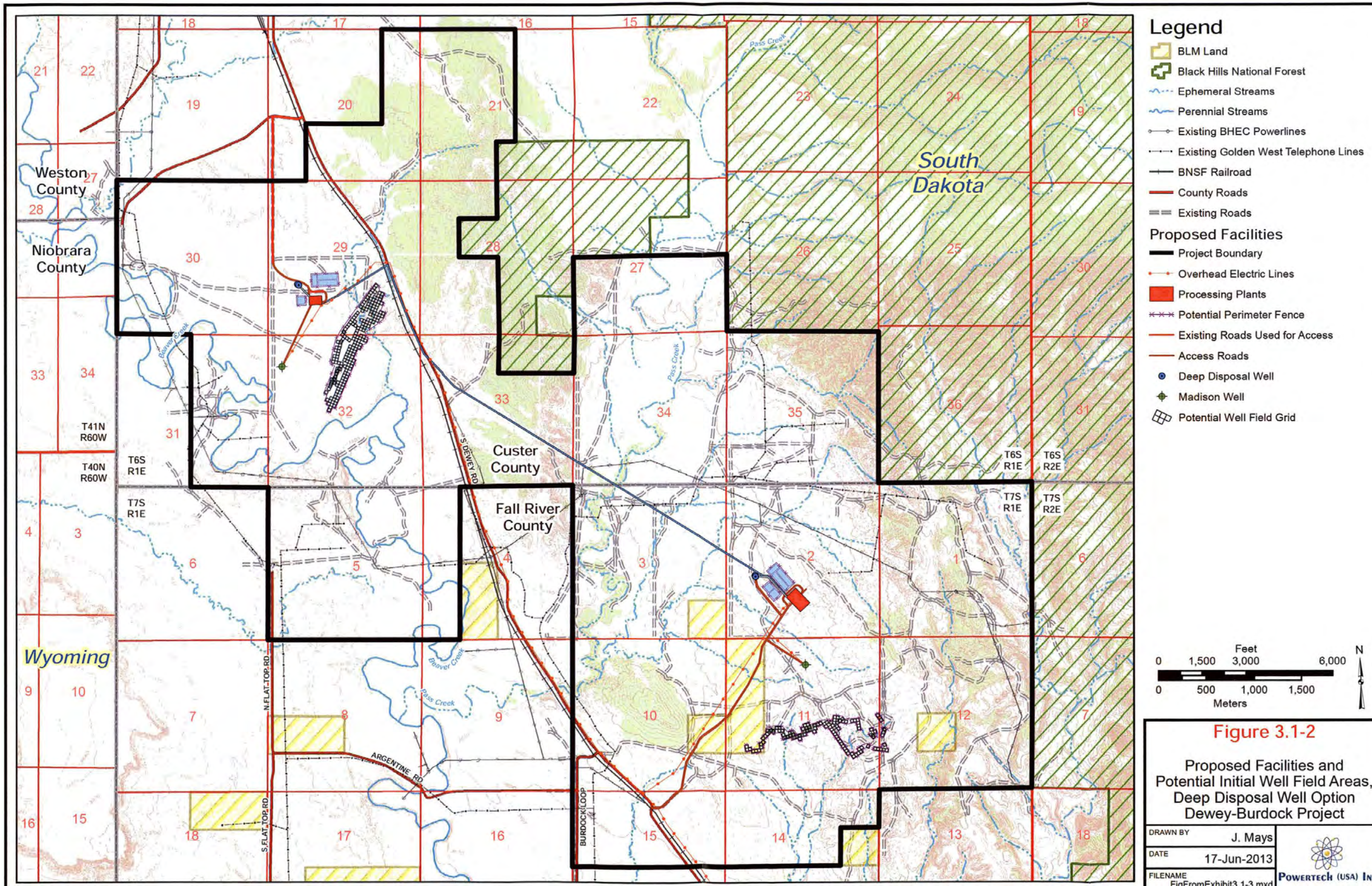

Figure 3.1-2

Proposed Facilities and Potential Initial Well Field Areas, Deep Disposal Well Option Dewey-Burdock Project

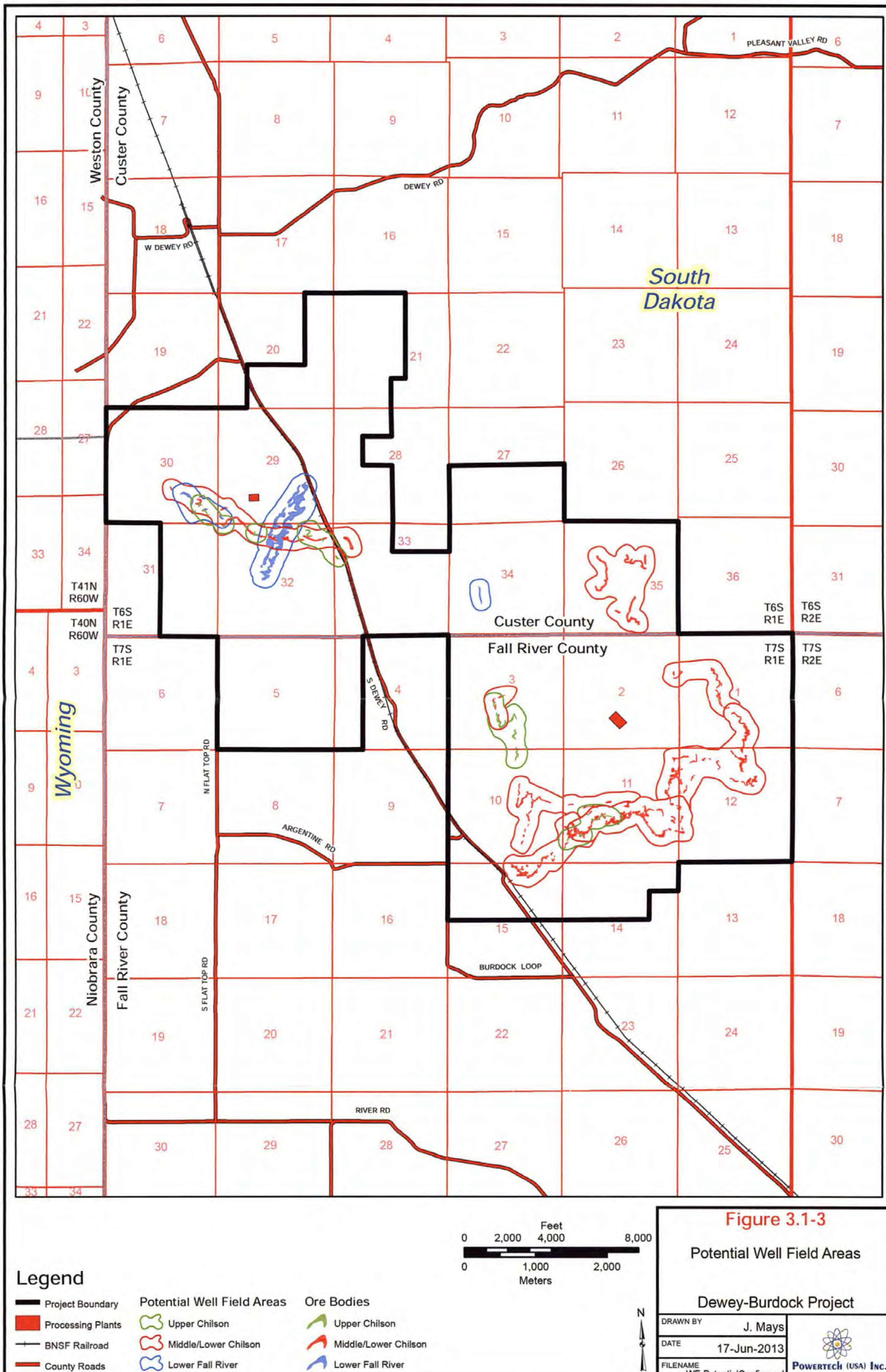

Figure 3.1-3
Potential Well Field Areas

located within the license boundary. This includes all ISR production and injection wells, monitor wells, pipelines, and facilities.

It is anticipated that lixiviant concentrations will be within the parameters outlined in Table 3.1-1. The ISL process involves an oxidation step that converts uranium in the solid state to a form that is easily dissolved by the leaching fluid. The reactions representing these steps are as follows:

Oxidation: UO_2 (solid) + $\frac{1}{2}O_2$ (in solution) $\rightarrow$ UO_3 (at solid surface)

Dissolution: $UO_3 + 2\ HCO_3^{-1} \rightarrow UO_2(CO_3)_2^{-2} + H_2O$

$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \rightarrow UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2\ (CO_3)_2^{-2}$ [i.e., UDC] and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$ [i.e., UTC]. The relative abundance of each is a function of pH and total carbonate strength.

The uranium-rich lixiviant is then extracted via production wells and pumped to an ion-exchange facility near the well field. At an IX facility, the uranium is removed from the pregnant lixiviant by IX onto resins.

Logistically, if the IX process occurs at a SF, the uranium-rich resin is physically removed from the IX columns at the SF and transported via tanker truck to the CPP where uranium is eluted from the resin. Regenerated resin is then returned to the IX columns within the SF. If IX occurs at the CPP, trucking is not necessary.

The following paragraphs describe the upfront uranium processing facilities, including: well field layout; design and construction of injection, production, and monitoring wells; layout of header houses and associated infrastructure; leak detection and cleanup procedures; water balance and general well field operations; evaporation ponds and land application areas; waste disposal well sites; surface water management; quality control; 11e.(2) waste disposal agreements, and ISL references.

3.1.1 Orebody

For a description of the orebody and mineralized zones see the geology Section 2.6. The aquifer characterization is summarized in Section 2.7.

3.1.1.1 Approach to Well Field Development

An ISL well field consists of a series of injection and production wells that are completed across the target mineralization zone. Prior to design of the wells, the ore bodies will be delineated with exploration holes drilled on 100-feet centers. As discussed earlier, these holes will be geologically and geophysically logged Using this information, each new injection and production well will be assigned lateral coordinates, a ground surface elevation, depth to base of casing, i.e., top of completion interval, and length of completion interval, before it is drilled.

For all injection and production wells, the base of casing will be established at or below the confining unit overlying the mineralized zone. The screened interval will be completed only across the targeted ore zone.

A typical (100 x 100 ft grid) well field layout is illustrated on Plates 3.1-2 through 3.1-5. This typical layout is based on the lateral distribution and grade of one of the uranium deposits within the PA.

The well field patterns may differ from well field to well field, but a typical pattern will consist of five wells, with one well in the center and four wells surrounding it oriented in four corners of a square between 50 and 150 feet. Typically, a production well is located in the center of the pattern, and the four corner wells are injection wells. Such a pattern will be modified as needed to fit the characteristics of each orebody. A typical well pattern for an orebody is illustrated in Plates 3.1-2 through 3.1-5.

The pattern dimensions will vary depending on the geometry of the orebody. All wells will be completed so they can be used as either injection or production wells, so that well field flow patterns can be changed as needed to improve uranium production and restore groundwater quality in the most efficient manner. Other well field designs that may be considered include alternating single lines of production and injection wells.

Production and injection wells will be connected to a common header house, as shown on Plate 3.1-6. Well head connection details for injection and production wells are illustrated on Figures 3.1-4 and 3.1-5, respectively.

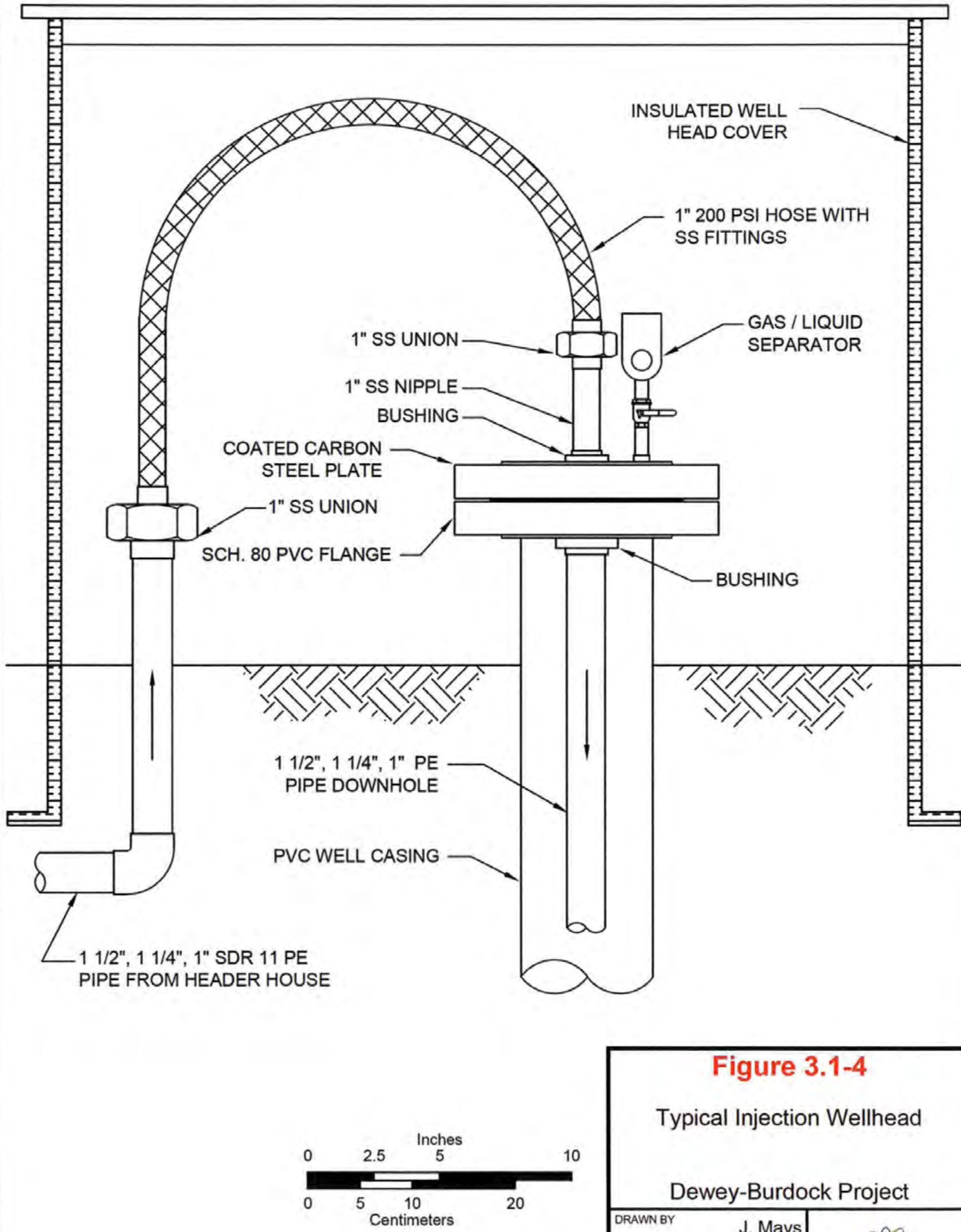

Figure 3.1-4

Typical Injection Wellhead

Dewey-Burdock Project

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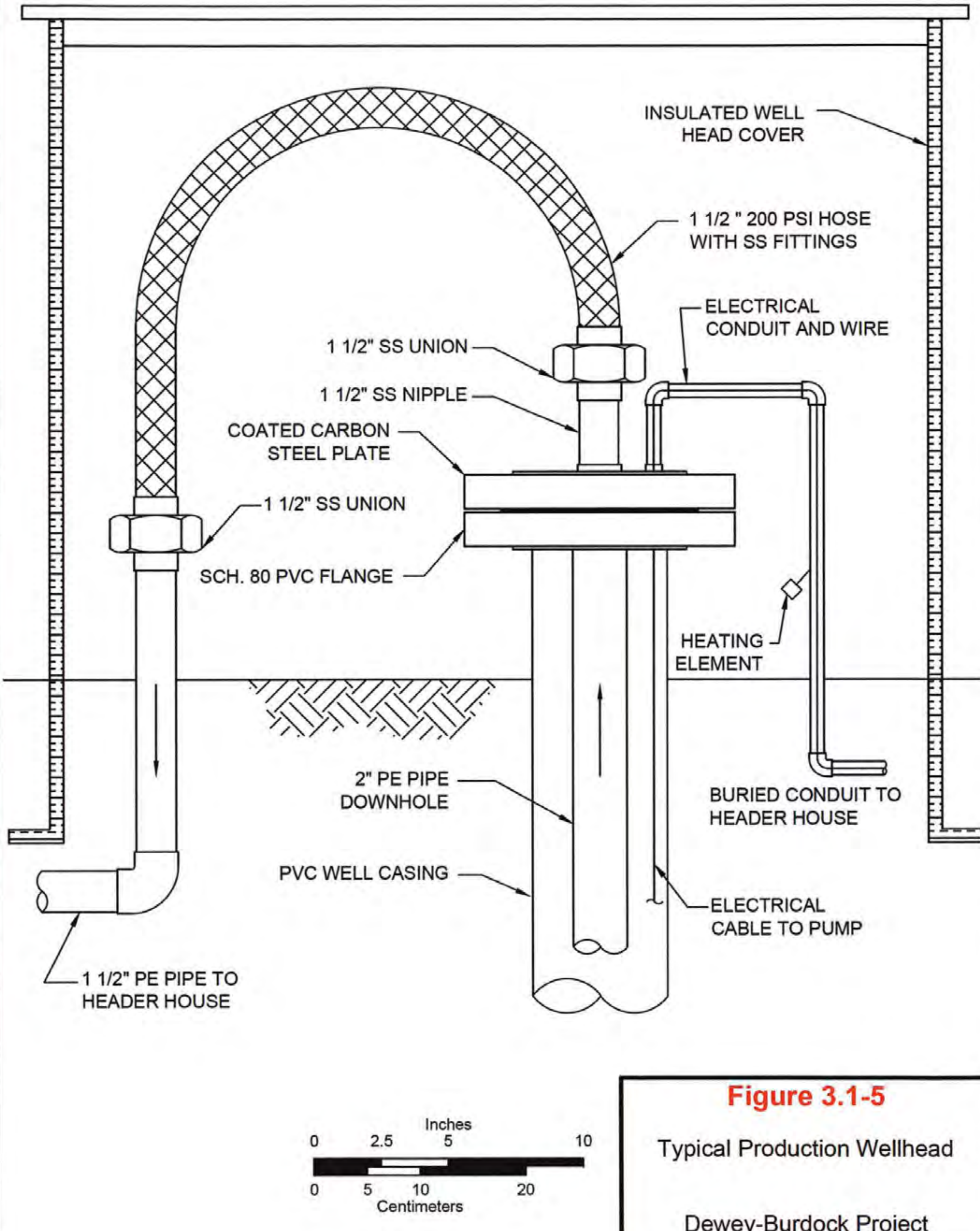

Figure 3.1-5

Typical Production Wellhead

Dewey-Burdock Project

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Typically, one header house will service up to 20 production wells and 80 injection wells. Piping between the wells and header house will consist of high density polyethylene (HDPE) pipe with heat-welded joints, buried below the frost line, approximately 5 feet below grade. The piping will typically be designed for operating pressure of 150-300 psig, but actual pressures will typically be less than 100 psig. The piping will terminate at the header house where it will be connected to manifolds equipped with control valves, flow meters, check valves, pressure sensors, oxygen and carbon dioxide feed systems (injection only), and programmable logic controllers. Electrical power to the header houses will be delivered via overhead power lines and via buried cable. Electrical power to the header houses will be delivered via overhead power lines and via buried cable (see Figures 3.1-1 and 3.1-2). Electrical power to individual wells will be delivered via buried cable from the header house.

As a well field expands, additional header houses will be constructed. They will be connected to one another via buried header piping that is sized to accommodate the necessary injection and production flow rates and pressures. In turn, header pipes from entire well fields will be connected to either a SF or CPP, as discussed earlier. A piping detail that shows the connection between the main header piping and laterals to header houses is shown in Plate 3.1-6.

Monitoring wells will be positioned around the perimeter of each well field ring, as illustrated on Plates 3.1-2 through 3.1-5. Internal to the well field additional monitoring wells will be installed. Perimeter wells will be screened across the entire production zone to monitor for potential lateral excursion within the zone outside the well field, and to demonstrate compliance with groundwater quality standards within this zone. Internal monitoring wells will be screened across the overlying and underlying aquifers, respectively, where the greatest potential for vertical excursion may occur.

The "greatest potential for excursion" is defined as those locations where an excursion has the greatest potential to occur based on the hydrogeologic data obtained and analyzed during development of the detailed well field package. This could include, for example, areas of higher permeability, pronounced anisotropy (varying hydrologic parameters measured in varying directions), and similar features that could create a preferential flow path for ISR fluids. At a minimum, monitor wells will be installed in the overlying aquifer at a density of one well per 4 acres of area under well pattern and in the underlying aquifer at a density of one well per 4 acres per the guidance provided in NUREG-1569. In assessing the potential for a vertical excursion to occur, the following criteria will be applied for installing overlying and underlying monitor wells within the pattern:

- Areas which may be associated with leakage around the injection well casing.
- Areas where the confining unit may be uncharacteristically thin.
- Areas which may be associated with leakage through improperly abandoned boreholes.
- Areas identified during hydrologic testing as having hydraulic communication with the overlying or underlying aquifer.

An in-depth discussion of the positioning and spacing of monitoring wells is provided in Section 3.1.3 of this application.

3.1.1.1.1 Approach to Well Field Development with Respect to Historical Mine Workings

As described in Section 2.6.4.2 the former Darrow and Triangle open-pit mines and associated underground workings in the eastern portion of the project area extracted ore from the Fall River Formation. There are no underground mines within the project area that are not associated with, adjacent to, or extensions of the open pits, all of which are within the Upper Fall River Formation. These open-pit mines and underground workings did not penetrate the underlying Fuson Shale, which physically and hydraulically separates the Fall River from the underlying Chilson Member of the Lakota Formation across the entire project area.

Powertech (USA) will not conduct ISR operations in ore bodies in the Fall River in the vicinity of the Darrow and Triangle pits. Powertech (USA) proposes to conduct ISR operations within the Chilson in the general vicinity of this historic mine workings. Because of the physical and hydraulic separation of the Chilson from the overlying Fall River Formation, ISR operations in the Chilson will not affect the Fall River or create or enhance migration of constituents of concern from the open-pit or underground mines.

Figure 2.6-3a shows the spatial relationship between Powertech (USA)'s potential well fields and the historical mine areas. The location of underground workings in the vicinity of potential well field areas also is shown on Cross Section F-F' (Plate 2.6-12f). An examination of Figure 2.6-3a shows that Burdock Well Field 7 (B-WF7) underlies portions of the historical Darrow mine area. The targeted production zone for B-WF7 is the Lower Chilson.

As also shown on Figure 2.6-3a, Burdock Well Field 8 (B-WF8) is proposed below and horizontally adjacent to the surface expression of an area of past mining disturbance in Section 35, T6S, R1E. Excavation in this area was underway when the Edgemont mill was closed. This operation was on land owned by the Spencer family, and Donald Spencer (2011) related that all mining operations ceased before reaching the ore horizon. The pit was backfilled and reclaimed. Powertech (USA)'s targeted uranium recovery horizon for B-WF8 is the Lower Chilson. This unit is at least 200 feet beneath the base of the Fuson Shale and is well below the historical mining disturbance in the Fall River Formation.

As demonstrated in Section 2.6.4.2, neither the surface mining activity nor the shallow underground workings intersected or compromised the integrity of the underlying Fuson Shale confining unit. Cross section F-F' (Plate 2.6-12f) illustrates the continuous Fuson Shale confining unit throughout this area. In addition, outcrop examinations of the Fuson Shale in Bennett Canyon, ½-mile up-dip from the Darrow Mine area, reveal the presence of continuous, low-permeability mudstones and shales. The targeted resources in B-WF7 & B-WF8 are well confined and unaffected by historical mining activities in overlying horizons.

The potential effects of ISR operations in the Chilson on the overlying Fall River Formation will be evaluated further as part of the planned delineation drilling and well field-scale pumping tests prior to the development of each well field. Powertech (USA) also will install and sample operational monitor wells in the Fall River, Chilson, and alluvium between the open-pit mines and potential well field areas. For additional information, refer to Section 5.7.8.2.

The conditions that made the historical mining areas amenable to conventional surface and underground mining (e.g., shallow cover and unsaturated conditions) make these areas unattractive for ISR operations. Conversely, the areas proposed by Powertech (USA) for ISR operations are much too deep and contain too much water for them to have been affected by historical surface or underground mining activities.

3.1.1.1.2 Approach to Well Field Development with Respect to Partially Saturated Conditions

Refer to Section 2.7.2.2.2.3 for a description of partially saturated conditions. The only instance where hydrologically unconfined (partially saturated) conditions exist within an area that Powertech (USA) proposes for ISR operations occurs in the eastern portion of the project area. Powertech (USA) does not plan to conduct ISR operations in the Fall River on the eastern edge of the project area (in the vicinity of the Triangle or Darrow pits), where the Fall River is geologically and hydrologically unconfined (partially saturated). However, Powertech (USA) proposes to conduct ISR operations in the underlying Chilson, which is confined above by the Fuson Shale and below by the Morrison Formation. As described in Section 2.6.2.2, the Fuson Shale has been identified and delineated by Powertech (USA) from geophysical logs for exploration holes and is more than 20 feet thick everywhere within the project area; the Fuson Member of the Lakota, which contains the Fuson Shale, is in aggregate 40 to 80 feet thick. Although the Chilson is not fully saturated near the eastern edge of the project boundary, the mineralization occurs near the base of the formation. As a result, any ISR operations will occur within the portion of the Chilson with available head sufficient for fluid control.

Within the project area, the Fall River Formation rises in elevation to the northeast. It subcrops on the eastern edge of the project area in the vicinity of the Darrow pits and crops out to the east in Bennett Canyon. In this area, the upper confining layer, namely the Graneros Group, is absent and the Fall River is geologically unconfined. Depending on location within this general area, the Fall River is partially saturated and the saturated thickness can be substantially less than 100 feet.

Similarly, the Chilson Member rises in elevation to the northeast and subcrops beneath the alluvium in Bennett Canyon. The potentiometric surface elevation for the Chilson is projected to be below the top of the formation on the eastern edge of the project area. Only in this limited area, the Chilson, although geologically confined by the overlying Fuson Shale, is partially saturated (i.e., the water table is below the top the formation). The projected limits for the fully saturated and partially saturated portions of the Fall River and the Chilson are shown on Figures 2.7-26 and 2.7-27, respectively.

Geologic cross section B-B' (Plate 2.6-12b) shows the potentiometric surfaces as well as the interbedded shales and siltstones within the Fall River and Chilson. The cross section depicts the location of the mineralization in the Chilson in relation to the Chilson potentiometric surface. Near the eastern portion of the project area the potentiometric surface is nearly 100 feet higher than the mineralization. Locally occurring shale units may serve to further confine the mineralization within the Chilson. As such, Powertech (USA) does not anticipate that ISR operations will occur where there is less than 50 feet of potentiometric head over the ore body.

After license issuance but prior to well field development, delineation drilling and well field pumping tests will be conducted to fully characterize the existing geologic and hydrogeologic conditions and to confirm sufficient head (>50 feet) is available to perform normal ISR operations. As an integral component of the characterization activities, a detailed evaluation will be made, based on actual site conditions, regarding the application of ISR under partially saturated conditions should it be necessary. Partially saturated conditions, if encountered, would be similar in many respects to what has been licensed at Moore Ranch and will be addressed similarly with modeling.

3.1.2 Well Construction and Integrity Testing

Well construction materials, methods, development, and integrity testing are described in the following subsections.

3.1.2.1 Well Materials of Construction

Well casing material will typically be thermoplastic such as polyvinyl chloride (PVC). Wells typically will be 4, 5 and 6-inch nominal diameter, with wall thickness appropriate for design conditions. In order to provide an adequate annular seal, the drill hole diameter will be at least two inches greater in nominal diameter than the outside diameter of the well casing. The annular seal will be pressure-grouted and sealed with either cement grout or bentonite grout.

Casing will be joined by fittings or using methods recommended by the casing manufacture.

3.1.2.2 Well Construction Methods

Typical well installation will begin with drilling a pilot bore hole through the ore zone to obtain a measurement of the uranium grade and the depth. The pilot bore hole will be geologically and geophysically logged. After logging, the pilot bore hole will be reamed to the appropriate diameter to the top of the ore zone. A continuous string of PVC casing will be placed into the reamed borehole. Casing centralizers will be installed as appropriate. With the casing in place a cement/bentonite grout will be pumped into the casing. The grout will circulate out the bottom of the casing and back up the casing annulus to the ground surface. The volume of grout necessary to cement the annulus will be calculated from the bore hole diameter of the casing with sufficient additional allowance to achieve grout returning to surface. Grout remaining inside the well casing may be displaced by water or heavy drill mud to minimize the column of the grout plug remaining inside the casing. Care will be taken to assure that at a grout plug remains inside the casing at completion. The casing and grout will then be allowed to set undisturbed for a minimum of 24 hours. When the grout has set, if the annular seal observed from the ground surface has settled below the ground surface, additional grout will be placed into the annular space to bring the grout seal to the ground surface.

After the 24-hour (minimum) setup period, a drill rig will be mobilized to finish well construction by drilling through the grout plug and through the mineralized zone to the specified total well depth. As illustrated in Figure 3.1-6, the open borehole will then be underreamed to a larger diameter.

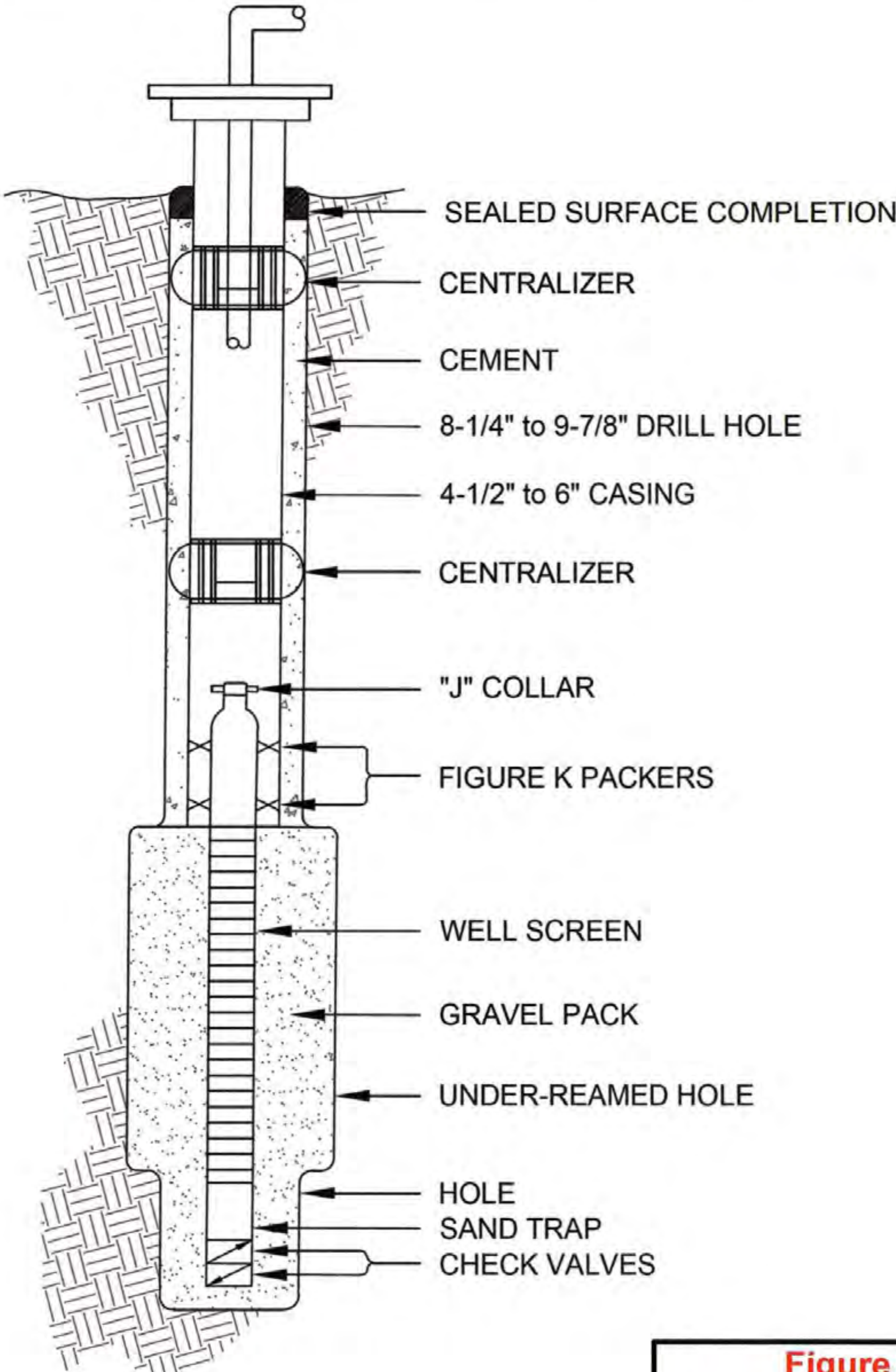

Figure 3.1-6

Typical Well Construction

Dewey-Burdock Project

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A well screen assembly will then be lowered through the casing into the open hole. The top of the well screen assembly will be positioned inside the well casing and centralized and sealed inside the casing using "K" packers. With the drill pipe attached to the well screen, a one-inch diameter tremie pipe will be inserted through drill pipe and screen, and through the sand trap check valves at the bottom of well screen assembly. Filter sand, comprised of well rounded silica sand sized to optimize hydraulic communication between the target zone and well screen, will then be placed between the well screen and the formation. The volume of sand introduced will be calculated such that it fills the annular space. The sand will not extend upward beyond the K packers due to packer design. A well completion report will then be prepared for each well. The reports will be kept available on-site for review. Copies will be submitted to regulatory agencies upon request.

3.1.2.3 Well Development

The primary goals of well development are to allow formation water to enter the well screen and flush out drilling mud, or cement filtrate water and to develop the well bore to remove the finer clays and silts to reduce the pressure drop between the formation and the well screen. This process is necessary to allow representative samples of groundwater to be collected, if applicable, and to ensure efficient injection and production operations. Wells will be developed immediately after construction using air lifting, swabbing, pumping or other accepted development techniques which will remove water and drilling fluids from the casing and borehole walls along the screened interval. Prior to obtaining baseline samples from monitor or restoration wells, additional well development will be conducted to ensure that representative formation water is sampled. The water will be pumped sufficiently to show stabilization of pH and conductivity values prior to sampling and used to indicate that development activities have been effective.

3.1.2.4 Well Integrity Testing

Field-testing of all injection, recovery, and monitor wells will be performed to demonstrate the mechanical integrity of the well casing. The mechanical integrity test (MIT) will be performed using pressure-packer tests. The bottom of the casing will be sealed with a plug, downhole packer, or other suitable device. The casing will be filled with water and the top of the casing will be sealed with a threaded cap or mechanical seal. The well casing will then be pressurized with water or air and monitored with a calibrated pressure gauge. Internal casing pressure will be increased to 125 percent of the maximum operating pressure of the well field, 125 percent of the maximum operating pressure rating of the well casing (which is always less that the maximum pressure rating of the pipe), or 90 percent of the formation fracture pressure (which equates to approximately 1 psi per foot of overburden above the bottom of casing), whichever is less. A well must maintain 90 percent of this pressure for a minimum of 10 minutes to pass the test.

If there are obvious leaks, or the pressure drops by more than 10 percent during the 10 minute period, the seals and fittings on the packer system will be checked and/or reset and another test will be conducted. If the pressure drops less than 10 percent the well casing will have demonstrated acceptable mechanical integrity.

If a well casing does not meet the MIT criteria, the well will be removed from service. The casing may be repaired and the well re-tested, or the well may be plugged and abandoned. Well plugging procedures are described in Section 5.7.1.3.4. If a repaired well passes the MIT, it will be employed in its intended service following demonstration that the well meets MIT criteria. If an acceptable test cannot be demonstrated following repairs, the well will be plugged and abandoned.

In addition to the integrity testing of new wells, a MIT will be conducted on any well following any repair where a downhole drill bit or under-reaming tool is used. Any injection well with evidence of suspected subsurface damage will require a new MIT prior to the well being returned to service. Mechanical integrity tests will also be repeated once every five years for all active wells.

The MIT of a well will be documented to include the well designation, date of test, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of the MITs will be maintained on-site and will be available for inspection by regulatory agencies. Results of MIT shall be reported within quarterly reports in accordance with the EPA UIC regulations in Title 40 Part 146.33.

3.1.3 Monitoring Well Layout and Design

As discussed in Sections 5 and 6 of this application, 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 for individual well fields is designed to (1) establish baseline water quality prior to production, (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 mineralized zone has been adequately restored following ISL operations. Objectives 1 (partially) and 4 will accomplished using injection and recovery wells.

Objectives 1 (partially), 2, and 3 will be accomplished using perimeter and internal non-production zone monitoring wells.

The production wells are laid out in a regular grid to efficiently contact the mineralized deposit (Figure 3.1-7). Generally, the wells are laid out in regular geometric shapes, usually squares, rectangles, triangles, or hexagons. The important features are that the patterns cover the economically mineable portions of the orebody, the production (pumping) well is in the center of each geometric shape, the injection wells are equally spaced from each other and from the production wells in each pattern (geometric shape). This is to ensure efficient contacting of the ore by uniform flow distribution and to facilitate control of the flow to prevent excursion of lixiviant to the monitor well ring. The injection wells are on the outside to ensure the ore is contacted with lixiviant and a bleed withdrawing of some 0.5 to 3 per cent of the lixiviant circulating to maintain a cone of depression ensuring outside groundwater in the ore zone flows in toward the production well field to prevent flow of lixiviant outwards (NMA, 2007).

The production zone monitor wells are completed in the ore zone around the perimeter of the production well fields spaced 400 feet outside the production well field and evenly spaced around the perimeter of the well field with a maximum spacing either 400 feet or the spacing that will ensure a 70 degree angle between adjacent production zone monitor wells and the nearest injection well (NUREG/CR-6733; NUREG-1910, 2008; NUREG-1569). Justification for the perimeter monitor well spacing is found in Section 5.7.8.4.3.

Monitor well design will be included in the well field hydrogeologic data packages described in Section 3.1.3.3. Protection from surface water is described in Section 3.1.7. Adequate access to the monitor wells will be available even during infrequent storm events.

3.1.3.1 Well Field Operational Monitoring

The primary purpose of a monitoring well is to serve as an early warning system for detection of excursions and to meet the operation point of compliance (POC) in accordance with NRC's interpretations of 10 CFR Part 40, Appendix A. The proposed monitoring system is described below.

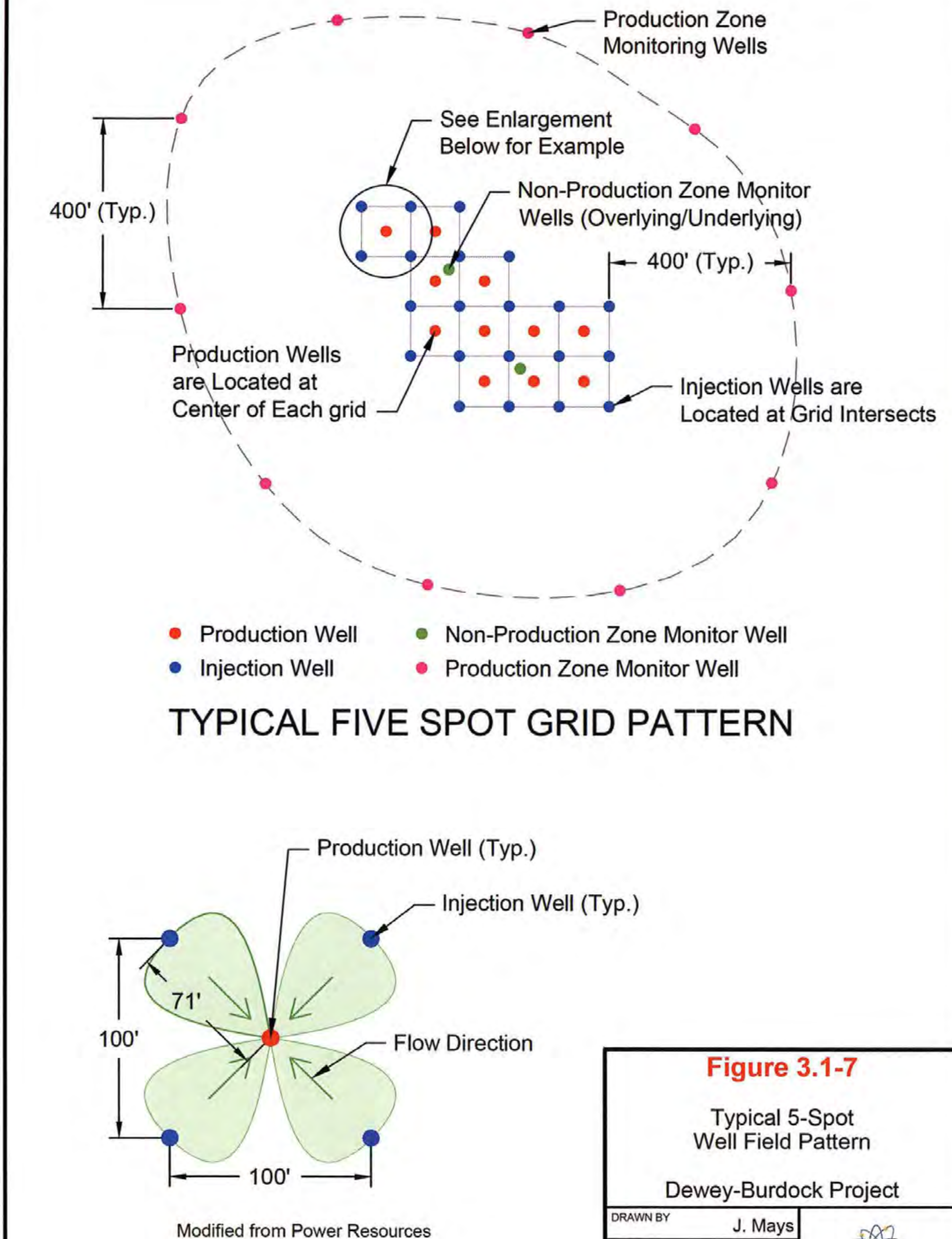


Figure 3.1-7

Typical 5-Spot
Well Field Pattern

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	FiveSpotPattern.dwg

POWERTECH (USA) INC.

3.1.3.1.1 Non-Production Monitoring Wells

Depending on-site specific conditions, non-production monitoring wells may consist of two types of monitor wells termed "overlying" and "underlying". The screened intervals of overlying wells are located in the sand units or aquifers above the ore-bearing stratum. The overlying non-production monitoring wells are designed to provide monitoring of any upward movement of lixiviant 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 and underlying wells are used to obtain baseline water quality data and are used in the development of UCLs for the overlying and underlying zones that will be used to determine if vertical migration of lixiviant is occurring. Vertical monitoring is generally set up with a density of wells ranging from one every three to five acres and where confining layers are very thick and permeabilities are negligible, requirements for vertical excursion monitoring can be relaxed or eliminated for underlying aquifers (NUREG/CR-6733, 2001). The screened zone for the overlying and underlying wells is determined from electric logs by qualified geologists or hydrogeologists.

General Monitor Well Layout

Monitor wells will be installed in each overlying aquifer. The term "overlying aquifer" refers to any hydrogeologic unit(s) above the production zone and separated by a confining layer. The terms "overlying aquifer" and "overlying hydrogeologic unit" are used interchangeably when describing well field operations in the project area. There may be more than one overlying hydrogeologic unit in a given well field, depending on the specific production zone and local geology. The presence or absence of local confining beds and the location of the production zone within the Fall River or Chilson will determine the number of overlying hydrogeologic units. At times, an alluvial unit may exist at the surface above the well field. This alluvial unit will be treated as an overlying hydrogeologic unit and monitored appropriately.

Monitor wells completed in the first overlying hydrogeologic unit will be designated with the prefix MO and will have a density of at least one well per 4 acres of well field pattern area. Subsequent overlying hydrogeologic units will have designations MO2, MO3, etc. and will have a density of at least one well per 8 acres of well field pattern area. Monitor wells completed in the first underlying hydrogeologic unit will be named with the prefix MU and will have a density of one well per 4 acres of pattern area. Only the first underlying hydrogeologic unit will be monitored.

The internal, non-production zone monitor wells will be screened across the entire overlying and underlying aquifer to avoid missing an excursion (defined as when a monitor well sample contains more than two of the excursion indicators at the UCL level, in accordance with NUREG-1910, Supplement 1, pg. 4-2a) occurring above or below the screened interval.

The generalized monitoring scheme for the Fall River and Chilson is presented in Figure 3.1-8. This approach will be used when there are no substantial confining layers between ore bodies within the Fall River or Chilson.

At times local confining units within the Fall River and Chilson may be utilized in the monitoring scheme. The presence or absence of these will be confirmed with delineation drilling and mapped in more detail in the process of development of each well field hydrogeologic data package. The monitoring system also will be specified in each hydrogeologic data package (refer to Section 3.1.3.3). Should sufficient confining units be mapped after more detailed delineation drilling, the following describes how the well fields would be monitored. The following information represents a conceptual description of monitor well design for the initial Burdock and Dewey well fields.

Conceptual Monitor Well Layout – Initial Burdock Well Fields

Figure 3.1-9 shows the anticipated monitor well configuration for Burdock Well Fields 1 and 3. For B-WF1 the anticipated production zone will be the Lower Chilson, in which case the overlying hydrogeologic units would include the Middle and Upper Chilson and the Lower and Upper Fall River. Since the production zone in B-WF1 is anticipated to be in the lowermost Chilson hydrogeologic unit, which is underlain by the Morrison Formation, no monitoring would occur in the underlying hydrogeologic unit (Unkpapa). Section 3.1.3.1.1.1 contains additional explanation. The Middle Chilson, being the first overlying hydrogeologic unit, would be monitored at a density of one well per 4 acres with monitor wells designated MO. Monitor wells would be completed in the Upper Chilson, the Lower Fall River, and the Upper Fall River at a density of one well per 8 acres in each unit. These wells would be designated MO2 (Upper Chilson), MO3 (Lower Fall River) and MO4 (Upper Fall River). For B-WF3, the anticipated production zone will be the Upper Chilson, in which case the first overlying hydrogeologic unit would be the Lower Fall River (monitor wells at one per 4 acres and designation MO) and the second overlying unit would be the Upper Fall River (monitor wells at one per 8 acres and designation MO2). For B-WF3 the Middle Chilson would be the underlying hydrogeologic unit and would be monitored at a density of one well per 4 acres of pattern with designation MU.

Figure 3.1-10 depicts the type log for B-WF1. This type log illustrates the various hydrogeologic units that Powertech (USA) anticipates monitoring in B-WF1 as described above.

In some cases, the production zone of one well field will be in the immediately overlying hydrogeologic unit of another well field. Monitoring for all hydrogeologic units will be continued in the same fashion as described above with the exception that the overlying monitor wells will be excluded from the production zone of an immediately overlying well field. This will only occur inside the perimeter well ring of the overlying well field.

As an example, Figure 3.1-9 shows the monitoring configuration of a production zone in the Upper Chilson in the Burdock area, B-WF3. When this well field is developed, there could be some MO2 wells in the Upper Chilson associated with a previous well field developed in the Lower Chilson within its perimeter monitor ring. When injection is started, use of these former MO2 wells for monitoring will cease. However, all other monitor wells for the Upper Fall River, Lower Fall River, Upper Chilson, and Middle Chilson associated with B-WF1 will remain in use.

Conceptual Monitor Well Layout – Initial Dewey Well Fields

Figure 3.1-11 shows the anticipated monitoring well configuration for the initial Dewey well fields. For D-WF1 the anticipated production zone will be the Lower Fall River, in which case the MO zone (with monitoring at one well per 4 acres) would be the Upper Fall River, and there would be no additional overlying hydrogeologic units. The MU zone (with monitoring at one well per 4 acres) would be the Upper Chilson. Similar conventions are shown for D-WF2 and D-WF3.

Figure 3.1-12 depicts the type log for D-WF1. This type log depicts the various hydrogeologic units that Powertech (USA) anticipates monitoring as described above.

Conclusion

During the ongoing well field development, the monitor well designations may change. However, the density of monitor wells in the overlying hydrogeologic units will remain as discussed above. Development of each well field monitoring system will be included in the hydrogeologic data packages prepared during the detailed design of each well field. Hydrogeologic data packages, including pump testing procedures used to establish that the injection wells are hydraulically isolated from vertical monitor wells, are described in Sections 3.1.3.2 and 3.1.3.3.

By properly designing and pump testing each well field and its associated monitor well network, including specifically addressing those areas having the greatest potential for excursions, Powertech (USA) will minimize the risk of excursions and minimize the potential impacts resulting from excursions. By routinely sampling monitor wells for changes in water level and concentrations of the highly mobile and conservative excursion parameters of chloride, total alkalinity and conductivity, Powertech (USA) will ensure that any potential excursions are identified and corrected quickly. As described on page B-75 of the Moore Ranch Final SEIS (NUREG-1910, Supplement 1, Appendix B), "An excursion is defined as an event where a monitoring well in overlying, underlying, or perimeter well ring detects an increase in specific water quality indicators, usually chloride, alkalinity and conductivity, which may signal that fluids are moving out from the wellfield...The perimeter monitoring wells are located in a buffer region surrounding the wellfield within the exempted portion of the aquifer. These wells are specifically located in this buffer zone to detect and correct an excursion before it reaches a USDW...To date, no excursion from an NRC-licensed ISR facility has contaminated a USDW."

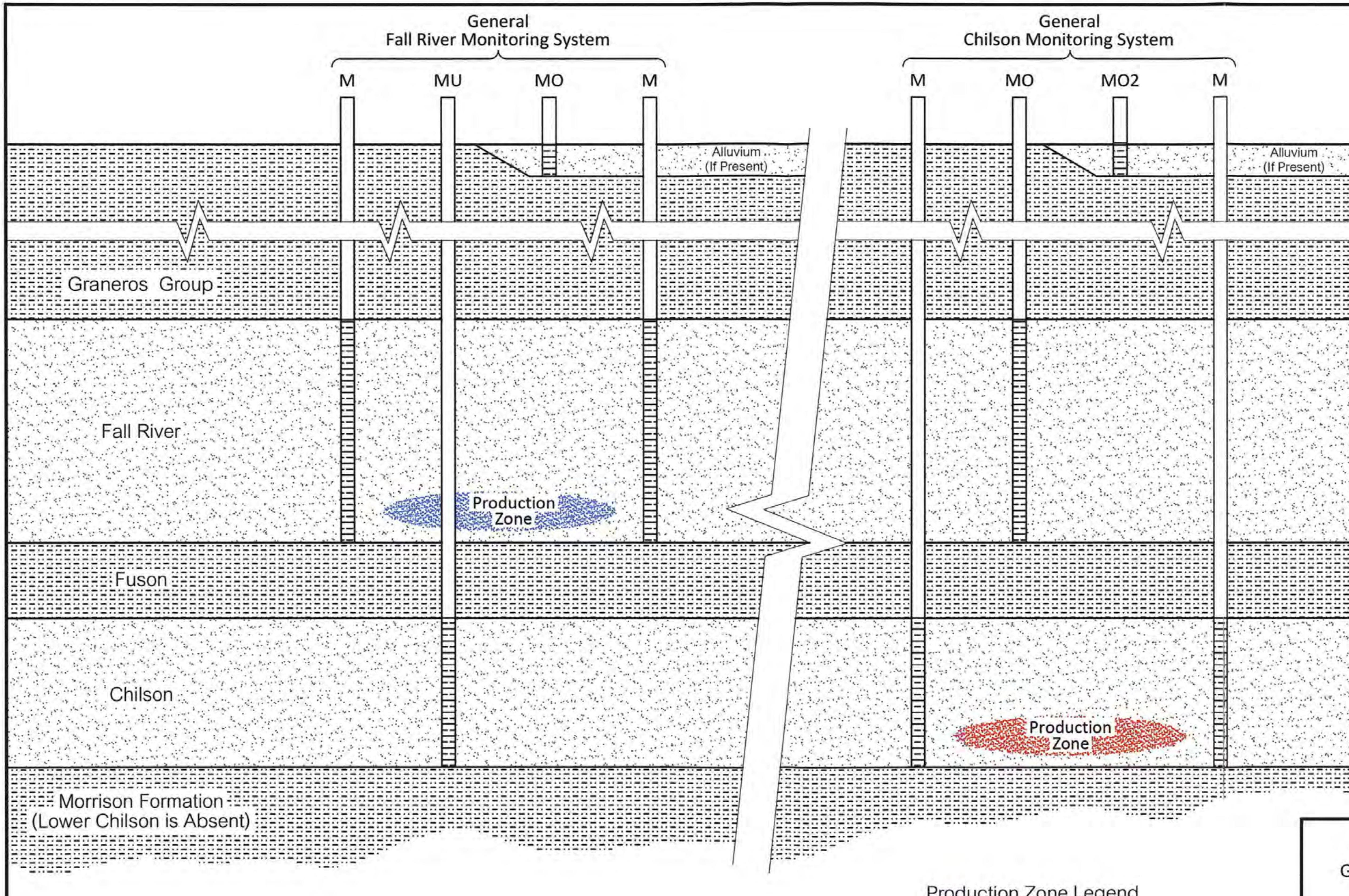
Additional information about sampling parameters, frequencies, and procedures is provided in Section 5 of this application.

3.1.3.1.1.1 Monitoring the Unkpapa Sandstone

The Unkpapa Sandstone is considered the first aquifer below the Morrison Formation, a regional confining unit 60 to 140 feet thick throughout the project area. The Unkpapa will be the underlying aquifer when there is not a suitable or distinct hydrogeologic unit within the Chilson (such as the Lower Chilson sand) below a production zone. For production zones in the lowest portion of the Chilson, the Unkpapa will be the underlying aquifer.

Excursion monitoring will not occur in the Unkpapa. The justification for not performing excursion monitoring is as follows:

1) The Unkpapa Sandstone shows substantially higher potentiometric head than the Fall River and Chilson throughout the project area. During ISR operations, the potentiometric head will be reduced (creating a cone of depression) in the Chilson and Fall River due to a net withdrawal (production flow greater than injection flow) in order to maintain well field bleed. Flow into the Unkpapa from production zones in the Fall River and Chilson operating at a substantially lower potentiometric head would be impossible.
2) The Morrison Formation is prevalent across the entire project area and will act as an aquitard to prevent flow into the Unkpapa from the Fall River and Chilson. This was demonstrated by the pumping tests conducted by Powertech (USA), where no response occurred in the Unkpapa during pumping of either the Fall River or Chilson.
3) The Unkpapa is a low-yield aquifer determined by a recent water supply well installation by Powertech (USA). Water samples from the Unkpapa can no longer be obtained from well 704 because this well was cemented off in the Unkpapa in 2009 and perforated in the Chilson due to low yield from the Unkpapa.



M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2 - Monitor Overlying Sand (1 per 8 acres)

Figure 3.1-8

Generalized Monitor Well Configuration

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	MonWell-GenConf.dwg

POWERTECH (USA) INC.

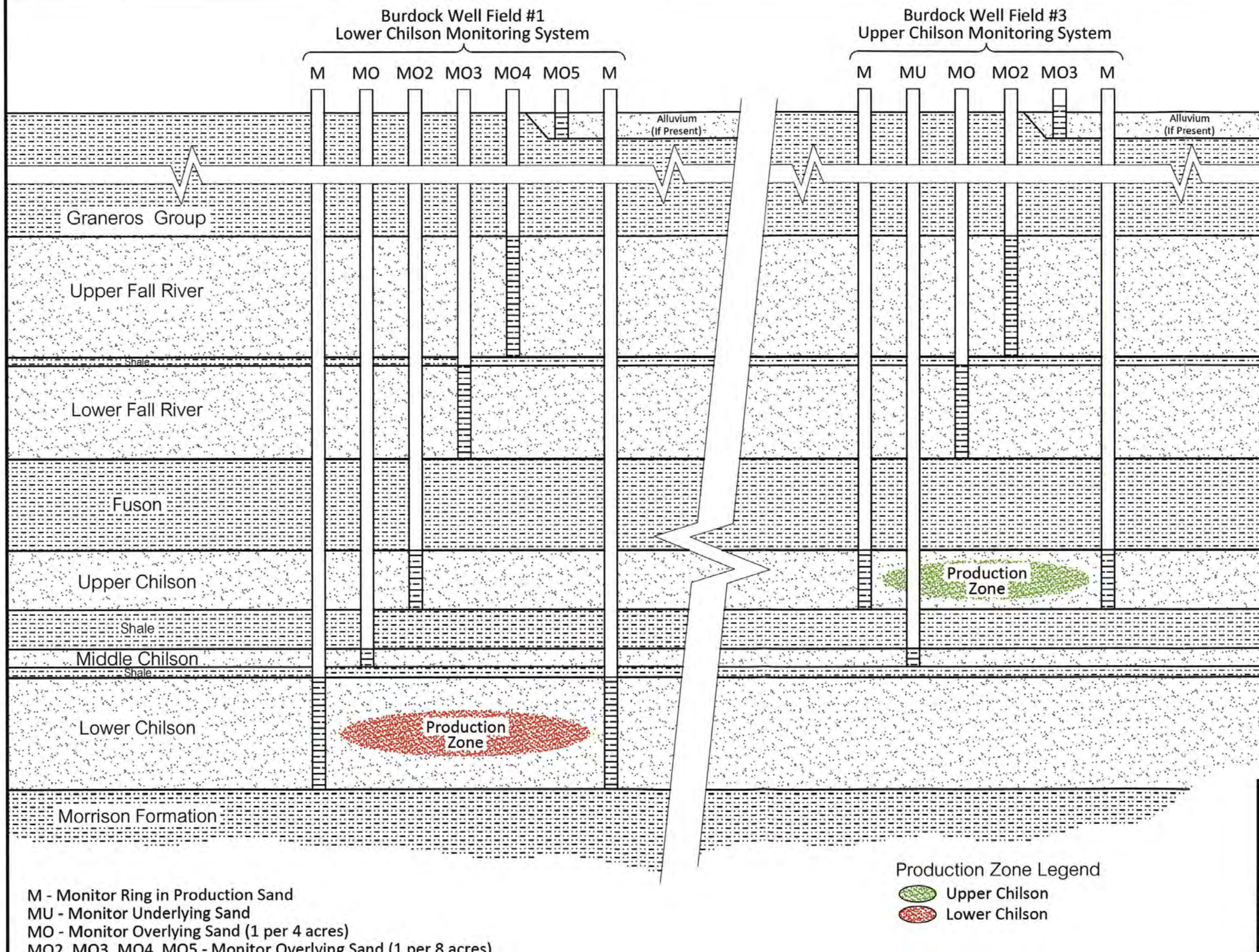


Figure 3.1-9

Anticipated Burdock Monitor Well Configuration

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	MonWell-BurdConf.dwg

POWERTECH (USA) INC.

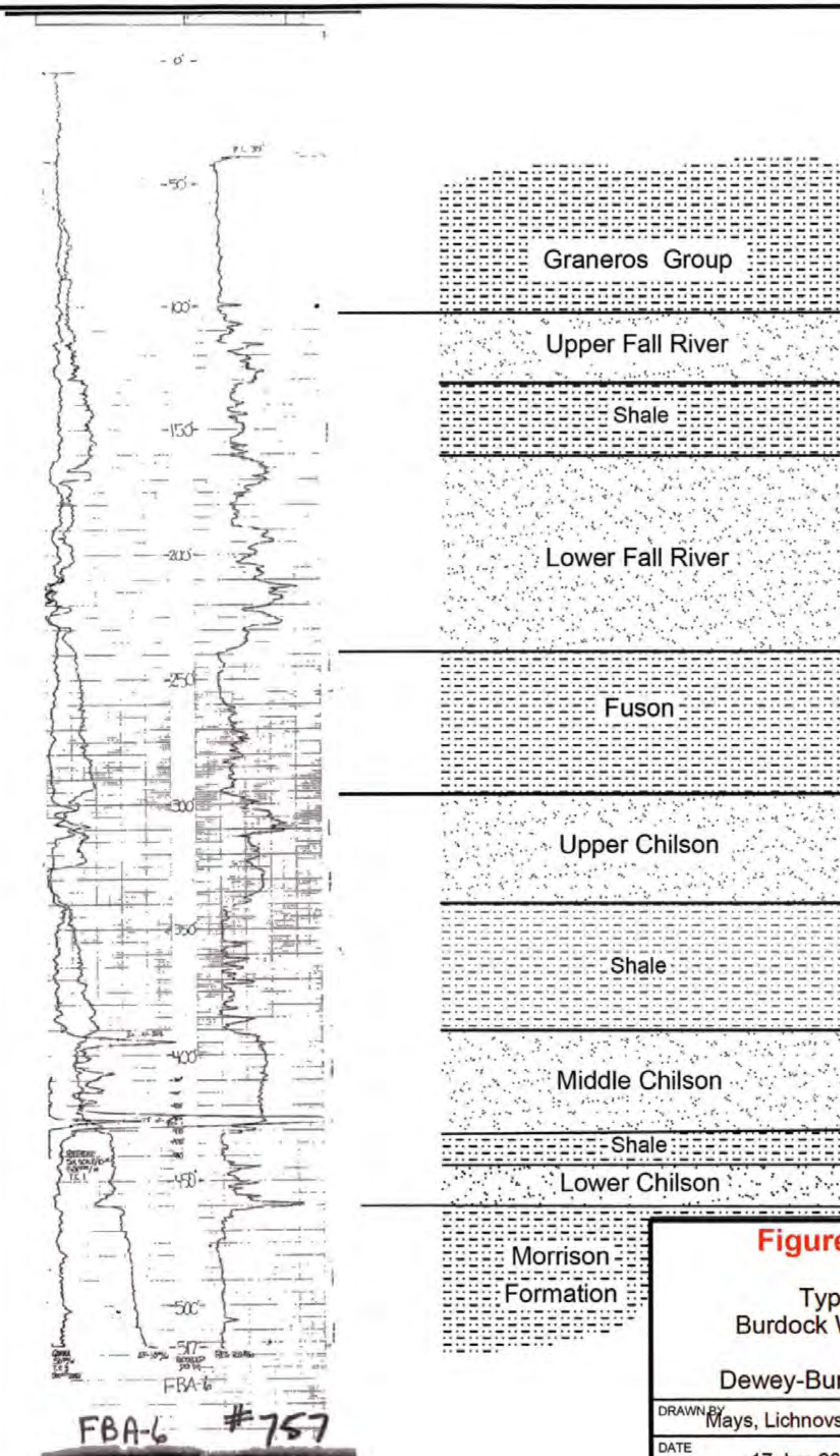
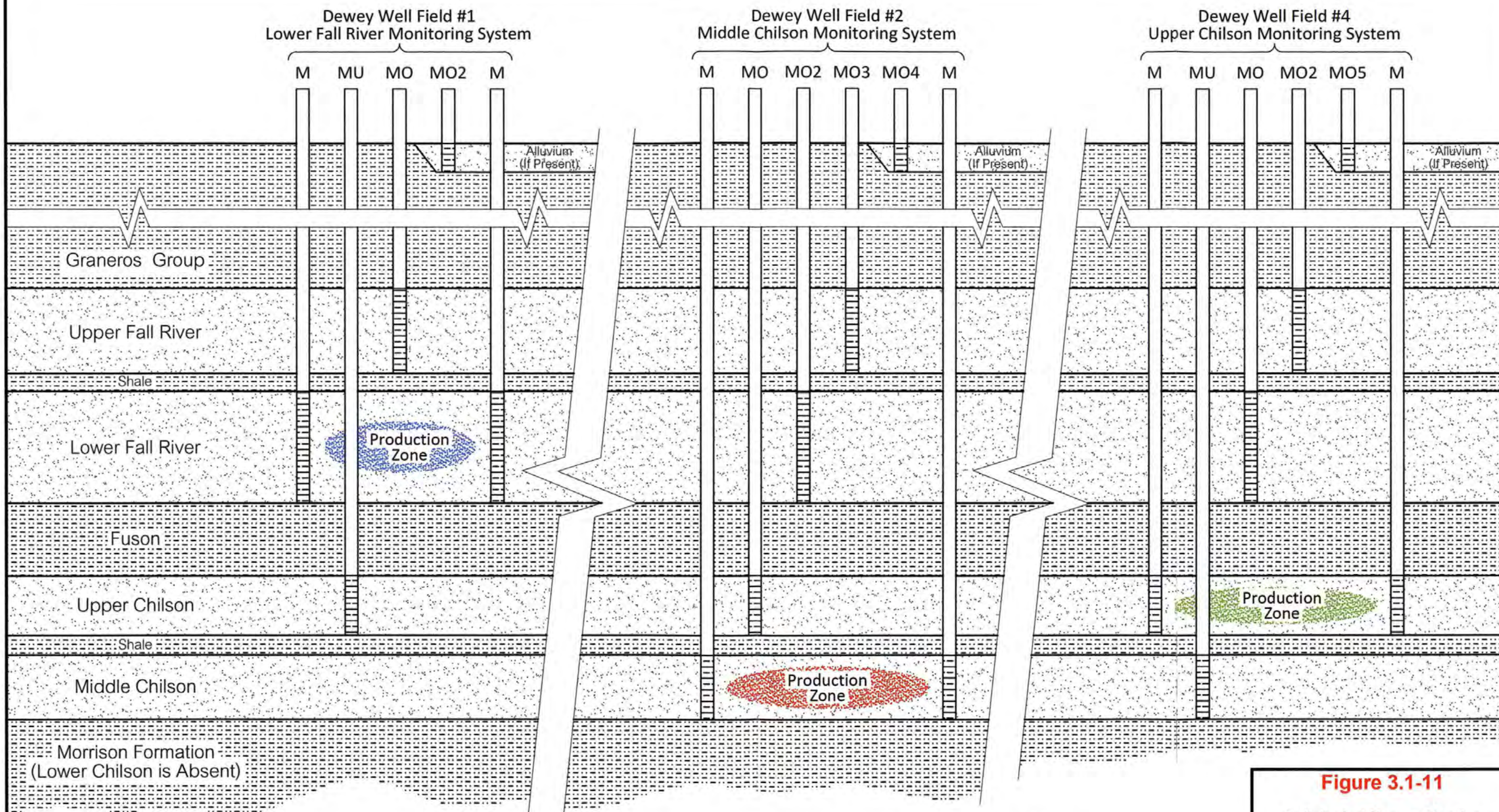


Figure 3.1-10

Type Log
Burdock Well Field 1

Dewey-Burdock Project

DRAWN BY Mays, Lichnovsky	POWERTECH (USA) INC.
DATE 17-Jun-2013	
FILENAME WF-B1-TypeLog.dwg	



M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2, MO3, MO4, MO5, MO6 - Monitor Overlying Sand (1 per 8 acres)

Figure 3.1-11

Anticipated Dewey Monitor Well Configuration

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	MonWell-DeweyConf.dwg

POWERTECH (USA) INC.

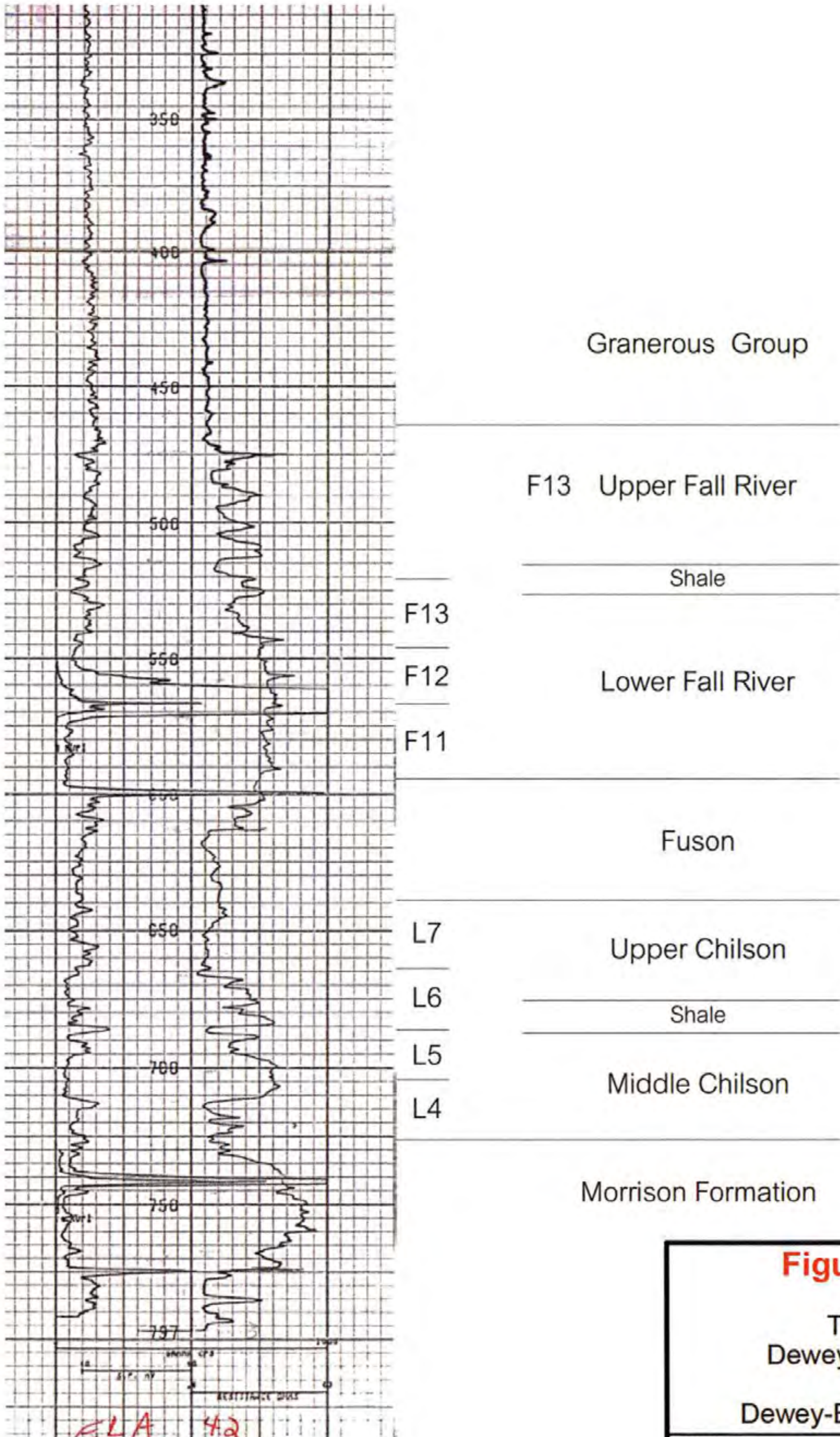


Figure 3.1-12

Type Log
Dewey Well Field 1

Dewey-Burdock Project

DRAWN BY	Bohner, Lichnovsky
DATE	17-Jun-2013
FILENAME	WF-D1-TypeLog.dwg

POWERTECH (USA) INC.

3.1.3.1.2 Production Monitoring Wells

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 within the sand unit or aquifer where production is occurring and, (2) to determine baseline water quality data and characterize the area outside the production pattern area. Upper Control Limits (UCLs) are determined from indicator constituents that are selected due to their nature of mobility to provide early warning with regards to a potential excursion; these constituents will be chloride, total alkalinity, and conductivity. By establishing UCLs, the operator is allowed the capability of early detection of an excursion at a monitor well and then has the time to apply corrective action before water quality outside the aquifer exemption boundary is adversely affected (NUREG/CR-6733, 2001). 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 production zone monitoring wells (NUREG/CR-6733; NUREG-1910, 2008; NUREG-1569). If the monitor wells are closer than 400 feet to the well field, the monitor wells will be located via a strategic distance to maintain a minimum angle between monitor wells and the nearest injection well of 70 degrees. This will ensure that no lixiviant will pass between the adjacent monitor wells undetected as the lixiviant would flow radially outward from the initiation point of an excursion. Justification for the perimeter monitor well spacing is found in Section 5.7.8.4.3. Production zone monitoring wells are installed before the start of production activities in order that required baseline sampling and hydrologic tests can be conducted. Well design, construction, and development will be identical to those of injection and recovery wells, except well screens will be completed across the entire mineralized sandstone as described below (Figure 3.1-6). Additional information about sampling parameters, frequencies, and procedures is provided in Section 5 of this application.

Consistent with NUREG-1569 (page 5-42), the perimeter monitor wells will be screened across the entire thickness of the production zone, which will be determined following completion of delineation drilling for each well field. In all cases, the screens will fully penetrate the hydrogeologic unit to be monitored, i.e., spanning the entire interval between the overlying and underlying confining beds. As described in Section 2.6, the Fuson Shale is pervasive throughout the project area and forms a confining unit between the Fall River and Chilson. No monitor well will be screened across the Fuson Shale and into the Fall River and Chilson.

In some areas, multiple ore bodies are vertically stacked within the Fall River or Chilson. The perimeter production zone monitor wells will be screened across the full thickness of the hydrogeological unit (Fall River or Chilson, but not both), and these multiple ore bodies treated as a single production zone for the purpose of determining the horizontal distance between the production zone and the monitor well ring. This approach will be utilized when there are no substantial confining layers between ore bodies within the hydrogeologic unit (Fall River or Chilson) and when the hydrogeologic unit containing the multiple ore bodies behaves as a single hydraulically connected unit. An example of this type of monitoring approach is shown in Figure 3.1-8.

In the case where a localized confining unit (other than the Fuson Shale) is present between stacked ore bodies within one of the primary hydrogeologic units (Fall River or Chilson), the monitoring approach may be modified such that perimeter monitor wells are screened only within the portion of the hydrogeologic unit in which the ore body is located. An example of this approach is described as follows. Based on characterization to date, the Chilson has been subdivided into three subunits: Upper Chilson, Middle Chilson, and Lower Chilson. In some cases, a low-permeability unit separates the Upper Chilson from the Middle and Lower Chilson. This relationship is shown on the geologic cross sections (Plates 2.6-12a through 2.6-12h and 2.6-12j). If it is demonstrated that the localized confining unit provides hydraulic separation between the Upper Chilson and the lower units of the Chilson, then monitor wells will be located and designed to monitor these zones separately as shown on Figures 3.1-9 and 3.1-11. Using this approach, if the ore body were located within the Upper Chilson unit, the perimeter monitor wells will only be screened across the Upper Chilson.

In places where there is no confining layer between the Middle and Lower Chilson and they become a single hydrogeologic unit, then these will be treated as one unit for purposes of monitoring. If they are separate units within the entire area of the perimeter monitor ring of the well field, then they will be treated as separate hydrogeologic units and monitored separately.

The screened intervals for the perimeter monitor wells will be further justified by demonstrating responses to pumping during the well field-scale pumping tests (see Section 3.1.3.2). Numerical modeling will also be conducted to further evaluate the likely magnitude of the response in the perimeter monitor wells to ISR operations.

3.1.3.2 Pump Testing

The following pump testing procedures will be used to establish that the production and injection wells are hydraulically connected to the perimeter production zone monitor wells, that the production and injection wells are hydraulically isolated from non-production zone vertical monitor wells, and to detect potentially improperly plugged wells or exploration holes. In the event that a well is located, it will be evaluated and, if necessary, reported to SERP and mitigated following the procedures described in Section 5.7.1.3.4. Pump testing results will be included in the well field hydrogeologic data package described in Section 3.1.3.3.

Pump Testing Design

An extensive pump test program will be designed and implemented prior to operation of each well field to evaluate the hydrogeology and assess the ability to operate the well field. Prior to pump testing several important well field development steps will be completed:

1) Delineation drilling at a spacing approximately equivalent to well field pattern size. As standard procedure, all delineation holes will be plugged and abandoned after drilling.
2) Detailed mapping of the ore bodies targeted for ISR operations and the lithology of overlying and underlying sand units and aquitards.
3) Revision of the conceptual geology and hydrogeology including definition of aquitards and sand units to be produced or monitored.
4) Design of the production and injection wells including well locations and screened intervals.
5) Design of the monitor well system based on production and injection well locations and refined conceptual geology and hydrogeology.
6) Specification of all monitor well locations and screened intervals.
7) Installation of all monitor wells and production wells used during pump testing.
8) Plugging and abandoning all water supply wells within ¼ mile of the well field or that have been determined through preliminary evaluation to be potentially impacted by ISR operations or to impact ISR operations.

Pump Testing Procedures

The entire monitoring system for the well field will be monitored during the pumping test, including but not necessarily limited to the following wells:

1) Pumping wells,
2) Monitor wells within the production zone (at a minimum density of 1 per 4 acres),
3) Perimeter production zone monitor wells,

4) Monitor wells in the immediately overlying non-production zone sand unit (at a minimum density of 1 per 4 acres),
5) Monitor wells in each subsequently overlying non-production zone sand unit (at a minimum density of 1 per 8 acres),
6) Monitor wells in the alluvium, if present (at a minimum density of 1 per 8 acres),
7) Monitor wells in the immediately underlying non-production zone sand unit, if the production zone does not occur immediately above the Morrison Formation (at a minimum density of 1 per 4 acres),
8) Any additional wells installed for investigating other hydrogeologic features, and
9) Any other wells within proximity to the well field that have been identified as having the potential to impact or be impacted by ISR operations.

All monitoring system wells will be monitored using downhole data logging pressure transducers, which will be corrected for variations in barometric pressure.

Prior to testing, static potentiometric water levels will be measured in every well in the monitoring system. These data will be used to map the preoperational potentiometric surface for each unit including alluvium, where present. Because of the high density of wells and artesian conditions at the site, any leakage across aquitards due to improperly plugged boreholes or wells will typically become apparent while preparing potentiometric surface maps. Four water samples will be collected from each monitor well and analyzed for the parameters. The water quality will be evaluated to identify any potential areas of leakage across aquitards due to improperly plugged boreholes or wells.

Pump testing will involve inducing stress on the production zone sand unit by operating pumping wells. The goal of the test will be to cause drawdown in the production zone extending to all perimeter monitor wells. More than one pumping well may be required to create drawdown in all perimeter monitor wells. Pump testing will create a cone of depression across the well field area to test the confinement between the production zone and the overlying and underlying sand units and alluvium, if present. The pump tests will specifically be designed to address potential leakage through confining units through improperly sealed or unplugged exploration boreholes, or associated with naturally occurring geologic features. The presence or lack of response in vertical monitor wells will be used for evaluation of confinement between these units and for identification of leakage due to anomalies such as improperly plugged boreholes. If leakage is present, the relative responses in the overlying, underlying, and/or alluvial monitor wells will indicate the proximity and direction towards the source of leakage.

If saturated alluvium is present within the well field, alluvial monitor wells will be installed and monitored above the production zone and within an appropriate distance from the well field. The water level in the alluvium will be mapped prior to testing and monitored during pump testing. If the potentiometric surface of the production zone unit rises above the base of the alluvium, pump testing will create sufficient drawdown to lower the production zone unit potentiometric surface below the lowest elevation of the alluvium in the well field. If there are anomalous conditions that cause communication between the production zone and alluvium such as an improperly plugged borehole, these conditions will be identified through responses in the alluvial monitor wells.

The pumping test duration will be sufficient to create a suitable response in the perimeter monitor wells. Typically, this will be a minimum drawdown of 1 foot in each perimeter monitor well. If hydrogeologic conditions dictate, less response may be justified.

The flow rate of the pumping test will be greater than or equal to the maximum well field bleed or the maximum expected flow rate of a single production well, whichever is greater.

Measurements during pump testing will include instantaneous and totalized flow, continuous pressure transducer measurements, barometric pressure, and time. A step rate test will be performed initially. There will be an initial stabilization phase with no flow, a stress period of constant flow, and a recovery period with no flow. During the entire test downhole pressure transducers will collect data in each monitor well.

Pump Test Evaluation

Evaluation of pump test data will address the following:

1) Demonstration of hydraulic connection across the production zone and between the production and injection wells and all perimeter monitor wells.
2) Confirmation that all monitor wells can suitably detect an excursion.
3) Verification of the geologic conceptual model for the well field.
4) Evaluation of the vertical confinement and hydraulic isolation between the production zone and overlying and underlying units.
5) Demonstration that solutions can be controlled with a typical well field bleed.
6) Calculation of the hydraulic conductivity, storativity, and transmissivity of the production zone sand unit.
7) Evaluation of anisotropy within the production zone sand unit.
8) Calculation of anticipated drawdown during ISR operation at typical bleed rates.
9) Detection of potentially improperly plugged wells or exploration boreholes.

3.1.3.3 Well Field Hydrogeologic Data Packages

Pumping test data and results will be included in the Well Field Hydrogeologic Data Packages. Upon completion of field data collection and laboratory analysis, the Well Field Hydrogeologic Data Package will be assembled and submitted for review by the Safety and Environmental Review Panel (SERP) for evaluation. The SERP evaluation will determine whether the results of the hydrologic testing and the planned ISR operations are consistent with standard operating procedures and technical requirements stated in the source and byproduct material license. The evaluation will include review of the potential impacts to human health and environment. If anomalous conditions are present or the SERP evaluation indicates potential to impact human health or the environment, the Well Field Hydrogeologic Data Package will be submitted to NRC for review and approval. Otherwise, the Well Field Hydrogeologic Data Package and written SERP evaluation will be maintained at the site and available for NRC review.

A Well Field Hydrogeologic Data Package will contain the following:

1) A description of the proposed well field (location, extent, etc.).
2) Map(s) showing the proposed production and injection well patterns and locations of all monitor wells.
3) Geologic cross sections and cross section location maps.
4) Isopach maps of the production zone sand and overlying and underlying confining units.
5) Discussion of how pump testing was performed, including well completion reports.
6) Discussion of the results and conclusions of the pump testing, including pump testing raw data, drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps and, when appropriate, directional transmissivity data and graphs.
7) Sufficient information to show that wells in the monitor well ring are in adequate communication with the production patterns.
8) Baseline water quality information including proposed UCLs for monitor wells and target restoration goals (TRGs).
9) Any other information pertinent to the proposed well field area tested will be included and discussed.

3.1.4 Hydraulic Well Field Control

Powertech (USA) will maintain hydraulic control of each well field from the first injection of lixiviant through the end of aquifer restoration. During uranium recovery, the groundwater removal rate in each well field will exceed the lixiviant injection rate, creating a cone of depression within each well field. During aquifer restoration, the groundwater removal rate in each well field will exceed the injection rate of permeate and clean makeup water from the Madison Formation or another suitable formation. If there are any delays between uranium recovery and aquifer restoration, production wells will continue to be operated as needed to maintain water levels within the perimeter monitor rings below baseline conditions. This activity may be intermittent or continuous.

Verification of hydraulic control will be performed through water level measurements in perimeter monitor wells. Water levels will be measured continuously using pressure transducers and recorded at a frequency appropriate to confirm hydraulic well field control. Other standard operating procedures to monitor and control well field operations are described in Sections 3.1.5 and 3.2-12.

3.1.5 Detection and Cleanup of Piping Leaks

Leak detection will be performed by daily visual inspection of all above-ground pipe, connections, and fittings by field personnel during their daily site visits. Operating pressures of all injection wells, recovery wells, and associated buried piping systems will also be monitored during these visits. In addition, the pressure and flow in each line will be monitored. Should pressure/flow fluctuate outside of "normal" operating ranges, the affected line will be shut down. An operator will then inspect the troubled component and determine the source of the problem. The troubled component will then be repaired, tested, and returned to service, as appropriate, and preventative measures will be implemented to prevent a recurrence.

Cleanup will involve characterizing the extent of release via visual observation coupled with sampling of soils for constituents of concern in accordance with a standard operating procedure. To the greatest extent practicable, impacted material will be consolidated into a centralized area to mitigate the potential for proliferation of small waste disposal sites within the license area. More information regarding spill management is presented in Subsection 5.7.1.3 (Spill Provision Plans) of this application.

3.1.6 Liquid Waste Disposal System Design

Powertech (USA) proposes two methods for disposal of liquid waste at the PA. These include deep disposal well and land application. The following sections describe the design of the land application system, deep disposal wells, and associated ponds. Section 4.2.2.4 provides additional details regarding liquid waste disposal, including water balance figures.

3.1.6.1 Pond Design

The total pond area proposed for the land application option is approximately 71 acres. The land application system will occupy around 760 acres; however, only 630 acres will typically be used at one time. The rest will be on standby. These values are based on the most current design of the land application system. Appendix 3.1-A of the approved license application provides pond design information for both liquid waste disposal options. The pond design is summarized below. Section 3.1.6.1.1 provides detailed descriptions of pond sizing calculations.

Land Application

The land application disposal option will include the following ponds:

- **Two (2) Radium Settling Ponds** - one near each land application area (Dewey and Burdock). Each pond will have an operating capacity of 39.4 acre-feet. Radium settling ponds for the land application disposal option were designed such that a single pond has sufficient capacity for radium removal of the entire project-wide wastewater stream at the maximum expected production bleed of 3% while maintaining a minimum retention time of 14.1 days.
- **Two (2) Spare Ponds** - one at each area. Each pond will have an operating capacity of 39.4 acre-feet. The spare ponds will be designed with the same dimensions and liner system as the radium settling ponds so that they can be used as either spare radium settling ponds or spare Central Plant Ponds.
- **Two (2) Outlet Ponds** - one at each area. Each pond will have an operating capacity of 4.9 acre-feet. The outlet ponds will be designed to temporarily store treated water from the radium settling ponds and provide extra capacity for the radium settling ponds during large precipitation events.
- **Eight (8) Storage Ponds** - four at each area. Each pond will have an operating capacity of 63.8 acre-feet. The storage ponds will be used to store treated water during the winter months when no liquid waste disposal by land application systems is available. The total storage required at each area was obtained using the SPAW model, which is discussed in more detail in the Pond Design Report (Appendix 3.1-A of the approved license application) and in Section 4.2.2.1.
- **Two (2) Spare Storage Ponds** - one at each area. Each pond will have an operating capacity of 63.8 acre-feet. The spare storage ponds will be designed with the same dimensions and liner system as the storage ponds so that they can be used in the event of an upset condition.

- **One (1) Central Plant Pond** - located at the Burdock CPP, with an operating capacity of 36.2 acre-feet. The storage capacity design for the Central Plant Pond allows for over 18 months of CPP liquid waste storage, which will be required during initial uranium recovery operations when no groundwater sweep water is available to blend with CPP liquid waste.

Deep Disposal Well

The deep disposal well liquid waste disposal option will include the following ponds:

- **Two (2) Radium Settling Ponds** - one at each area. Each pond will have an operating capacity of 15.9 acre-feet. Radium settling ponds for the DDW option were designed such that a single pond has sufficient capacity for radium removal of the entire project-wide liquid waste stream at the maximum expected production bleed of 3% while maintaining a minimum retention time of 12.7 days.
- **Two (2) Spare Ponds** - one at each area. Each pond will have an operating capacity of 15.9 acre-feet. The spare ponds will be designed with the same dimensions and liner system as the radium settling ponds so that they can be used as either spare radium settling ponds or spare Central Plant Ponds.
- **Two (2) Outlet Ponds** - one at each area. Each pond will have an operating capacity of 5.1 acre-feet. The outlet ponds will be designed to temporarily store treated water from the radium settling ponds and provide extra capacity for the radium settling ponds during large precipitation events.
- **Two (2) Surge Ponds** - one at each area. Each pond will have an operating capacity of 8.4 acre-feet. The surge ponds will provide surge capacity for treated liquid waste flowing out of the radium settling ponds. They have been sized to accommodate 7 days of water production.
- **One (1) Central Plant Pond** - located at the Burdock CPP, with an operating capacity of 15.9 acre-feet.

All ponds have been designed to accommodate the design flows of liquid waste plus the precipitation from the 100-year precipitation event, while maintaining 3 feet of freeboard.

In the event that both deep disposal wells and land application are used, the pond capacity will be in between the two sizes discussed above.

Seismic stability analyses for the pond designs are discussed in Sections 3.11.4 and 3.11.5 of the Dewey-Burdock Pond Design Report (Appendix 3.1-A of the approved license application), which concludes, "The factors of safety indicate that the inner and outer slopes are stable under static and maximum credible earthquake seismic loading conditions."

3.1.6.1.1 Pond Sizing and Sludge Accumulation

<u>Radium Settling Ponds</u>

Powertech (USA) has designed the radium settling ponds for a project life extending well beyond 10 years. The radium settling ponds have been sized conservatively in that each pond has been designed to process the entire project-wide liquid waste stream with a minimum retention time of approximately 13 days at the maximum production bleed rate of 3%. In actual practice, the production bleed will typically be about 0.875% and the liquid waste will typically be divided between the Dewey and Burdock radium settling ponds. Higher bleed rates, up to 3%, will only be used for relatively short time periods as needed to control the sub-surface movement of lixiviant.

The inputs to the radium settling pond retention times and sludge accumulation rate calculations are presented in Table 3.1-2. The Pond Design Report is provided as Appendix 3.1-A of the approved license application.

The Dewey-Burdock Project is expected to produce liquid waste from project year 2 through the first quarter of project year 10, for a total of 8.25 years. Table 3.1-3 shows estimates of the production bleed and liquid waste produced from uranium recovery, aquifer restoration and CPP operations. The estimated production bleed and CPP wastewater volume were calculated based on estimates of the volume of barren lixiviant required to recover U_3O_8 at the Dewey-Burdock Project. The restoration waste volumes were calculated assuming 6 pore volumes of restoration composite. This table also shows the design values for the total volume of sludge accumulated and the computed mean pond retention times for both the deep disposal well and land application disposal options at the typical production bleed rate of 0.875%. The pond retention times were computed both for initial ISR operations, when no sludge will have accumulated, and at project end, when the liquid retention time will be reduced due to accumulated sludge, which will reduce the available pond volume. Additionally, pond retention times were computed for extended periods of operation, including 10 and 20 years of ISR operation. In order to calculate the volumes of liquid waste for computing the sludge accumulation and retention times after 10 and 20 years of operations, the typical liquid waste flow rates for uranium recovery with concurrent aquifer restoration were used. These values are 547 gpm for the land application option and 197 gpm for the deep disposal well option (see Sections 4.2.2.1 and 4.2.2.2, respectively). This results in a very conservative estimate of the volume of sludge accumulation and subsequent reduction in retention pond capacity because it is very unlikely that these flow rates would be sustained for 10- or 20-year periods. The volumes of sludge presented in Table 3.1-3 were computed based on the addition of barium chloride at a rate of 20 mg/L of wastewater and assuming the pond sludge is comprised of the resultant barium

Table 3.1-2: Radium Settling Pond Sludge Accumulation Rates and Retention Times

Radium Settling Pond Parameter	Disposal Option	Value
Pond Sludge Accumulation Rate	Unspecified	See note
	DDW	795 ft^3/yr
	Land App.	1,780 ft^3/yr
Single Pond Retention Time	DDW	12.7 d @ 282 gpm
	Land App.	14.1 d @ 632 gpm
Pond Life/ Project Life	DDW	Pond life is greater than 10 years as described below.
	Land App.	

Note: Unspecified waste disposal option is not currently being evaluated for the Dewey-Burdock Project.

Table 3.1-3: Estimated Sludge Accumulation and Effect on Pond Retention Times for Typical Production Bleed of 0.875%

Radium Settling Pond Parameters	Units*	Liquid Waste Disposal Option	
		DDW	LA
Production Bleed	Mgal	127	127
Restoration Wastewater	Mgal	162	539
CPP Wastewater	Mgal	43	43
Total Project Wastewater	Mgal	332	709
Volume of Sludge @ Project End	ac-ft	0.04	0.09
Volume of Sludge @ 10 Years	ac-ft	0.13	0.35
Volume of Sludge @ 20 Years	ac-ft	0.25	0.71
Operating Capacity of 1 Radium Settling Pond	ac-ft	15.9	39.4
Retention Time, Initial	d	18.3	16.3
Retention Time, Project End	d	18.2	16.3
Retention Time @ 10 Years	d	18.1	16.2
Retention Time @ 20 Years	d	18.0	16.0

* Mgal = million gallons
DDW = deep disposal well
LA = land application
ac-ft = acre-feet
d = days

sulfate, with a solids content of 40 percent by weight and a specific gravity of 1.4. These values are considered to be conservative.

As shown in Table 3.1-3, the volume of sludge which will accumulate over 10- and 20-year periods is relatively small compared to the overall pond volume. For example, after 20 years of pond operation at the typical production bleed of 0.875%, the estimated volume of accumulated sludge is 0.25 ac-ft for the deep disposal well option and 0.71 ac-ft for the land application option, which reduces the liquid retention time in the ponds by approximately 0.3 day, a reduction of less than 2% of the initial pond retention time. The resulting retention time after 20 years is estimated to be 16 to 18 days, depending on the liquid waste disposal option. As stated in the Pond Design Report (Appendix 3.1-A of the approved license application), "a literature survey of radium settling ponds has indicated that typical retention times range from 8 to 14 days." Therefore, radium settling ponds at the Dewey-Burdock Project will have adequate retention times even after 20 years of service, which is significantly longer than the anticipated service life of 8.25 years. In addition, the Satellite Facility and CPP will each have a spare pond suitable for use as a settling pond if the primary ponds need to be temporarily removed from service for sludge removal or repair.

Radium settling pond sludge accumulation and retention times were also evaluated for the maximum production bleed of 3%. These values are presented in Table 3.1-4. The volumes of production bleed and CPP and restoration wastewater were calculated as described above for Table 3.1-3. This table shows that even at the maximum production bleed, pond retention times will still be within the acceptable range of 8 to 14 days for typical radium settling ponds.

Central Plant Pond

The purpose of the Central Plant Pond is to temporarily store liquid waste originating from the CPP during uranium recovery and aquifer restoration operations until the CPP liquid waste can be blended with other sources of liquid waste and treated to meet discharge standards.

The CPP liquid waste stream will consist of process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), and may also contain laboratory wastewater, laundry water, plant washdown water, plant sump water, and other minor sources of liquid waste excluding domestic sewage. The CPP liquid waste will be blended with well field production bleed and aquifer restoration bleed prior to final treatment to applicable standards for removal of uranium and other radionuclides.

Table 3.1-4: Estimated Sludge Accumulation and Effect on Pond Retention Times for a Maximum Production Bleed of 3%

Radium Settling Pond Parameters	Units*	Liquid Waste Disposal Option	
		DDW	LA
Production Bleed	Mgal	436	436
Restoration Wastewater	Mgal	162	539
CPP Wastewater	Mgal	43	43
Total Project Wastewater	Mgal	641	1018
Volume of Sludge @ Project End	ac-ft	0.08	0.13
Volume of Sludge @ 10 Years	ac-ft	0.18	0.41
Volume of Sludge @ 20 Years	ac-ft	0.36	0.82
Operating Capacity of 1 Radium Settling Pond	ac-ft	15.9	39.4
Retention Time, Initial	d	12.8	14.1
Retention Time, Project End	d	12.7	14.1
Retention Time @ 10 Years	d	12.6	14.0
Retention Time @ 20 Years	d	12.5	13.8

* Mgal = million gallons
DDW = deep disposal well
LA = land application
ac-ft = acre-feet
d = days

The Central Plant Pond has been designed to accommodate the CPP liquid waste design flow plus direct precipitation from the 100-year storm event, while maintaining 3 feet of freeboard. As shown in Table 3.1-5, the Central Plant Pond capacity will depend on the liquid waste disposal option. The active waste storage capacity, excluding freeboard and reserve capacity for precipitation, will be 15.2 ac-ft for the DDW option, which is sufficient storage for approximately 287 days at the typical CPP liquid waste production rate of 12 gpm. The Central Plant Pond active waste storage capacity for the land application disposal option will be 35.0 ac-ft. This capacity will allow storage of up to 660 days of CPP liquid waste production at 12 gpm. The Central Plant Pond capacity allows for adequate storage for CPP liquid waste during the initial project startup period when uranium recovery is occurring, but before aquifer restoration activities have started. During this time, CPP liquid waste will need to be stored for approximately 18 months until groundwater sweep water is available for blending with the CPP liquid waste. In addition, the larger capacity will also provide more flexibility for blending the liquid wastes during normal operation. This will be necessary because the land application disposal option will be more sensitive to higher dissolved solids concentrations in the waste stream. A larger Central Plant Pond will also allow for additional excess storage during the winter months when no land application will occur.

Table 3.1-5: Central Plant Pond Size and Capacity

Parameters	Units	Deep Disposal Well Option	Land Application Option
Central Plant Pond Total Capacity	ac-ft	15.9	36.2
100-year Precipitation Volume	ac-ft	0.7	1.2
Central Plant Pond Waste Storage Capacity	ac-ft	15.2	35.0
CPP Liquid Waste Flow Rate	gpm	12	12
Liquid Waste Storage Capacity in Time of Operation[1]	yr	0.79	1.81
	d	287	660

[1] During uranium recovery and concurrent uranium recovery and aquifer restoration. Refer to the water balance presented in Section 4.2.2.4.

The flow rate of the CPP liquid waste from the Central Plant Pond to the radium settling pond will be adjusted according to the concentration of dissolved solids in the CPP liquid water stream. When well field liquid waste has relatively lower concentrations of dissolved solids, for example when restoration is near completion in a particular well field, the percentage of CPP liquid waste in the waste disposal stream can be higher, or when well field liquid waste has a relatively higher concentration of dissolved solids (e.g., near the end of uranium recovery in a particular well field), the percentage of CPP liquid waste in the waste disposal stream can be lower. Powertech (USA) may also choose to treat the high TDS wastewater from the CPP prior to discharge to the Central Plant Pond or further treatment and discharge to the radium settling ponds.

3.1.6.1.2 Pond Leak Detection

The designs of all proposed ponds consist of a dual liner system with a leak detection system (refer to Appendix 3.1-A of the approved license application). The primary liner and secondary liner are separated by a geonet which provides a physical separation and allows fluid flow between the two liners. The contour of each secondary liner in each pond is graded at approximately 2 percent towards a leak detection sump. Any leakage from the primary liner will be contained by the secondary liner and collected in the leak detection sump. The sump is routinely monitored for the presence of fluid as described below. This leak detection sump is monitored through a pipe installed within the impoundment wall. This pipe allows a submersible pump to be installed within the sump for the purpose of monitoring and/or removal of fluid should a leak occur.

Detection within the leak detection sump will initiate measures to take the pond out of use, remove its contents to another pond, and initiate an investigation into the cause of, and ultimately the repair of the condition creating the leak. The ponds are designed to be completely emptied with the use of a submersible pump.

Pond Inspection

An inspection program based on RG 3.11 will be implemented for all ponds. A detailed checklist will be developed and followed to document the observations of each significant geotechnical, structural, and hydraulic feature, including control equipment. Inspections will be conducted by trained personnel who are knowledgeable of the pond construction and safety features. Inspections will be documented and the reports retained on site for reference and inspection by regulatory authorities. Inspections will include but are not limited to the following:

- Daily inspections of the liner, liner slopes, and other earthwork features
- Daily inspections of pond freeboard
- Monthly inspection of the functionality of leak detection systems
- Daily checks for water accumulation in leak detection systems
- Quarterly inspections of embankment settlement and slope stability. Unscheduled inspections will be performed after occurrence of significant earthquakes, tornadoes, intense local rainfall, or other unusual events

If these inspections reveal any damage or defects that could result in leakage, this information will be reported to the NRC within 24 hours, and appropriate repairs will be implemented as soon as possible.

If significant water is found in the leak detection system, the water in the standpipes will be sampled immediately for indicator parameters to confirm that the water in the detection system is from the pond. The indicator parameters which are proposed to be used are chloride and conductivity. If the analysis confirms a leak, a secondary sample shall be collected and analyzed within 24 hours. Upon confirmation of a leak by the second analysis, the pond will be taken out of service until repairs can be completed. The leak will be reported to the NRC within 24 hours of the confirmation. A pond removed from service because of a confirmed leak will be dewatered by transferring the contents to a spare pond. Regardless of the disposal option used at the project, the Dewey and Burdock areas will each have a spare pond of identical capacity, construction, and dimensions as the primary radium settling ponds. At the Burdock area, the spare pond may also serve as a spare for the Central Plant Pond. A spare storage pond will also be included at each area in the land application disposal option.

3.1.6.1.3 Pond Quality Control Program

Detailed construction specifications, testing, and QA/QC procedures for the ponds are provided in Appendix 3.1-B of the approved license application. The following is a summary of the construction specifications and testing and inspection program for pond construction. In the following specifications "engineer" refers to a professional engineer licensed in South Dakota.

Construction specifications include the following:

i) Clearing, grubbing and stripping: The natural ground surface shall be cleared and stripped and/or grubbed of all organic and objectionable materials. The limits of stripping shall generally be 10.0 feet outside of the work activity areas.

ii) Excavation and fill placement: Excavation shall be to the lines and grades shown on the pond drawings. Excavations shall not exceed a vertical tolerance of plus or minus 0.1 foot, and a horizontal tolerance of 0.5 foot. Fill and backfill shall be placed within a vertical tolerance of plus or minus 0.1 foot, and a horizontal tolerance of 0.5 foot, unless otherwise approved by the Engineer. All precautions necessary to preserve, in an undisturbed condition, all areas outside the lines and grades shown on the drawings, will be taken. Fill will be constructed in near horizontal layers with each layer being completed over the full length and breadth of the zone before placement of subsequent layers. Each zone will be constructed with materials meeting the specified requirements, and shall be free from lenses, pockets and layers of materials, which are substantially different in gradation from the surrounding material in the same zone. All over-sized material shall be removed from the fill material either prior to being placed, or after it is dumped and spread but prior to compaction. The Engineer will conduct testing, as discussed below, to establish suitability of all fill materials used. No fill material shall be placed until the Engineer has inspected and approved the foundation or in-place lift.

iii) Rolling: Compaction of each layer of fill shall proceed in a systematic, orderly and continuous manner that has been approved by the Engineer, to ensure that each layer receives the compaction specified. Compaction equipment shall be routed parallel to the embankment axis or the long axis of the fill zone, and overlap between roll patterns shall be a minimum of 12 inches. The rolling pattern for compaction of all zone boundaries or construction joints shall be such that the full number of passes required in one of the adjacent zones, or on one side of the construction joint, extends completely across the boundary or joint. Compaction equipment shall be of the types and sizes specified in Section 4.6 of Appendix 3.1-B of the approved license application.

iv) Compaction and moisture control: All material, after placing, spreading and leveling to the appropriate layer thickness shall be uniformly compacted in accordance with the requirements for each type of fill as indicated in Table 3.1-6:

v) Finishing: Finished grades shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.

Table 3.1-6: Compaction Requirements

Material	Compaction Specifications	Moisture Content
Prepared Subgrade	92% of Maximum Dry Density by ASTM D1557	+/- 3% of Optimum
Random Fill	92% of Maximum Dry Density by ASTM D1557	+/- 3% of Optimum
Soil Liner	92% of Maximum Dry Density by ASTM D1557	0 to +5% of Optimum

Subgrade sterilization and liner sub-drainage and gas venting do not apply to the pond designs presented in Appendix 3.1-B of the approved license application.

Testing and Inspection Program

Inspection of earthwork will involve testing and visual examination of all materials being used for construction to establish compliance with the material requirements, moisture conditioning, spreading procedures, layer thicknesses, and compaction requirements. To ensure that satisfactory quality control is maintained and that the design objectives are achieved, specific testing requirements will be implemented for all materials placed within the Work area. Tests to be carried out will be divided into two categories; control tests and record tests. Control tests will be used to verify whether the materials comply with the specifications prior to placement. Record tests will be used during placement and after completion of the work to assess whether the work and materials meet the requirements of the specifications.

Control tests will include: i) particle size distribution for fill materials, soil liner, filter sand and riprap; ii) moisture content of fill materials and the soil liner; iii) Modified Proctor compaction tests (ASTM D1557) of fill materials and the soil liner: iv) Atterberg limits of fill materials and soil liner; v) and other tests of fill materials taken from borrow areas and on the fill, as necessary to assess whether the fill material is in compliance with the technical specifications.

The record tests will include: i) particle size distribution for fill materials, soil liner and filter sand; ii) field density test on fill materials and the soil liner; iii) moisture content of the fill materials and soil liner; iv) laboratory compaction and particle size distribution of materials recovered from select field density test locations; v) in-situ laboratory permeability tests on fill materials and the soil liner; vi) Atterberg limit tests on fill materials and the soil liner; vii) other tests on fill compacted in place as necessary to assess whether the compacted fill is in full compliance with the technical specifications.

Testing Frequencies

Geotechnical tests will be conducted to establish compliance of the work with the technical specifications. Standard procedures will be used for all tests. The following tables from Appendix 3.1-B of the approved license application show the test methods and frequency of testing for various materials.

Table 3.1-7: Test Methods

Test Designation[(1),(2)]	Type of Test	Test Methods (ASTM)
C1, R1	Atterberg Limits	D4318
R2a C2, R2b	Nuclear Method Moisture Content Laboratory Moisture Content	D6938 D2216
C3, R3	Particle Size Distribution	D422[(3)]
C4, R4	Laboratory Compaction	D1557
R5a R5b R5c	Nuclear Method Field Density Sand Cone Field Density Water Replacement Field Density	D6938 D1556 D5030
C6, R6	Laboratory Permeability Test	D5084
C7, R7	Riprap Particle Size Distribution	Pebble Count

Notes:

1. C- Denotes Control Tests
2. R- Denotes Record Tests
3. Hydrometer tests down to the 2-micron size will be carried out as directed by the Engineer but will generally not be required. All samples are to be wash graded over a #200 sieve.

Table 3.1-8: Test Frequency- Prepared Subgrade

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	2,000 yd^2
C2, R2a, R2b	Moisture Content	1,000 yd^2
C3, R3	Particle Size Distribution	2,000 yd^2
C4, R4	Laboratory Compaction	2,000 yd^2
R5a	Nuclear Density	1,000 yd^2
R5b	Sand Cone Density	5,000 yd^2

Table 3.1-9: Test Frequency- Random Fill

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	5,000 yd^3
C2, R2a, R2b	Moisture Content	2,500 yd^3
C3, R3	Particle Size Distribution	5,000 yd^3
C4, R4	Laboratory Compaction (Modified Proctor)	5,000 yd^3
R5a	Nuclear Density	1,000 yd^3
R5b	Sand Cone Density	10,000 yd^3
C6, R6	Laboratory Permeability Test	5,000 yd^3

Table 3.1-10: Test Frequency - Soil Liner

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	1,000 yd^3
C2, R2a, R2b	Moisture Content	500 yd^3
C3, R3	Particle Size Distribution	1,000 yd^3
C4a, R4a	Laboratory Compaction	1,000 yd^3
R5a	Nuclear Density	1,000 yd^3
R5b	Sand Cone Density	2,500 yd^3
C6, R6	Laboratory Permeability Test	1,000 yd^3

Table 3.1-11: Test Frequency - Filter Sand

Test Designation	Type of Test	Frequency (1 per)
C3, R3	Particle Size Distribution	250 yd^3

Table 3.1-12: Test Frequency - Riprap

Test Designation	Type of Test	Frequency (1 per)
C7, R7	Riprap Particle Size Distribution	1,000 yd^3

3.1.6.2 Land Application System Design

Two general land application areas are proposed for liquid waste disposal within the project area, one near the Dewey satellite facility and one near the Burdock CPP. Each land application area will have 315 acres of irrigated area along with 65 acres of auxiliary area on standby. The required land application area was estimated from the disposal capacity obtained using the SPAW (Soil-Plant-Atmosphere-Water) model, which was developed by the USDA to simulate the daily hydrologic budget for agricultural landscapes. The inputs to the model include climatic data, soil profile information, and crop growth information. Additional information on the SPAW model, as well as the model inputs and outputs, is included in the Pond Design Report (Appendix 3.1-A of the approved license application).

In the land application option, pumping will occur 24 hours a day. The estimated daily water budgets obtained from SPAW modeling indicate that each land application area will be capable of disposing approximately 297 gpm from March 29 to May 10, about 653 gpm from May 11 to September 24, and approximately 297 gpm from September 25 to October 31. Normally there will not be land application disposal from approximately October 31 to March 29. Detailed information regarding the SPAW model inputs and outputs are discussed in Appendix D to the Pond Design report, which is provided as Appendix 3.1-A of the approved license application. The land application system will be capable of handling all of the expected liquid waste throughout each phase of the project. During the winter months liquid waste will be stored in ponds, which are described in more detail in Sections 3.1.6.1 and 4.2.2. The capacity required to store the liquid waste throughout the winter months was calculated using the SPAW model to be approximately 216 acre-feet. By comparison, the total storage pond capacity under the land application option will be approximately 510 acre-feet, not including spare storage ponds. Figure 3.1-1 depicts the proposed facilities in the land application option.

3.1.6.2.1 Relationship between Land Application and Potential Well Field Areas

The locations of the proposed land application areas in relation to potential well field areas are depicted on Figures 3.1-13 and 3.1-14. Figure 3.1-13 shows minimal overlap between Dewey land application areas and potential well field areas. The only land application areas that potentially will overlap with well fields are designated for standby operation. These standby areas will serve as contingency areas and generally will not be used at the same time as the underlying well fields.

Figure 3.1-14 shows that there is also limited potential overlap between Burdock land application areas and potential well field areas. In this case overlap will likely be limited to perimeter monitor wells.

Although overlap between active land application areas and potential well field areas will be limited, there may be times that production, injection and monitor wells are operated within active land application areas. Powertech (USA) will design and construct the well fields and land application systems to avoid any potential conflicts and minimize potential risks. The irrigation nozzles will be suspended above the well head covers, and wells and fences will be positioned to avoid the center pivot wheel pathways. Injection, production and monitor wells will have sealed well heads to prevent entry of the land application water. The well heads will also have sufficient aboveground casing to ensure that surface water cannot enter the wells. Injection and production pipelines will be buried and will not conflict with land application systems. Perimeter monitor wells will have pressure transducers that will allow remote monitoring of water levels. If necessary, discharge piping and pressure transducer cable will be installed from the monitor wells to remote sampling locations outside of the land application area. This would allow Powertech (USA) personnel to measure water levels and sample monitor wells without traveling through active land application areas. Inspections of well field components will be conducted routinely as discussed in Sections 3.1.5 and 3.2.12.

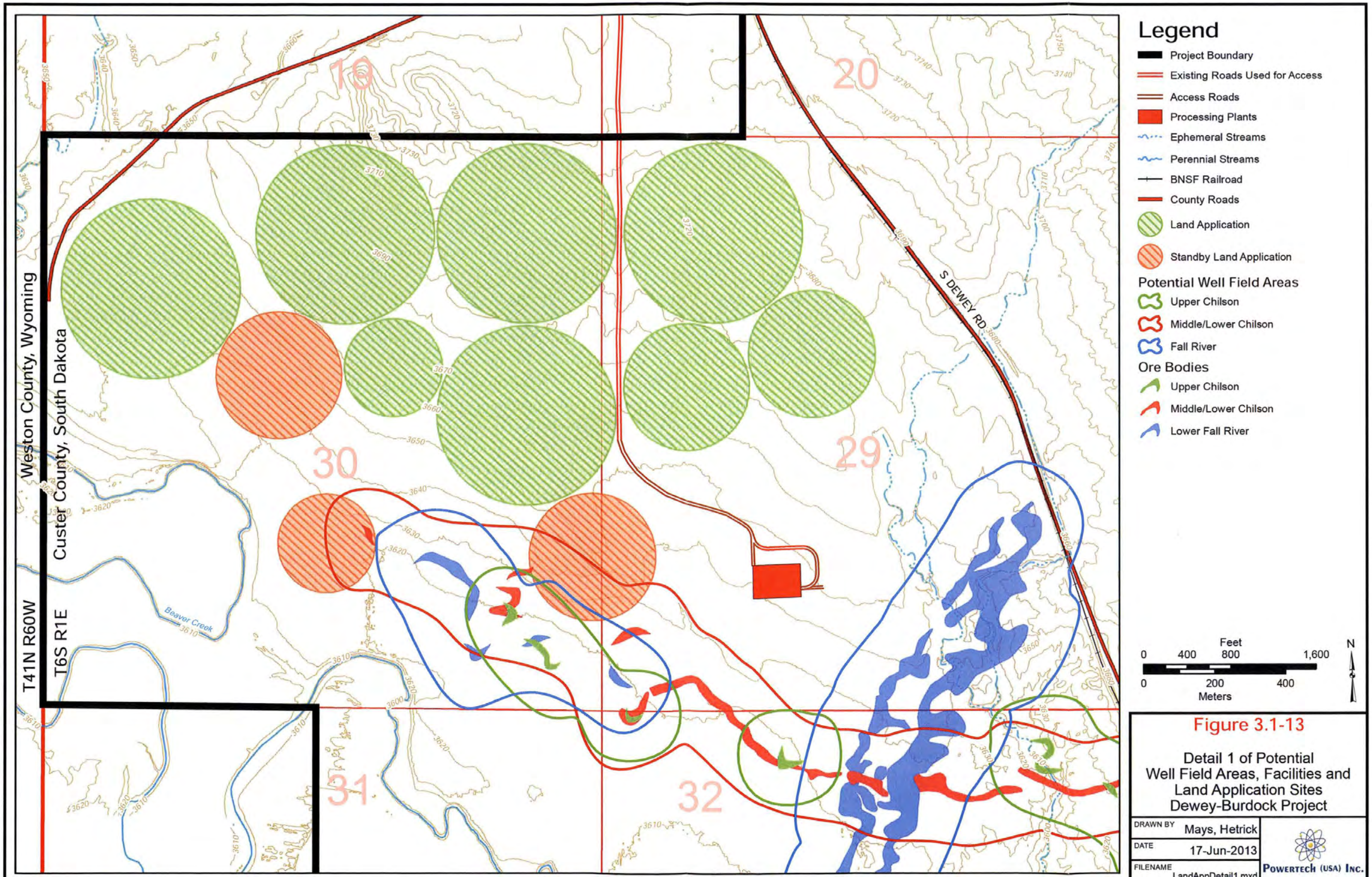


Figure 3.1-13
Detail 1 of Potential Well Field Areas, Facilities and Land Application Sites Dewey-Burdock Project

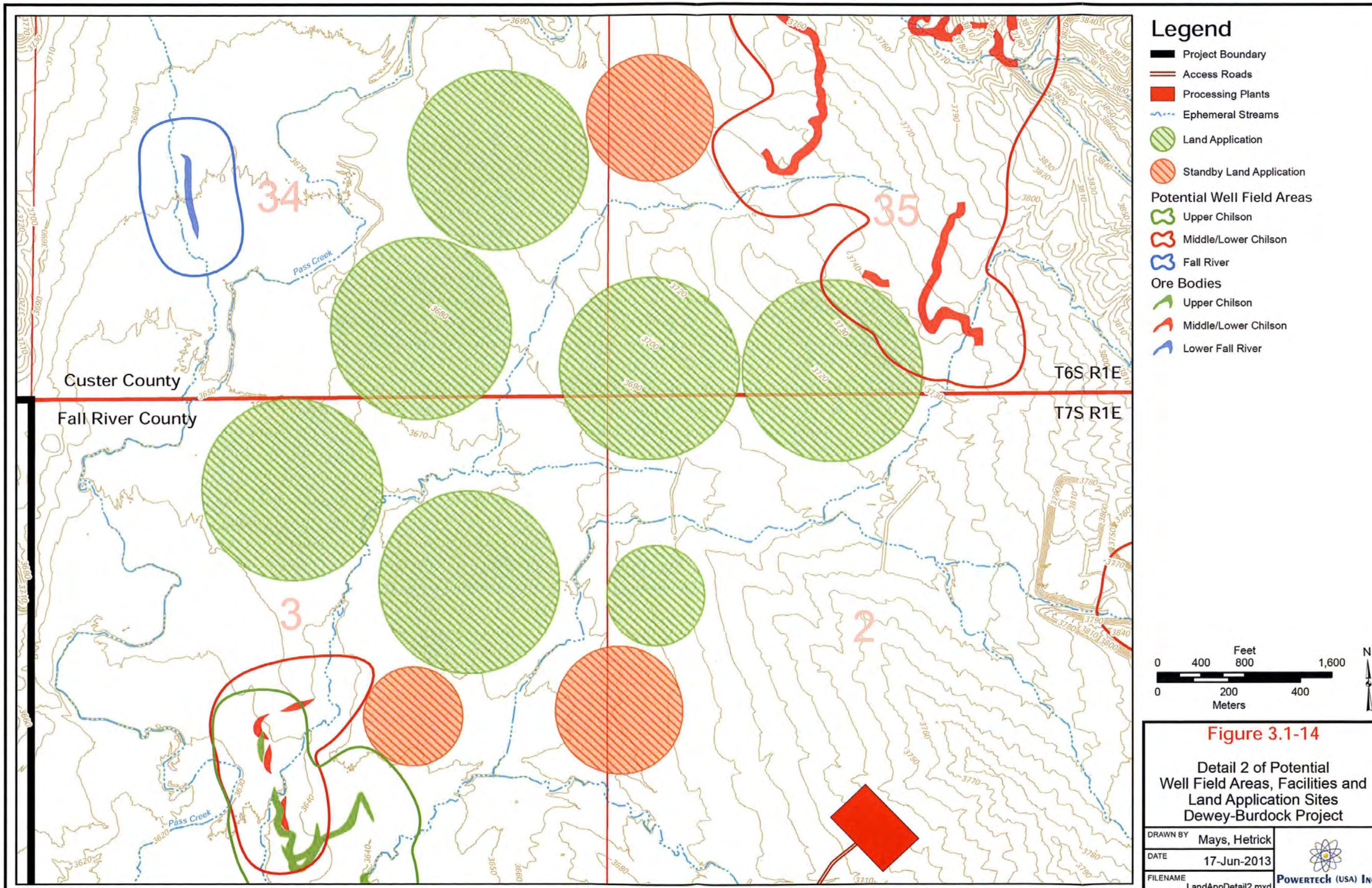


Figure 3.1-14

Detail 2 of Potential Well Field Areas, Facilities and Land Application Sites Dewey-Burdock Project

3.1.6.3 Deep Disposal Well Design

The Class V UIC Permit Application for disposal of non-hazardous liquid wastes was submitted by Powertech (USA) to EPA in March 2010. The application is included as Appendix 2.7-L of the approved license application. Through its submittal of a UIC permit application for Class V non-hazardous injection wells, Powertech (USA) requested an Area Permit and authorization from EPA to install and operate four to eight non-hazardous Class V disposal wells at the Dewey-Burdock Project in Fall River and Custer Counties, South Dakota.

Injected fluids will be delivered to the Minnelusa and Deadwood Formations in separate wells under positive pressure injection through tubing and a packer. Fresh water aquifers will be protected by casing and cement. The wells will have one cemented long string protective casing extending into the injection interval and the wellbores will be perforated over the injection interval. The annulus area between the protective casing and injection tubing strings will be filled with inhibited fresh water. Annulus pressure will be continuously monitored to detect potential leaks in the tubing and casing strings. An analysis of potential target disposal zones is included in the Class V application and is summarized below.

Synopsis of Analyses to Determine Target Disposal Zone(s)

The Class V application is for an Area Permit and authorization to install and operate four to eight Class V non-hazardous disposal wells for underground injection of fluids from Powertech (USA)'s Dewey-Burdock uranium ISR project.

Within the Black Hills area, both groundwater quality and use are highly variable and dependent on location. Regionally, the major bedrock aquifers in the Black Hills area include the Deadwood Formation, Madison Limestone, Minnelusa, Minnekahta, and Inyan Kara Group. These aquifers are regionally extensive in areas surrounding the Black Hills. Based on TDS concentrations, only the Madison and Inyan Kara are considered to be Underground Sources of Drinking Water (USDWs) in the Dewey-Burdock area. The Deadwood, Minnelusa, and Minnekahta are not used as a water supply and are not USDWs in the Dewey-Burdock area. As summarized below, the Deadwood and Minnelusa appear to have suitably high TDS and porosity to be considered as injection zones for deep disposal wells.

Minor aquifers include the Sundance Formation and Unkpapa sandstone which may be USDWs in the Dewey-Burdock area.

Deadwood Formation - The Cambrian Deadwood Formation consists of massive to thinly-bedded, brown to light-gray sandstone, greenish glauconitic shale, dolomite, and flat-pebble limestone conglomerate and ranges from 0 to 500 feet thick. Because of its depth and stratigraphic position immediately overlying the Precambrian basement, the Deadwood is not a USDW in the project area. There are no known water wells completed in the Deadwood in the project area. Although water-quality data are not available for the Deadwood Formation locally, it is likely that TDS concentrations are in excess of 10,000 mg/L.

Madison Formation - The Mississippian Madison aquifer is contained within the limestones, siltstones, sandstones and dolomites of the Madison Limestone Group. Generally, water in the Madison is confined except in outcrop areas and frequently exists under artesian pressure. Water in the Madison is typically fresh only near the recharge areas, becoming slightly saline to saline as it moves down-gradient. In the deeper parts of the Williston Basin, the water is a brine with TDS concentrations larger than 300,000 mg/L. Locally, the Madison is used as a water supply for the City of Edgemont, approximately 12 miles southeast of the project area.

Minnelusa Formation - The Pennsylvanian/Permian Minnelusa Formation consists of yellow to red, cross-stratified sandstone, limestone, dolomite, and shale. The Minnelusa aquifer occurs primarily in the sandstone and anhydrite beds in the upper part of the formation. The Minnelusa is confined above by the Opeche Shale and below by layers of lower permeability within the Minnelusa.

The Minnelusa is an oil and gas producer in the vicinity of the project area. TDS concentrations locally are in excess of 10,000 mg/L. The Minnelusa is not used locally as a source of water supply. As such, the Minnelusa is not considered to be a USDW in the project area.

Minnekahta Formation - The Permian Minnekahta Limestone is a thin to medium-bedded, fine-grained, purple to gray, laminated limestone, which ranges in thickness from 25 to 65 feet. The Minnekahta is considered a major aquifer in parts of the Black Hills area but does not supply any known water wells in the project area.

Sundance - The Sundance Formation consists of greenish-gray shale with thin limestone lenses, glauconitic sandstone, with red sandstone near the middle of the formation. The Sundance ranges from 250 to 450 feet thick.

Unkpapa - The Unkpapa Sandstone is a massive fine-grained sandstone, 0 to 225 feet thick.

Inyan Kara Group - The Inyan Kara Group includes the Lakota and Fall River Formations; the Lakota Formation is divided into the Chilson, Minnewaste, and Fuson Members. The Inyan Kara is confined by thick shales of the Graneros Group except in outcrop areas around the Black Hills Uplift. Although the Inyan Kara aquifer is widespread, it contains little fresh water except in small areas in central and south-central Montana and north and east of the Black Hills Uplift. In the project area, the Inyan Kara is used as a source of water supply.

Basis for Number of Wells

During development of the Class V UIC Permit Application, it was estimated that four to eight deep disposal wells will be necessary to handle the volume of liquid wastes for disposal from the Dewey-Burdock Project. The number of wells that may be required will be determined following drilling of a test well and is dependent upon well capacity. Redundancy with regard to deep well disposal of liquid waste is provided by multiple wells interconnected via pipeline to the plant. Because of this redundancy, shut down of a single disposal well would not adversely impact production operations or restoration.

The use of surface impoundments provides an additional layer of redundancy for disposal of liquid wastes during ISR operations. Pond capacity is described in Section 3.1.6.1.

Status of Application for Class V UIC Permit

The Class V Application was submitted to EPA on March 20, 2010 and deemed complete on April 28, 2010. EPA's review of the Application is in progress.

Compliance with Requirements of 10 CFR § 20.2002

For information on the anticipated treated liquid waste water quality and the anticipated effluent limits for Class V deep disposal wells, refer to Section 3.1.6.4. Because liquid waste will be treated to the 10 CFR 20, Appendix B, Table 2, Column 2 standards, it will not be classified as radioactive waste.

3.1.6.4 Liquid Waste Quality and Treatment

The anticipated liquid waste quality at the Dewey-Burdock Project is presented in Table 3.1-13. A discussion of the anticipated liquid waste quality in relation to Class V DDW regulations and land application requirements is presented below.

Table 3.1-13 shows the estimated water quality of various liquid waste streams for the Highland ISR Facility. The water quality of liquid waste from the Dewey-Burdock Project is expected to fall within the broad ranges of concentrations shown in the table because both the Dewey-Burdock Project and Highland ISR Facility will use virtually identical processes and chemistry during ISR operations. The column labeled "Restoration Wastes" is expected to be representative of the quality of the production bleed and the restoration composite streams at the Dewey-Burdock Project prior to treatment. In the land application disposal option, the final liquid waste disposal stream is expected to have similar water quality to the range shown under "Restoration Wastes" in Table 3.1-13, except that radium-226 and gross alpha will be reduced by treatment in the radium settling ponds. For the DDW liquid waste disposal option, the restoration composite will be treated with RO and the resulting brine will be combined with other liquid waste (e.g., production bleed, process solutions, etc.) in the lined ponds prior to disposal in the DDWs. In the DDW liquid waste disposal option, the water quality of the composite liquid waste stream will more closely resemble the first four columns in Table 3.1-13 depending on the specific contribution from each of the liquid waste sources. The anticipated land application liquid waste water quality is shown in Table 4.2-7.

EPA issued a final rulemaking in December 1999 that revised the Class V Underground Injection Control (UIC) regulations. The revisions reclassified all wells which dispose of radioactive waste as Class I wells (40 CFR 144.6(a) and 146.5(a)). Since South Dakota law prohibits Class I DDWs, the liquid waste stream will be treated to remove radioactive constituents. It will then be disposed in Class V DDWs or a land application system. In order to meet the Class V UIC or land application requirements, Powertech (USA) will treat the liquid waste to reduce radionuclide activities below the established limits for discharge of radionuclides to the environment, which are listed in 10 CFR Part 20, Appendix B, Table 2, Column 2. These limits are presented in Table 3.1-14. These limits are based on Annual Limits on Intake (ALI) of radionuclides for occupational exposure. Waste streams containing radionuclides below these regulatory limits are not classified as radioactive waste as per 10 CFR 20.2002.

Liquid wastes will be treated to achieve uranium effluent limits in the IX columns. It is not anticipated that thorium-230 and lead-210 will be present at concentrations above the limits; however, if concentrations are above the limits, the effluent will be treated as necessary to satisfy the Appendix B limits. Radium-226 will be treated in radium settling ponds by adding barium chloride to the liquid waste to co-precipitate radium-226 with barium sulfate. Additional information about the radium settling pond design can be found in the Pond Design Report (Appendix 3.1-A of the approved license application). The technology for radium removal by barium chloride is well developed (e.g., Kirby and Salutsky, 1964).

Table 3.1-13: Estimated Liquid Waste Water Quality

Estimated Flow Rates and Constituents in Liquid Waste Streams for the Highland In-Situ Leach Facility*					
	Water Softener Brine	**Resin Rinse**	**Elution Bleed**	**Yellowcake Wash Water**	**Restoration Wastes**
Flow Rate, gal/min	1	<3	3	7	450
As, ppm					0.1–0.3
Ca, ppm	3,000–5,000				
Cl, ppm	15,000–20,000	10,000–15,000	12,000–15,000	4,000–6,000	
CO_3, ppm		500–800			300–600
HCO_3, ppm		600–900			400–700
Mg, ppm	1,000–2,000				
Na, ppm	10,000–15,000	6,000–11,000	6,000–8,000	3,000–4,000	380–720
NH_4, ppm			640–180		
Se, ppm					0.05–0.15
Ra-226, pCi/L	<5	100–200	100–300	20–50	50–100
SO_4, ppm					100–200
Th-230, pCi/L	<5	50–100	10–30	10–20	50–150
U, ppm	<1	1–3	5–10	3–5	<1
Gross Alpha, pCi/L					2,000–3,000
Gross Beta, pCi/L					2,500–3,500
*NRC. NUREG–0489, "Final Environmental Statement Related to Operation of Highland Uranium"					

Source: NUREG-1910, Table 2.7-3

Table 3.1-14: Anticipated Effluent Limits for Class V DDWs

Radionuclide	**Anticipated Effluent Limits**	
Units	µCi/ml	pCi/L
Lead-210	1E-8	10
Radium-226	6E-8	60
Uranium-nat.	3E-7	300
Thorium-230	1E-7	100

Source: 10 CFR 20 Appendix B, Table 2, Column 2

3.1.7 Surface Water Management

Powertech (USA) has evaluated flood inundation boundaries and will construct facilities outside of these boundaries to avoid potential impacts to facilities from flooding and potential impacts to Beaver Creek and Pass Creek in the event of any potential spills or leaks.

Estimates of peak flood discharges and water levels produced by floods on Pass Creek, Beaver Creek and local small drainages are provided in Section 2.7.1 and Appendix 2.7-M of the approved license application. Plate 2.7-1 depicts the modeled flood inundation areas for all surface water features during the 100-year, 24-hour storm event in relation to proposed facilities and infrastructure. As described in Appendix 2.7-M of the approved license application, HEC-HMS models were used to calculate peak discharges, and HEC-RAS models were used to compute water-surface profiles and inundated areas for the respective runoff events.

Where possible, facilities will be located out of the 100-yr flood inundation boundary. Facilities which must be located within such boundaries will be protected from flood damage by the use of straw bales, collector ditches, and/or berms. Diversion channel designs for the plant sites and ponds are provided in Appendix 3.1-B of the approved license application. Diversion channels for the CPP facilities are depicted on Drawing No. 101 (pg. 3.1-B-33), and diversion channels for the Satellite Facility are depicted on Drawing No. 102 (pg. 3.1-B-34). As shown on these drawings, control structures (collector ditches and berms) will be used to prevent surface runoff for events up to and including the 100-yr, 24-hr rainfall event from entering the ponds. Collector ditches will be designed to have velocities less than 5 feet per second or appropriate erosion control measures, such as fabric mats or riprap, will be constructed to minimize the potential for erosion. If it is necessary to place a well head within the inundation boundary, diversions or erosion control structures will be constructed to divert flow and protect the well head. The well head also will be sealed to withstand brief periods of submergence. Pipelines will be buried below the frost line and will not be subject to flooding. Pipeline valve stations will be located outside of the 100-year flood inundation boundary.

Surface water/groundwater interactions and potential impacts to these media from site activities are discussed in Section 7 of this application.

3.1.8 Quality Control

Quality Control during construction, operations, and reclamation will be assured through strict compliance with construction plans and specifications, operations manuals, and standard operating procedures. During construction, quality will be assured through material testing programs prescribed in the specifications, review of testing results by the design engineer, and inspection and acceptance of work products by the owner's representative.

During operations, standard operating procedures developed during project design will be followed. Operations supervisors will instruct field personnel as to the documented procedures and routinely inspect and document their performance.

Refer to Section 3.1.6.1.3 for the pond construction quality control program.

3.1.9 Approved Waste Disposal Agreement for 11e.(2) Material

Powertech (USA) will provide an approved waste disposal agreement for 11e.(2) byproduct material prior to beginning operations. Powertech (USA) understands that without such an agreement operations cannot begin. Powertech (USA), therefore, acknowledges that without an approved 11e.(2) byproduct material disposal agreement in place prior to issuance of a license, NRC will include a license condition requiring verification of an approved 11e.(2) byproduct material disposal agreement at an NRC or NRC Agreement State licensed disposal facility prior to the start of operations.

3.2 Central Processing (CPP) and Chemical Storage Facilities; Equipment Used and Material Processed

One SF will be located at the Dewey site and a combination SF/CPP will be located at the Burdock site (Figures 3.1-1 and 3.1-2). The downstream uranium recovery processes described in the preceding section will be accomplished in several steps. Uranium recovery from the solution by IX, subsequent processing of the loaded IX resin to remove the uranium (elution), the precipitation of uranium, thickening of the uranium slurry, and the dewatering, drying, and packaging of solid uranium oxide (yellowcake) will be performed at the CPP.

The sites for both the CPP and the SF have been designed to provide security and ease of access for operating purposes. The sites are designed with ample areas for access by resin transfer trucks as well as truck transports for chemical delivery and shipment of product and byproduct materials.

Figure 3.2-2 shows the site layout of the CPP site, including the placement of an office building, a maintenance shop and the CPP proper. Traffic routes and truck turning radii are indicated on this figure. The site layout for the SF is shown in Figure 3.2-3.

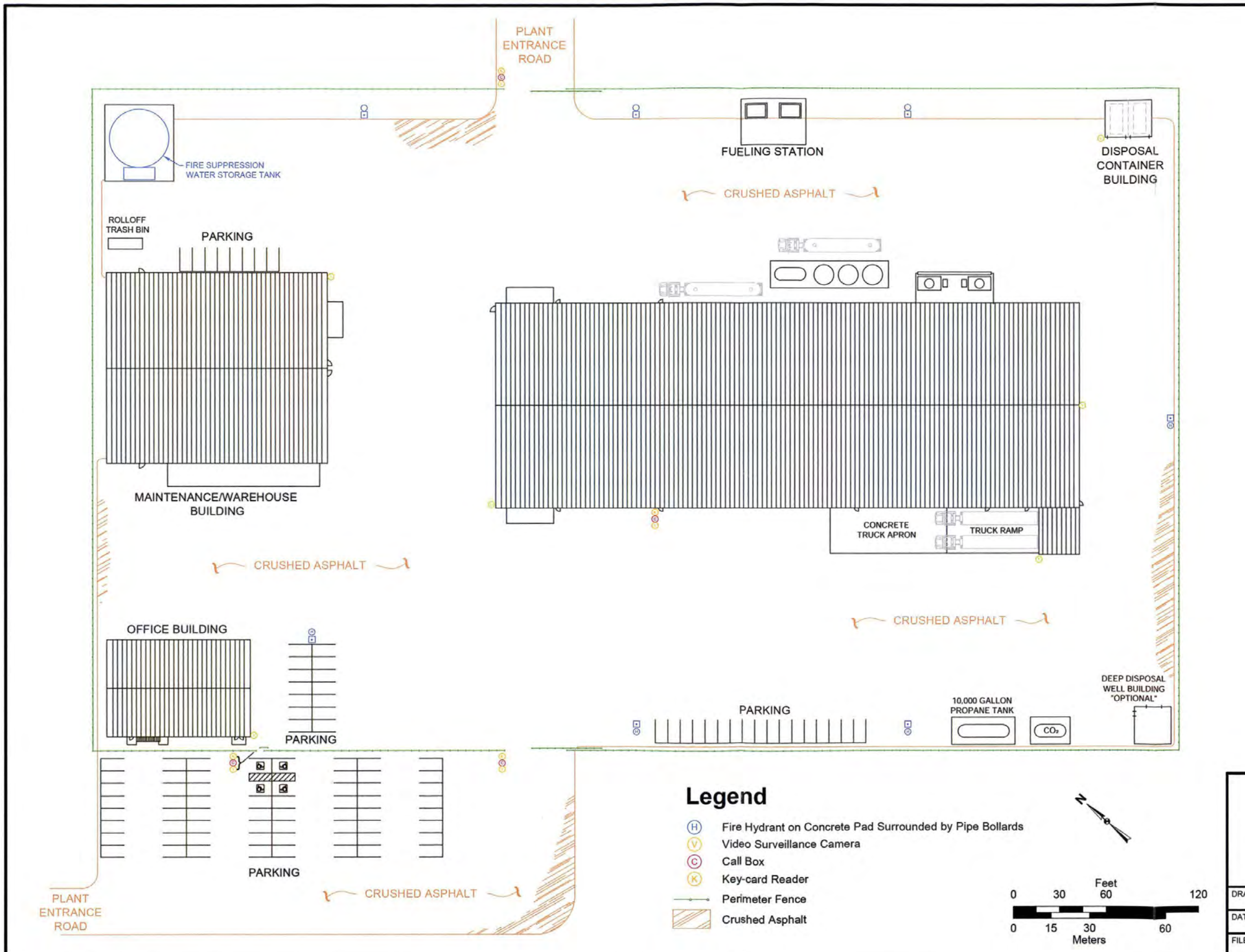
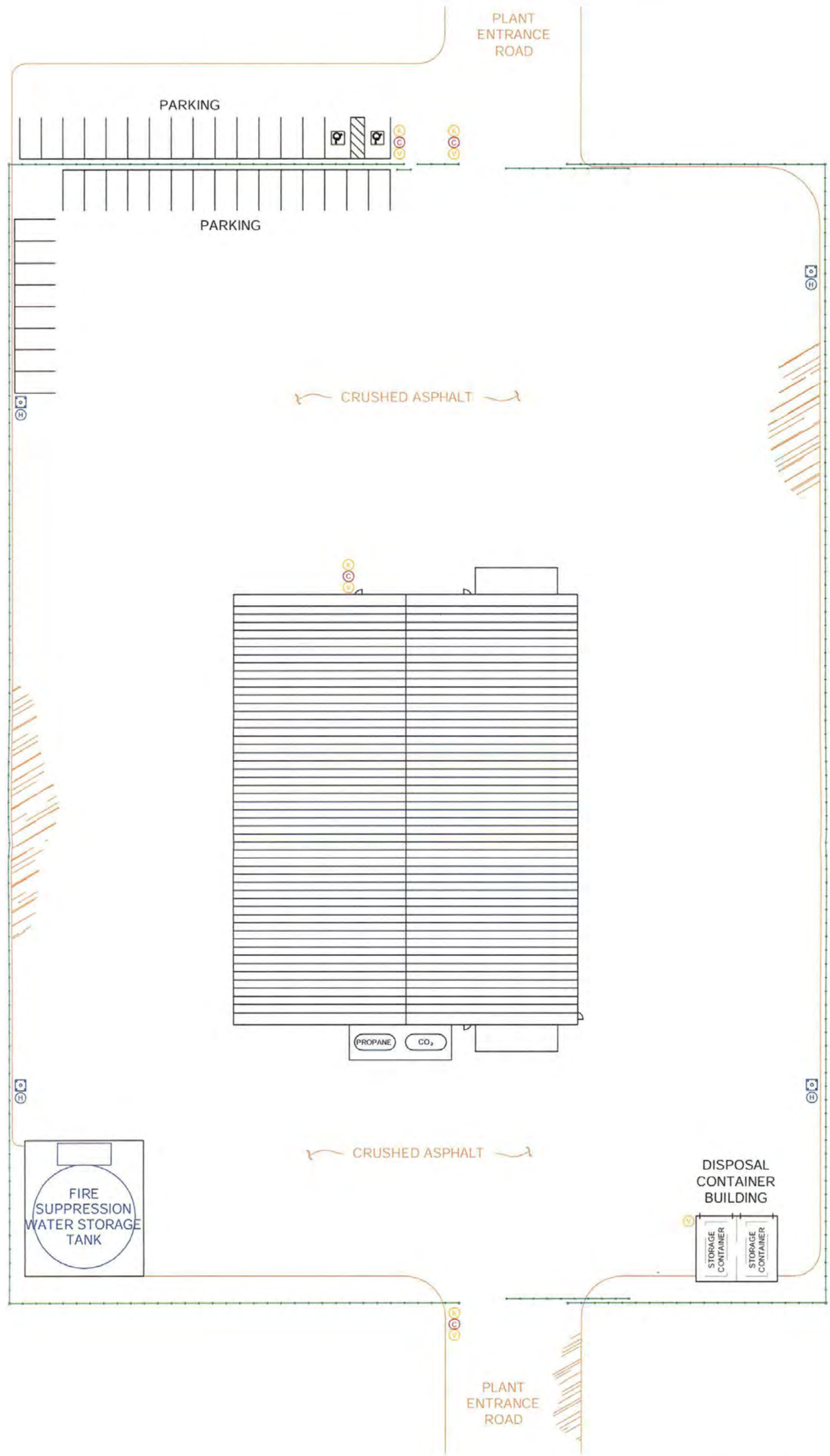


Figure 3.2-2	
General Site Plan Central Processing Plant Dewey-Burdock Project	
DRAWN BY S. Hetrick	Powertech (USA) Inc.
DATE 02-Jan-2014	
FILENAME CPP-SitePlan-New.dwg	



Legend

- (H) Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- (V) Video Surveillance Camera
- (C) Call Box
- (K) Key-card Reader
- Perimeter Fence
- Crushed Asphalt

Figure 3.2-3

General Site Plan
Satellite Facility

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	17-Dec-2013
FILENAME	Figure 3.2-3.dwg

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All buildings, structures, foundations, and equipment will be designed in accordance with recommendations in the latest versions of the International Building Code and ASCE-7 published by the American Society of Civil Engineers. Maps published in ASCE-7, and the latest version of the USGS Earthquake Ground Motion Tool, along with information regarding soil characteristics provided by the project professional geotechnical engineer, will be used to determine seismic loadings and design requirements.

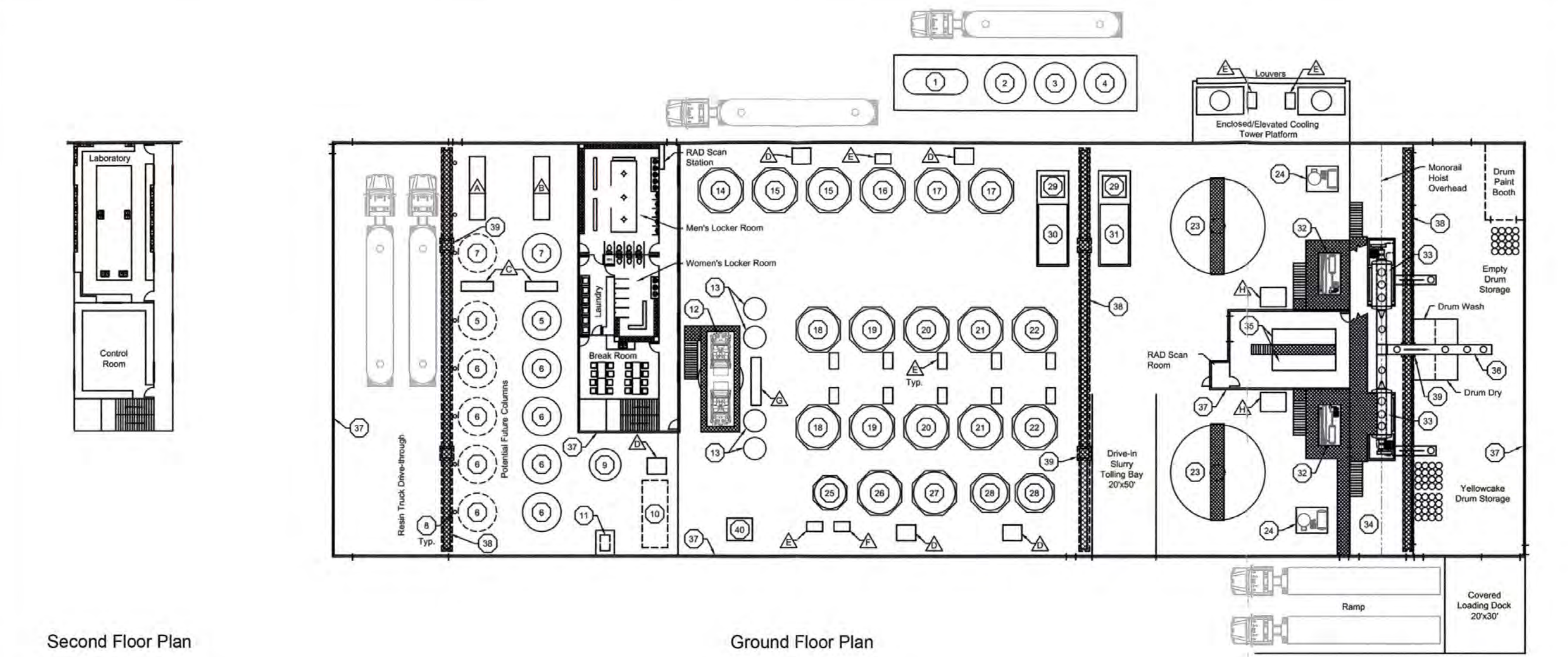
3.2.1 CPP Equipment

The processing facilities will be housed in pre-engineered metal buildings. The equipment layout within these buildings is shown in Figures 3.2-4 and 3.2-5 for the CPP and SF, respectively. The CPP includes the following:

- IX
- Chemical addition
- Filtration
- Elution circuit
- Precipitation and thickening circuit
- Product dewatering, drying and packaging
- Liquid waste stream circuit
- Drum storage and decontamination area
- Waste Storage buildings are located at the SF in Dewey and the CPP area at Burdock.

Based on preliminary design and site geotechnical evaluations, the project CPP will be located within Section 2, T7S, R1E. Chemical storage and a septic tank and leachfield will also be located within this area. The Dewey SF will be located in Section 29, T6S, R1E. These plant locations are shown in Figures 3.1-1 and 3.1-2.

Powertech (USA) proposes to install up to eight underground pipelines between the CPP and the Satellite Facility to transport the various fluids present during ISR operations. Conduits for electronic communication and control purposes may also be installed between the CPP and the Satellite Facility. The fluids that will be transported include, but are not limited to: barren and pregnant lixiviant, restoration water, RO reject brines, wastewater resulting from well drilling and maintenance operations, and supply water from the Madison Formation or other aquifers. All infrastructure associated with the project will be located within the license boundary.



Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'Ø
6. Process IX Column 12'Ø
7. Bleed IX Column 12'Ø
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'Ø
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'Ø
14. Reclamation Make-up Water 13'Ø
15. NaCl 13'Ø
16. Na_2CO_3 13'Ø
17. Utility Water 13'Ø
18. Fresh Eluant 13'Ø
19. Lean Eluant 13'Ø
20. Intermediate Eluant 13'Ø
21. Rich Eluant 13'Ø
22. Precipitation 13'Ø
23. 30'Ø Thickener, 5'Ø Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'Ø
26. High TDS Wastewater Tank 13'Ø
27. Low TDS Wastewater Tank 13'Ø
28. Solids Removal Tank 11'Ø
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A: 5'x20' - PC Booster Pumps
- B: 5'x20' - IC Booster Pumps
- C: 3'x10' - Pump
- D: 6'x5' - Pump
- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump

Feet: 0, 15, 30, 60
Meters: 0, 5, 10, 20

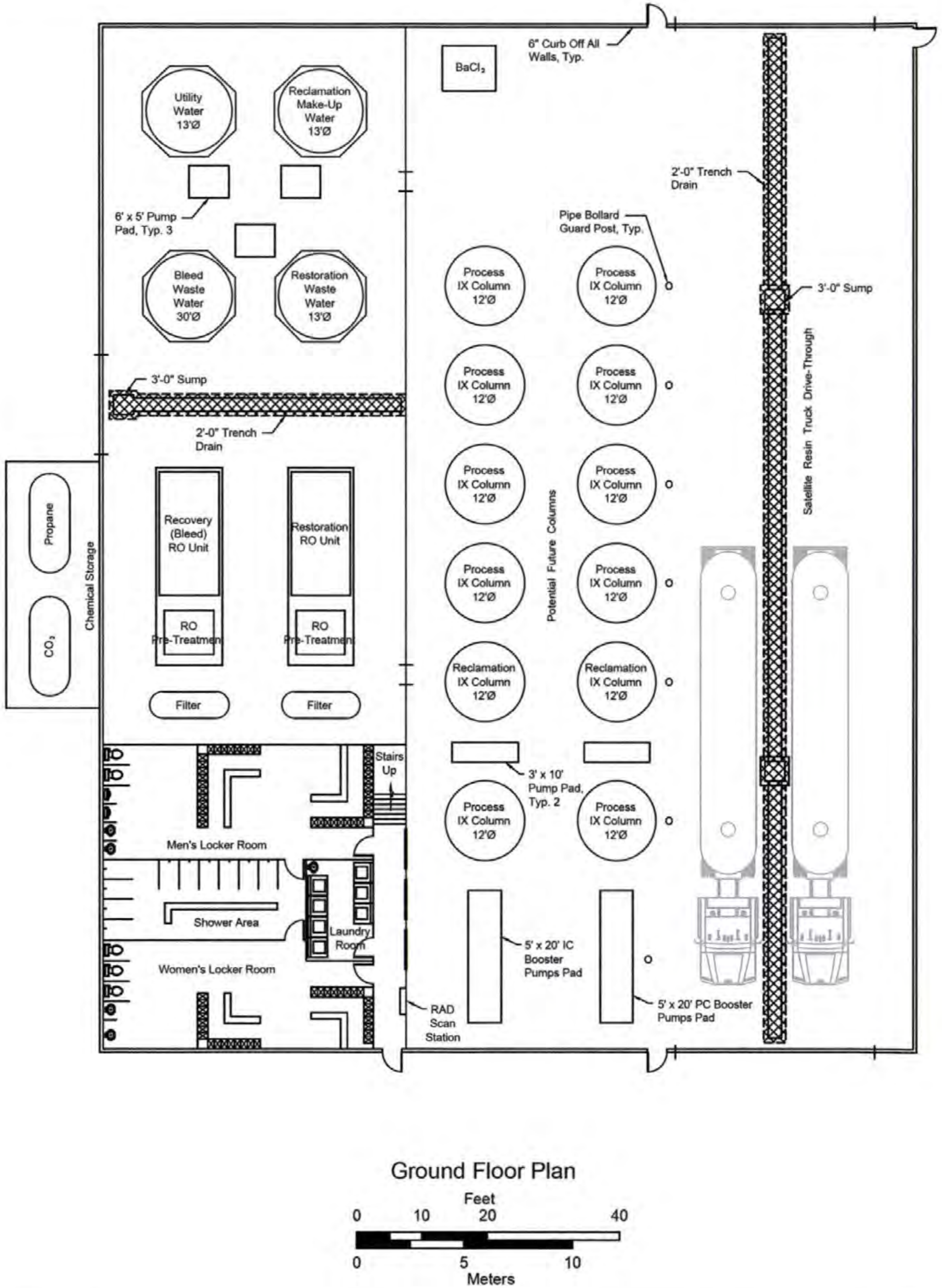
Figure 3.2-4

Central Processing Plant Detail

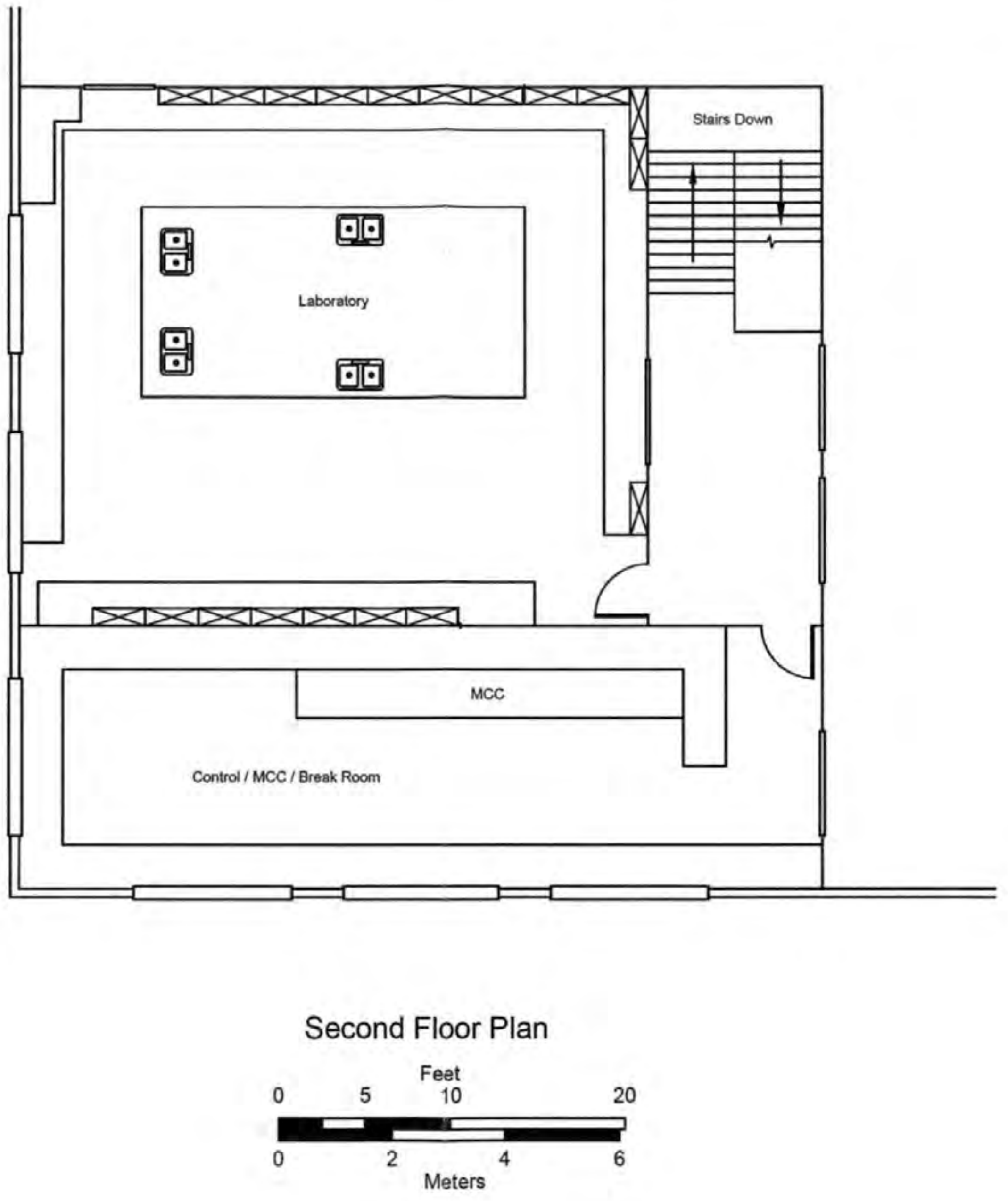
Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	CPP-Floorplan.dwg

Powertech (USA) Inc.



Ground Floor Plan



Second Floor Plan

Figure 3.2-5

Satellite Facility Plant Detail

Dewey-Burdock Project

DRAWN BY J. Mays

DATE 14-Jun-2013

FILENAME SPP-Floorplan.dwg

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The CPP will serve production from Dewey-Burdock ISL operations, and possibly resin from other potential Powertech (USA) satellite projects in the area. In addition, depending on market conditions and regional demand for yellowcake processing, the CPP may be used for tolling arrangements with other ISL operations licensed under a different operator.

The following subsections present a description of each recovery and processing system and the equipment components comprising each system. An overall process flow diagram is presented in Figure 3.2-6.

3.2.2 Recovery

Recovery of the uranium from the uranium bearing or pregnant lixiviant solution will be accomplished via an ion exchange process. The pregnant lixiviant from the well field will be pumped through IX vessels containing uranium-specific IX resin beads (Dowex 21K XLT or equivalent). As the lixiviant flows through the resin beds, the complexed uranium molecules attach themselves to the beads of resin, displacing a chloride ion or bicarbonate ion as shown below:

$$2\ RCl + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + 2Cl^{-1}$$

$$2\ RHCO_3 + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

Each resin bead has a finite number of sites where the uranium complex can attach. When most of the available sites in the resin bed are occupied by uranyl dicarbonate (UDC) or uranyl tricarbonate (UTC) ions, the resin will be considered to be "loaded" and will be ready for processing.

The IX vessels will be designed to operate in downflow mode, and each will contain approximately 500 ft^3 of IX resin. The IX vessels will be arranged in multiples of two vessels in series. The lixiviant will be passed through the primary or lead vessel which will be where most of the resin loading takes place. The lixiviant will then pass through the secondary or lag vessel where the solution will be "polished" by removal of any remaining dissolved uranium. When the lead vessel becomes loaded, it will be taken off line and flow of lixiviant will be routed to the secondary vessel which will become the lead vessel. The resin in the off-line vessel will be removed and regenerated resin will be returned to the vessel. The vessel containing the regenerated resin will be then brought back on line in the lag position. The resin that was removed will be transferred to the elution and regeneration process in the CPP.

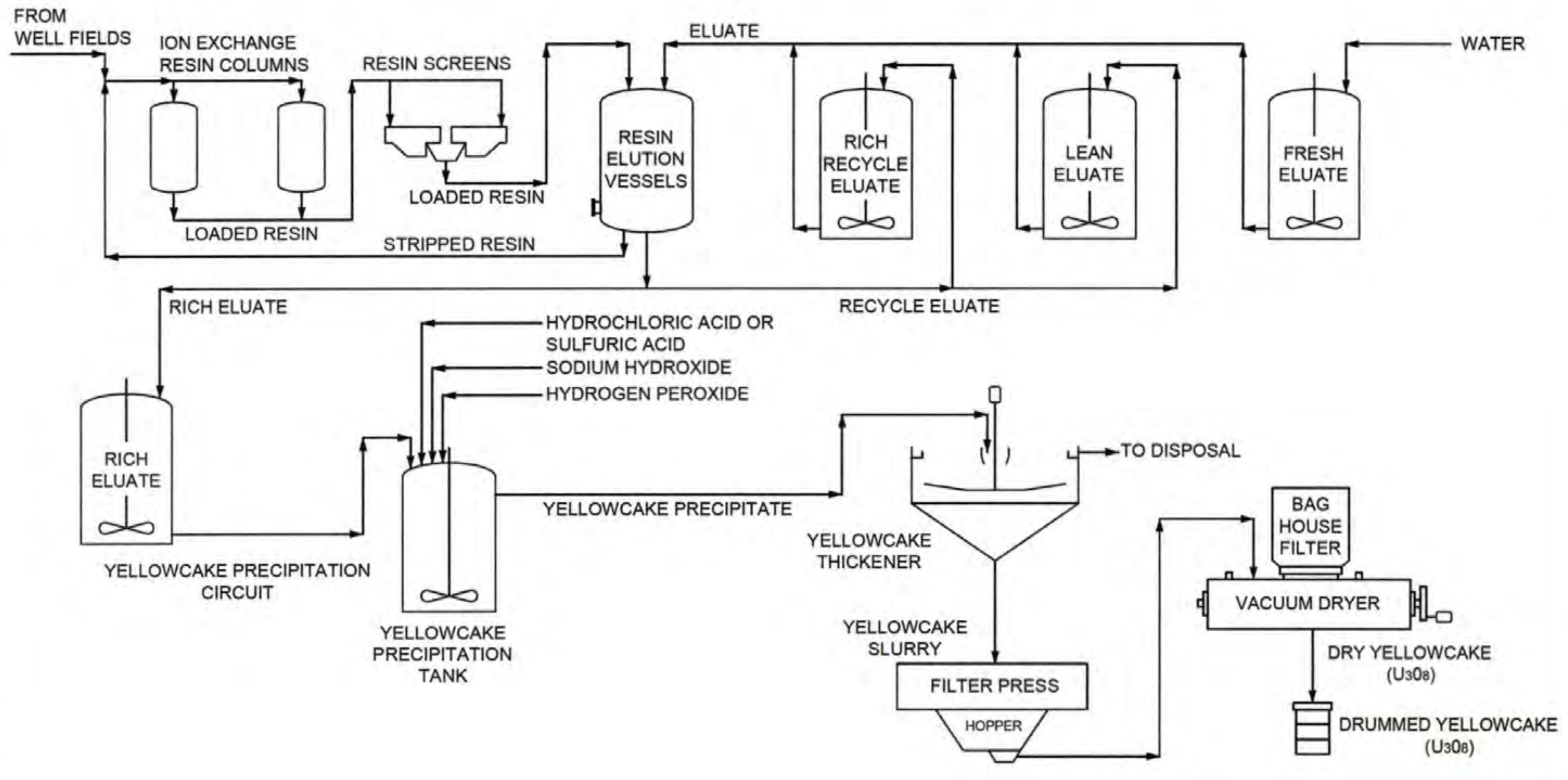


Figure 3.2-6

Process Flow Diagram

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	14-Jun-2013
FILENAME	PFD.dwg

POWERTECH (USA) INC.

After passing through the IX vessels, the barren lixiviant will be returned to the well field where oxygen and carbon dioxide will be added prior to reinjection. A booster pump station may be required to achieve the required injection pressure. A sidestream referred to as the production bleed will be removed from the barren lixiviant and routed to either the wastewater system or the production bleed reverse osmosis (RO) system, depending on which liquid waste disposal option, as discussed in Section 3.1.6, is utilized. The flowrate of this sidestream will be approximately 0.5 percent to 3 percent of the pregnant lixiviant flowrate. The purpose of the production bleed stream is to maintain a hydraulic gradient towards the well field, as discussed in Section 3.1.

3.2.2.1 Recovery Equipment

The recovery equipment includes the recovery IX vessels, the production bleed reverse osmosis system (deep disposal well option only), and the recovery and injection composite booster pumps.

Ion Exchange Vessels

The IX columns will be vertical cylindrical pressure vessels with dished heads. The vessels will be constructed of fiberglass-reinforced plastic (FRP), and will be approximately 13 feet in diameter with a seam to seam height of 8 feet. The vessels will be constructed according to American Society of Mechanical Engineers (ASME) Section VIII specifications. Each vessel will be equipped with an upper flow distribution plate and a lower flow distribution manifold constructed of stainless steel pipe and slotted well screen. The IX vessels will be designed to provide optimum contact time between pregnant lixiviant and IX resin. These vessels can be operated at a wide range of flowrates without loss of performance.

At the SF and the CPP, the air/vacuum relief valves on the IX columns will be piped together in a manifold which will be vented above the roofline of the building. In addition, a flexible duct designed to attach to tanker trucks during loading and unloading of resin will be connected to this vent manifold. This vent system will not have a fan because vacuum relief requires an inflow of air.

Each vessel will be equipped with a pressure relief valve and an air/vacuum release valve. Pressure transmitters and pressure gauges on the inlet and outlet piping connected to each vessel will measure and indicate pressure both locally and in the control room. Control interlocks with the well pumps and booster pumps will be used to prevent system pressure from exceeding the pressure rating of the lowest rated system component.

Production Bleed RO System (Deep Disposal Well Option)

The production bleed RO system will be designed to accommodate the production bleed flow, rejecting approximately 30 percent of the flow as brine and returning 70 percent of the flow as permeate. The production bleed RO system will be a packaged system including feed conditioning, filtration, membranes, and control system.

Booster Pumps

Booster pumps may be used to convey pregnant lixiviant to the SF or CPP, and to convey barren lixiviant from the SF or CPP to the well field. These pumps will be in-line centrifugal pumps, and will each have the capacity to pump 50 percent of the design flow. The pumps will be equipped with pressure indicators on the discharge lines, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room located in the SF or CPP, respectively. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.3 Resin Transfer

Resin will be transferred out of IX vessels at the CPP and SF to the elution circuit where it will be regenerated by contacting it with concentrated salt solutions. The concentrated salt solution displaces the UDC and UTC and replaces them with chloride or carbonate ions. The regenerated resin will be then transferred back to IX vessels.

At the CPP, resin transfer will be accomplished by pumping water into the top of the IX vessel with the bottom discharge valve open. This will force the resin to flow out of the vessel into the transfer pipe. The resin and water will be pumped via the transfer piping to one of two elevated shaker screens. The shaker screens will be inclined, vibrating screens which will separate transfer water, loaded resin, and waste into separate streams. The transfer water will pass through the screens and flow by gravity into a collection tank which feeds the resin transfer pumps. The loaded resin will drop into one of four elution columns to be regenerated. The oversized or undersized solid waste from the shaker screens will consist of broken resin beads, silt and sand from the wells, and scale removed from the resin, and will collect in a hopper to be periodically removed and drummed for disposal.

Following elution of the resin, the transfer process will be reversed. Water will be pumped into the top of the elution column with the bottom discharge valve open. This will force the resin out of the column and into the resin transfer piping. The resin and water will be pumped back to the IX vessel where they will enter through a nozzle on the side of the vessel. The resin transfer water will exit the vessel through the bottom liquid distributor and flow back to the resin transfer water tank. The resin will remain in the IX vessel because it will not be able to pass through the screen openings in the bottom liquid distributor.

At the SF, loaded resin will be transferred from the IX vessels to a tanker truck that enters the building (Figure 3.2-5). Resin transfer will be accomplished through resin transfer piping and hoses that connect the exchange vessels to the transfer truck. With the connections made and transfer valves opened, resin transfer water will be pumped into the top of the IX vessel with the bottom discharge valve of the vessel open. This will force the resin to flow out of the vessel and into the tanker truck. Water and resin will enter the tanker, and water will exit the tanker through a screened outlet port and be returned to the resin transfer water tank. The resin, which cannot pass the screen, will remain in the tanker. When the resin has been flushed from the vessel and piping, the excess transfer water is drained from the truck, the valves controlling the transfer will be closed and the hoses disconnected from the truck.

The truck will then transport the resin to the CPP where the truck will be connected via hoses to the resin transfer water headers. To transfer resin out of the tanker, water will be introduced to the tanker from the resin transfer water tank, and water and resin will flow out of the tanker to the vibrating screens described above. To transfer resin back into the tanker following elution, water and resin will be pumped out of the columns as described above, and routed into the tanker via the hose connections between the tanker and the resin transfer header. As with the transfer at the SF, the resin will remain in the tanker and the transfer water will return to the resin transfer water tank. When the tanker returns to the SF, the regenerated resin will be transferred back into the IX vessel using the same methods.

3.2.3.1 Resin Transfer Equipment

Equipment associated with the resin transfer system includes a resin transfer tanker truck, two shaker screens, a shaker screen water tank, a resin transfer water tank, and a resin transfer pump.

Resin Transfer Tanker Truck

Resin transfer tanker trucks will have one or more compartments with sloped bottoms and screened bottom outlet nozzles. Resin transfer tanker trucks will have a minimum capacity of 500 ft3 per compartment.

Shaker Screens

The shaker screens will be packaged units that allow adjustment of angle and motion to optimize separation. The screens will be installed on an elevated platform to allow resin to drop into the elution columns. Hoods will be constructed above each shaker screen. Each hood will be connected to a vent header that will exhaust through a vent in the building roof to prevent radon accumulation inside the CPP.

Shaker Screen Water Tank

The shaker screen water tank will be a vertical cylindrical atmospheric tank with a cone bottom and flat cover. The tank will be constructed of fiberglass reinforced plastic (FRP) and will be elevated to allow gravity flow of water into the resin transfer water tank from the shaker screen. Waste solids from the resin transfer process will collect in the conical bottom of the tank and will be removed periodically and disposed. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The tank will be connected to a vent header which will exhaust through a vent on the building roof.

Resin Transfer Water Tank

The resin transfer water tank will have a capacity of approximately 12,000 gallons. This tank will be a vertical cylindrical atmospheric tank with a flat bottom and flat cover. The tank will be constructed of FRP, and will be approximately 13 ft in diameter with a height of 13 ft. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The tank will be connected to a vent header which exhausts through a vent on the building roof.

Resin Transfer Water Pump

The resin transfer water pump will have a capacity of approximately 300 gpm. This pump will be a horizontal, end-suction centrifugal pump and will be constructed of ductile iron. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.4 Elution

The elution process will remove the UDC and UTC from the resin and restore the resin to its chloride form to allow it to be put back into service to remove uranium from pregnant lixiviant. This process is represented by the following equations:

$R_2UO_2(CO_3)_2 + 2C1^- \rightarrow 2\ RCl + UO_2(CO_3)_2^{-2}$
$R_4UO_2(CO_3)_3 + 4Cl^- \rightarrow 4RCl + UO2(CO_3)_3^{-4}$

Elution will be a four-stage process that takes place in an elution column and will involve contacting the loaded resin with batches of eluant solution containing approximately 10 percent by weight sodium chloride and 2 percent by weight sodium carbonate. Each elution stage will strip the resin of additional uranium complex and further restore the exchange capacity of the resin. Following the final elution stage, more than 95 percent of the uranyl carbonate complex will have been removed from the resin.

In the first elution stage, intermediate eluant will be pumped from the intermediate eluant tank through the elution column, stripping approximately 80 percent of the uranyl carbonate ions from the resin. After exiting the column, this solution will be pumped into the rich eluate tank.

In the second elution stage, lean eluant will be pumped from the lean eluant tank through the elution column, stripping approximately 60 to 70 percent of the remaining uranyl carbonates from the resin. After exiting the column, this solution will be pumped into the empty intermediate eluant tank to be used as intermediate eluant in the processing of the next batch of loaded resin.

In the third elution stage, fresh eluant will be pumped from the fresh eluant tank through the elution column, stripping approximately 30 to 40 percent of the remaining uranyl carbonate ions from the resin. After exiting the column, this solution will be pumped into the lean eluant tank to be used as lean eluant in the processing of the next batch of loaded resin.

In the fourth and final elution stage, utility water will be pumped from the utility water tank through the elution column, displacing the eluant entrained in the resin. After exiting the column, the rinse water will be pumped into the fresh eluant tank. Saturated sodium chloride and sodium carbonate solutions will be pumped into the fresh eluant tank to make up the next batch of fresh eluant.

3.2.4.1 Elution System Equipment

Elution system equipment includes four elution columns, eight eluant/eluate tanks, and elution pumps.

Elution Columns

The four elution columns will be vertical cylindrical pressure vessels with dished heads. The vessels will be constructed of FRP. The vessels will be constructed according to ASME Section VIII specifications. Each vessel will be equipped with upper and lower flow distribution manifolds constructed of stainless steel pipe and slotted well screen. The elution columns will be designed to provide optimum contact time between eluant solutions and IX resin. These columns will be capable of being operated over a range of flowrates without loss of performance.

Each column will be equipped with a pressure relief valve and an air/vacuum release valve. Each column will also be equipped with a level indicator/transmitter which will measure and indicate level in the column both locally and in the control room. Pressure transmitters and pressure gauges on the inlet and outlet piping connected to each vessel will measure and indicate pressure both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof to minimize radon emissions within the CPP building.

Elution Tanks

There will be a total of 8 elution tanks in the CPP. These include two Fresh Eluant Tanks, two Lean Eluant Tanks, two Intermediate Eluant Tanks, and two Rich Eluate Tanks. Each elution tank will have a capacity of approximately 16,500 gallons. Each tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which will exhaust through a vent on the building roof to prevent radon accumulation inside the CPP building.

Elution Pumps

There will be a total of 10 elution pumps, each with a capacity of approximately 150 gpm. These pumps will be horizontal, end-suction centrifugal pumps and have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.5 Precipitation

The precipitation process will be designed to break the uranyl carbonate complex, precipitate the uranium as uranium peroxide, and settle the precipitated solids from the eluant solution. The precipitation process will be comprised of a series of chemical addition steps, each causing a specific change in the rich eluate solution.

Prior to beginning the precipitation process, the rich eluate transfer pump will be used to transfer the rich eluate from the rich eluate tank to the precipitation tank. The precipitation tank contents will be mixed via an agitator. The first stage of chemical addition will be to add sulfuric or hydrochloric acid to bring the pH down to a range of approximately 2-3 pH units. This change in pH will cause the uranyl carbonate complex to break, liberating carbon dioxide, which will be vented from the tank, as illustrated in the following chemical reaction.

$$UO_2(CO_3)_3^{-4} + 6H^+ \rightarrow UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

Following completion of CO2 evolution, sodium hydroxide will be added to raise the pH of the solution to between 4 and 5 pH units. When the pH has stabilized, hydrogen peroxide (H2O2) will be added to the solution to form insoluble uranium peroxide (UO4). Following addition of H2O2 , the agitator speed will be slowed down to promote crystal growth.

$$UO_2^{++} + H_2O_2 + 2H_20 \rightarrow UO_4 \bullet 2H_2O + 2H^+$$

After a precipitation period of up to 8 hours, sodium hydroxide will be added to raise the pH to approximately 7, and the contents of the precipitation tank will be pumped into the thickener using the precipitation transfer pumps.

3.2.5.1 Precipitation System Equipment

Precipitation system equipment will include precipitation tanks, transfer pumps, and thickeners.

Precipitation Tanks

There will be two precipitation tanks in the CPP. Each precipitation tank will have a capacity of approximately 20,000 gallons. Each tank will be a vertical cylindrical atmospheric tank with sloped bottom and flat cover. Each tank will be constructed of FRP. Each tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be equipped with a pH sensor connected to a pH indicator/controller in the control room. Each tank will be connected to a vent header which will exhaust through a vent on the building roof to prevent radon accumulation inside the CPP building.

Thickeners

There will be two gravity thickeners in the CPP. Each thickener will be a rubber lined 30-ft. diameter steel tank with conical bottom. The thickeners have a rake mechanism which has angled arms that match the angle of the conical bottom of the tank. As the rake rotates, the motion of the paddles through the sludge blanket at the bottom of the thickener will express liquid out of the sludge and increases the solids content of the sludge. The liquid and suspended solids from the precipitation tank will be introduced into the thickener via a center feed tube. The suspended solids will settle out of the liquid as it flows from the center of the thickener to the side overflow launders. Clarified effluent will spill over a weir into the launders, and from there it will be collected and directed to the solids removal tank in the wastewater system.

Precipitation Transfer Pumps

There will be 2 precipitation transfer pumps, each with a capacity of approximately 200 gpm. Each pump will be a horizontal, end-suction centrifugal pump and has wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room.

Pressure Filtration

The pressure filtration system will be designed to dewater, rinse, and air dry the precipitated uranium peroxide present in the thickener underflow. The thickener underflow will be pumped by progressive cavity pumps into the two horizontal plate and frame filter presses where the solids content of the thickener underflow will be increased to approximately 60 percent by weight by first pressing the slurry between filtration diaphragm plates. Then the press pressure will be released and utility water will be pumped through the filter cake to remove impurities, particularly chloride. The plates will then be pressed again, followed by introducing compressed air to the pressed cake to further dry it. Upon completion of the drying cycle, the filter cake will be conveyed out of each filter chamber on the moving filter cloth and directed into the two filter press cake chutes. An enclosed inclined screw conveyor will convey the filter cake from the shoot to the feed inlet on one of the two vacuum dryers.

Wastewater exiting the filter press will flow into a sump and be pumped into the solids removal tank in the wastewater system.

In order to minimize the potential for fugitive dust particles, the filter presses will located in a separate room and each will be enclosed in an interlocked cover. The connections between the cake chutes and enclosed screw conveyors will be gasketed and flanged, the screw conveyors will be enclosed, and the connection between each screw conveyor and knife gate valve on the dryer feed inlet will be gasketed and flanged. HVAC considerations for this system are discussed in Section 3.2.11 below.

The filter presses will be equipped with pressure gauges that indicate the pressure in the hydraulic system, as well as an inlet pressure indicator transmitter. Inlet pressure will be interlocked with the feed pumps to prevent over-pressurization of the filter presses.

3.2.6 Drying and Packaging

The uranium peroxide filter cake will be dried in a rotary vacuum dryer at approximately 250°F. Angled paddles attached to a central shaft in the dryer will agitate the filter cake to promote even drying. The dryers will be heated with a thermal fluid (e.g., MultiTherm IG-4) that will be circulated through the dryer shell and the rotating central shaft. The thermal fluid (TF) will be heated by an electric heater with a pump for circulating the TF through the shell and central shaft of the dryer.

The vapor pulled from the dryer by the vacuum pump will be filtered through a baghouse filter located on the top of the dryer to remove particles down to approximately 1 micron in size. The vapor exiting the baghouse will be cooled using a condenser to remove water vapor and remaining small particles. Liquid ring vacuum pumps will provide the vacuum source. The water that will be collected from the condenser will be pumped to the solids removal tank in the wastewater system.

Two rotary vacuum dryers, baghouses, and packaging equipment will be housed in a separate room in the CPP. The vacuum pump and condenser system for each dryer, and the TF heaters and pumps will be located in the main CPP area to provide access for operation and maintenance. The vacuum pumps will discharge to the dryer room. Air in the dryer and packaging room will be monitored routinely for airborne dust. A dedicated air handler equipped with HEPA filters will ventilate the dryer and packaging room and will provide an additional level of controlling particulate emissions.

3.2.6.1 Drying and Packaging Equipment

The major components of the system include the vacuum dryers, baghouses, vacuum pump and condenser systems, thermal fluid heaters, and the packaging system.

Vacuum Dryer

There will be two vacuum dryers in the CPP. The dryer chambers will be designed for 450° F and full vacuum, and a production rate of 2200 dry pounds per day. The dryer chambers will be heated externally and fitted with rotating paddles attached to a central shaft to agitate the yellowcake. The chamber will have a top port for loading the dewatered filter cake and a bottom port for unloading the dry powder. A port will be provided for pulling vapors through the baghouse using the vacuum pump.

Refer to Section 4.1.2.2 for monitoring and logging procedures that will be used to ensure adequate vacuum levels are maintained.

Baghouse Filter

Each dryer will be connected to a baghouse filter enclosure. Each baghouse filter will have an integrated compressed air blow down system. The baghouse filters will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be discharged back to the drying chamber. The bag house filters will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system.

Vacuum Pump and Condenser System

The vacuum pump and condenser systems will include water sealed liquid ring vacuum pumps with seal water reservoirs, seal water cooling heat exchangers, condensers, condensate receivers, and condensate pumps. Three of these systems will be provided, with two being on line and the third acting as a backup unit. The suction side of the vacuum pump will pull vapors from the vacuum dryer through the baghouse and then through the condenser. Seal water will be cooled in a heat exchanger as it flows to the vacuum pump head. Cooling water from the cooling tower will be circulated through the condenser and the seal water heat exchanger. Condensate from the condenser will flow into a receiver tank constructed of 304 SS. When the receiver tank is full as sensed by a level switch, a condensate transfer pump will pump the condensate to the solids removal tank in the wastewater system.

Thermal Fluid Heaters

Packaged electrical thermal fluid heaters will be used to circulate hot thermal fluid through the shell and central shaft of the rotary dryers. Each thermal fluid heater will be equipped with a circulating pump to circulate the thermal fluid through the dryer and back to the heater.

Packaging System

The packaging system will be operated on a batch basis and will include conveyors, scales, and a spray booth. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a knife gate valve on the bottom port of the dryer into 55-gallon steel drums. Particulate emissions will be minimized by use a sealed hood that fits on the top of the drum. A weigh scale will be used to determine when a drum is full. A conveyor system will allow drums from both dryers to be moved from beneath the dryer to an enclosed spray booth where each drum will be rinsed with a spray of water. The conveyor system will then move the drum to a scanning station where the drum will be hand scanned for radioactivity and then placed in the storage area or rinsed further.

3.2.7 Restoration

The restoration system is designed to extract, store, and distribute makeup water for restoration of well fields. The restoration system may also incorporate a reverse osmosis (RO) system to remove TDS from extracted water and return low TDS permeate to the restoration system. Reject from the reverse osmosis system, if utilized will be routed to a high TDS wastewater system.

3.2.7.1 Restoration System Equipment

Restoration system equipment includes a restoration water tank, a restoration makeup water pump, and a restoration RO system. Each SF will be equipped for restoration of post-production well fields.

Restoration Water Tank

The restoration water tank will be constructed of FRP. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Restoration Makeup Water Pump

The restoration makeup water pump will have wetted parts constructed of ductile iron. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

Restoration Reverse Osmosis System

The restoration RO system at each site will be a packaged system capable of treating approximately 500 gpm and producing a permeate stream and a reject brine. This system will include necessary pretreatment, including multi-media or sand filters and feed conditioning.

3.2.8 Chemical Storage and Feeding Systems

The ISL process requires chemical storage and feeding systems to store and dose chemicals at various stages in the extraction, processing, and waste treatment processes. The chemicals to be utilized in uranium processing at the project are listed in Table 3.2-1. The potential for any of these chemicals to impact radiological safety is variable in likelihood and consequence. Chemicals that have the potential to impact radiological safety include hydrochloric acid, sulfuric acid, hydrogen peroxide, and sodium hydroxide. Oxygen, because of its ability to support combustion, also requires special handling. In all instances, process controls and preventative safety measures minimize the risk of increased radiological exposure or release. Each chemical storage and feeding system will be designed to safely store and accurately deliver process chemicals to the process delivery points. All chemical storage tanks will be clearly labeled to identify contents. Design criteria for chemical storage and feeding systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Powertech (USA) employees and members of the public, both with regard to the specific chemicals and with regard to the potential release of radioactive materials in the event of an accident.

Table 3.2-1: Process-related Chemicals and Quantities Stored On-site

Chemical Name	No. Tanks	Unit Storage Capacity	Units	Usage Rate ton/yr	Hazard Classification
Burdock CPP and Well Fields					
Sodium Chloride (NaCl)	2	20,000	gal	2,250	Non-flammable
Sodium Carbonate (Na_2CO_3) i.e., Soda Ash	1	20,000	gal	450	Non-flammable
Hydrochloric Acid (HCl, 32%, or Sulfuric Acid (H_2SO_4 93%)	1	7,000	gal	487	Toxic, reactive, corrosive
Sodium Hydroxide (NaOH 50%)	1	7,000	gal	446	Toxic, reactive, corrosive
Hydrogen Peroxide (H_2O_2 50%)	1	7,000	gal	177	Oxidizer, irritant, corrosive
Oxygen (O_2, liquid)	1	11,000	gal	979	Cryogenic, oxidizer
Carbon Dioxide (CO_2)	1	6,000	gal	245	Asphyxiant, freezing hazard
Barium Chloride ($BaCl_2$)	1	275	50-kg sacks	7	Toxic, non-flammable
Dewey Satellite Facility and Well Fields					
Oxygen (O_2, liquid)	1	11,000	gal	653	Cryogenic, oxidizer
Carbon Dioxide	1	6,000	gal	163	Asphyxiant, freezing hazard
Barium Chloride	1	138	50-kg sacks	7	Toxic, non-flammable

Any negative impact to radiological safety from use of these chemicals would be due to accidents, improper use, or human error. Nevertheless, these chemicals would only indirectly cause a radiological hazard as they do not contain radiological materials themselves.

Figures 3.2-4 and 3.2-5 show the storage locations of all chemicals used in uranium processing, with the exception of oxygen. Oxygen will be stored as cryogenic liquid in tanks located in the well field areas. Oxygen storage tanks will be located near but at a safe distance from header houses as required by NFPA and OSHA standards. Figures 3.2-7 and 3.2-8 depict the potential oxygen storage tank locations for the Burdock and Dewey initial well fields, respectively.

At the CPP, the chemicals include sulfuric and/or hydrochloric acid, hydrogen peroxide, and sodium hydroxide. Of these, only hydrogen peroxide presents a fire hazard if it comes in contact with combustible materials. These chemicals are corrosive and reactive. Areas within the CPP and chemical storage areas will be provided with secondary containment consisting of concrete curbs around the floor perimeters. Curbs will also divide areas to prevent mixing of incompatible fluids

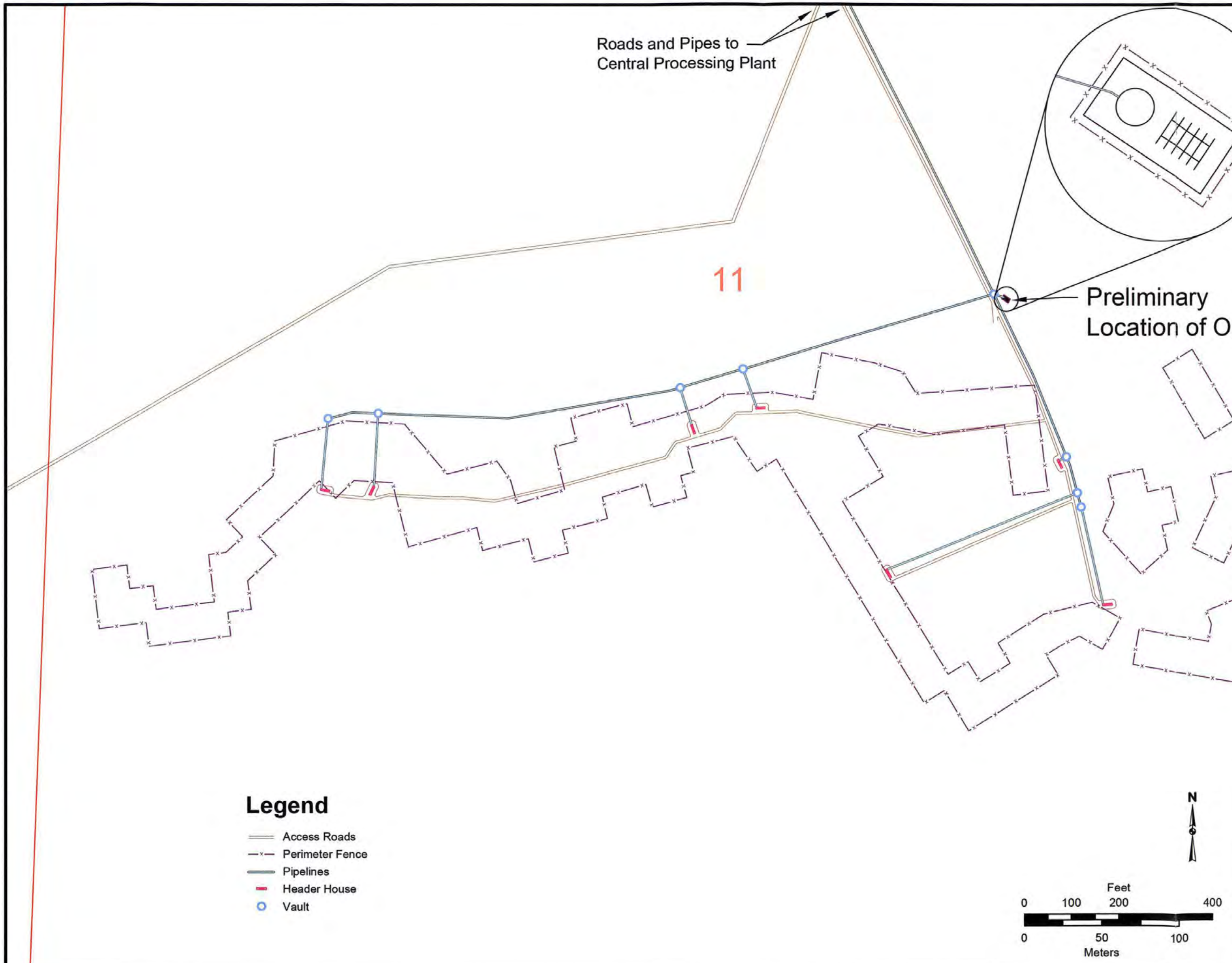


Figure 3.2-7

Preliminary Oxygen Tank Location
Burdock Well Field 1
Township 7S, Range 1E
Dewey-Burdock Project

DRAWN BY	Munro, Hetrick
DATE	17-Jun-2013
FILENAME	WF-B1-O2TankLoc.dwg

POWERTECH (USA) INC.

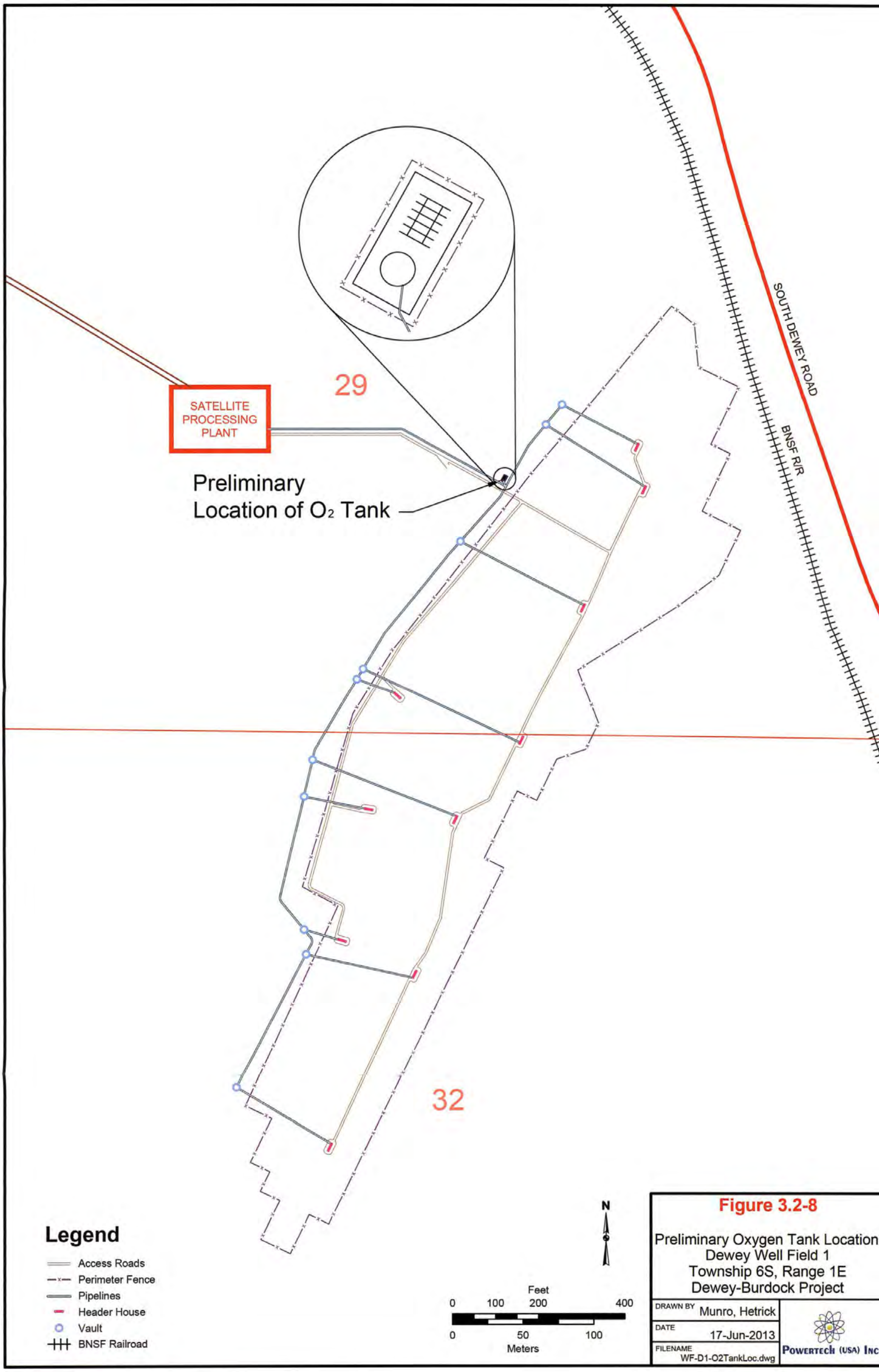


Figure 3.2-8

Preliminary Oxygen Tank Location
Dewey Well Field 1
Township 6S, Range 1E
Dewey-Burdock Project

in the event of a leak or spill. Concrete floors, secondary containment, and sumps in areas where corrosive fluids could be spilled will be coated with corrosion resistant materials as recommended by the manufacturer. Thickeners will be plain carbon steel construction lined with chlorobutyl or bromobutyl rubber and capable of operating at 175° F in a highly acidic environment. Elastomeric linings will also be used to resist abrasion from the slurries in these tanks. All slurry piping will use materials that are abrasion and corrosion resistant and solution piping will be appropriately corrosion resistant. Tanks holding process solutions will be constructed from FRP using resins and liners appropriate to the conditions as recommended by the manufacturers.

At the Dewey Satellite Facility, none of the chemicals listed above will be present. The only chemicals to be stored and used at the Satellite Facility will be relatively small quantities of RO pretreatment chemicals such as antiscalant.

3.2.8.1 Sodium Chloride Storage

Sodium chloride will be used to make up fresh eluant and will be stored in tanks as a saturated solution (approximately 26 percent by weight) in equilibrium with a bed of crystals in each storage tank. Dry sodium chloride will be delivered by truck and will be blown into the storage tanks using air pressure.

Sodium Chloride Tanks

There will be two Sodium Chloride Tanks, each with a capacity of approximately 20,000 gallons. These tanks will be a vertical cylindrical atmospheric tank with a sloped bottom and flat cover. Each tank will be constructed of FRP, and will be approximately 13 ft in diameter with a height of 20 ft. Each tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof, and will be equipped with a scrubber to prevent emission of particulates during truck unloading.

Sodium Chloride Pumps

There will be two sodium chloride pumps that will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.2 Sodium Carbonate Storage

Sodium carbonate will be used to make up fresh eluant and will be stored in tanks as a saturated solution in equilibrium with a bed of crystals in the storage tank. Sodium carbonate solution must be kept above 140 F to prevent precipitation in the tank and piping. This will be accomplished by heating the water added to the tank, and continuously circulating liquid from the tank through a heat exchanger. An electric heater will be used to heat a thermal fluid to heat the exchanger. Dry sodium carbonate will be delivered by truck and will be blown into the storage tanks using air pressure.

Sodium Carbonate Tank

The sodium carbonate tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The tank will be connected to a vent header which exhausts through a vent on the building roof, and will be equipped with a scrubber to prevent emission of particulates during truck unloading.

Sodium Carbonate Pumps

The sodium carbonate pumps will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.3 Acid Storage and Feeding System

Sulfuric acid and/or hydrochloric acid will be used in the precipitation circuit of the CPP to break down the uranium carbonate complexes. The hazards associated with use and storage of acid include corrosiveness, toxicity to tissue, and reactivity with other chemicals at the project such as sodium carbonate and water. Acid storage tanks will be isolated from other chemicals to reduce the risk of reactions. The acid storage and feeding system will include one or more storage tanks and delivery pumps. The storage tank will be located adjacent to the CPP in the chemical storage area. The chemical storage area will include a lined concrete secondary containment basin designed to contain at least 110 percent of the largest tank volume plus a 25 year, 24 hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The acid feed pump will be located inside the building, directly adjacent to the storage tank.

Acid Storage Tank

The acid storage tank will be designed to store sulfuric or hydrochloric acid. The tank will be constructed of HDPE, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. The acid storage tank will be located outside the CPP as shown in Figure 3.2-4. The acid storage tank will be vented directly to the atmosphere. Sulfuric acid will be purchased and stored as standard commercial grade concentrated acid (approximately 93% H_2SO_4 by weight). The storage tank will be made either of carbon steel or ultra-high-molecular-weight, cross linked polyethylene. Piping and pump material will be chosen based on compatibility. The freezing point of 93% sulfuric acid is approximately -28.9°C (-20°F); therefore, freeze protection of the storage tank and outside piping (insulation and heat tracing) will be used. Powertech (USA) will develop and implement an emergency response plan and emergency notification procedures in the event of an accidental release.

Acid Transfer Pump

The acid feed pump will have wetted parts constructed of FRP. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.4 Sodium Hydroxide Storage and Feeding System

The sodium hydroxide system will include a storage tank and delivery pump. The storage tank will be located adjacent to the CPP in the chemical storage area in a concrete secondary containment basin designed to contain at least 110 percent of the tank volume plus a 25-year, 24-hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The sodium hydroxide feed pump will be located inside the building, directly adjacent to the storage tank. Sodium hydroxide will be purchased as aqueous caustic soda, and will be pumped directly into the storage tank from the supplier's tanker trucks.

Sodium Hydroxide Storage Tank

The sodium hydroxide storage tank will be constructed of carbon steel. The tank will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Sodium Hydroxide Pump

The sodium hydroxide feed pump will have wetted parts constructed of FRP. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.5 Hydrogen Peroxide Storage and Feeding System

The hydrogen peroxide system will include a storage tank and delivery pump. The storage tank will be located adjacent to the CPP in the chemical storage area in a concrete secondary containment basin designed to contain at least 110 percent of the tank volume plus a 25 year, 24 hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The site will have storage facilities for 7,000 gallons (70,000 pounds) of 50% H_2O_2. Hydrogen peroxide is a strong oxidizer, can be very reactive and is easily decomposable. Its hazardous decomposition products include oxygen, heat, and steam.

The hydrogen peroxide feed pump will be located inside the building, directly adjacent to the storage tank.

Hydrogen Peroxide Storage Tank

The hydrogen peroxide storage tank will be constructed of HDPE, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Hydrogen Peroxide Pump

The hydrogen peroxide feed pump will have wetted parts constructed of FRP. The pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.8.6 Oxygen Storage and Feeding System

Liquid oxygen will be present within the well fields. The primary hazard associated with oxygen is fire since it is a strong oxidizer in the presence of combustible materials. To reduce the risk of an accident that could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored near the well fields, so that in the event of an accidental release the gas would disperse and not cause a fire hazard to project equipment or infrastructure. Where above-ground oxygen storage or conveyance facilities exist, barriers will be used to prevent impacts from mobile equipment. Oxygen conveyance pipelines will be surveyed and marked with tracer wire to make them locatable by field personnel during excavation activities. A fire within a header house, where the oxygen is metered into separate injection lines, could damage equipment and instrumentation within the header house but would be unlikely to result in a spill of injection or recovery fluids. If a spill of lixiviant were to occur, well field personnel will have been trained in emergency procedures for responding to well field spills containing radiological materials. Oxygen will be stored in storage vessels designed, fabricated, tested, and inspected in accordance with the ASME Boiler and Pressure Vessel Code. Oxygen storage vessels will be equipped with safety relief devices and will be located at least 25 feet from buildings or as required by applicable NFPA and OSHA standards. Oxygen will be delivered and stored as a cryogenic liquid and then conveyed to the injection point (either upstream of the injection manifold within the header house or at each well head) as a gas through piping made from appropriate materials. Oxygen storage and delivery systems will be designed and fabricated in accordance with NFPA 55 and OSHA standards for the installation of bulk oxygen systems on industrial premises (29 CFR 1910.104). To reduce the risk of an accident which could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored a sufficient distance from other infrastructure and storage areas. Facilities used to store oxygen will conform to standards detailed in NFPA 55. Typically, oxygen storage and dispensing systems will be leased from the bulk oxygen vendor. Conveyance systems for oxygen will be clean of oil and grease because these substances will burn violently if ignited in the presence of oxygen. The proper pressure relief devices, component isolation and barriers will also be employed. Cleaning of equipment used for delivering and storing oxygen will be done in accordance with CGA G4.1. The design and installation of the oxygen piping system will be done according to the requirements of CGA G4.4. Powertech (USA) will develop procedures that implement emergency response instructions for a spill or fire involving oxygen systems.

3.2.8.7 Carbon Dioxide Storage and Feeding System

The carbon dioxide storage and feeding system will be used to dissolve carbon dioxide into the pregnant lixiviant to improve recovery of uranium in the IX vessel. This system will be a vendor supplied packaged system including cryogenic tank, vaporizer, pressure gauges, and pressure relief devices.

3.2.8.8 Barium Chloride Storage and Feeding System

The barium chloride storage and feeding system includes a storage tank, agitator, and chemical metering pump. This system will be designed to dissolve solid barium chloride in water to make up the solution for feeding into the low TDS wastewater for radium precipitation. Barium chloride will be stored as palletized sacks at the locations shown on Figures 3.2-4 and 3.2-5.

3.2.8.9 Byproduct Storage

Prior to transportation to a licensed disposal facility, byproduct material will be stored in designated storage buildings (also referred to as "byproduct storage buildings"), one located at the CPP site and one located at the SF site. These buildings will consist of a concrete slab with a containment curb surrounding the perimeter. Storage of byproduct material will be within "roll-off" containers (bins) which are both liquid tight and fully enclosed. As each storage building can accommodate two 20 cubic yard bins, the volume of byproduct material could accumulate to 30 to 40 cubic yards at each of the two storage locations prior to transport. There are two bays in each storage building, each accessed by an overhead roll-up door and allowing exchange of containers necessary for transport to a licensed 11e.(2) disposal site. The concrete slabs will be designed to allow external decontamination of the roll-off bins prior to transport.

The byproduct storage buildings will allow for control of byproduct materials and specific segregation of these wastes from other non-11e.(2) wastes. Typically these wastes are expected to consist of contaminated used equipment parts, personal protective equipment, and wastes from cleanup of spills or other housekeeping activities. Other waste not in contact with the uranium production process will be disposed of in regular dumpsters situated at a separate location.

Containment of these byproduct wastes within a designated, fully enclosed building will allow for proper control of the materials, monitoring, and necessary restricted access. These measures will ensure best possible control of 11e.(2)solid and liquid wastes to minimize any potential exposures or contamination.

3.2.9 Utility Water

The utility water system will be used to extract, store, and distribute water for consumptive process uses and potable uses. Water will be extracted from wells drilled in a suitable formation in the vicinity of the SF and CPP. Water for potable uses will be chlorinated and stored in a pressurized tank.

3.2.9.1 Utility Water System Equipment

The utility water system equipment will include the utility water tank and utility water pumps.

Utility Water Tank

The utility water tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Utility Water Pump

The utility water pump will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

3.2.10 Wastewater

The wastewater system will be designed to receive, treat, and discharge wastewater generated at various stages of the process. The wastewater system will be divided into two main categories of wastewater, high TDS wastewater, and low TDS wastewater. High TDS wastewater consists of waste eluant brine from the CPP and the reject streams from process bleed or restoration reverse osmosis systems if these systems are in use. Low TDS water sources include process bleed and extracted restoration water that have not been concentrated by a reverse osmosis process.

High TDS wastewater will flow by gravity from the solids removal tank to the high TDS wastewater tank. This wastewater will then be pumped to the liquid waste disposal system.

Low TDS wastewater will be collected in the low TDS wastewater tank and then pumped to a radium precipitation tank where barium chloride will be added to co-precipitate barium and radium sulfates. Treated wastewater will flow from the radium precipitation tank to the radium settling ponds for removal of the precipitate by settling.

3.2.10.1 Wastewater System Equipment

Wastewater system equipment includes the solids removal tank, the high TDS wastewater tank, the low TDS wastewater tank, the wastewater pumps, the radium precipitation tank and agitator.

Solids Removal Tank

The Solids Removal Tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof.

High TDS Wastewater Tank

The High TDS Wastewater Tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room. Each tank will be connected to a vent header which exhausts through a vent on the building roof.

Low TDS Wastewater Tank

The Low TDS Wastewater Tank will be constructed of FRP, and will be equipped with a level indicator/transmitter which will measure and indicate tank level both locally and in the control room.

Wastewater Pumps

Wastewater pumps will be provided for both high TDS wastewater and for low TDS wastewater, as needed, depending on the processing option selected in the final design. Each pump will have wetted parts constructed of FRP. Each pump will be equipped with a pressure indicator on the pump discharge line, and a flow meter and flow indicator transmitter in the discharge line. Flow will be indicated both locally and in the control room. The measured flow will be used to control pump motor speed via a variable frequency drive.

Radium Precipitation Tank

The radium precipitation tank will be used to add barium chloride to the wastewater and provide thorough mixing prior to discharge to the radium settling ponds.

3.2.11 HVAC System

The heating, ventilating and air conditioning (HVAC) systems in the SF and CPP will be designed to provide routine heating, cooling and required air changes in occupied areas, as well as mitigate the potential for human exposure to radionuclides. The primary exposure concerns will be radon gas and uranium oxide dust or particulates.

The HVAC system for the main plant area will be designed both for controlling the temperature in the main plant area, and for preventing the buildup of fugitive radon emissions by ensuring a minimum number of air changes.

Radon gas is a daughter product of radium, which is present in the orebody, and thus is mobilized and dissolved into the pregnant lixiviant during production. The potential for radon emissions from the process arises when the pressurized flow from the extraction wells and booster pumps is exposed to atmospheric pressure. The two process systems with the potential for radon emissions are the IX vessels via the air/vacuum relief valves, and the shaker screens where the loaded resin and resin transfer water will be pumped onto an open screen at atmospheric pressure.

The shaker screens will each have a dedicated vent hood directly overhead. The vent hoods will be connected to an exhaust fan designed to create sufficient air flow and velocity to minimize the emission of radon in the vicinity of the shaker screens. The exhaust fans will discharge the air through a vent in the roof of the building. The vent will be located away from air intakes for the building.

Systems that have the potential to emit dust particles containing uranium include the filter presses, the dryers, and the drum filling stations.

The filter presses will be installed in a dedicated filtration room, and the vacuum dryers will be installed in a dedicated dryer room. These two rooms will be serviced with dedicated HVAC equipment that includes particulate filtration to minimize the potential for personnel exposure within the rooms and to prevent the emission of particles.

3.2.12 Instrumentation and Control

Powertech (USA) will install automated control and data recording systems at the Dewey Satellite Facility and the Burdock CPP which will provide centralized monitoring and control of the process variables including the flows and pressures of production, injection, and waste streams. The systems will include alarms and automatic shutoffs to detect and control a potential release or spill.

Pressure and flow sensors will be installed, for the purpose of leak detection, on the main trunklines that connect the CPP and Satellite Facility to the well fields. In addition, flow rates of each production well and each injection well will be automatically measured. Measurements will be collected and transmitted to both the CPP and Satellite Facility control systems. Should pressures or flows fluctuate outside of normal operating ranges, alarms will provide immediate warning to operators which will result in a timely response and appropriate corrective action.

Both external and internal shutdown controls will be installed at each header house to provide for operator safety and spill control. The external and internal shutdown controls are designed for automatic and remote shutdown of each header house. In the event of a header house shutdown, an alarm will occur and the flows of all injection and production wells in that header house will be automatically stopped. The alarm will activate a blinking light on the outside of the header house and will cause an alarm signal to be sent to the CPP and Satellite Facility control rooms.

An external header house shutdown will activate an electrical disconnect switch located on the outside of the header house or at the transformer pole which will shut down all electrical power to the header house. This will mitigate potential electrical hazards while de-energizing the header house and operating equipment. The production pumps will be de-energized which will result in flow stopping from all production wells. A control valve that will close when de-energized will be used on the injection header, which will stop the flow to all injection wells.

Internal shutdown controls will not involve de-energization of the header house but will result in the same alarm condition and shutdown of flow to all production and injection wells feeding the header house.

Each header house will also include a sump equipped with a water level sensor so that if a leak occurs, and the water level approaches a preset level, the sensors will cause an automatic shutdown of the header house. A pressure switch will be installed on the injection header to ensure that fluid pressures do not exceed the mechanical integrity test pressures of the injection wells served by that header house. If the injection pressure reaches the maximum set value in the pressure switch, an automatic header house shutdown will occur. Downhole pressure transducers will be installed in all monitor wells for the measurement of potentiometric head. These instruments will alert operators to any significant change in the water levels within the monitor wells to provide an early warning of a potential lixiviant excursion. Operators may then follow standard operating procedures to make adjustments to well field production and/or injection flow rates to avoid an excursion due to any unbalanced flow condition in a well field.

If an excursion or pipeline leak were to occur, procedures will be in place to address and correct it. Well field operators will conduct daily visual inspections of well field facilities, including header houses and all visible pipes, connections, and fittings. Operating flow rates and pressures of all injection wells, production wells, and associated buried piping systems will also be monitored and recorded on a daily basis. The CPP and Satellite Facility control rooms will both receive the pressure and flow data transmitted from the well fields, trunklines, and header houses. This information will provide the plant operators access to instantaneous data on well field operating conditions, enabling them to respond appropriately to unexpected or upset conditions, and allow them to direct well field operators to specific locations where immediate attention is needed.

A detailed description of the deep disposal wells operation and control is included in Section 2.K, "Injection Procedures," of Appendix 2.7-L of the approved license application, which includes the Class V UIC permit application. The automated control system on the Class V deep disposal wells will include control switches to alert the operator if certain operating conditions are encountered. A high injection pressure switch (set below the permitted maximum) and a low annulus differential pressure switch (set above the permitted minimum) will shut off injection pump power and will alert the operator so that the well can be fully isolated and secured. The alarm will sound in the central control room of the CPP and/or Satellite Facility, whichever is nearer. In the event that any of the permit condition related set points are exceeded, injection operations will cease immediately until the problem is identified and corrected. The system will then be manually restarted by an operator when operating parameter compliance is verified.

3.2.13 Backup Power

Backup generators will be installed to maintain continuous instrumentation monitoring and alarms in the CPP, Satellite Facility, and well fields. Backup power will also be provided for lights and emergency exits.

Loss of power to the project site will cause production wells to stop operating, resulting in shutdown of all production and injection flows. This condition avoids flow imbalance within the well fields, but a well field bleed would not be maintained during the power failure. The time span for the aquifer to recover from operational drawdown back to its natural groundwater gradient is much longer than the duration of a typical power outage. Since lixiviant would not begin to travel to the monitoring ring until the cone of depression caused by the bleed had recovered and groundwater had returned to its natural gradient, excursions are very unlikely within the short time period of a typical power outage.

The likelihood of a long-duration regional power outage has been considerably reduced by passage of the Energy Policy Act of 2005. This act created the North American Electric Reliability Corporation (NERC) to develop and enforce compliance with mandatory reliability standards in the U.S. NERC's standards are mandatory and enforceable throughout the 50 United States and several provinces in Canada. The major interconnections which cover most of the continental U.S. and Canada include the Eastern Interconnection (most of eastern North America) and the Western Interconnection (Rocky Mountains to the Pacific Coast). The Eastern Interconnection is tied to the Western Interconnection via high voltage DC transmission facilities.

The Dewey-Burdock project area is in the Western Interconnection, but very close to the boundary between the Eastern and Western Interconnections. Because of the reliability added since NERC was created, it is difficult to conceive of a natural event that would cause loss of electric power for an extended period of time. Tornadoes, blizzards or freezing rain can knock out power generating or transmitting facilities. Transmission facilities can be replaced fairly quickly (relative to groundwater flow rates) and power sources can be substituted through the NERC interconnection.

Thus, power outages in the project area would not be likely to last more than a few days or weeks under most conceivable scenarios. The project area is in fairly close proximity to the Powder River Basin area in northeastern Wyoming, home to several coal-fired and gas turbine generating facilities and industrial activities including oil and gas production and very large surface coal mines. Proximity to this region would facilitate acquisition of portable generators to keep the CPP and well field facilities operating until normal power supplies could be restored. Powertech (USA) will have temporary generators to operate well field pumps sufficient to maintain a cone of depression within the well field. These will be used if power outages occur with expected duration of more than a few weeks. Two or more small portable generators will provide sufficient energy to maintain a bleed sufficient to prevent excursions.

Shutdown due to power failure during winter months is not expected to be problematic because well field pipelines will be buried below the frost line. Heating of the Satellite Facility and CPP will use propane or natural gas and will require little or no power to operate.

3.3 OSHA Design Criteria

In addition to the design criteria discussed in the preceding subsections worker health and safety measures identified in 29 CFR Part 1910 will be incorporated into design of the ISL production and processing facilities, as discussed below.

Walking and working surfaces (Subpart D) - Aisles, passageways, and storage areas will be designed to be free of obstruction such that emergency egress will not be hindered. Wet areas in the plant will be provided with drainage, platforms, mats, or other dry walking surfaces, as necessary. All open-sided platforms or other working areas greater than 4 feet high will be equipped with standard railings. Flights of stairs more than 4 risers high will be equipped with standard hand railings in accordance with OSHA requirements.

- Means of egress (Subpart E) – Building will be designed and maintained to facilitate emergency egress. Exits will be clearly marked with illuminated exit signs.
- Occupational Health and Environmental Control (Subpart G) – Facilities will be designed with adequate ventilation systems to control worker exposure to vapors and temperature extremes. Noise will be minimized using engineering and administrative controls to ensure worker noise exposures are maintained below the permissible limits. As necessary, air compressors will be isolated to minimize noise levels within the processing facilities.
- Hazardous Materials (Subpart H) –Acid, caustic, and hydrogen peroxide storage areas will be individually curbed to provide secondary containment for each chemical. Sodium chloride, sodium carbonate, and barium chloride storage tanks will also have secondary containment, but do not need to be individually segregated. Operators will be provided hazard communication training, will have an MSDS onsite for these chemicals, and will have appropriate personal protective equipment (PPE) available for tank system maintenance and spill cleanup. An emergency eyewash/shower will be located adjacent to the storage areas. Spill response procedures will be included in the plant operating procedures. If used, flammable materials will be stored in the flammable storage locker.
- Personal Protective Equipment (PPE) (Subpart I) - The standards associated with respiratory, electrical, head, foot, and eye protection will apply. A workplace hazard assessment will be performed and documented. The requirement for PPE will be minimized by engineering and administrative controls that will be used to mitigate identified hazards. PPE will be used only to supplement these controls when required to ensure protection of employees. PPE in the form of respiratory protective equipment will be mandatory for workers in areas where the use of process and engineering controls may not be adequate to maintain regulated exposure levels to airborne radioactive and/or toxic materials.
- General Environmental Controls (Subpart J) - The general sanitation requirements for fixed facilities are applicable to the treatment facility. A restroom with a toilet and sink serviced by potable water will be provided. Fire systems and physical hazards will be color coded in accordance with subpart requirements. In addition to OSHA requirements, piping and facilities systems will be labeled.
- Medical and First Aid (Subpart K) - Plant operators will be trained in first aid and cardiopulmonary resuscitation. A first aid kit, eyewash, and emergency shower will be available.
- Fire Protection (Subpart L) – Portable fire extinguishers will be placed within the plant such that the maximum travel distance to an extinguisher will be less than 50 feet. Portable extinguishers will be inspected monthly and subjected to an annual maintenance check. In

addition, the CPP, office building, maintenance area, and warehouse will be equipped with automatic fire sprinklers.

- Compressed Gas Equipment (Subpart M) - Compressed air piping, safety valves, and pressure gages will be constructed to American Society of Mechanical Engineers (ASME) standards. Safety valves will be inspected frequently and at regular intervals to determine operational condition.

- Materials Handling and Storage (Subpart N) - Safe clearances, secure storage, good housekeeping, and guarding of fall hazards will be used to protect workers. Forklift operators will be trained in accordance with 29 CFR 1910.178.

- Machinery and Machine Guarding (Subpart O) – Workers will be protected from physical hazards associated with grinding, fans, rotating shafts, and pinch points through guarding in conformance with subpart requirements.

- Electrical Installations (Subpart S) - All electrical installations will be made in conformance with the National Electric Code and will be designed and installed by competent persons. Ground-fault circuit interrupters will be used for power tools or for other circuits that are not part of the plant's permanent wiring. Operators will be trained in electrical safety.

- Toxic and Hazardous Substances (Subpart Z) - Potential chemical hazards at the plant include acids, caustics, oxidants, brine solutions, barium chloride, ammonium sulfate, uranium, radium, and radon gas. Fire notification to employees will be through voice communication. Fire Department response will be initiated through the 911 emergency telephone system. Workers will be provided hazard communication training and exposure monitoring will be conducted as necessary to ensure compliance with subpart requirements.

3.4 References for Uranium Processing

The uranium processing techniques proposed for this project are well documented in the literature and have been successfully implemented in the United States for the past 20 years.

3.5 Master Schedule

The Dewey-Burdock ISL schedule is shown on Figure 1.9-1. The schedule is preliminary based on Powertech (USA)'s current knowledge of the recoverable reserves, land ownership, available water rights, and uranium market conditions. As the project is developed, the schedule will be updated accordingly. Refer to Figure 6.1-1 for a more detailed project schedule for individual well fields.

3.6 References

Center for Nuclear Waste Regulatory Analyses, NUREG/CR-6733, "*A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licenses*", 2001.

Compressed Gas Association, CGA G-4.1, "*Cleaning Equipment for Oxygen Service*", (CGA, 2000).

Compressed Gas Association, CGA G-4.4, "*Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems*", (CGA, 1993).

Hunkin, G. G., 1977, "*Uranium In-Situ Leaching in the Tertiary Deposits of South Texas, Chapter 3: Resource Development / Utilization in Geology of Alternate Energy Resources in the South-Central United States*" (M. D. Campbell (ed), Houston Geological Society, pp. 67-82. See: http://www.ela-iet.com/ie08000B.htm

Kirby, H.W. and M. Salutsky, 1964, "The Radiochemistry of Radium," National Academy of Sciences – National Research Council, December 1964.

National Fire Protection Association, NFPA-50, "*Standard for Bulk Oxygen Systems at Consumer Sites*", (NFPA, 1996).

Sterrett, R. J., "*Groundwater and Wells*", Third Edition, (Johnson Division, 2008).

U.S. Nuclear Regulatory Commission, June 2003, "*NUREG-1569 – Standard Review Plan for In Situ Leach Uranium Extraction License Applications – Final Report*", USNRC, Office of Nuclear Material Safety and Safeguards, Washington, D.C.

US Nuclear Regulatory Commission, NUREG-1910, "*Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities*", US Nuclear Regulatory Commission, July, 2008.

4.0 Effluent Control Systems

4.1 Gaseous and Airborne Particulates

Powertech (USA) Inc. will conduct an airborne radiation monitoring program at the Dewey-Burdock facility which is consistent with the recommendations contained in RG 8.30 and will consist of monitoring radon decay products as well as airborne particulate monitoring. Powertech (USA) Inc. will also conduct an airborne effluent and environmental monitoring program during construction and operations consistent with recommendations in USNRC Regulatory Guide 4.14 "*Radiological Effluent and Environmental Monitoring at Uranium Mills*" (RG 4.14).

This section describes the expected radionuclide airborne emissions from the Dewey-Burdock uranium recovery facilities. Airborne emissions are categorized in two subsections, radon and radionuclide particulates. Potential sources of emissions and a basic description of monitoring for worker protection are described based on the design of the Dewey-Burdock ISL process as well as the emission controls systems that will be employed to maintain radionuclide effluents well below regulatory limits and as low as is reasonably achievable.

4.1.1 Radon

According to RG 8.30, measurements of radon decay products are a better measure for worker dose than measurements of radon. Therefore, measurements of radon decay products will be made in the facility. Working level (WL) measurements for radon decay products will be made on a monthly basis in areas where radon decay product concentrations are likely to exceed 0.03 WL as described in RG 8.30. The time, date, and state of operation of the equipment in the vicinity of the measurement will be recorded. Refer to section 5.0 Operations for a detailed description of the radon and radon decay products monitoring program and the proposed locations of monitoring stations.

The primary radioactive airborne effluent at the Dewey-Burdock ISL Facility will be radon-222 gas. Radon-222 is dissolved in the pregnant lixiviant that comes from the well field into the facility for separation of uranium. At the locations where the lixiviant solution is initially exposed to atmospheric pressure and ambient temperatures, radon gas will be evolved. These locations constitute primary release points and are expected to include the IX vessels into which the lixiviant is directed for loading of the uranium onto resin and the elevated shaker screens, which will receive the loaded resin prior to elution (NMA 2007, Brown 1982, 2007, 2008). The IX vessels will normally operate as sealed, pressurized vessels, so that radon releases from the IX vessels will only occur during resin transfer operations. Dedicated local exhaust at the IX vessels and shaker screens will be directed to a manifold that is exhausted to the atmosphere outside the building via an induced draft fan. The primary release point will be located away from building intakes to prevent introducing exhausted radon back into the facility. Exhausting radon-222 gas to the atmosphere outside the plant minimizes opportunity for in-growth of radon particulate daughter products (progeny) in occupied work areas and therefore minimizes employee airborne exposure. Small amounts of radon-222 may also be released from the well field, solution spills, filter changes, 11e (2) by-product impoundment areas, reverse osmosis (RO) system operation during groundwater restoration, and maintenance activities. These secondary and/or infrequent additional releases would be quite small relative to radon dissolved in the pregnant lixiviant returning from underground. Radon releases associated with these secondary release points have been shown to be minor components of the overall facility radon-222 source term. (NMA 2007, Marple and Dziuk 1982, Brown 1980, 2007, 2008). An operational monitoring program will be utilized that is similar to the preoperational monitoring program set up to measure radionuclide particulates and radon -222 that may result in the atmosphere outside the building and other specified locations within the PA.

The filters from air samplers operating continuously will be analyzed quarterly for natural uranium, thorium-230, radium-226, and lead-210. Samplers will have sensors to measure total air flow within a sampling period. Passive track-etch detectors will be deployed at each station for monitoring radon-222 on a quarterly basis. The maximum LLDs for the analyses will be consistent with the recommendations of RG 4.14. Additionally, effluent release points from the yellowcake dryer and packaging will be sampled quarterly. The grab samples will be isokinetic in nature and will be analyzed for natural uranium, thorium-230, radium-226, and lead-210. The maximum LLDs for the analyses will be consistent with recommendations of RG 4.14. Refer to section 5.0 Operations for a detailed description of the particulate air monitoring program and the proposed locations of monitoring stations.

The general HVAC system in the plant will further reduce employee exposure by removing radon from plant air and will be exhausted through a separate vent. This system will be connected via ductwork and manifolds to the eluant and precipitation tanks. Potential release points as well as general air in the plant will be routinely sampled for radon daughters to assure that concentration levels of radon and progeny are maintained as low as reasonably achievable (ALARA). Sampling and monitoring methods specific for radon progeny will be used (USNRC 2002a). Results of monitoring obtained during initial plant operation will be used to adjust monitoring programs (location, frequency, etc), upgrade ventilation and/or other effluent control equipment as may be necessary.

Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. Redundancy of fans will minimize employee exposures should any single fan fail. Discharge points will be located away from building ventilation intakes to prevent introducing exhausted radon back into the facility (NRC 2002b). Airflow through any openings in the vessels will be from the process area into the vessel and then into the ventilation systems, maintaining negative flow into the vessel and controlling any releases. (note that the lixiviant circuit through IX will be a closed system; atmospheric conditions will initially be encountered during resin transfer at the shaker screens.) Tank ventilation of this type has been successfully utilized at other ISL facilities and proven to be an effective method for minimizing employee exposure. (Brown 1982, 2007, 2008)

The general building ventilation system will be designed to maintain air flow from the least likely to most likely process areas with potential for airborne releases and then exhaust to outside areas. Ventilation systems will exhaust outside the building and draw in fresh air. During favorable weather conditions, open doorways and convection vents in the roof will provide supplemental work area ventilation. Refer to Section 5.7.3.1 for additional discussion of radon released under such conditions.

Section 7.3 describes methods used to estimate potential radiological impacts resulting from planned activities to members of the public near the proposed facility. The CPP will be located near the center of the license area, and the radon exhaust point will be located on or near the CPP roof. Based on use of modern ISR equipment, engineering controls such as building ventilation, and routine sampling and monitoring described below, radon effluent and worker exposure to radon decay products will be maintained at levels that are ALARA. As described in Section 5.7.7, the highest predicted Total Effective Dose Equivalent (TEDE) to a resident is 2.21 mrem per year for an adult, which is in compliance with the requirements of 10 CFR §20.1302.

To ensure effluents are ALARA, Powertech has committed to use sealed, pressurized, downflow IX vessels to limit routine radon-222 emissions from the CPP or Satellite Facility to resin transfer operations only. The radon emissions from the resin transfer operation will be exhausted using a dedicated ventilation system and released via a primary release point on or near the roof of the facility. The primary release point will be located away from building intakes to prevent introducing exhausted radon back into the facility. The normal HVAC system will also aid in reducing radon-222 and decay product concentrations within the facility. Potential release points as well as general air in the plant will be routinely sampled for radon and decay products to assure concentration levels are maintained ALARA. Results of monitoring obtained during initial plant operation will be used to adjust monitoring programs and upgrade ventilation and/or other effluent control equipment as necessary.

4.1.2 Radionuclide Particulates

Since there will be no ore grinding at the facility, no monitoring of airborne uranium ore dust will be necessary. However, airborne yellowcake will be monitored at the facility. The facility will be drying yellowcake under low temperature (less than 400 °C). According to the footnotes of 10 CFR 20 Appendix B, yellowcake dried under low temperature should be considered soluble. Refer to Section 5.7.3.2 for additional explanation. Weekly 30 minute grab samples (low volume breathing zone samples) will be taken in airborne radioactivity areas. Breathing zone samples provide a better estimate of airborne particulate concentrations to which workers are exposed, resulting in a more representative estimate of actual intakes. The sensitivity of this method shall be at least 1×10^{-11} µCi / mL. Breathing zone samples will be taken during non-routine operations with potential for a worker to receive exposure to airborne yellowcake above 1×10^{-10} µCi / mL. Refer to section 5.0 Operations for a detailed description of the radon and radon decay products monitoring program and the proposed locations of monitoring stations.

Potential radiological air particulate effluents are generated primarily from dried uranium concentrate in the yellowcake drying and processing areas. Following precipitation, the uranium concentrate is fed to a gravity thickener. The gravity-thickened yellowcake solids solution will be pumped into a plate and frame filter press for dewatering from which the product is only at an approximately 60 percent solids content. Dewatered yellowcake drops from the filter press into a live bottom hopper with a screw auger to move the pressed yellowcake slurry to a sump where a progressing-cavity positive displacement pump transfers the yellowcake to the dryers. Although minor spills can occur during the thickening and dewatering process, they will be cleaned up quickly and subsequently surveyed to minimize any potential airborne source.

4.1.2.1 Yellowcake Drying and Packaging

The yellowcake drying and packaging area at the Dewey-Burdock ISL facility will be serviced by a dedicated ventilation system. By design, vacuum dryers do not discharge uranium for the following reasons. The vacuum drying system is proven technology, which is being used successfully at several facilities where uranium oxide is being produced, including ISL facilities (NMA 2007). The off gas treatment system of the vacuum dryers includes a baghouse, condenser, vacuum pump, and packaging hood. The potential radionuclide particulate releases from the drying process and associated off gas treatment system are discussed below.

The yellowcake will be dried at approximately 250 degrees Fahrenheit (°F) in the rotary vacuum drying process. The off gases generated during the drying cycle are filtered through a baghouse, which is located on the top of the dryer, to remove particles down to approximately 1 micron in size. The gases are then cooled and scrubbed in a surface condenser to further remove the smaller size fraction particulates and the water vapor during the drying process. Two rotary vacuum dryers will be located in a separate building attached to the CPP. This attached building will contain the dryers, the baghouses on the dryers, and a condenser scrubber and vacuum pump system for each dryer. The dryers will be heated with a heat transfer fluid (HTF) that circulates through the shell and the rotating central shaft. The heat transfer fluid will be heated by two natural gas or propane-fired HTF heaters, each provided with HTF pumps for circulating the HTF through the shell and central shaft of the dryer. The HTF heaters and pumps will be in a separate structure attached to the back of the dryer building. The water-sealed vacuum pumps will provide the vacuum source while the dryer is being loaded and while the yellowcake is unloaded into drums.

The vacuum dryers are steel vessels heated externally as described above and fitted with rotating plows to stir the yellowcake. The chamber will have a top port for loading the wet yellowcake and a bottom port for unloading the dry powder. A third port will be provided for venting through the baghouse during the drying procedure. The baghouse and vapor filtration unit will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The baghouse will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system.

The condenser will be located downstream of the baghouse and will be water cooled. It will be used to remove the water vapor from the non-condensable gases emanating from the drying chamber. The gases are moved through the condenser by the vacuum system. Dust passing through the bag filters is wetted and entrained in the condensing moisture within this unit. The vacuum pump will be rotary water sealed providing negative pressure on the entire system during the drying cycle. It will also be used to provide negative pressure during transfer of the dry powder from the drying chamber to 55-gallon steel drums. The water seal of the rotary vacuum pump captures entrained particulate matter remaining in the gas streams.

The packaging system will be operated on a batch basis. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a bottom port into 55-gallon steel drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture will be provided by a sealed hood that fits on the top of the drum, which will be vented through a sock filter to the condenser and the vacuum pump system when the powder is being transferred.

4.1.2.2 Atmospheric Discharges from the Yellowcake Drying and Packaging System

There are three discharge locations associated with the yellowcake drying and packaging system. These include: i) the yellowcake discharge valve located directly below the dryer, through which drums are filled with yellowcake, ii) the condensed water vapor that is removed from the condenser and recycled to the yellowcake thickener, and iii) very small amounts of air that are drawn through the vacuum pump and are exhausted into the dryer room of the CPP. The system of treating gases emanating from the dryer chamber with bag house filters and water condenser is designed to capture virtually all particles from the vapor stream leaving the dryer (NUREG-1910, pg. 2-25). Furthermore, NUREG-1569, Section 7.3.1.2.2 states, "When a vacuum dryer is used for yellowcake, then dust emissions from drying may also be assumed to be negligible."

Points of discharge will be routinely monitored via filter collection and radiochemical analysis for Natural U, Th 230, Ra 226 and Pb 210 to ensure radionuclide effluent releases are maintained ALARA. The water that is collected from the condenser will be recycled to the precipitation circuit, eluant makeup, or disposed with other process water. General plant air will be monitored routinely for airborne radionuclides.

The system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures. The system will alarm if there is an indication that the emission control system is not performing within operating specifications. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition, and the dryer will not be unloaded or reloaded until the emission control system is returned to normal service.

To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signal an audible alarm at the dryer and in the CPP control room if the air pressure (i.e. vacuum level) falls below the specified threshold. The operation of this system is routinely monitored during dryer operations. The operator will perform a manual check of the vacuum alarm before each packaging event and document inspections of the vacuum level hourly or more frequently during dryer operations. Additionally, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

4.1.3 Other Airborne Emissions

Other emissions to the air are possible from limited vehicular traffic (exhaust and dust). Potential impacts from potential emissions from process chemicals that will be used at the plant are described in Section 7.5. There will not be any significant combustion related emissions from the process facility as commercial electrical power is available to the site.

4.1.4 Accident Scenarios

The accident scenarios with potential to occur at the facility are those typical of other ISR facilities. These scenarios have been evaluated in NUREG/CR-6733, A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees (NRC, 2001) and are discussed below. Three primary engineering controls that will exist at the site include 1) downflow pressurized IX columns, 2) building ventilation, and 3) use of a modern vacuum yellowcake dryer. Also included in the engineering controls will be alarms to indicate suboptimal operating conditions of the effluent control systems and concrete curbs and sumps to contain any process spills. Administrative controls such as training for emergency scenarios will be in place to provide appropriate worker protection in the event the effluent control systems fail under an emergency situation. In brief, the engineering controls coupled with appropriate administrative controls will mitigate any potential health and safety impacts of system failures at the facility.

NRC has evaluated likely accident scenarios and the associated radiological consequences for a typical ISR facility. This analysis is contained in NUREG/CR-6733. A series of potential accident scenarios which could occur in the CPP or Satellite Facility area were evaluated and included the following:

- Yellowcake thickener failure and spill
- Radon release in enclosed process areas
- Pregnant lixiviant and loaded resin spills
- Yellowcake dryer hazard analysis

The estimated radiological consequence resulting from these accidents ranged from no significant radiological exposures, in the case of the thickener failure and pregnant lixiviant/loaded resin spill, to a significant radiological exposure which could result in doses to workers exceeding those allowed in 10 CFR Part 20. Due to the short term nature of the above scenarios and assuming spills and releases are mitigated promptly, no scenario was expected to result in a significant estimated radiological dose to members of the public.

Given the accident scenarios described above, if effluent controls are operable during and while responding to the accident, they will reduce the potential radiological consequence to the workers involved in the response by reducing airborne radionuclide concentrations. If the effluent controls are not operable because of the accident, this reduction in airborne radionuclide concentrations would not occur and administrative controls and personal protective equipment would play a larger role in minimizing worker doses.

During an accident, administrative controls will be in place such as standard operating procedures for spill response and cleanup, programs for radiation and occupational monitoring, and training for workers in radiological health and emergency response. Administrative controls coupled with proper use of personal protective equipment (PPE) such as respirators are the best tools to reduce worker doses and will be provided.

Other approaches to mitigate system failures that may result in exceeding exposure limits include but are not necessarily limited to the following:

1) A team of responders, trained for radiation health and emergency response, will be available. Specific training will include: response monitoring, PPE use and response to fires, large lixiviant spills or ion-exchange system failure.
2) Powertech (USA) will train local emergency response personnel in the potential hazards present within the project area.
3) A yellowcake thickener failure and spill will result in the immediate evacuation of normal operating personnel within the spill area and cleanup of the saturated product prior to drying. Employees performing the cleanup will utilize the appropriate PPE to minimize exposure to any product that may dry during cleanup. Yellowcake residue that may remain within the thickener area will be washed into a sump, thus mitigating the potential for exposure to employees.
4) Radon release into an enclosed area will result in an immediate evacuation within the release area of normal operating personnel, manual shutdown of the release point (if automated shutoff system failed) and promotion of ventilation within the area manually (if automated ventilation system failed). Employees performing manual shutdown within the area of the release will utilize the appropriate PPE (such as atmosphere-supplying respirators designed to protect against gases) to minimize exposure to radon and radon decay products. Radon samples will be taken and if above normal working levels, workers will remain evacuated and only return to normal duties within the release area upon re-establishment of normal working levels.
5) A pregnant lixiviant spill will be mitigated in a manner consistent with the location and degree of spill. Normal operating employees within the spill area will be evacuated. Response personnel will utilize the appropriate PPE to protect against radon and radon decay products exposure as discussed above and cleanup will result.

A yellowcake dryer upset response would be dictated by the severity of the upset.

Mitigation response may include a combination of additional site-specific response actions such as:

- Workers, including the spill response team, will have access to respiratory equipment in the yellowcake dryer area.
- All practicable measures will be taken to control emissions at the source. The operator will reduce exposure to airborne effluent releases by implementing emission controls (such as wetting) and institutional controls (such as extending the area of upset so as to exclude any personnel not responding to the upset).
- Siting of the CPP near the center of the license area will serve to protect against off-site exposures in the event of a yellowcake dryer upset.
- Individual dose standards will be strictly implemented to assure exposures are limited and reduced to the maximum extent reasonably achievable and to limit contamination to the designated upset area.
- All drying and packaging operations will terminate until cleanup is complete, the area has been cleared for potential exposure, and equipment has been restored to proper operating conditions and efficiencies.
- Cessations, corrective actions and restarts will be reported to the NRC within 10 days of the upset or off-normal performance.

4.2 Liquid Waste

4.2.1 Sources of Liquid Waste

Several sources of liquid waste are collected as a result of ISL production:

- Storm water runoff
- Waste petroleum products and chemicals
- Domestic sewage and
- Three types of byproduct materials

According to the latest interpretation concerning 11e.(2) defined in Chapter 2, Section 11 of the AEA of 1954, more fluid type wastes are associated in order to provide regulation within the ISL industry (NUREG-1575, 2000). Three types of liquid waste fall within the confines of the 11e.(2) definition:

- Liquid process wastes, such as production bleed, resin transfer water and brine generated from the elution and precipitation circuits;

- Groundwater generated during aquifer restoration; and
- Affected groundwater generated during well development.

The following sections presents potential liquid waste sources and effluent controls to be utilized during process operations at the Dewey-Burdock project.

4.2.1.1 Liquid Process Waste

The primary source of liquid waste, as previously discussed in Section 3.0, is the operation of the IX process which generates production bleed. Other sources of liquid waste from the CPP include laboratory chemicals, laundry water, plant wash down water and the waste brine 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 Dewey-Burdock facility. Liquid process waste will either be sent to a deep disposal well or will be treated with barium chloride and then used for land application within the project area using center-pivot sprinklers (refer to Section 4.2.2).

4.2.1.2 Aquifer Restoration

During aquifer restoration, the technology selected will depend on the liquid waste disposal option. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. Additional information about aquifer restoration methods is provided in Section 6.1.3.

4.2.1.3 Water Collected from Well Field Development

During well development or redevelopment, water will be collected, treated and the waste will be disposed of via a deep disposal well or treatment and land application. Water from injection lixiviant or recovery fluids recovered from areas where a liquid release has occurred from a pipeline or well will be placed into the wastewater disposal system for either deep well disposal or treatment and land application.

4.2.1.4 Storm Water Runoff

Another source of liquid waste is stormwater runoff. DENR is responsible for administering the stormwater management program that is closely modeled after the federal National Pollutant Discharge Elimination System (NPDES) program. Facility drainage will be designed to route stormwater runoff either away from or around the plant, ancillary buildings and parking areas, and chemical storage. The design of the project facilities, combined with engineering and procedural controls contained in a Best Management Practices (BMP) Plan, will ensure that stormwater runoff is not a potential source of pollution.

4.2.2 Liquid Waste Disposal

Powertech (USA) proposes two options for liquid waste disposal at the Dewey-Burdock Project. Liquid waste includes the production bleed, groundwater generated during aquifer restoration, process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), affected well development water, laboratory wastewater, laundry water, and plant wash down water. The preferred disposal option is underground injection of treated liquid waste in non-hazardous Class V deep disposal wells (DDWs). In this disposal option liquid waste will be treated to satisfy EPA non-hazardous waste requirements and injected into the Minnelusa and/or Deadwood Formations in four to eight DDWs being permitted pursuant to the SDWA through the EPA UIC Program. Further details about the proposed DDW liquid waste disposal option are presented below, including information about the pending UIC permit. Powertech (USA) will provide updated information regarding its Class V application when appropriate milestones are reached. It is anticipated that all liquid waste will be disposed using this option if sufficient capacity is available in DDWs.

The alternate liquid waste disposal option is land application. This option involves treatment in lined settling ponds followed by seasonal application of treated liquid waste through center pivot sprinklers. Land application, if used, will be carried out under a Groundwater Discharge Plan (GDP) permit through the SD DENR. Depending on the availability and capacity of DDWs, Powertech (USA) may use land application in conjunction with DDWs or by itself. Additional details about the design and permitting status of the land application system are provided below.

4.2.2.1 Land Application

Land application, if used, will be carried out under a GDP permit through SD DENR. A copy of the SD DENR application to permit land application of treated liquid waste has been provided to NRC (see ML12089A360). The land application system will consist of irrigation center pivots, associated pumps and piping, radium settling ponds, and outlet and storage ponds.

Two general land application areas are proposed for liquid waste disposal within the project area, one near the Dewey Satellite Facility and one near the Burdock CPP. Each land application area is anticipated to have 315 acres of irrigated area consisting of individual 50-, 25-, and 15-acre center pivots. In addition each site also will have approximately 65 acres of center pivots on standby, which can be used during repairs and maintenance of other center pivots or used on a rotating basis. The total land application area at the project will be 760 acres, with only 630 acres needed for design flow rates. Center pivot irrigation systems will typically operate 24 hours per day during the growing season, which is approximately April through October. During winter months, when land application will not be used, the treated liquid waste stream will be temporarily stored in storage ponds, which will be located near both the Dewey and Burdock processing facilities. Section 3.1.6.1 contains more specific information concerning pond sizes and functions.

Disposal capacity for the land application system was estimated using the SPAW (Soil-Plant-Atmosphere-Water) model, which is described below. In addition to estimating the water budget for agricultural landscapes, the SPAW model also was used to estimate the water budget for impoundments.

In the land application option, groundwater withdrawn during aquifer restoration will not be treated with RO. Instead, the aquifer restoration water will be disposed directly in land application systems following treatment to remove uranium and radium. The typical liquid waste flows using the land application option are 47 gpm during uranium recovery without concurrent restoration, 547 gpm during concurrent uranium recovery and aquifer restoration, and about 500 gpm during aquifer restoration only.

In the land application option, pumping will occur 24 hours a day. The estimated daily water budgets obtained from SPAW modeling indicate that each land application area will be capable of disposing approximately 297 gpm from March 29 to May 10, about 653 gpm from May 11 to September 24, and approximately 297 gpm from September 25 to October 31. Normally there will not be land application disposal from approximately October 31 to March 29. Detailed information regarding the SPAW model inputs and outputs are discussed in Appendix D to the Pond Design Report, which is provided as Appendix 3.1-A of the approved license application.

The land application system will be capable of handling all of the expected liquid waste throughout each phase of the project. During the winter months liquid waste will be stored in ponds, which are described in more detail in Sections 3.1.6.1. The capacity required to store the liquid waste throughout the winter months was calculated using the SPAW model to be approximately 216 acre-feet. By comparison, the total storage pond capacity under the land application option will be approximately 510 acre-feet, not including spare storage ponds. The combined capacity of both areas will be more than sufficient to dispose of the liquid waste stream during the spring, summer, and fall months. In addition, adequate excess capacity will be present during these months to dispose of stored surplus liquid waste from the winter months. Figure 3.1-1 depicts the proposed facilities in the land application option. The water balance for the land application option is presented in Section 4.2.2.4. Water treatment is discussed in Section 3.1.6.4.

4.2.2.1.1 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.

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.

4.2.2.1.2 Model Input Parameters

4.2.2.1.2.1 Meteorological Parameters

The local climate at the project site is continental, with hot summers, cold winters, and an average annual precipitation of 16.4 inches. The wettest months are from April to September. May and June are the months of highest average precipitation, with occasional thunderstorms that can be severe. Typical daytime temperatures range from 35 degrees Fahrenheit (°F) in January to 85 °F in July, with nighttime temperatures dropping by approximately 15 to 30 °F.

Because of limited on-site climatic data, twenty-eight years of daily precipitation and temperature values (from 1980 to 2007) from the nearest available meteorological station at Edgemont, South Dakota were downloaded from the National Climatic Data Center and used as input data for the SPAW Model. The Edgemont station is approximately 13 miles southeast of the site at an elevation of 3460 feet above mean sea level (amsl). The project plant site is at 3720 feet amsl. Table 4.2-1 shows the average monthly air temperature data at the Edgemont station for the 28-year period of record.

Table 4.2-1: Average Monthly and Annual Air Temperature at Edgemont, SD Station (°F)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
22.6	26.8	36.6	46.7	56.9	66.4	74.3	72.5	61.3	47.8	33.0	22.6	47.3

4.2.2.1.2.1.1 Precipitation

Daily precipitation values for the 28-year period of record from the Edgemont station were used as input data for the SPAW Model. Where daily data were absent in the record, the daily average for that month from the 28-yr record was used. No adjustments were made to the precipitation values for the 260-foot elevation difference between the Edgemont station and the project site. Table 4.2-2 shows the average monthly precipitation at the Edgemont station for the 28-yr period of record.

Table 4.2-2: Average Monthly and Annual Precipitation at Edgemont, SD Station (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.33	0.50	1.09	1.87	2.48	2.60	2.17	1.59	1.38	1.31	0.69	0.43	16.44

4.2.2.1.2.1.2 Potential Evapotranspiration

The SPAW model requires daily potential evapotranspiration (PET) data. Lake evaporation is a close estimate of PET, and is similar to PET values estimated using the Penman method. The mean annual lake evaporation (PET equivalent) at the site was determined to be 44 inches using the Evaporation Atlas for the Contiguous 48 United States (Farnsworth and Thompson, 1982). The monthly PET was calculated by applying the values for the monthly distribution of evaporation for the north central United States that are contained in the SPAW model. The daily PET for each month was then calculated by dividing the monthly PET by the number of days in the month. Table 4.2-3 shows the estimated average monthly and annual potential evapotranspiration at the site that was calculated using this method.

Table 4.2-3: Average Monthly and Annual Potential Evapotranspiration at Project Site (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.92	1.23	1.98	3.30	4.40	5.76	7.08	6.95	5.50	3.74	2.02	1.10	44.0

4.2.2.1.2.2 Material Properties

To characterize the soils at the site, eleven test pits were excavated on July 11 and 12, 2008. Samples were collected at various depths and analyzed for particle size distribution, dry bulk density, permeability, and other geotechnical parameters. Test pits 1 through 5 were excavated at the Dewey land application area, and test pits 6 through 11 were excavated at the Burdock land application area. The test pit locations are shown on Plate 2.5-1. Table 4.2-4 shows the USDA soil texture and dry bulk density for the test pit samples. These are the parameters that are used as input to the SPAW model.

Natural Resources Conservation Service (NRCS) soil survey maps for the PA were downloaded from the NRCS Web Soil Survey. The particle size distributions for the NRCS soil mapping units were compared to the laboratory particle size distributions for the test pit soil samples. This comparison showed that the laboratory results for the test pit samples generally fell within the range of particle size distributions for the NRCS survey soil mapping units.

In addition to soil data from test pits, soil samples were obtained from 37 auger holes of which 18 were at the Dewey site and 19 were at the Burdock site located as shown on Plate 2.5-1. Soil samples were collected by BKS at various depths and analyzed for selected physical/chemical characteristics including saturated paste extracts for electrical conductivity (EC), pH, Ca, Mg, Na, Cl, SO_4, HCO_3, As, Ba, Cd, Cr, Pb, Hg, Se, and Ag. USDA percent sand, silt and clay, as well as organic matter, natural moisture content, and saturation moisture content also were determined. Table 4.2-5 summarizes average values at each site for EC, pH, organic matter, Ca, Mg, Na, sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), residual sodium carbonate (RSC), USDA soil texture, and as concentrations for the upper soil layer (0 to 11 inches below ground surface) and the deeper soil layer (approximately 50 inches below ground surface) for the auger samples. These are the parameters that are used to assess the success of growing alfalfa using the treated process water.

Table 4.2-4: Summary of Test Pit Soil Properties USDA Soil Texture Class and Dry Bulk Densities

Sample No.	Depth	Gravel	Sand	Silt	Clay	Dry Bulk Density
Units:	(ft)	% by wt	% by wt	% by wt	% by wt	(lb/ft^3)
TP01-1	1	0.20	26.20	38.00	35.60	N/A
TP01-3	3	0.10	25.70	27.20	47.00	101.20
TP01-7	7	0.90	8.10	57.20	33.80	86.30
TP02-1	1	0.00	19.90	40.70	39.40	94.50
TP02-4	4	0.00	16.70	34.60	48.70	101.50
TP02-7	7	0.20	26.70	34.80	38.30	92.50
TP03-1	1	0.00	24.30	24.80	50.90	90.00
TP03-7	7	0.00	2.40	25.10	72.50	104.60
TP03-11	11	60.00	25.00	8.90	6.10	
TP04-1	1	2.20	47.80	18.20	31.80	98.10
TP04-7	7	1.30	27.50	28.00	43.20	113.30
TP05-1	1	1.50	24.00	31.60	42.90	97.00
TP05-4	4	2.00	30.00	23.40	44.60	94.80
TP05-8	8	0.80	22.10	57.60	19.50	106.30
TP06-1	1	0.30	17.90	30.80	51.00	N/A
TP06-7	7	0.00	42.00	31.80	26.20	N/A
TP06-10	10	0.00	40.00	31.20	28.80	N/A
TP07-1	1	0.60	17.40	27.30	54.70	105.30
TP07-5	5	0.1	22.1	25.9	51.9	103.90
TP07-10	10	0.3	19.7	6.9	73.1	105.40
TP08-2	2	0.1	11.9	35.7	52.3	95.20
TP08-6	6	0.4	56.6	25.4	17.6	103.40
TP09-1	1	0.3	15.2	39	45.5	94.90
TP09-4	4	0.1	35.9	37.8	26.2	109.60
TP10-1	1	1.8	21.1	34.8	42.3	99.10
TP10-7	7	0.4	11.1	30.3	58.2	105.80

Notes: N/A = Results for these samples were not available.

Table 4.2-5: Summary of Dewey and Burdock Soil Physical/Chemical Characteristics in Land Application Areas[7]

Area	Depth	EC	pH	Organic Matter	Ca	Mg	Na	SAR	ESP[6]	USDA	As
	(in)	(mS/cm)	(std. units)	(%)	(meq/L)	(meq/L)	(meq/L)	(unitless)	(unitless)	Texture	(mg/kg)
Dewey[1]	0 - 11	1.22	6.8	1.6	4.4	2.8	6.3	3.19	3.33	C-CL-SiCL	16.8
	≈50	5.40	6.8	0.5	16.9	27.0	33.0	7.39	8.79	SiC-CL-C-SL	13.1
Dewey[3]	84	--[5]	--[5]	1.3	100.4	50.2	78.6	10.90	12.91	C	--[5]
Burdock[2]	0 - 11	1.64	7.3	1.8	8.2	4.1	5.3	1.91	1.53	C-CL-SiC	9.6
	≈50	5.98	7.7	0.7	24.5	34.7	37.5	6.16	7.26	C-CL-SiC-L	9.4
Burdock[4]	84	--[5]	--[5]	1.1	100.6	84.9	28.3	4.80	5.50	CL	--[5]

(1) Average of 18 values from auger cores. BKS Environmental Associates, Inc. (Oct. 7, 2008).
(2) Average of 19 values from auger cores. BKS Environmental Associates, Inc. (Oct. 7, 2008)
(3) Average of 3 values from test pits. Knight Piésold and Co. (2008)
(4) Average of 2 values from test pits. Knight Piésold and Co. (2008)
(5) -- means no data available.
(6) Calculated from average SAR.
(7) See Plate 2.5-1 for locations of auger cores, test pits, and irrigated areas.

Analysis of Table 4.2-5 indicates that the existing soils to be irrigated at both the Dewey and Burdock sites indicates that the existing soils are fine grained; comprised of primarily clay, clay loam, and silty clay textures. Particularly at Dewey, the sodicity of the soils, as reflected by SAR, could be a source of concern if these soils are irrigated. At both the Dewey and Burdock sites the physical/chemical constituents increase with soil depth and are typically high values below the top one-foot of soil, as would be expected in these fine-grained soils of marine sediment parent material.

The two potential issues associated with long-term application of treated process water to the Dewey and Burdock sites are changes in the physical properties of the soils (lower hydraulic conductivity and crusting) and changes to the chemical properties of the soils (increased salts and trace metals). These potential changes will be closely monitored.

4.2.2.1.2.3 Irrigation Water Properties

During land application, 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 alfalfa or other crops as shown in Table 4.2-6. Pursuant to applicable standards, irrigation water quality is commonly assessed in terms of soluble salt content, percentage of sodium, boron, and bicarbonate contents. In the case of the water used for irrigation the soluble salts are on the order of 3,000 to 4,000 µS/cm at 25 °C. 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 water erosion during 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.

(1) ESP = Exchangeable Sodium Percentage. Empirical relationship from Withers and Vipond (1980).

$$ESP = \frac{100(-0.0126 + 0.01475 * SAR)}{1 + (-0.0126 + 0.01475 * SAR)}$$

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

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

Table 4.2-6: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Production Ground Water Quality Assuming High Chloride Concentrations[4]

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				
Spec. Cond. (µS/cm)	3,000					4,000				
As	0.01					0.01				
V	<10					6				

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

Table 4.2-7 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.

4.2.2.1.3 Modeling Approach

The general assumptions for the SPAW model include the following:

1. The model is a one-dimensional vertical model.
2. The model assumes that the modeled area is spatially uniform in soil, crop and climate characteristics.
3. Model inputs and outputs are based on daily values.
4. The model does not does not include flow routing or channel descriptors.
5. Daily runoff is estimated as an equivalent depth over the simulation field by the USDA/SCS Curve Number method.
6. The field budget utilizes a one-dimensional vertical system beginning above the plant canopy and proceeding downward through the soil profile to a depth sufficient to represent the complete root penetration and subsurface hydrologic processes (lateral soil water flow is not simulated).

Specific assumptions related to this project are as follows:

1. Daily precipitation and temperature data used in the model are based on 28 years of record from the Edgemont, South Dakota station.
2. SPAW modeling was done for two land application and pond areas, the Dewey site and the Burdock site.
3. Soils data used in the modeling of the Dewey site was based on a composite of soils data from Test Pits 1, 2 and 5.
4. Soils data used in the modeling of the Burdock site was based on a composite of soils data from Test Pits 8, 9 and 10.

Table 4.2-7: 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	0.34	0.34
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 Adsorption 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-production water quality data from other ISL sites in Wyoming and Nebraska, with adjustments as necessary to account for planned post-production 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.

5. The 24/7 year-round inflow rate from process water and bleed water at each site is 310 gpm.
6. The irrigation season is from March 29 to October 31 each year (217 days).
7. Model runs were conducted assuming no crop (bare soil). This assumption ensures that the results will be conservative in terms of the resulting evapotranspiration and runoff, since it is difficult to model the response to alfalfa or other crops to the quality of the applied irrigation water and to the soil conditions present at the site.
8. The irrigation water will be applied at a rate that balances the total amount of process inflow water. The modeled application rate is 297 gpm from March 29 to May 10, 653 gpm from May 11 to September 24, and 297 gpm from September 25 to October 31.
9. Irrigation tailwater and runoff from the land application areas will be conveyed to collection areas at the edges of the land application areas and allowed to evaporate and seep into the soil.
10. The storage impoundments are designed to contain the one percent exceedance probability event (100-year event) plus 3 feet of freeboard.
11. All storage impoundments have side slopes of 3 to 1 and are 30 feet deep.

The objective of the SPAW modeling was to help design a land application system that: (1) maximizes evapotranspiration; (2) minimizes surface runoff; (3) minimizes percolation below the rooting zone; (4) minimizes the irrigated acreage required; and (5) minimizes the required volume of the storage ponds while maintaining a one percent probability that the design pond volume will be exceeded during the operating life of the facility.

SPAW modeling was performed at both the Dewey and Burdock sites. A composite of the soil properties at each site was created for use in the model using analytical data from three test pits from each site. Test pits 1, 2 and 5 were used for the Dewey site and test pits 8, 9 and 10 were used for the Burdock site. The composites were created by taking the averages of the gravel, sand and clay fractions and the dry bulk densities for each depth interval for the three test pits at each site.

The SPAW modeling assumed that the facility will operate on a year-round basis for 15 years. Twenty-eight years of daily precipitation, temperature and evaporation data from January 1, 1980 to December 31, 2007 were used to create 28 unique and equally likely simulations of the process water balance. Each simulation used 15 years of sequential climatic data corresponding to the 15 years of operation of the facility. The climatic data intervals used for each of the 28 simulations are shown in Table 4.2-8.

Field simulations using the SPAW model were run using each of the 28 climatic data intervals shown in Table 4.2-8. The results of these field simulations were used as the input to pond simulations for the same 28 climatic intervals. The result was a daily pond volume for each day of the year for each of the 28 15-year simulations.

Table 4.2-8: Sequential Water Balance Simulations

Simulation No.	15-Year Climatic Data Interval
1	01/01/1980 to 12/31/1994
2	01/01/1981 to 12/31/1995
3	01/01/1982 to 12/31/1996
4	01/01/1983 to 12/31/1997
5	01/01/1984 to 12/31/1998
6	01/01/1985 to 12/31/1999
7	01/01/1986 to 12/31/2000
8	01/01/1987 to 12/31/2001
9	01/01/1988 to 12/31/2002
10	01/01/1989 to 12/31/2003
11	01/01/1990 to 12/31/2004
12	01/01/1991 to 12/31/2005
13	01/01/1992 to 12/31/2006
14	01/01/1993 to 12/31/2007
15	01/01/1994 to 12/31/1980
16	01/01/1995 to 12/31/1981
17	01/01/1996 to 12/31/1982
18	01/01/1997 to 12/31/1983
19	01/01/1998 to 12/31/1984
20	01/01/1999 to 12/31/1985
21	01/01/2000 to 12/31/1986
22	01/01/2001 to 12/31/1987
23	01/01/2002 to 12/31/1988
24	01/01/2003 to 12/31/1989
25	01/01/2004 to 12/31/1990
26	01/01/2005 to 12/31/1991
27	01/01/2006 to 12/31/1992
28	01/01/2007 to 12/31/1993

The pond volume with a 1 percent exceedance probability during a 15-year operating period was estimated as follows. First, the average pond volume for each day during the 15-year operating period for the 28 simulations was calculated. Then, the pond volume for each day of the 15-year period with a 1 percent exceedance probability was calculated using the Grumbel Extreme Value distribution, which resulted in 5,475 possible values. The greatest of these 5,475 values was then selected as the maximum possible volume with a 1 percent exceedance probability during a 15-year period.

4.2.2.1.4 Model Results

Field Model Results

Based on the SPAW modeling, the total irrigated area at the Dewey site would be 315 acres. In addition, there would be 65 acres on standby. Pumping at Dewey would occur for 24 hours every day from March 29 to May 10 at a rate of 297 gpm; from May 11 to September 24 at a rate of 653 gpm; and from September 25 to October 31 at a rate of 297 gpm.

The irrigated area at the Burdock site would also be 315 acres, with an additional 65 acres on standby. Pumping at Burdock would also occur for 24 hours every day from March 29 to May 10 at a rate of 297 gpm; from May 11 to September 24 at a rate of 653 gpm; and from September 25 to October 31 at a rate of 297 gpm.

The annual summaries of the SPAW field modeling results for the twenty-eight 15-year simulations at both the Dewey and Burdock sites are shown in Appendix D of Appendix 3.1-A of the approved license application. The center pivot areas at both the Dewey and Burdock sites are shown on Figure 3.1-1.

Pond Model Results

Based on the assumptions listed above (Section 4.2.2.1.3), the model results showed that the total irrigation storage pond volume having a 1-percent exceedance probability is 216 acre-feet at both the Dewey and Burdock sites. An additional 31 acre-feet of capacity was added to the ponds at each site, for a total pond capacity of 247 acre-feet. This additional capacity acts as contingency storage for days at the beginning of the irrigation season when weather conditions may limit pumping for land application. Four single-lined impoundments (ponds), each with dimensions of 465 feet x 465 x 30 feet deep and a capacity of 61.8 acre-feet, will be operational at any given time at both the Dewey and Burdock sites, providing a total capacity of 247.2 acre-feet at each site. This capacity includes the volume with a 1 percent exceedance probability, plus 3 feet of freeboard. A double-lined radium settling pond with leak detection will also be constructed at each site, with an operational storage of 39.2 acre-ft, which includes sufficient capacity for the settling of barium sulfate and radium, the total volume of which over the 15-year operating life is estimated to be 0.036 acre-feet. In addition, there will be a Central Plant Pond at the Burdock site. The CPP pond will be 362 feet x 362 feet x 25 feet deep including 3 feet of freeboard, with a total capacity of 36.2 acre-feet.

The annual summaries of the SPAW pond modeling results for the twenty-eight 15-year simulations at the Burdock site are provided in Appendix D of Appendix 3.1-A of the approved license application. The climatic conditions and pond inflow rates are the same for both sites, and therefore the SPAW pond modeling results are also the same.

4.2.2.1.5 Land Application Monitoring

The land application system will be permitted through SD DENR under a Groundwater Discharge Plan permit. The system will be monitored in accordance with SD DENR requirements for potential environmental effects and to track system performance. A general summary of system monitoring is described in the following section. A detailed description of the system monitoring plan is contained in Section 6 of the Groundwater Discharge Plan permit application. The following types of samples will be collected for laboratory analysis:

- Supplemental freshwater (if needed)
- Land applied process water
- Air
- Soil
- Biomass
- Surface Water
- Groundwater

The parameters for analysis of each sample type (water, soils, vegetation and air) will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7.

4.2.2.1.5.1 Supplemental Freshwater

In the event that supplemental freshwater from the Madison aquifer or another suitable formation is used to supplement the water from the storage ponds for land application, grab samples of this supplemental freshwater will be collected in accordance with SD DENR requirements during times of use. The parameters for analysis will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7.

Samples will be collected in accordance with SD DENR requirements.

4.2.2.1.5.2 Land Applied Process Water

Grab samples of land applied process water will be collected in accordance with SD DENR requirements from a point in the distribution system downstream from the storage ponds. The parameters for analysis will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7.

4.2.2.1.5.3 Air

Locations of air monitoring stations are shown in Figure 5.7-10. The filters from air samplers operating continuously will be analyzed for at least two quarters prior to the beginning of operations, and then quarterly for the parameters provided in RG 4.14. The samplers will have sensors to measure total air flow within a sampling period. Passive track-etch detectors will be deployed at each station for monitoring radon-222 on a quarterly basis.

4.2.2.1.5.4 Soil

Soil samples will be collected from within each pivot area prior to the beginning of operations and at the end of each irrigation season after operations begin in accordance with SD DENR requirements. The parameters for analysis will be in accordance with the operational radiological monitoring program provided in RG 4.14 and selected parameters listed in Table 4.2-7. Suction lysimeters will be placed in each of the center pivot circles at both the Dewey and Burdock sites to obtain pore water samples for the physical/chemical analyses provided in RG 4.14 and selected parameters listed in Table 4.2-7. Lysimeter depths will be coordinated with SD DENR.

Pore water samples and measurements of soil moisture will be done in accordance with SD DENR requirements. Supplemental measures of hydraulic conductivity may be done if it appears to change during the operation of the irrigation systems.

4.2.2.1.5.5 Biomass

Samples of the crops or vegetation grown on the land application areas at Dewey and at Burdock will be collected at the end of each irrigation season during operations. The number of samples will be coordinated with SD DENR. Samples of livestock that have been fed crops grown on the land application pivot areas at the PA during operations will be collected once per year, shortly after slaughter. The samples of vegetation and livestock will be analyzed for the parameters provided in RG 4.14.

4.2.2.1.5.6 Surface Water

Surface water samples will be collected at operational monitoring points shown on Plate 5.7-1. Samples will be collected quarterly at each of the monitoring stations and analyzed for the parameters provided in RG 4.14 and selected parameters listed in Table 4.2-7.

4.2.2.1.5.7 Groundwater

Groundwater samples will be collected quarterly from a monitoring network established according to SD DENR requirements. These samples will be analyzed for the parameters provided in RG 4.14 and selected parameters listed in Table 4.2-7.

All sampling activities will be conducted in accordance with an approved quality assurance/quality control plan. Records of all sampling activities and laboratory analyses will be maintained and periodic reports of all sampling and analyses will be submitted to the South Dakota Department of Environment and Natural Resources (DENR).

4.2.2.2 Deep Disposal Wells

Powertech (USA) submitted a Class V UIC permit application to EPA Region 8 in March 2010 for authorization to install and operate four to eight DDWs within the project area. A copy of the permit application is provided in Appendix 2.7-L of the approved license application. Additional information is found in Section 3.1.6.3. DDWs will target the Pennsylvanian and Permian-age Minnelusa Formation and the Cambrian-age Deadwood Formation. The targeted injection interval in the Minnelusa Formation ranges from 1,615 to 2,540 feet below ground surface (bgs), and the targeted injection interval in the Deadwood Formation ranges from 3,095 to 3,530 feet bgs.

Powertech (USA) has requested an Area Permit authorizing the installation and operation of four to eight DDWs within the project area. The number of wells required will depend on well capacity. Powertech (USA) has requested authorization to inject up to 300 gpm in a maximum of eight wells. Proposed locations for the first four wells are provided in Figure 3.1-2. The initial four DDWs are proposed at two sites, one near the Dewey Satellite Facility and one near the Burdock CPP. Two disposal wells are proposed at each site with one well targeting the Minnelusa Formation and one targeting the Deadwood Formation. Based on the anticipated porosity, thickness, lateral extent, and permeability of the receiving formations, the capacity of each Class V DDW is expected to range from 50 to 75 gpm.

Prior to Class V DDW disposal, liquid waste will be treated as necessary to comply with non-hazardous Class V UIC requirements (refer to Section 3.1.6.4). Treatment will typically include removal of uranium and other dissolved species in IX columns followed by radium removal through co-precipitation with barium sulfate in radium settling ponds. Surface facilities near the Burdock CPP and Dewey Satellite Facility related to liquid waste disposal in the DDW option will include radium settling ponds, outlet and surge ponds, a Central Plant Pond located at the Burdock CPP, and surface facilities required for DDW operation such as pretreatment facilities, screen/filters, and high pressure pumps for DDWs. Proposed facilities for the deep disposal option are depicted on Figure 3.1-2.

In the DDW option, RO treatment with permeate injection will be the primary method of aquifer restoration. Groundwater withdrawn during aquifer restoration will be treated using RO, and the resulting brine will be treated and disposed with other treated liquid waste in DDWs. As described in Section 4.2.2.4, the total liquid waste flow rate will be approximately 47 gpm during uranium recovery without concurrent restoration, approximately 197 gpm during concurrent uranium recovery and restoration, and approximately 150 gpm during aquifer restoration alone. The planned DDW capacity of up to 300 gpm significantly exceeds the anticipated liquid waste flow rate in the DDW option.

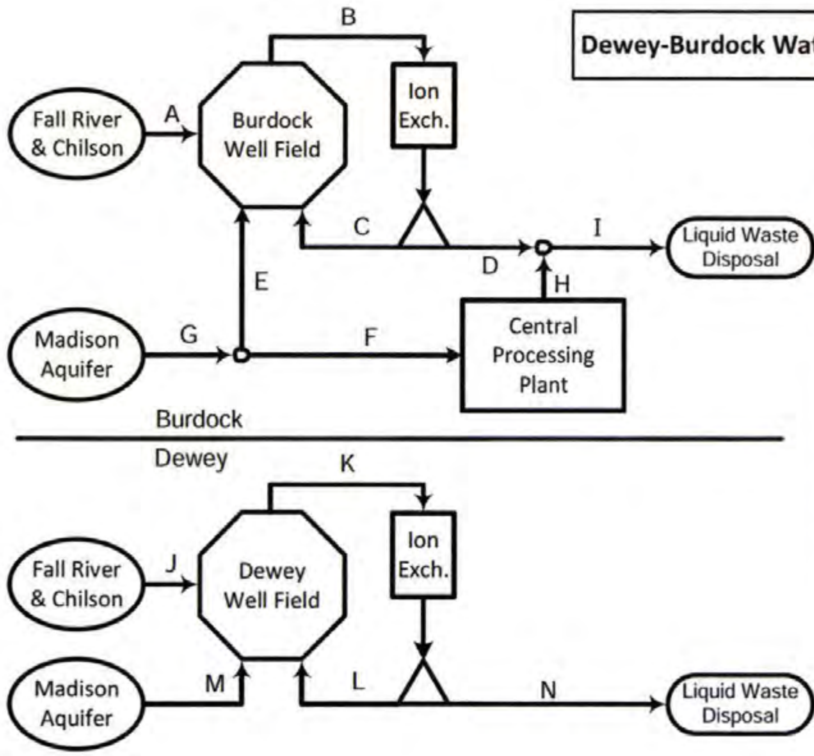
4.2.2.3 Combined Liquid Waste Disposal Option

If Class V DDWs are constructed but lack sufficient capacity to dispose of the entire liquid waste stream, Powertech (USA) will combine the use of DDWs and land application. In this option land application facilities will be constructed and used on an as-needed basis depending on the DDW capacity.

4.2.2.4 Water Balance

Typical water balances during uranium recovery and aquifer restoration are presented in Figure 4.2-1. The figure depicts typical flow rates during the uranium recovery and aquifer restoration phases. Table 4.2-10 shows the typical design flow rates during concurrent uranium recovery and

Dewey-Burdock Water Balance



Stream ID	Description
A	Burdock Aquifer Bleed
B	Burdock Extraction Composite
C	Burdock Reinjection
D	Burdock Well Field Bleed
E	Burdock Madison Make-up
F	Burdock Fresh Brine Make-up
G	Burdock Madison, Total
H	Burdock CPP Brine
I	Burdock Liquid Waste
J	Dewey Aquifer Bleed
K	Dewey Extraction Composite
L	Dewey Reinjection
M	Dewey Madison Make-up
N	Dewey Liquid Waste

Water Balance Flow Rates (gal/min)

Operation phase	Aquifer bleed option	Disposal Option	Burdock								
			Stream ID								
			A	B	C	D	E	F	G	H	I
Recovery	0.875%	DDW	21	2400	2379	21	0	12	12	12	33
		LA	21	2400	2379	21	0	12	12	12	33
Restoration	Without Groundwater Sweep	DDW	2.5	250	175	75	73	0	73	0	75
		LA	2.5	250	0	250	248	0	248	0	250
	With Groundwater Sweep	DDW	42	250	175	75	33	0	33	0	75
		LA	42	250	0	250	208	0	208	0	250

Water Balance Flow Rates (gal/min)

Operation phase	Aquifer bleed option	Disposal Option	Dewey				
			Stream ID				
			J	K	L	M	N
Recovery	0.875%	DDW	14	1600	1586	0	14
		LA	14	1600	1586	0	14
Restoration	Without Groundwater Sweep	DDW	2.5	250	175	73	75
		LA	2.5	250	0	248	250
	With Groundwater Sweep	DDW	42	250	175	33	75
		LA	42	250	0	208	250

Figure 4.2-1: Typical Project-wide Flow Rates during Uranium Recovery and Aquifer Restoration

Table 4.2-10: Typical Project-Wide Flow Rates during Concurrent Uranium Recovery and Aquifer Restoration

Typical Project-wide Flow Rates		Disposal Option			
		Deep Disposal Well		Land Application	
Restoration Option		Without Groundwater Sweep	With Groundwater Sweep	Without Groundwater Sweep	With Groundwater Sweep
Fall River & Chilson	gal/min	40	118	40	118
Madison Formation	gal/min	157	79	507	429
Wastewater Disposal	gal/min	197	197	547	547

aquifer restoration. Detailed descriptions of the water balances for the Dewey-Burdock Project are provided below along with a discussion of liquid waste disposal capacities. The water balances encompass the entire system, including the well fields, Satellite Facility, CPP and liquid waste disposal in accordance with guidance in NUREG-1569, Section 3.1.2.

4.2.2.4.1 Uranium Recovery Water Balance

During uranium recovery, the flow rates will be the same for either liquid waste disposal option. The typical production bleed will be approximately 0.875%. The typical well field production will be approximately 2,400 gpm (Stream B) from Burdock well fields and 1,600 gpm (Stream K) from Dewey wells fields. Note that these are typical flow rates provided to illustrate the water balance when the Dewey and Burdock well fields are operating simultaneously. An important value is the sum of Streams B and K, which represents the typical project-wide production flow rate. This will be approximately 4,000 gpm, which represents the average annual flow rate proposed at full production for the Dewey-Burdock Project. The proportion of the total flow originating in the Dewey and Burdock well fields will vary depending on the well field development sequence. Multiplying the typical production bleed by the typical production flow rates yields typical production bleed flow rates of 21 gpm (Stream A) at Burdock, and 14 gpm (Stream J) at Dewey. Liquid waste from uranium recovery operations at the Dewey area will consist almost entirely of production bleed. At the Burdock area, liquid waste will also include process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), affected well development water, laboratory wastewater, laundry water, and plant wash down water. Liquid waste flow rates, which are represented by Streams I and N, will typically be approximately 33 gpm and 14 gpm, respectively. As described in Section 3.1.6.4, all liquid waste will be treated prior to disposal via deep disposal wells and/or land application.

4.2.2.4.2 Aquifer Restoration Water Balance

Powertech (USA) proposes two options for disposal of liquid waste at the Dewey-Burdock Project: (1) injection of treated liquid waste in non-hazardous Class V DDWs, and/or (2) land application of treated liquid waste using center pivots. The disposal option selected will determine the method of aquifer restoration used. RO treatment with permeate injection will be used in the DDW option, and groundwater sweep with injection of clean makeup water from the Madison Formation will be used in the land application option. The aquifer restoration methods are described in detail in Section 6.1.3. Both disposal options are included in the water balance to illustrate the different liquid waste disposal flow rates in each option. In the DDW option, the groundwater withdrawn during aquifer restoration will be treated by RO. The concentrated brine solution will be disposed in the DDWs, while the permeate will be reinjected along with Madison Formation makeup water into the well fields. This will reduce the overall flow rate of liquid waste. Flow rates will be higher if land application is used, because the entire restoration stream will be disposed in the land application system.

Although a 1% restoration bleed will be adequate to maintain hydraulic control of well fields undergoing active aquifer restoration, additional bleed may be required at times. For example, additional restoration bleed may be used to recover flare of lixiviant outside of the well field pattern area. In addition to the restoration methods described above, Powertech (USA) may withdraw up to one pore volume of water through groundwater sweep over the course of aquifer restoration. This will result in an average restoration bleed of approximately 17%. The liquid waste disposal systems have been designed to accommodate both options and both options are depicted on the water balance.

The typical restoration extraction flow rate from the Dewey and Burdock well fields will be approximately 250 gpm each for a total of 500 gpm. The total project-wide restoration extraction flow rate will be approximately 500 gpm, while the specific contribution from the Dewey and Burdock well fields will vary. If groundwater sweep is not used, approximately 2.5 gpm less will be injected than is recovered. For the DDW option, RO treatment of the restoration solution typically will result in 175 gpm of permeate returning to each of the Dewey and Burdock well fields (Stream C for Burdock and Stream L for Dewey) and 75 gpm of liquid waste being routed to the DDWs (Stream I for Burdock and Stream N for Dewey). If land application is used for liquid waste disposal, all 250 gpm of the restoration extraction solution will be sent to the land application systems. In this case clean makeup water from the Madison Formation will be injected instead of permeate. Regardless of the disposal option, the balance of any water required to maintain the restoration bleed of 1% will be supplied from the Madison Formation.

If groundwater sweep of one pore volume is used, overall restoration bleed will average approximately 17%, resulting in 42 gpm being removed from the ore zone aquifer under both disposal options. Similar to the aquifer restoration option without groundwater sweep, the resulting liquid waste disposal flow rates will typically be 75 gpm for the DDW option and 250 gpm for the land application option.

Note that Streams F and H, which represent the flows from the Madison Formation to the CPP and from the CPP to liquid waste disposal, are typically zero during aquifer restoration without concurrent uranium recovery. While there will be times during this phase when liquid waste will be generated from the CPP, they will be infrequent due to the small number of resin transfers and elution and precipitation cycles during this phase. During this phase the water supply needs for the CPP will be nearly zero in the typical water balance.

4.2.2.4.3 Concurrent Uranium Recovery and Aquifer Restoration Water Balance

A typical water balance for concurrent uranium recovery and aquifer restoration is shown in Table 4.2-10. The table shows the typical combined flow from the Fall River Formation and Chilson Member and the flow from the Madison Formation. It also shows the typical liquid waste disposal flow rates under the different restoration options. The typical values for Fall River and Chilson flow rates were obtained by adding the Streams A and J in Figure 4.2-1 for both uranium recovery and aquifer restoration. The typical Madison Formation makeup water flow rate was obtained by adding Streams G and M in Figure 4.2-1 for uranium recovery and aquifer restoration. The liquid waste disposal flow rate was obtained by adding the Streams I and N in Figure 4.2-1 for uranium recovery and aquifer restoration. The typical liquid waste flow rates during concurrent uranium recovery and aquifer restoration will be approximately 197 gpm for the DDW option and 547 gpm for the land application option.

4.2.2.4.4 Liquid Waste Disposal Capacity

Liquid waste disposal capacity using land application and DDW options is discussed in Section 4.2.2.1 and 4.2.2.2, respectively. In both liquid waste disposal options the planned capacity exceeds the anticipated liquid waste flow rate.

4.2.3 Potential Pollution Events Involving Liquid Waste

Although there are potential sources of pollution at the project facility, Powertech (USA)'s Environmental Management Programs combined with existing regulatory requirements from the NRC and DENR establish a framework that significantly reduces the possibility of an event. Additionally, extensive personnel training, which is standard policy for all Powertech (USA) operations, will be implemented at the project. Detailed procedures for inspections of waste management facilities and systems will be included in Powertech's (USA)'s Environmental Management Programs, which will be tailored for use at the project.

The following represent potential sources of pollution:

- Spills from well field buildings, pipelines, and well heads
- CPP and SF
- Deep well pump houses and well heads
- Domestic liquid waste

4.2.3.1 Spills from Well Field Buildings, Pipelines, and Well Heads

There will be no process chemicals or effluents stored within well field buildings or pipelines. As such, they are not considered to be a potential source of pollutants during normal operations. However, these well field features could contribute to pollution in the unlikely event of a release of injection or recovery solutions due to pipe or well failure. The chances of such a failure are minimized by leak checking the piping prior to installation. Additionally, the flows through the pipe will be at a relatively low pressure and can easily be stopped, further reducing the chance of a spill migrating far from the source. Well field header houses will be equipped with wet alarms for early detection of leaks, further minimizing the potential for a large event. Due to a decrease in flow and pressure, large leaks in the pipe would quickly become apparent to the plant operators, and the release could be mitigated rapidly. All piping will be leak checked prior to installation and operation.

Generally, piping from the plant either to or within the well field will be constructed of PVC or high density polyethylene (HDPE) with butt welded joints or equivalent. All pipelines will be pressure tested before initial operation, and it is unlikely that a break would occur in a section of underground pipe as no additional stress is placed on the pipe. Piping from the well fields will be buried below the frost line, minimizing the possibility of an accident resulting in an event. Additionally, underground pipelines will further be protected from vehicles driving over the lines, which is a major source for potential failure. Typically, the only exposed pipes will be at the CPP, wellheads, and in the header houses in the well field, where trunk line flows and manifold pressures will be monitored for process control. All tanks and pipelines that contain fluids subject to freezing will be heat traced to maintain the contacts above the freezing point of the material. Header houses, valve vaults, and well head covers will contain electric heaters to prevent freezing temperatures from occurring in these structures (refer to Section 7.5.1.1).

Refer to Section 3.2.12 for a description of the leak detection systems that will be implemented in the well fields, pipelines and header houses. Engineering and administrative controls at the CPP will help to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.

4.2.3.2 Central Processing Plant

The CPP will serve as the hub for production operations at the project; therefore, the CPP will likely have the greatest potential for spills or accidents potentially resulting in the release of pollutants. Spills at the CPP could result from a release of process chemicals from bulk storage tanks, or from structural failure of either piping or bulk storage tanks.

Chemical storage tanks outside will be contained within a curbed area designed to accommodate at least 110 percent of the capacity of the largest tank plus a 25-year, 24-hour storm event to ensure containment during a potential precipitation event. Fuel storage tanks will be contained within concrete lined and fenced storage facility to prevent potential impacts to the surface.

The CPP will be designed such that any release of liquid waste will be contained within the structure. A concrete curb will be built around the entire process building and will be designed to contain the contents of the largest tank within the building in the event of a rupture. Refer to Section 7.5.7 for a description of the curb capacity. The pumping system will immediately be shut down in the event of a piping failure, limiting any further release. Liquid inside the CPP building, from either a spill or from washdown water, will be drained through a sump and then sent to the liquid waste system for disposal or treatment and land application.

4.2.3.3 Deep Disposal Well Pumphouses and Wellheads

Waste disposal well pumphouses and wellheads will be designed such that any release of liquids will be contained within the building or the bermed containment area surrounding the facilities. Liquid inside the building will be contained and then recycled to the liquid waste system. See also Section 3.2.12, which describes the instrumentation and control systems that will be implemented for deep disposal wells.

4.2.3.4 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.

4.3 Transportation Vehicles

An accident involving transportation vehicles to and from the project site could potentially release pollutants to the environment. Transport vehicles at the project site include, but are not limited to: vehicles delivering bulk chemical products, transport of radioactive contaminated waste from the project site to an approved disposal site, or transport of waste brines from the CPP, or from vehicles carrying dried yellowcake product from the CPP.

Chemicals and products delivered to or transported from the project site will be transported in accordance with all SDDOT regulations. As part of Powertech's (USA)'s Environmental Management Program, emergency response procedures will be developed and implemented to ensure a rapid response to any transportation incidents. All appropriate personnel will be appropriately trained in emergency response procedures to facilitate proper response from Powertech (USA) employees in transportation incidents.

4.4 Solid Waste and Contaminated Equipment

4.4.1 11e.(2) Byproduct Material

Solid 11e.(2) byproduct material generated at the site is expected to include impounded 11e.(2) byproduct material extracted directly from the ISL process (radium removal and reverse osmosis units, spent resins, etc) as well as material contaminated with radionuclide by-products (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 by-product material becomes deposited in process components. Mobilization of other uranium series radionuclides (Th 230, Pb 210) has been indicated to be minimal (Brown 1982). Two categories of radioactive solid waste (i.e., "11e.(2) by-product material") are discussed, impounded by-product material extracted directly from the process and equipment contaminated with by-product material.

4.4.1.1 *Impounded Byproduct Material*

Small volumes of solid 11e.(2) byproduct material are typically generated at ISLs 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.

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. Prior to transportation to a licensed disposal facility, byproduct material will be stored in designated storage buildings (also referred to as "byproduct storage buildings"), one located at the CPP site and one located at the SF site. These buildings will consist of a concrete slab with a containment curb surrounding the perimeter. Storage of byproduct material will be within "roll-off" containers (bins) which are both liquid tight and fully enclosed. As each storage building can accommodate two 20 cubic yard bins, the volume of byproduct material could accumulate to 30 to 40 cubic yards at each of the two storage locations prior to transport. There are two bays in each storage building, each accessed by an overhead roll-up door and allowing exchange of containers necessary for transport to a licensed 11e(2) disposal site. The concrete slabs will be designed to allow external decontamination of the roll-off bins prior to transport.

The byproduct storage buildings will allow for control of byproduct materials and specific segregation of these wastes from other non-11e(2) wastes. Typically these wastes are expected to consist of contaminated used equipment parts, personal protective equipment, and wastes from cleanup of spills or other housekeeping activities. Other waste not in contact with the uranium production process will be disposed of in regular dumpsters situated at a separate location.

Containment of these byproduct wastes within a designated, fully enclosed building will allow for proper control of the materials, monitoring, and necessary restricted access. These measures will ensure best possible control of 11e(2)solid and liquid wastes to minimize any potential exposures or contamination.

Powertech (USA) estimates that the project will produce approximately 100 yd^3 of solid or sludge 11e.(2) byproduct material per year from the radium ponds and from miscellaneous supplies. 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 site or licensed mill tailings facility in accordance with the requirements of the NRC.

4.4.1.2 Contaminated Equipment

This category of solid 11e.(2) byproduct material includes process and other ancillary equipment and materials that have become contaminated with low levels of by-product materials as a result of use and/or contact with process streams. Equipment and materials generated by this project that may become contaminated with by-product materials include items such as rags, trash, worn or replaced parts from equipment, piping, fittings, pumps, filters, protective clothing, etc. In some cases, reusable items with economic value (e.g., tools) may be decontaminated prior to release from the restricted area. If decontamination of equipment is deemed desirable and practical, surveys for residual surface contamination will be made before releasing the material from the restricted area. Decontaminated materials must have activity levels lower than those specified in Table 2 of NRC Regulatory Guide 8.30 (NRC, 2002).

4.4.2 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 kg of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. In the event that Powertech (USA) is not classified as a CESQG, Powertech (USA) will obtain the appropriate approvals or permits. 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.

4.5 Reference

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5.0 Operations

During operation of the facility, Powertech (USA) via the company's Safety and Environmental Review Panel (SERP) will ensure that the facility will apply to all applicable laws and regulations. Powertech (USA) will also maintain the health and safety of the workers, general public, and the environment while the facility is in operation. This includes maintaining potential occupational and public exposures to ionizing radiation as low as reasonably achievable (ALARA).

5.1 Corporate Organization and Administrative Procedures

This section provides functional positions within the Powertech (USA) organization that have direct responsibility to ensure corporate commitment to operating the facility in a manner that is protective of human health and the environment, including the principle of ALARA. The organizational accountability of these functional positions is also presented.

5.1.1 Corporate and Facility Organization

The organizational structure of Powertech (USA) and the facility is shown in Figures 5.1-1 and 5.1-2, respectively. The organization structure defines Chief Operating Officer (COO) as having direct supervision over the Vice President of Environmental Health & Safety and the Facility Manager of the facility.

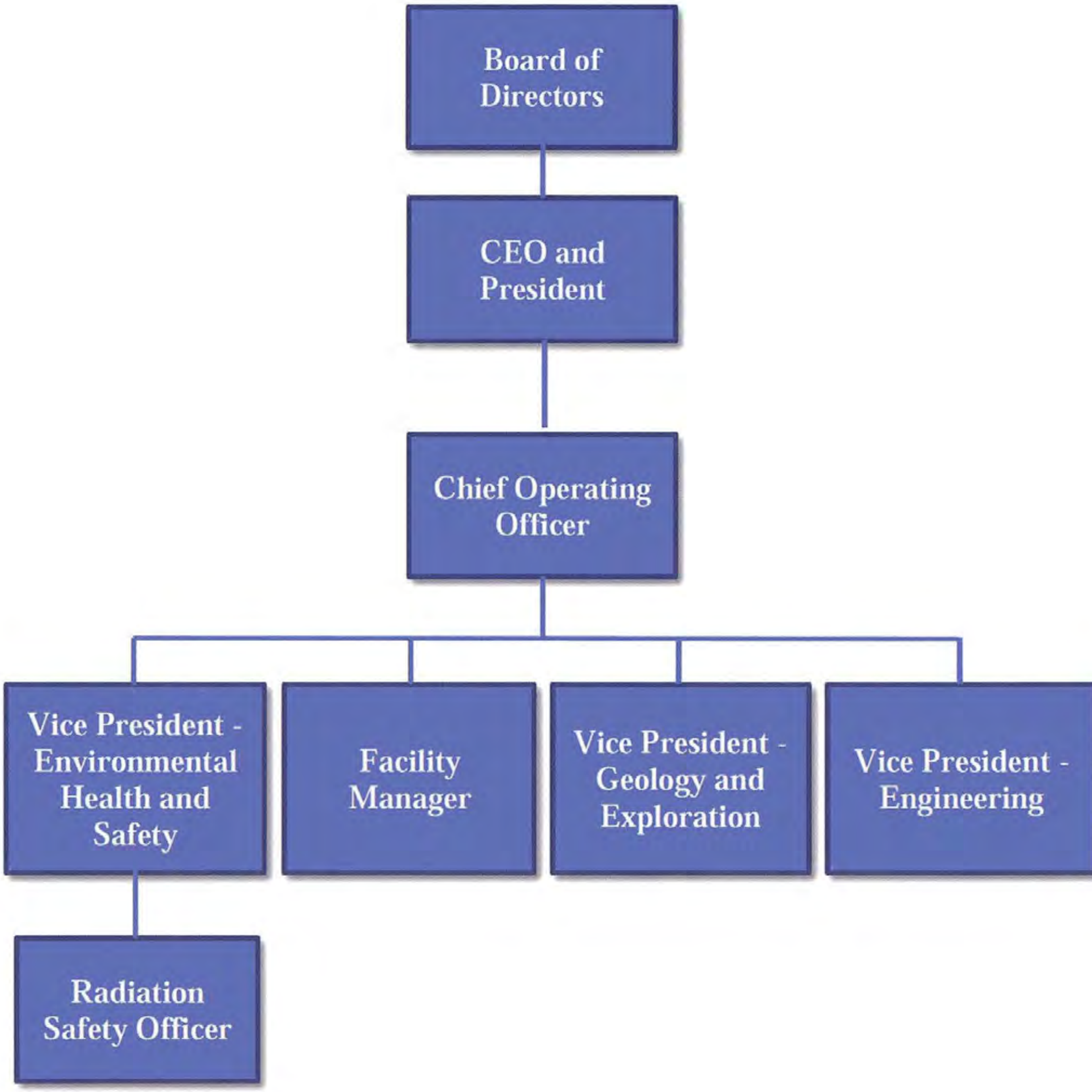


Figure 5.1-1: Organizational Structure

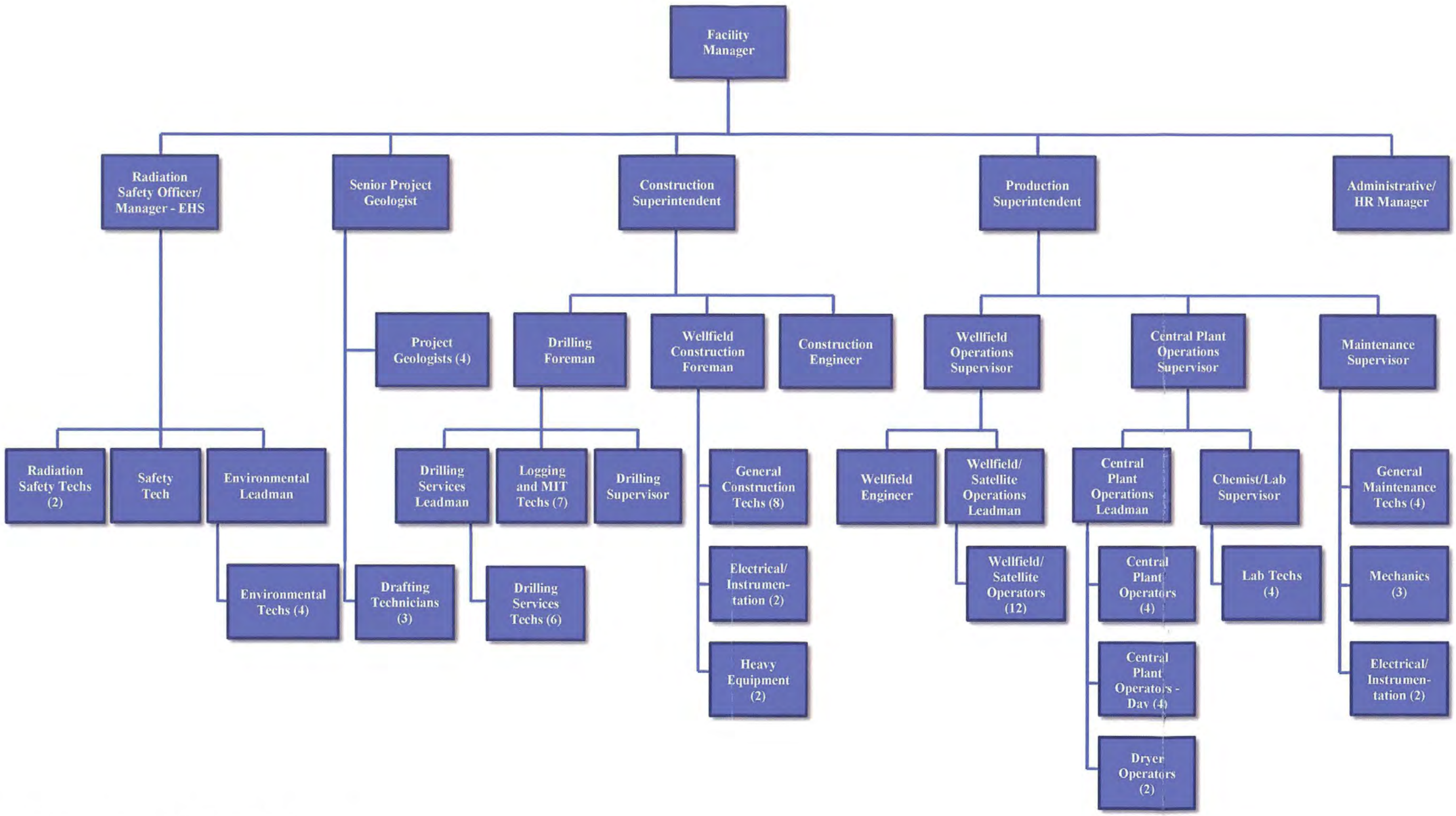


Figure 5.1-2: Facility Organizational Structure

5.1.2 Chief Operating Officer

The COO is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at all Powertech (USA) facilities. The COO is directly responsible for ensuring that Powertech (USA) personnel comply with corporate industrial safety, radiation safety, and environmental protection programs. The COO is also responsible for company compliance with all regulatory license conditions/stipulations, regulations, and reporting requirements. The COO has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees, public health, or the environment, or a violation of state or federal regulations. The COO has the authority to assign corporate resources (e.g. capital equipment, personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met.

5.1.3 Vice President of Environmental Health & Safety

The Vice President of Environmental Health & Safety is responsible for all radiation protection, health and safety, and environmental programs for Powertech (USA) and ensuring these programs meet applicable regulatory requirements and industry best management practices. The Vice President is responsible for ensuring that all company operations comply with all applicable laws and regulations. The Vice President reports directly to the COO.

5.1.4 Facility Manager

The Facility Manager will be responsible for all operations at the project facility. The Facility Manager will be responsible for compliance with all applicable laws and regulations as well as corporate health, safety and environmental programs. The Facility Manager will have the authority to terminate immediately any operation of the facility that is determined to be a threat to employees, public health, or the environment, or a violation of laws or regulations. The Facility Manager reports directly to the COO. The Facility Manager has the authority to assign facility resources (e.g. capital equipment, personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met. The Facility Manager will act promptly on recommendations made by the Radiation Safety Officer (RSO) to correct deficiencies identified in the radiation or environmental monitoring programs, but will not have the authority to unilaterally override the RSO's decision to suspend, postpone, or modify an activity.

5.1.5 Radiation Safety Officer

The Radiation Safety Officer (RSO) will be the person in charge of and responsible for the radiation protection and as low as reasonably achievable (ALARA) program. The RSO will ensure that equipment and laboratory facilities are adequate for monitoring and evaluating the relative attainment of the ALARA objective. The RSO will develop, review, and enact changes in the program so that protection against uranium and its progeny and the ALARA principle are maintained during the operation of the facility. These changes include new equipment, process changes, and changes in the operating procedures.

The RSO will possess the authority to enforce regulations and administrative policies that may affect any aspect of the radiological protection program. The RSO will have the authority to suspend, postpone, or modify any activity that the RSO determines is not in compliance with regulations and administrative policy. The RSO will also be a member of the SERP described in Section 5.2.3 and will meet the qualifications outlined in NRC guidance.

The RSO reports directly to the Vice President of Environmental Health & Safety.

5.1.6 Radiation Safety Technician

Powertech (USA) will utilize Radiation Safety Technicians (RST; also referred to as Health Physics Technicians in RG 8.31). The RST will be a member of the radiation safety staff. Qualifications and training requirements are described in Section 5.4. The RST will meet the minimum training requirements of the RSO and will be a qualified designee to replace the RSO in daily visual inspection of all work and storage areas in the facility to determine if SOPs are being followed properly and good radiation practices are being implemented and in reviewing and signing radiation work permits (RWPs). The RST will perform these functions when the RSO is not available, e.g., during off shifts.

5.2 Management Control Program

This section describes administrative controls within the Powertech (USA) organization that are intended to ensure the facility is operated in a manner that is protective of human health and the environment, including the principle of ALARA.

5.2.1 Routine Activities

All routine activities involving handling, processing, or storing of radioactive material at the Dewey-Burdock facility will be documented by written standard operating procedures (SOPs). In addition, written SOPs will be established for health physics monitoring, sampling, analysis, and instrument calibration. These SOPs involving radioactive material handling will incorporate pertinent radiation safety practices.

Each SOP will be reviewed and approved in writing by the RSO or RST prior to implementation. Any proposed changes to an SOP must also be reviewed and approved in writing by the RSO or the RST. The RSO will review each SOP at least annually to ensure it follows any newly established radiation protection practices.

Up-to-date copies of the SOPs, along with accident response and radiological fire protection plans, will be made available to all employees. All SOPs will be managed in a manner which allows for tracking of revisions and dates of the revisions.

5.2.2 Non-Routine Activities

Any activities with potential for significant exposure to radioactive material and not documented by existing SOPs will require radiation work permits (RWPs). RWPs are job-specific permits that describe the following:

1. The details of the job to be performed,
2. Precautions necessary to maintain radiation exposures ALARA, and
3. The radiological monitoring and sampling necessary before, during, and following completion of the job.

The RSO or RST must review and sign off on the RWP before the associated work is to be performed. The RST will perform this function when the RSO is not available, e.g., during off shifts. The RST will meet the RG 8.31 requirement as a member of the radiation safety staff who has specialized radiation protection training and will be authorized to review and sign RWPs when the RSO is not available.

5.2.3 Safety and Environmental Review Panel

A SERP will be established. The SERP will consist of at least three members. One member will be the RSO. Another member will be someone with authority to implement managerial and financial changes (e.g. the Facility Manager). Another member will be someone with authority to make operational changes (e.g. the Production Superintendent). The SERP may include others on a temporary or permanent basis whenever the SERP requires additional technical or scientific expertise and may be other employees or consultants. At least one member of the SERP shall be designated as chairman.

The purpose of the SERP will be to evaluate, discuss, approve, and record any changes to any SOP, the facility, or tests and experiments involving safety or the environment. The changes will not require a license amendment pursuant to 10 CFR 40.44 as long as the changes do not:

- Create a possibility of an accident unlike what is evaluated in the license application (as updated)
- Create a possibility of a malfunction of a structure, system, or control unlike what is evaluated in this license application (as updated)
- Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report or the environmental assessment or technical evaluation reports or other analyses and evaluations for license amendments

Records of the evaluations made by the SERP will be made. These records will provide the basis for determining if the implementations of the changes do not require a license amendment pursuant to 10 CFR 40.44. Any change approved by the SERP will be documented in writing by showing the affected operating procedure, facility, and/or test and experiment before and after the change along with the date of the change. Even though Powertech (USA) is a newly formed corporation, it possesses more than 200 years of technical experience with ISL operations. The SERP will evaluate each well field package as it is developed. The SERP evaluation will determine whether the results of the hydrologic testing and the planned ISR operations are consistent with SOPs and technical requirements stated in the source and byproduct material license. The evaluation will include review of the potential impacts to human health and environment. If anomalous conditions are present or the SERP evaluation indicates potential to impact human health or the environment, the well field package will be submitted to NRC for review and approval. Otherwise, the well field package and written SERP evaluation will be maintained at the site and available for NRC review.

The SERP will have the authority to raise issues regarding the health and safety of the workers, general public, and/or the environment due to the operation of the facility to the Facility Manager and the Vice President of Environmental Health & Safety.

An annual report will be prepared which describes actions taken by the SERP including changes to operating procedures, the facility, or tests and experiments that involve safety or the environment enacted since the previous report was issued. The report will also document the reason for each change, whether the change required a license amendment, and the basis for determination.

5.2.4 Radioactive Material Postings

In order to be exempted from the requirements of 20 CFR 1902(e), all entrances to the facility will be conspicuously posted with the following statement: "ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."

5.2.5 Record Keeping

All records will be maintained as hard copy originals or stored electronically.

The following information will be permanently maintained both on-site and at an off-site location until license termination:

- Records of on-site radioactive waste disposal.
- Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.
- Records of spills, excursions, facility stoppages, contamination events, and unusual occurrences.
- Records of inspections of waste retention systems.
  - Records of the occupational monitoring described in Section 5.7.
  - Information related to the radiological characterization of the facility.
  - Drawing and photographs of structures, equipment, restricted areas, wellfields, and storage areas with radioactive materials and all of their modifications.

Additionally, records of survey and calibrations will be maintained for at least 3 years.

All records will be stored in a manner to prevent record loss from fire, flood, or other unforeseen events beyond the control of Powertech (USA). All records will be legible throughout the retention period described above.

5.2.6 Reporting

Consistent with NUREG-1569, Acceptance Criterion 5.2.3(1), Powertech (USA) commits to the development of written operating procedures within the management control program to address reporting requirements in 10 CFR Part 20, Subpart M and 10 CFR §40.60. These include appropriate reporting requirements listed in RG 10.1, Compilation of Reporting Requirements for Persons Subject to NRC Regulations (NRC, 1981). Powertech (USA) will prepare the written operating procedures describing reporting requirements after license issuance but prior to ISR operations. Specific reporting requirements include, but are not limited to, the following:

- Reports of theft or loss of licensed material (10 CFR §20.2201),
- Notification of incidents (10 CFR §20.2202),
- Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the constraints or limits (10 CFR §20.2203),
- Reports of planned special exposures (10 CFR §20.2204),
- Reports to individuals of exceeding dose limits (10 CFR §20.2205),
- Reporting requirements under 10 CFR §40.60,
- Reporting requirements under 10 CFR §40.64,
- Effluent monitoring reporting requirements (10 CFR §40.65), and
- Requirements for advance notice of export shipments of natural uranium (10 CFR §40.66).

Consistent with 10 CFR 20.2202, Powertech (USA) will notify the NRC within 4 hours of any event that could cause a release of licensed material or an exposure to radiation or radioactive materials exceeding the regulatory limits.

Specific incident reporting requirements under 10 CFR §40.60 include notifying the NRC within 24 hours of any of the following events:

- An unplanned contamination event that involves a quantity of licensed material greater than 5 times the lowest annual limit on intake or requires restricted access to the contaminated area, by workers or the public, for more than 24 hours.
- Equipment necessary for control of radioactive material or radiation fails and there is no adequate redundancy/substitute.
- An event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body.
- An unplanned fire or explosion affecting the integrity of either a container of licensed material containing a quantity greater than 5 times the lowest annual limit on intake or the licensed material itself.

The NRC will be notified within 48 hours of any event in which spills, evaporation pond leaks, or excursions of source material and process chemicals occurred.

A written report will be made and sent to the NRC Headquarters Manager within 30 days of each event listed above. That report will contain details about the event including the conditions leading up to the event, corrective measures taken, and their results.

The following reports will be submitted to the NRC at the indicated frequency:

- Annually, a SERP report as described in Section 5.2.3.
- Semiannually, an effluent and environmental monitoring report as required by 10 CFR 40.65.

- Annually, the ALARA audit report detailed in Section 5.3.3.
- Annually, summary of monitoring data detailed in Section 5.7 and any corrective actions resulting from SERP actions, inspections described in Section 5.3 or reporting triggers described above.
- Annually, a Land Use Survey describing any changes to the land use within the license boundary or within 3.3 km of the license boundary in accordance with NUREG-1569, Acceptance Criterion 5.2.3(13).

5.2.7 Historic and Cultural Resources Inventory

Powertech (USA) will administer a historic and cultural resources inventory before engaging in any development activity not previously assessed by NRC or any cooperating agency. Any disturbances to be associated with such development will be addressed in compliance with the National Historic Preservation Act (NHPA), the Archeological Resources Protection Act, and their implementing regulations. Any disturbances also will be addressed in compliance with Powertech (USA)'s Memorandum of Agreement (MOA) with the South Dakota State Archeologist and any future MOAs developed by Powertech (USA) or NRC under the NHPA. Powertech (USA) executed the MOA with the South Dakota State Archeologist in September 2008. The MOA, which is provided in Appendix 2.4-B of the approved license application, establishes procedures to avoid or mitigate potential effects on archaeological and historic sites pursuant to South Dakota statutes 45-6D-14 and 45-6B.

Powertech (USA) will immediately cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Powertech (USA) will notify appropriate authorities per any license conditions and will not go forward without appropriate approvals from NRC or other agencies as appropriate. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until authorization to proceed has been received. The procedure described in this section will continue up to and through final license termination.

5.3 Management and Audit Program

This section describes management and audit programs Powertech (USA) will use to periodically evaluate compliance with and effectiveness of the radiation protection, operational monitoring, and environmental programs at the facility. A series of health physics inspections and audits of the radiation protection and ALARA programs will be conducted.

Licensee management items in Regulatory Guide 8.31, Section 1.1 are listed below followed by the appropriate section where each commitment is made within the respective discussion of the applicable program and/or management schema described.

1) A strong commitment to and continuing support for the development and implementation of the radiation protection and ALARA program.
   Addressed in Section 5.0.
2) Information and policy statements to employees, contractors, and visitors.
   Addressed in Section 5.5.
3) A periodic management audit program that reviews procedural and operational efforts to maintain exposures ALARA.
   Addressed in Section 5.3.
4) Continuing management evaluation of the radiation safety (health physics) program, its staff, and its allocation of adequate space and money.
   Addressed in Section 5.0 and Section 5.3.
5) Appropriate briefings and training in radiation safety, including ALARA concepts for all uranium employees in the facility and, when appropriate, for contractors and visitors.
   Addressed in Section 5.5, Section 3.3, Section 4.2.3, Section 5.3.4, and Section 5.4.

Powertech (USA) is confident that the information contained within the application is in line with the general operating philosophies acceptable to the NRC staff as described in Regulatory Guide 8.10. The application strongly supports the management's commitment to maintaining exposures ALARA and reducing exposures when possible. This is demonstrated throughout the report, including the following sections: 4.1.1 Radon; 4.1.2.2 Atmospheric Discharges from the Yellowcake Drying and Packaging System; 5.0 Operations; 5.1 Corporate Organization and Administrative Procedures; 5.1.5 Radiation Safety Officer; 5.2 Management Control Program; 5.3 Management and Audit Program; 5.3.4 ALARA and Radiation Protection Program; 5.5.1 Initial Training; 5.7 Radiation Safety Controls and Monitoring; 6.3.2 Preliminary Radiological Surveys and Contamination Control; 6.4.1.3 Uranium Chemical Toxicity Assessment; and 6.4.3 Surface Soil Cleanup Verification and Sampling Plans.

5.3.1 Health Physics Inspections – Daily

The RSO or RST will conduct a daily visual inspection of all work and storage areas in the facility. The purpose of these inspections is to determine if good radiation practices are being implemented properly, including minimization of contamination through proper housekeeping and cleanup, SOPs are being followed, and if issues identified in prior inspections have been addressed and corrected.

The criteria used to determine who is a qualified RST to replace the RSO in daily visual inspections of all work and storage areas in the facility to determine if SOPs are being followed properly and good radiation practices are being implemented are: A) satisfy one of the alternative requirements for education, training and experience as described in RG 8.31 and summarized in Section 5.4, and B) demonstrate a working knowledge of: i) the proper operation of health physics instruments used at the facility, ii) surveying and sampling techniques, iii) personnel dosimetry requirements, iv) which locations, operations and jobs are associated with the highest exposures, and v) why exposures may increase or decrease during work execution. The criteria are consistent with Section 2.4.2 of Regulatory Guide 8.31.

5.3.2 Health Physics Inspections – Weekly

Once a week, the RSO and Facility Manager will perform an inspection of all facility areas. The purpose of these inspections is to examine the general radiation control practices and observe the required changes in procedure and equipment.

Procedural deviation or other issues potentially affecting facility compliance, health and safety, or environmental impacts found during the inspections will be recorded in an inspection logbook or equivalent tracking system along with the date of the inspection and the signature of the inspector. These entries will be kept on file for at least a year. The RSO will discuss the problems with members of management that have the authority and responsibility to rectify them.

Additionally, the RSO will review the shift logs and daily work-orders, on a regular basis, where there was potential of exposing employees. The RSO will determine if each action was authorized in writing by a person with the proper authority (the RSO or RST).

5.3.3 Health Physics Reviews – Monthly

At least monthly, the RSO will review the results of daily and weekly inspections, including a review of all monitoring and exposure data for the month. The RSO will then write a report summarizing the significant worker protection activities for the month. The report will summarize the most recent personnel exposure data, bioassays, and time-weighted calculations for the month along with the pertinent radiation survey records for the month.

Additionally, the monthly reports will discuss any trends or deviations from the radiation protection and ALARA program, including an evaluation of the adequacy of the implementation of license conditions regarding radiation protection and ALARA. The reports will also provide a description of unresolved issues and the proposed corrective measures. Monthly summary reports will be submitted to the Facility Manager and made available to the Senior Project Geologist, Construction Superintendent, Production Superintendent, and Administrative/HR Manager. These monthly RSO reports will be maintained on file and readily accessible for at least 5 years.

5.3.4 ALARA Requirements and Radiation Protection Program

Goal of the Radiation Protection Program:

Powertech (USA) will develop, document and implement a radiation protection program commensurate with the scope and extent of the licensed activities that will ensure compliance with the provisions in 10 CFR § 20.1101. The radiation protection program will include implementing procedures and conducting operations in such a manner as to reduce airborne effluent releases to levels that are ALARA. The program's primary function will be to ensure doses to workers and members of the public are ALARA. A summary of the means by which this goal will be accomplished is described below.

Institutional Controls:

Management and Audit Program: The management and audit program will function to ensure vigilance toward the protection of human health and the environment. The management and audit program will be designed to provide quality assurance based upon reviews and evaluations of the effectiveness of radiation protection provided for workers and members of the public (MOP). Specifically, the semiannual effluent report required by 10 CFR § 40.65 will specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents during the previous six months of operation, and such other information as the NRC may require to estimate maximum potential annual radiation doses to the public resulting from effluent releases.

Powertech (USA)'s goal of the radiation protection program is to ensure doses to workers and the MOP are ALARA, consistent with 10 CFR § 20.1101(b).

Inspections and Audits Performed to Ensure ALARA Goal:

- Accident reports and corrective action plans
- Effluent monitoring programs and air emissions restriction plan
- Emergency plans
- Radiation exposure records and monitoring program
- Security of licensed materials on site

- Retention system program and reports
- Transportation of licensed material
- Environmental monitoring program
- Inspection and documentation of equipment operation to ensure the equipment is operating consistently near peak efficiency. This includes drying and packaging operations
- Other institutional controls that will be utilized to prevent and minimize the potential for exposure to MOP including the remoteness of the project area and restriction of land and groundwater use

Engineering Controls:

Constraint on Radioactive Effluents to Air: Powertech (USA) will establish a plan to restrict air emissions of radioactive material to the environment, excluding radon-222 and decay products, to ensure that the individual MOP likely to receive the highest dose will not be expected to receive a total effective dose equivalent (TEDE) in excess of 10 mrem (0.1 mSv) per year from these emissions. If an over exposure does occur, Powertech (USA) will promptly report the incident according to 10 CFR § 20.2203 and implement corrective action and preventative measures against recurrence.

Effluent Control and Monitoring: This program will establish the control and monitoring system utilized for the facility and ensure monitoring locations are optimized for the intended function. The monitoring system will be utilized to assess the worker and MOP exposures. The system will be designed in a manner that is appropriate for the types of effluent(s) generated at the facility. Adequate ventilation systems will be installed, maintained and monitored to ensure exposures are ALARA.

Waste Storage Program: Powertech (USA) will develop and implement a waste storage system that will ensure that the design and installation is conducted in such a manner as to assure any dose that may result is ALARA. A monitoring program will be established for the waste storage system that will ensure the ponds are operated and maintained in a manner that prevents the movement of waste(s) to undesirable areas. Contingency plans will be built into the program to address all reasonable system failures.

Additional engineering controls that will be utilized to minimize the potential for exposure to MOP include locating the CPP near the center of the license area, optimizing the number of well fields in operation at one time, fencing, signage, physical access controls, and groundwater monitoring systems.

The implementation of institutional and engineering controls will ensure to the extent practicable that the TEDE to individual members of the public from the licensed operation does not exceed 0.010 rem/yr (10 mrem/yr).

Public Exposure at ISR Facilities:

According to NUREG-1910 (pg. 3.2-81), the TEDE to the average U.S. resident from natural background and man-made sources is 360 mrem/yr. NRC's regulations in 10 CFR Part 20 specify annual dose limits to MOP of 1 mSv (100 mrem) TEDE (above background). The potential for exposure of MOP to TEDE greater than the annual dose limits from an ISR facility is very remote. As described in pg. 4.2-55 of NUREG-1910, "Because of the distance to offsite receptors, radiological doses from normal operations are expected to have a SMALL impact on the general public." Further, the Generic Environmental Report in Support of the Nuclear Regulatory Commission's Generic Environmental Impact Statement for In Situ Uranium Recovery Facilities (NMA, 2007) concludes, "With respect to ISR operations, the potential impacts from radiation dose are, by orders of magnitude, lower than those posed by conventional mining/milling.

"Many of the dose pathways relevant to conventional mining/milling, such as ore removal, hauling, ore storage, mill tailings, and wind-blown particulates are not present, and therefore do not pose any risk, at ISR facilities, since no ore or waste rock is brought to the surface and there are no tailings associated with ISR activities. Thus, it is anticipated that the potential doses to actual members of the public who live near ISR facilities will be significantly lower, on the order of 1 mrem/year which equates to NCRP's negligible individual risk level (NIRL). Thus, it is highly unlikely that an ISR worker, much less a member of the public [even one who works occasionally within the project area], will receive a dose in excess of 10 CFR § 20.1301 regulatory limits."

This is demonstrated in Section 5.7.7.12. The analysis presented in this section shows that public and occupational exposure to radon decay products will be far below regulatory limits.

Annual ALARA and Radiation Protection Program Audit:

The ALARA and radiation protection program will undergo audits annually. The audits will be performed by a team consisting of people who are knowledgeable about the radiation protection program at the facility. One team member will be experienced in the operational aspects of radiation protection practices specific to uranium recovery facilities. The RSO will not be a member of the audit team but will be available to support the team and provide needed information.

A written report of the audit will be sent to the Vice President of Environmental Health & Safety and Facility Manager. At a minimum, the reports will summarize the following data:

- Employee exposure records (external and internal)
- Bioassay results
- Inspection log entries and summary reports of daily, weekly, and monthly inspections
- Documented training program activities
- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on overexposure of workers submitted to the NRC
- Operating procedures that were reviewed during this time period

Also, the reports shall include the following:

- Trend evaluation of personnel exposures for identifiable categories of workers and types of operational activities
- Assessment of whether equipment for exposure control is being properly used, maintained, and inspected
- Recommendations on ways to further reduce personnel exposures from uranium and its progeny

5.4 Qualifications for Personnel Implementing the Radiation Safety Program

The minimum qualifications for the RSO are:

- A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in radiation protection at a uranium recovery facility. Two years of relevant experience will generally be considered equivalent to one year of academic study.
- At least one year of uranium recovery work experience in applied health physics, radiation protection, industrial hygiene, or similar area. This experience should involve hands-on work with radiation detection and measurement equipment, not strictly administrative work.
- At least four weeks of specialized classroom training in health physics.
- A thorough knowledge of the health physics instrumentation used in the facility, the chemical and analytical procedures used for radiological sampling and monitoring, methods used to calculate personnel exposure to uranium and its progeny, the uranium recovery process, and the facility hazards and their controls.

The minimum qualifications for the RST will include:

- Training equal to the minimum qualifications of the appointed RSO as specified in Section 2.4 of RG 8.31.
- Must pass a test with an 80 percent score or better regarding the minimum training of the RSO.
- The level of experience required will be commensurate with the type, form and the anticipated radiation hazards to be encountered while acting as a designee for the appointed RSO.

On-the job training overseen by the RSO will provide expertise regarding implementation of site-specific radiological safety protocols and any necessary specialized radiation safety training concerning a specific RWP. For more information see Section 5.2.2. The minimum combination of education, training, and experience for an RST includes the following:

- An associate's degree or two or more years of study in the physical sciences, engineering, or a health-related field; at least four weeks of generalized training in radiation health protection applicable to uranium recovery facilities (up to two weeks may be on-the-job training); and one year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures that apply to uranium recovery facility operations; or
- A high school diploma; at least three months of specialized training in radiation health protection relevant to uranium recovery facilities (up to one month may be on-the-job training); and two years relevant work experience in applied radiation protection.

5.5 Radiation Safety Training

This section describes minimal training requirements to ensure all employees and visitors have an adequate level of knowledge to recognize and are aware of potential radiological hazards associated with activities they will be involved with at the facility. Appendix 5.5-A of the approved license application provides written radiological safety instructions for workers.

5.5.1 Initial Training

Prior to working at the facility, all facility workers and supervisors subject to occupational radiation dose limits (i.e. radiation workers) will be instructed by means of a documented training class in the risks of radiation exposure and the fundamentals of protection against exposure to uranium and its progeny. Other guidance to be provided as appropriate is found in NRC Regulatory Guide 8.13 *"Instruction Concerning Prenatal Radiation Exposure"* and NRC Regulatory Guide 8.29 *"Instruction Concerning Risks From Occupational Radiation Exposure"*. The course of instruction will include the following topics:

- Fundamentals of Health Protection
  - The radiological and toxicological hazards of exposure to uranium and its progeny
  - How uranium and its progeny enter the body (inhalation, ingestion, and skin penetration)
  - Why exposures to uranium and its progeny should be kept ALARA
- Personal Hygiene
  - Wearing protective clothing
  - Using respirators correctly
  - Eating, drinking, and smoking only in designated areas
  - Using proper methods for decontamination (for example, showers)
- Facility-Provided Protection
  - Ventilation systems and effluent controls
  - Cleanliness of the work place
  - Features designed for radiation safety for process equipment
  - SOPs
  - Security and access control to designated areas
  - Electronic data gathering and storage
  - Automated processes
- Health Protection Measurements
  - Measurement of airborne radioactive materials
  - Bioassays to detect uranium radionuclides
  - Surveys to detect contamination of personnel and equipment
  - Personnel dosimetry
- Radiation Protection Regulations
  - Regulatory authority of the NRC, Mine Safety and Health Administration (MSHA), and Occupational Health and Safety Administration (OSHA)
  - Rights of employees in 10 CFR Part 19

  - Requirements for radiation protection in 10 CFR Part 20

- Emergency/contingency Plans

A written or oral test with questions directly related to the training topics will be given to each worker. The instructor will review the test results and discuss incorrect answers with each worker. Workers who fail the test (less than 70 percent correct) will be retested after receiving additional training.

All new workers will be given specialized instruction on the health and radiation safety aspects of the specific jobs they will perform. This instruction will be in the form of individualized on-the-job training. Radiation safety matters of concern that arise during operations will be discussed with all workers during regularly scheduled safety meetings.

Powertech (USA) also commits to the development of a program for training on identification of, standards for, and health and safety procedures for nonradiological hazards. The training will be based on OSHA regulations and will address occupational safety (ergonomics, drug and alcohol abuse in the work place, hazardous material handling, confined spaces, etc.), general safety (hazard recognition, security, etc.), and job-specific categories of training for employees whose job function includes construction, electrical work, hazardous materials handling, or operation of machinery.

Prenatal and Fetal Exposure Policy

To ensure that the radiation dose to an embryo/fetus during the entire pregnancy of a declared pregnant worker does not present a health threat and is maintained ALARA, Powertech (USA) will take the following steps:

1) Advise all female workers of child-bearing age at the time of employment that if they are pregnant or become pregnant during their employment, they can voluntarily declare their pregnancy to Powertech (USA) to limit radiation exposure to their unborn child. Powertech (USA) will provide copies of this policy to all female employees.
2) Powertech (USA) encourages pregnant women to declare their pregnancy in order to protect the embryo/fetus.
3) In addition to providing instruction in accordance with §19.12 of 10 CFR Part 19, provide to all female employees instruction specified by NRC's RG 8.13, specifically concerning biological risks to the embryo/fetus exposed to radiation, the dose limit for the embryo/fetus and suggestions for reducing radiation exposure.
4) Limit the exposure to the unborn child from occupational exposure of the expectant mother to 500 millirems for the entire pregnancy, if the pregnancy has been declared by the mother.

5) Avoid assigning job duties that could result in substantial variations in the rate of exposure.

5.5.2 Refresher Training

Each radiation worker and supervisor will be provided annual refresher training. Refresher training will include relevant information that has become available during the past year, a review of safety problems that have arisen during the year, changes in regulations and license conditions, exposure trends, and other current topics.

5.5.3 Visitor Training

All visitors who enter process areas and have not received training described in Section 5.5.1 will be escorted by someone trained and knowledgeable about the hazards at the facility. At a minimum, visitors will be instructed specifically on what they should do to avoid possible hazards (radiological and nonradiological) in the areas of the facility they will be visiting.

5.5.4 Contractor Training

Contractors that have work assignments at the facility will be given appropriate training and safety instruction. Contract workers who will perform work on heavily contaminated equipment or within the process area shall receive the same training and radiation safety instruction normally required of all radiation workers. Only job-specific radiation safety instruction is necessary for contract workers who have previously received full training on prior work assignments at the facility or have documentation of recent and relevant radiation safety training elsewhere.

5.5.5 RSO Training

The RSO will receive a minimum of 40 hours of documented refresher training in health physics at least once every two years.

5.5.6 Training Documentation

All workers will be required to sign a statement that they have received radiation safety training. The statement will indicate the content of the training and the date(s) the training was received. The statement will be co-signed by the instructor. This documentation applies to initial and refresher training.

5.6 Facility Security

As required in 10 CFR 20, Subpart I, Powertech (USA) will secure from unauthorized removal or access licensed materials stored in controlled or unrestricted areas using the following passive and administrative controls:

- All areas where licensed material is stored (e.g. well fields, CPP, SFs will be fenced.
- All gates accessing areas where licensed material is stored will be posted as described in Section 5.2.4 and locked when facility personnel are not immediately available to prevent unauthorized access to or removal of licensed materials.
- Facility fences, gates, and postings will be inspected daily as part of the inspection programs described in 5.3.1 and 5.3.2.
- A 24-hour per day, 7 day per week staff will be on duty at the facility.
- Visitors to the facility will enter through an access point at the main plant entrance where they will sign in and receive training required in Section 5.5.3.

Powertech (USA) will control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and is not in storage. An example of licensed material not being in storage is licensed material being transported from the SF to the CPP. Passive and administrative controls to prevent unauthorized access to and removal of licensed material not in storage include:

- SOPs assessing the possible transportation security risks and identifying measures to mitigate these risks
- Locks and/or tamper indicators on all openings where licensed material is kept
- Off-site vehicles transferring licensed materials will always be secure if left unattended
- Off-site vehicles transferring licensed materials will be visible by an employee at all times when left unattended outside of a restricted area

The requirements of 49 CFR 172 will apply to shipments of licensed material which Powertech (USA) offers for transport for commercial use. Powertech (USA) will develop SOPs for these cases and will evaluate the ability of potential commercial contractors offering transportation services to comply with the requirements of 49 CFR 172 prior to entering into a contracting agreement.

5.7 Radiation Safety Controls and Monitoring

This section describes the active and passive effluent control techniques used to ensure that occupational and public doses of ionizing radiation will be ALARA. The monitoring program used to confirm that ALARA is attained is also described.

5.7.1 Effluent Control Techniques

The project will generate effluent typical of other ISL facilities. Both the Dewey site and the Burdock sites will include well field and IX operations with similar effluents and effluent control techniques. At the Burdock site, the CPP will also produce effluents typical from a yellowcake processing facility.

Airborne emissions of concern include the release or potential release of radon-222 and dried yellowcake dust. Liquid phase effluents consist of well field bleed streams that will contain both uranium and radium, as well as a liquid brine stream from the CPP. Solid wastes include contaminated equipment and protective clothing as well as solid residues from settling and evaporation ponds.

Monthly "grab" sampling of the treated wastewater streams generated at the facility, and stored in the respective storage reservoir, will be necessary to demonstrate that the barium chloride treatment systems are operating properly and treating radium-226 concentrations to maintain regulatory compliance.

5.7.1.1 Airborne Effluents

Under routine operation radon-222 would be the only effluent of concern from production and restoration solutions. The airborne particulate of most concern in an ISL facility is yellowcake dust. Yellowcake drying will be conducted in hot-oil rotary dryers operated under vacuum to prevent the release of uranium during drying. Powertech (USA) will operate in conformance with 10 CFR Part 40, Appendix A, Criterion 8 to assure that all airborne effluent releases are ALARA. Powertech (USA) will use a non-emissions vacuum dryer, which has no exhaustible effluent and therefore no stack or stack emissions. According to NUREG-1910 (Table 7.4-1), use of vacuum dryers is a listed Best Management Practice. Routine wash-down procedures will keep work areas clean of accumulating uranium as well as dirt and dust from outside sources. Yellowcake is only present as a dry solid from the end of the dryer cycle through packaging operations.

The process facility is designed such that the dryer and packaging operation are contained within a separate room, with its own HVAC system as well as a sealed hood system to prevent leakage of yellowcake solids during transfer from the dryer to the packaging drums. A dedicated air handler equipped with high efficiency particulate air (HEPA) filters will ventilate the dryer and packaging room and will provide an additional level of controlling particulate emissions.

The principles of 10 CFR Part 40, Appendix A, Criterion 8 regarding hourly monitoring and logging to ensure the vacuum dryer is operating near or at peak efficiency will be followed. To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signals an audible alarm at the dryer and in the CPP control room if the air pressure (i.e. vacuum level) falls below specified levels, and the operation of this system is routinely monitored during dryer operations. The operator will perform and document inspections of the vacuum level hourly or more frequently during dryer operations. Powertech (USA) staff also will perform a manual check of the vacuum alarm before each packaging event. Additionally, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

The venting systems described above will be completely separate from the building heating, ventilating, and air conditioning (HVAC) system. The HVAC system will be on when the buildings are normally closed due to weather or other factors.

Pregnant lixiviant will come into the SF and some radon-222 will be present. The lixiviant will be directed to the down-flow IX vessels to separate out uranium.

At both the SF and the CPP, the air/vacuum relief valves on the IX columns will be piped together in a manifold which will be vented above the roofline of the building. In addition, a flexible duct designed to attach to tanker trucks during loading and unloading of resin will be connected to this vent manifold. Pressure transmitters and pressure gauges on the inlet and outlet piping connected to each vessel will measure and indicate pressure both locally and in the control room. This vent system will not have a fan because vacuum relief requires an inflow of air. This vacuum relief system will minimizes exposure to personnel.

Small amount of radon-222 may be encountered during a spill, filter changes, IX resin transfer operations and maintenance activities. Exhaust fans will be placed in key areas of the building to remove any radon that may be released inside the building. Based on similar facilities historical operational experience, personnel exposures are not expected to be significant.

Consistent with RG 8.30 and to ensure airborne effluents are ALARA according to 10 CFR 20.1301, a ventilation survey will be conducted daily in areas with airborne radioactivity. The survey will be performed by the radiation safety staff during a daily walk through of the facility. Surveys will consist of operational checks of ventilation systems, to ensure they are operating effectively. Whenever equipment or procedures in the CPP or the Satellite Facility are changed in a manner that affects ventilation, the radiation safety staff will conduct a ventilation rate survey using an anemometer or pitot tube to ensure that the ventilation system is operating effectively. The verification procedure will also ensure effluent is within ALARA constraints established under 10 CFR 20.1101(d). Also, the principles in RG 3.56 regarding routine equipment inspections on the ventilation and effluent control equipment will be implemented to ensure radiation safety protocol. More detailed information on effluent controls are discussed in Sections 3.0 and 4.0 of this application. Inspections of radiation controls and equipment will be conducted during radiation safety inspections as discussed in Section 5.3.1.

5.7.1.2 Liquid Effluents

Liquid effluents consist of two types:

Liquid Process Waste

Liquid effluents from the operation will include: production bleed, groundwater generated during aquifer restoration, process solutions, affected well development water, plant wash-down water, laundry water, analytical laboratory waste, and facility sanitary waste. Refer to Section 4.2 for a description of liquid waste disposal options and water balance diagrams.

The net production bleed stream will flow at a rate of one half to three percent of the flow rate of production composite. Production bleed will be routed to either the wastewater disposal system or the production bleed RO unit. The restoration bleed will typically be 1 percent of the restoration flow rate unless groundwater sweep is used, in which case the average restoration bleed will be approximately 17 percent. Both production composites removed during recovery and restoration streams will first be treated in the IX columns to remove uranium to low levels. The restoration stream will undergo treatment that depends on the liquid waste disposal option. The restoration stream will be treated by RO in the deep disposal well option, with the brine undergoing treatment in lined settling ponds prior to disposal in DDWs. In the land application option, the entire restoration stream recovered from the well field will be treated in lined settling ponds prior to seasonal application through center pivot sprinklers. All liquid process waste streams will be treated to remove radium by the addition of a small amount of barium chloride and the settling out of the resultant barium-radium sulfate solids in a settling pond. After radium removal, the pond water will be pumped to one or more deep disposal wells and/or land application sites.

Water balance diagrams depicting typical liquid waste flow rates during ISR uranium recovery, aquifer restoration, and concurrent uranium recovery and aquifer restoration are presented in Section 4.2.2.4.

Aquifer Restoration

The technology selected for aquifer restoration will depend on the liquid waste disposal option. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. Groundwater restoration methods are described in Section 6.1.3.

Facility sanitary waste will be relatively small in quantity and will be treated in an appropriately sized septic system with sanitary drain field.

5.7.1.3 Spill Provision Plans

Procedures to address potential spills will be the responsibility of the radiation safety department; engineers and operations supervisors will assist in development of procedures. The SERP will review the procedure for effectiveness. Procedures developed will implement appropriate protocol to handle potential spills of radioactive materials. Nine responsibilities comprise basic activities:

- Resources and manpower assigned.
- Material and Inventory.
- Identification of potential spill sources.
- Spill reporting and visual inspection program established.
- Review of past spill incidents.
- Coordination among all departments for containment of spills.
- Emergency response protocol established.
- Program implementation, review and updating.
- New construction and changes in process relative to prevention and control of spills will be reviewed.

There are two types of spills that may result from an in situ operation:

Surface Releases

Potential surface releases may be the result of a tank failure, ruptured pipe, or transportation incident.

Failure of a process vessel will be contained within the CPP via concrete containment curbs and directed into a sump (equipped with a level alarm) that will transport the solution to the appropriate tank or disposal system.

Measures for Preventing Tank Failures

Section 4.2.3.2 and the provisions of 40 CFR Part 68, and others, will be followed to prevent tank failures. The primary methods for prevention of tank failure include the following:

- routine inspection
- installation of devices to avoid over pressurization or excessive level
- use of tanks and vessels that meet applicable ASME and/or ASTM codes appropriate to their function and operating conditions.
- proper engineering design of tanks and supporting structures, foundations, and footings.

Methods of Containing Tank Failures

The facility floors will be surrounded by 6-inch containment curbs and sloped toward the trench drains and sumps. Spilled or leaked fluid will be transferred to the waste tanks, from which it can be directed to liquid waste treatment and disposal. If a spill occurs in the recovery area, the spilled fluid could also be returned to the process circuit for processing, or stored temporarily in the Central Plant Pond.

Capacity of the Curbed Areas

The CPP and the Satellite Facility buildings will be designed with concrete containment curbs around the building perimeters. The largest liquid-containing vessel in the CPP is the yellowcake thickener with a capacity of 37,500 gallons (5,000 ft^3). Two vessels are currently planned for a combined capacity of 75,000 gallons (10,000 ft^3). A 6-inch high containment curb around the entire perimeter of the CPP floor would contain 10,750 ft^3. This would be more than enough to contain the entire contents of both thickeners in the extremely unlikely event that both thickeners should fail simultaneously and spill their entire contents onto the floor of the CPP before any of the contents flowed into the sump. The sumps will provide additional temporary containment capacity such that the total containment capacity of curbs and sumps is above 200% of the largest liquid-containing tank or vessel in the CPP. The thickeners will be separated by sufficient distance that collapse of the support footing for one thickener could not cause that thickener to fall into the second thickener. Standard operating procedures and employee training will be in place for emergency situations including spills in the CPP and Satellite Facility.

For the Satellite Facility, the largest liquid-containing vessel will be the utility water tank, with a volume of 16,000 gallons (2,139 ft^3). The Satellite Facility will include a 6-inch high containment curb around the perimeter wall of the building slab. The containment curb capacity will be at least 7,680 ft^3, or more than 350% of the volume of the utility water tank. Sumps will provide additional incremental containment capacity. Sump pumps will direct the spill to the radium settling pond for treatment and disposal. Depending on the nature of the spilled fluid, the sump pumps may be used to pump the spilled fluid through the ion exchange system for removal of uranium and other dissolved constituents prior to disposal.

Spilled fluids will be removed from the sumps by pumps and transported to the appropriate disposal system or recycled back to the appropriate process component. The primary contingency for spills within the elution and thickening area of the CPP is placement of the spilled liquid in the Central Plant Pond. This pond will have minimum capacity of 15.2 ac-ft (662,112 ft^3) not including allowance for storm water, or over 66 times the combined volume of both thickeners. At full level there is 3 ft of freeboard, which amounts to over 174,000 ft^3, or over 17 times the combined volume of both thickeners. Stated another way, with the Central Plant Pond full to its normal capacity, the addition of 10,000 ft^3 of liquid would increase the liquid depth in the pond by less than 0.2 ft.

Likely Consequences of Leak or Spill Events

The design of the process buildings (CPP and Satellite Facility) will include curbed foundations as noted previously, such that any spill will be contained within the building, regardless of sump pump operation. In the event of a total electrical failure, such that no pumps would be operational, a spill due to a vessel failure would be contained within the building in which the vessel failure occurred.

Piping system leaks is the most common source of surface releases that occur at an in situ facility. Generally these spills are small due to engineering controls set up to detect changes in pressure within the piping systems. Operators are alerted via an alarm system when pressure changes occur. Well field piping systems are constructed of PVC or high density polyethylene (HDPE) materials with butt welded joints or the equivalent. All pipelines will be pressure tested at operating pressures before put online. No additional stress is placed on the buried pipes so it is improbable a break would occur. The underground portions of the pipes are protected from vehicles and exposed pipes only occur at the wellheads and header houses. Trunkline flows and wellhead pressures will be monitored for process control. Spill response is specifically addressed in the Emergency Response Procedures (Energy Metals Corporation, U.S, 2007).

Spills related to transportation will be addressed in Powertech (USA)'s Emergency Response Action Plan. Specific actions involving response to a radioactive materials shipment will include instructions for appropriate packaging, documentation, driver emergency and accident response procedures and cleanup and recovery protocol.

Subsurface Releases

Potential subsurface releases such as a well excursion may result in the migration of process fluids.

Monitoring wells will be set up around the well field for detection of any leach fluids that may potentially migrate away from the production zone due to an imbalance in well field pressure. The monitoring well detection system is a proven method historically among ISL operations. Powertech (USA) proposes to locate a ring of monitoring wells no farther than 400 feet from the well field. These monitoring wells will be screened in the same zone as the production well. There will be additional wells monitoring the aquifers above and potentially below the ore-bearing aquifer. Sampling of monitoring wells will occur at least twice monthly and no more than 14 days apart in any given month during ISR operations and at least every 60 days during active aquifer restoration. Recovery and monitoring work in conjunction, as a coordinated effluent control system, and has proven effective in early detection of recovery fluids for a number of reasons:

- Close proximity of monitoring wells to well field
- Low flow of production wells
- Cone of depression created from production bleed

The overall effect of the system makes non-detection highly unlikely.

Effluent controls for preventing migration of recovery solutions to overlying and underlying aquifers consist of:

- Plugging and Abandonment of historical wells and exploration holes if they pose the potential to impact the control and containment of well field solutions within the project area (see Section 5.7.1.3.3).
- Conducting Mechanical Integrity Tests (MITs) on each well before it is put on line.
- Sampling the monitoring wells located within the overlying and underlying aquifers on a frequent schedule.

These controls work together to prevent and detect production fluid migration. Plugging exploration holes prevents connection of the ore-bearing aquifer to overlying and underlying aquifers. The EPA UIC requirement of MITs assures proper well construction and is the first line of defense for maintaining appropriate pressure without leakage. Sampling the monitor wells will enable early detection of any production solutions should an excursion occur.

Sediment or erosion of existing soils has the potential to lead to a release of undesirable elements in addition to the aforementioned spills. The greatest likely hood of this type of release may occur during the construction phase of the project. Two types of Best Management Practices (BMPs) will be employed to minimize the effects of runoff during precipitation events. One type is erosion prevention practices and the second type is sediment control practices.

Erosion Prevention Practices utilize ground covers that prevent different types of erosion from occurring. Ground covers include but are not limited to:

- Vegetation
- Riprap
- Mulch
- Blankets

Sediment control practices prevent soil particles that are being carried in storm water from leaving the site. These types of controls may consist of:

- Silt fence
- Sediment traps
- Sediment basins
- Vegetative cover

Leaving as much of the vegetation in place for as much of the construction period as possible will reduce the potential for a precipitation event to cause significant erosion and soil loss on-site. Utilizing erosion prevention and sediment controls in combination will prevent sediment loss during a major precipitation event. In addition to the above mentioned controls, engineering design and administrative controls will also minimize and control erosion and runoff. Should a pipeline failure coincide with a precipitation event, there is potential for a release. Relative soil saturation beneath the leak area would be a determining factor to what extent the material would be able to be absorbed. In any event with rapid detection and quick spill response a pipeline failure and migration of solutions due to runoff would be minimal.

5.7.1.3.1 Evaluation of Potential Impacts to Water Supply Wells

During the design of each well field, all nearby water supply wells will be evaluated for the potential to be impacted by ISR operations or the potential to interfere with ISR operations. If needed, this evaluation will also include groundwater modeling. The results of the evaluation will be contained within a well replacement plan described in the hydrogeologic data package for each well field.

At a minimum, all domestic wells within the project area and all stock wells within ¼ mile of well fields will be removed from private use. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well.

The well owner will be notified in writing prior to removing any well from private use. Powertech (USA) will work with the well owner to determine whether a replacement well or alternate water supply is needed.

Section 5.7.8 describes the operational groundwater monitoring plan that will be used to assess potential impacts to domestic and livestock wells. The monitor well ring will provide advance warning before any wells outside the ring have potential to be impacted. If routine monitoring of a water supply well indicates diminished water quantity or quality, the well owner will be notified in writing and the well will be removed from use. Powertech (USA) will work with the well owner to determine if well replacement is necessary. Well replacement procedures are described below. The monitoring and well replacement or abandonment procedures to be implemented by Powertech (USA) will assure that there will be no effects on anyone or any water well outside the monitor well ring.

The following provides details on specific wells and describes procedures Powertech (USA) will utilize to protect public health.

Wells 12, 51, 510, 619, 620 and 650 are used for stock watering and are located within the project area. Powertech (USA) has verified the locations of the wells; however, not all completion details are currently known. A down-hole camera or other tool will be used to determine well construction details in all of the wells. These stock wells are more than ¼ mile from currently identified potential well field areas. They will be evaluated during the course of well field development and delineation drilling for the potential to be adversely affected by or to adversely affect ISR operations.

Wells 14 and 51 are both used to supply water for livestock. Well 14 is located approximately ¾ mile northwest of the Burdock Well Field I and is completed in the Lower Fall River Formation. Well 51 is completed in the Chilson and is located outside of the project area, approximately 1 mile west of the Burdock Well Field I.

Well 16 is a domestic well that provides water to a seasonal residence. The well is located within a proposed well field and will be removed from private use prior to operations. Since the construction details of the well are unknown, Powertech (USA) has implemented an investigation plan with the landowner to enter the well with a down-hole camera or other tool to determine construction details. Based on well construction the well will either be used as a monitor well or plugged and abandoned. Powertech (USA) has drilled a replacement well into the Unkpapa for well 16.

A field investigation of the location designated as well 605 showed only a vertical pipe discharging to a livestock watering tank. Powertech (USA) determined that the vertical pipe is not actually a well but the end of an underground pipeline supplied from well 668 by artesian pressure.

Well 609 is an historical monitor well. According to TVA documents, this well is completed at a depth of 1,000 ft (verified by Powertech (USA)) and screened from 903 to 966 ft across the lower Chilson. Since the well is located approximately 0.4 mile from a proposed well field, it will be evaluated as part of the well field design. The evaluation will determine if the well has the potential to be adversely affected or to adversely affect ISR operations. If it is determined that the well has potential to adversely affect ISR operations, the well will be plugged and abandoned or otherwise mitigated.

Well 618 is located within ¼ mile of a proposed well field and occasionally used for livestock watering purposes. The exact construction details of the well are unknown; therefore, prior to well field design Powertech (USA) will conduct an investigation of the well using a down-hole tool to determine the well depth and screened interval. Due to its proximity to a proposed well field, the well will be removed from private use.

Well 628 is located approximately ¾ mile from the nearest proposed well field and is used for occasional livestock watering. Although complete construction details of the well are currently unknown, Powertech (USA) has determined that the total well depth is 520 feet, and groundwater levels suggest that the well is screened in the upper Fall River Formation. Prior to well field design, an additional investigation of the well will be completed using a down-hole camera or other tool to determine the screened interval. If it is determined that the well has potential to adversely affect or be adversely affected by ISR operations or if routine monitoring indicates changes in water quality, the well will be removed from private use.

Well 637 is an historical monitor well located within a proposed well field. A field investigation determined that the well consists of a 2-inch steel casing, although other construction details are unknown. Prior to well field design a down-hole tool will be utilized to determine the screened interval and total depth. During well field design well 637 will be evaluated to determine if the well has the potential to be adversely affected or to adversely affect ISR operations. If it is determined that the well has potential to adversely affect ISR operations, the well will be plugged and abandoned or otherwise mitigated.

Well 668 is located within a proposed well field area. The well was installed by TVA as an aquifer pump test well for hydrogeologic investigations and is currently used for livestock. According to TVA documents, the well has a total depth of 574 feet and is screened across the Chilson and Fall River. This was recently verified by Powertech.

5.7.1.3.2 Wells to Be Removed from Use

All existing domestic wells within the project area will be removed from private use prior to ISR operations, including wells 13, 16, 40, 42, 43, 703, 704, 4002. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the wells for monitoring or plug and abandon the wells.

Stock wells within the project area will be evaluated as potential well fields are designed. At a minimum all stock wells that are within ¼ mile of any well field will be removed from private use prior to operation of that well field. In addition, stock wells that could be adversely affected by or could adversely affect ISR operations will be removed from private use. The stock wells currently anticipated to be removed from private use include wells 17, 38, 49, 61, 618, and 668. Currently, well 628 is not expected to be removed from private use as it is more than ¼ mile from any potential well field areas. Additional delineation drilling after license issuance may change the extent of the potential well field areas or provide additional well field areas within the project area. Therefore, each potential well field will be evaluated with regard to existing nearby stock water use and an evaluation will be included within the well field hydrogeologic data package for each well field.

Figure 5.7-1 shows the location of all domestic and stock wells currently anticipated to be removed from private use. Wells 20 and 135 are not within 2 km of the project boundary and will not be adversely affected by ISR operations.

Prior to ISR operations, Powertech (USA) will assume control of all wells within the project area boundary listed as "monitor" in Table 1 of Appendix 2.2-A of the approved license application. These will be secured at the well heads to prevent unauthorized use.

5.7.1.3.3 Water Supply Well Replacement Procedures

Replacement wells will be located an appropriate distance from the well fields and will target an aquifer outside of the ore zone that provides water in a quantity equal to that of the original well and of a quality which is suitable for the same uses as the original well, subject to the lease agreement and South Dakota State water law.

Lease agreements for the entire project area currently allow Powertech (USA) to remove and replace the water supply wells as needed. The following is an excerpt from the lease agreements with each landowner. (Note: all lease agreements formerly held by Denver Uranium have been assigned to Powertech (USA).)

> *"DENVER URANIUM shall compensate LESSOR for water wells owned by LESSOR at the execution of this lease, as follows: Any such water which falls within an area to be mined by DENVER URANIUM, shall be removed from LESSOR's use. Prior to removal, DENVER URANIUM shall arrange for the drilling of a replacement water well or wells, outside of the mining area, in locations mutually agreed upon between LESSOR and DENVER URANIUM, as may be necessary to provide water in a quantity equal to the original well and of a quality which is suitable for all uses the original water well served at the time such well was removed from LESSOR's use."*

An example of a replacement well is provided in Figure 5.7-1a, which shows use of the project Madison well to supply water by pipeline to local stock tanks.

5.7.1.3.4 Exploration Hole Mitigation Procedures

As with any other site proposed for ISR uranium recovery, historical exploration holes and wells are present within the project area. Powertech (USA) will use the best available information and best professional practices to locate boreholes or wells in the vicinity of potential well field areas, including historical records, use of color infrared imagery, field investigations, and potentiometric surface evaluation and pump testing conducted for each well field as part of the development of

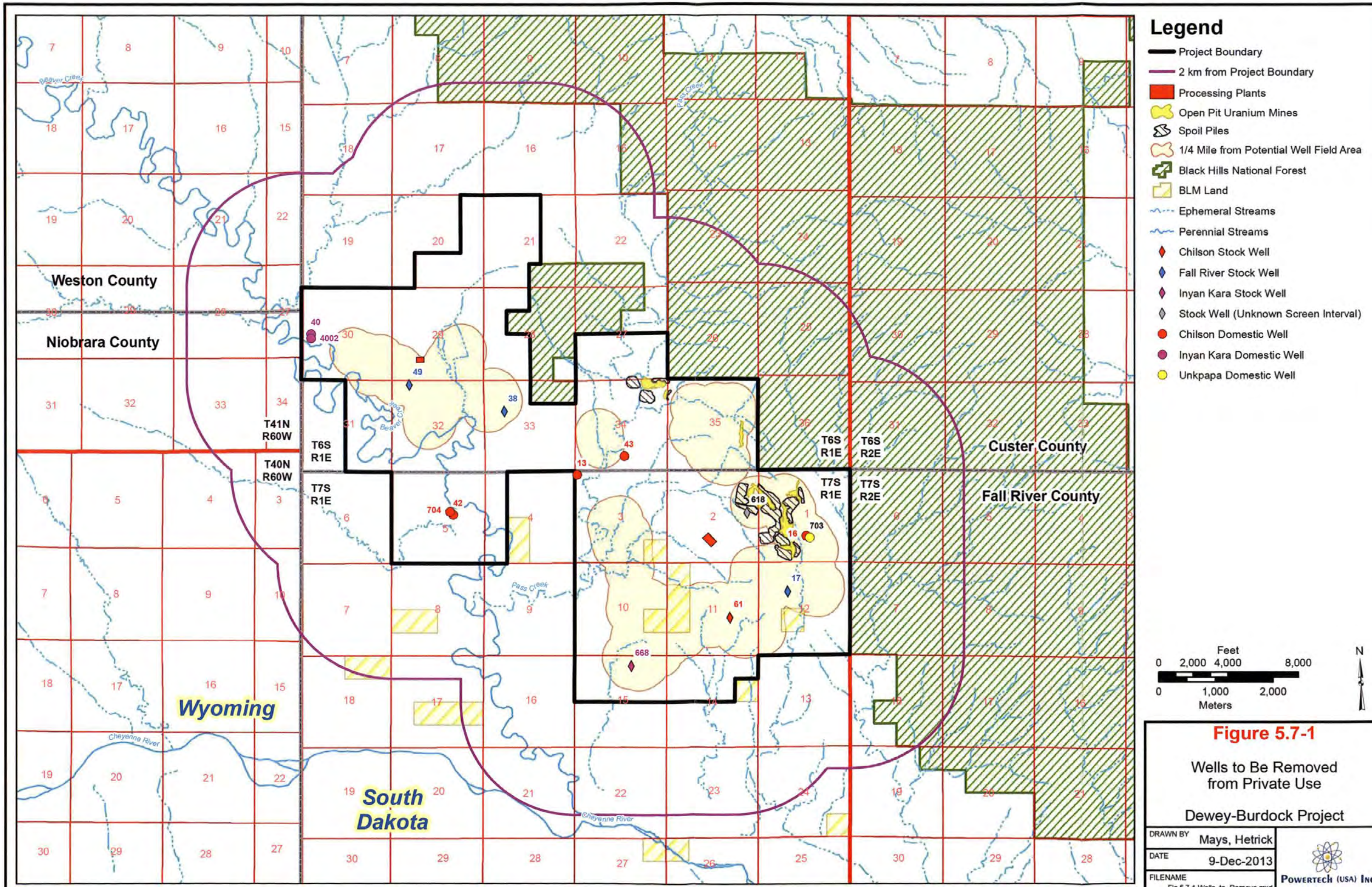
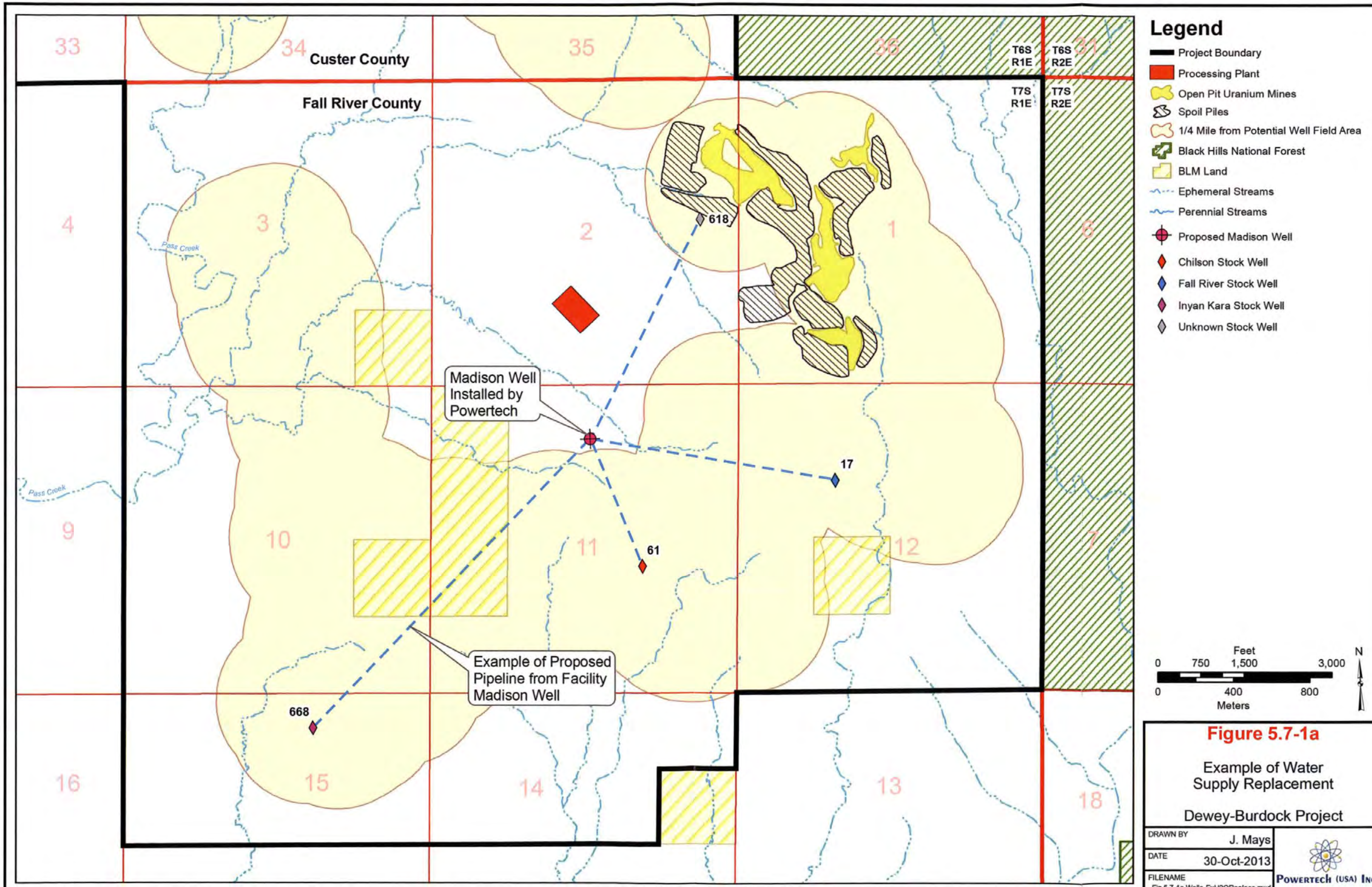


Figure 5.7-1

Wells to Be Removed from Private Use

Dewey-Burdock Project


Legend
Project Boundary
Processing Plant
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Proposed Madison Well
Chilson Stock Well
Fall River Stock Well
Inyan Kara Stock Well
Unknown Stock Well
Custer County
Fall River County
T6S R1E
T6S R2E
T7S R1E
T7S R2E
33
34
35
36
31
4
3
2
1
6
9
10
11
12
7
16
15
14
13
18
Pass Creek
Madison Well Installed by Powertech
Example of Proposed Pipeline from Facility Madison Well
618
17
61
668
Feet
0 750 1,500 3,000
0 400 800
Meters
N
Figure 5.7-1a
Example of Water Supply Replacement
Dewey-Burdock Project
DRAWN BY J. Mays
DATE 30-Oct-2013
FILENAME Fig 5.7-1a Wells-ExH2OReplace.mxd
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complete well field hydrogeologic packages. As with other ISR facilities, Powertech (USA) anticipates that some unplugged holes or wells may be encountered during well field design. Consistent with standard industry operating practices and experience, the following describes the procedures Powertech (USA) will implement to detect and mitigate any unplugged holes or wells that have the potential to impact the control and containment of well field solutions.

Powertech (USA) commits to properly plugging and abandoning or mitigating any of the following should they pose the potential to impact the control and containment of well field solutions within the project area:

1) Historical wells and exploration holes
2) Holes drilled by Powertech (USA) for the purposes of delineation and exploration
3) Any wells failing mechanical integrity testing (MIT) including those installed by Powertech (USA) and those installed before Powertech (USA)

Powertech (USA) will attempt to locate with best professional practices any presently unknown boreholes or wells in the vicinity of every potential well field. Historical records will be used to determine the presence of previous boreholes and wells. Pump testing conducted as part of routine well field hydrogeologic package development will use an array of monitor wells designed to detect and locate any unknown boreholes or wells. The pump testing also will be designed to provide sufficient hydrogeologic data to demonstrate that the well field design and monitoring systems are sufficient to control and detect any potential excursions. Details of the pump testing program are provided in Section 3.1.3.2.

Should any hole or well at or near potential well fields be suspected of being improperly plugged and abandoned, Powertech (USA) will use best professional practices to precisely locate and re-enter the suspected problem hole with a drill rig or tremie pipe. Powertech (USA) will evaluate mitigation alternatives including plugging and abandoning the hole or well with grout as described below. Powertech (USA) may enter the well with logging equipment prior to plugging and abandoning the well to confirm that the well poses a potential problem.

It is not surprising that there is little evidence of unplugged drill holes in the project area, even though there is a long history of mineral exploration in this area and much of this occurred prior to enactment of modern laws and regulations governing plugging and abandoning drill holes. This is because of the well-known natural tendency of drill holes to seal themselves by collapsing, caving and swelling of the formations through which the holes are drilled. During exploration, drill holes must be logged promptly after drilling in order to minimize the risk of losing logging tools or losing the ability to access the full depth of the holes due to the processes described above. During the pump testing that will be done as part of the preparation of the hydrogeologic package for each well field, special attention will be paid to known or suspected locations of exploration holes to detect evidence of interaquifer communication that might be the result of unplugged drill holes.

Plugging and Abandonment Procedures

Powertech (USA)'s standard operating procedures will include plugging and abandoning all boreholes completed during the process of exploration and delineation drilling. Any wells installed by Powertech (USA) which fail MIT and cannot be repaired also will be plugged and abandoned.

Powertech (USA) will plug all wells or exploration holes with bentonite or cement grout. The weight and composition of the cement will be sufficient to control artesian conditions and meet the well abandonment standards of the State of South Dakota, including Chapter 74:11:08 (Capping, Sealing, and Plugging Exploration Test Holes) and Chapter 74:02:04:67 (Requirements for Plugging Wells or Test Holes Completed into Confined Aquifers or Encountering More than One Aquifer) of the South Dakota Administrative Rules. Cementing will be completed from total depth to surface using a drill pipe. Records will be kept of each well or exploration hole cemented including at a minimum the following information:

- well or hole ID, total depth, and location
- driller, company, or person doing the cementing work
- total volume of cement placed down hole
- viscosity and density of the slurry used

Powertech (USA) will remove surface casing and set a cement plug to a depth 6 ft below the ground surface on each well or borehole plugged and abandoned.

Mitigation and Avoidance

Boreholes or wells which may potentially impact control of well field operations will be evaluated using pump test data and groundwater modeling. Should it be determined that it is not possible to mitigate potential adverse impacts from any unplugged borehole or well that is discovered, the affected well field will be designed to minimize any potential impacts.

The monitoring system will be designed to demonstrate well field control. This may include monitor wells in addition to those provided for normal well field operations. All of these details will be included in the well field hydrogeologic data package that will be prepared for each well field and reviewed by Powertech (USA)'s SERP prior to operation of that well field (see Section 3.1.3.3).

5.7.1.4 Contaminated Equipment

Solid wastes generated by this project that are contaminated with process related material consist of materials such as rags, contaminated personal protective equipment, trash, packing material, worn or replaced parts from equipment, piping, sediments removed from process pumps and vessels . Radioactive solid waste that has a contamination level requiring controlled disposal will be isolated in drums or other suitable containers and disposed in a NRC licensed facility or as otherwise approved by the NRC. The combined operations at the SF and CPP will generate between approximately 100 to 300 yd^3 of radioactive contaminated waste each year. During final decommissioning of the CPP facilities and SFs, the volume of solid waste will increase.

5.7.2 External Radiation Monitoring Program

Powertech (USA) will monitor external radiation exposure at the Dewey-Burdock facility. The monitoring will be done in three ways: continuous measurements at fixed locations, employee monitoring, and period work area surveys. The external radiation monitoring program will be consistent with the recommendation contained in NRC Regulatory Guide 8.30 *"Health Physics Surveys in Uranium Recovery Facilities."*

5.7.2.1 Fixed Location Monitoring

External radiation exposure measurements will be made in the locations shown in Figures 5.7-2 through 5.7-5. The designated monitoring locations are measurement locations, not fixed radiation monitoring points. The measurements at these locations will be made quarterly using radiation survey meters.

5.7.2.2 Employee Monitoring

Pursuant to 10 CFR 20.1502, employees working at the facility will be monitored for external radiation exposure if they have the potential to receive 10 percent of an applicable limit in a year. OSL dosimeters will be utilized quarterly for assessing the external dose for individuals who may potentially exceed 10 percent of the annual occupational limit (10 CFR 20.1201(a)). Powertech (USA) may monitor other workers, although not required, for occupational exposures during the first year of operations, or any other period deemed necessary, to ensure that all workers are receiving less than 10 percent of the 5 rem annual limit. After the periodic evaluation, monitoring may be reduced or eliminated at some locations. This decision will be at the discretion of the RSO and the SERP. The number and category (based on the organizational chart shown on Figure 5.1.2) of personnel that will be included in the external radiation monitoring program are shown in Table 5.7.2-1.

Table 5.7.2-1: Number and Category of Personnel Included in the External Radiation Monitoring Program

Category	Number of Employees*
Construction Superintendent	31
Production Superintendent	43
Radiation Safety Officer	9
Total	83

*Includes category supervisor and all personnel working under each category supervisor

Monitoring requirements will be determined in accordance with guidance found in NRC Regulatory Guide 8.34.

The applicable adult worker radiation dose limits are as follows:

- 5 rem deep-dose equivalent (DDE)
- 15 rems lens dose equivalent (LDE)
- 50 rems shallow-dose equivalent to the skin (SDE)
- 50 rems shallow-dose equivalent to any extremity

Applicable limits for minors working at the facility are 10 percent of the adult limits listed above.

Applicable limits for declared pregnant workers are the same as adult workers with the exception of the DDE with is 10 percent of the adult limit for the period of gestation.

Multiple dosimeters may be issued to employees that have the potential to receive two or more of the doses listed above. The dosimeters will have a sensitivity of 1 mrem and will be issued by a company currently holding personal dosimeter accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST).

The dosimeters will be exchanged monthly for worker with declared pregnancies and quarterly for all other radiation workers.

All external doses received by monitored personnel above 10 percent of the above limits will be reported on NRC Form 5 or in a format which contains all the information listed on NRC Form 5.

5.7.2.2.1 Employee Monitoring in High Radiation Areas

A high radiation area is defined in 10 CFR Part 20 as "an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates." The existence of such a high radiation area within an ISR facility is highly unlikely due to the nature of the radioactive materials involved. However, in the unlikely event an individual had to enter a high radiation area, the work will be conducted under a Radiation Work Permit, which characterizes the radiological hazards and identifies controls, both engineering and administrative, and PPE to keep radiation doses to levels that are ALARA. The individual will be monitored with a personal monitoring device and equipped with a calibrated rate meter and appropriate detector. Any work performed within the area will be limited and performed in such a manner as to maintain doses to levels that are ALARA. In accordance with Subpart G §20.1601, Powertech (USA) will have qualified staff (e.g., RSO, RSTs) present and prepared to implement and utilize monitoring devices and the controls deemed applicable to the specific circumstances and area in order to control access and exposure.

5.7.2.3 External Radiation Surveys

Shortly after the facility becomes operational, at least 20 gamma radiation measurements will be taken in order to characterize the radiation levels at the facility, as stated in RG 8.30. The locations where these measurements will be performed are depicted on Figures 5.7-2 through 5.7-5. Based on these measurements, areas where a person may receive a dose of 5 mrem in 1 hour at 30 cm (1 foot) from a radiation source or radiation-emitting surface will be posted as a "Radiation Area" as required in 10 CFR 20.1902(a). For areas with radiation levels less than those defined for a radiation area, follow-up measurements will be performed semiannually to evaluate potential impacts of changing process conditions on facility radiation levels.

Areas posted as "radiation areas" will be investigated to determine the source of radiation and will be surveyed for gamma radiation on a quarterly basis as described in RG 8.30. Methods to reduce radiation levels using engineering controls, process adjustments, or maintenance practices will be evaluated once the source of radiation is determined.

The typical gamma exposure rates during operation are expected to range from background up to 1,000 μR per hour. The gamma dose rates will be estimated by assuming 1 μR per hour is equivalent to 1 μrem per hour. There may be rare occasions where the gamma dose rate may approach 5 mrem per hour. The instrument that will be used for most gamma surveys is the Ludlum 19 or equivalent. The typical operating specifications for this instrument are shown in Table 5.7.2-2. This instrument can measure dose rates up to 5 mrem/hr. If gamma dose rates larger than 5 mrem/hr are evident, a Ludlum model 44-38 or equivalent type of detector coupled with an appropriate rate meter will be used. The typical operating specifications for the Ludlum model 44-38 are shown in Table 5.7.2-2. The Ludlum 44-38 can also be used when performing beta surveys where appropriate in and around the process area. Both instruments will be on site and available for use by properly trained staff during operations.

Table 5.7.2-2: Ludlum 19 and Ludlum 44-38 Operating Specifications.

Instrument Model	Instrument Type	Radiation Type	Measurement Range	Sensitivity
Ludlum Model 19	Sodium Iodide (Tl) scintillometer (1 in x 1 in)	Gamma	0 – 5,000 μR/hr	175 cpm per μR/hr (Cs-137)
Ludlum Model 44-38	Geiger-Mueller (GM), halogen quenched	Gamma and beta	Up to 50 mR/hr	1,200 cpm per mR/hr (Cs-137) with window closed

The instrumentation will be calibrated according to the manufacturer's instructions or at least once a year. Operational checks on the instruments will be performed before each daily use. The instruments will be operated according to manufacturer's recommendation.

Since yellowcake will be generated at the facility, there is a potential hazard from external beta radiation. Specifically, operations requiring direct handling of aged yellowcake may lead to significant exposures to the skin. Therefore, a beta survey will be conducted at or near surfaces for each operation requiring direct handling of yellowcake. A beta survey will also be conducted when the equipment or operating procedures are changed in a way that may affect the exposure of the worker to beta radiation. These surveys will also be used in determining the level of personal protective equipment (PPE) required for the operations.

The instrumentation to be used in the beta surveys will be portable, have sufficient efficiency for detecting beta radiation, and have a low efficiency for detecting gamma radiation. An example is a Ludlum Model 44-9 Pancake G-M Detector coupled with an appropriate ratemeter/scaler.

Beta doses will be determined using one of two ways. One method uses the information acquired during the beta radiation surveys. Average beta radiation fluence rates can be estimated, assuming all net counts are beta radiation from the yellowcake. The estimated average particle fluence rates, along with the amount of time spent on each operation by each worker and the average energy of beta radiation emitted from yellowcake can be used to determine the amount of radiation dose to the skin of the workers from beta radiation. The other method to determine beta radiation doses involve using Figures 1 and 2 from RG 8.30.

5.7.2.4 Action Levels for Gamma Dose Rates and Dosimeter Results

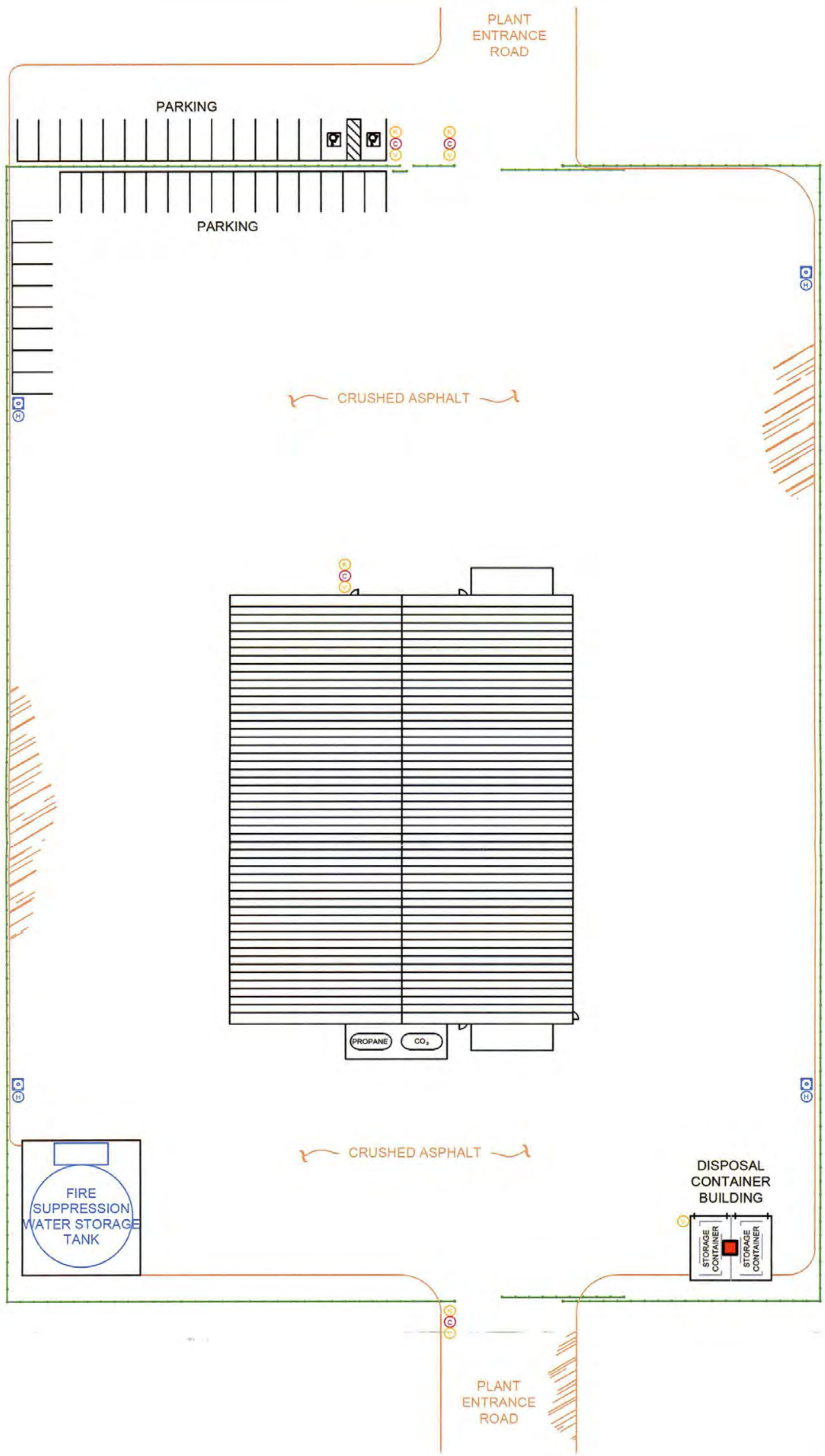
Action levels for gamma radiation dose rates will be as follows:

1) Areas with gamma exposure rate measurements above 0.25 mR/hr will require individuals working in and around the area to wear personal dosimeters. An evaluation regarding the cause of the exposure rate will be conducted and steps will be taken to keep exposure rates ALARA.
2) Areas with gamma exposure rate measurements above 5 mR/hr will be posted as Radiation Areas. An evaluation regarding the cause of the exposure rate will be conducted and steps will be taken to reduce the exposure rate.

In addition, once typical operational gamma dose rate levels have been established, additional administrative action levels may be established as deemed appropriate by the RSO and as reviewed by the SERP.

For dosimeter results, the following action levels will apply:

1) Measured individual worker external whole body deep radiation doses above 125 mrem per calendar quarter or 500 mrem per calendar year will result in investigations as to the cause of the dosimeter result, and steps will be taken to keep radiation doses ALARA.
2) Measured individual worker shallow-doses (skin) above 1,250 mrem per calendar quarter or 5,000 mrem per calendar year will also result in investigations as to cause and procedures to mitigate.
3) Measured individual worker external whole body radiation deep doses above 312 mrem per calendar quarter or 1,250 mrem per calendar year will result in work restrictions for the affected workers until an investigation has determined that



Legend

- Exposure Rate Monitoring Location
- (H) Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- (V) Video Surveillance Camera
- (C) Call Box
- (K) Key-card Reader
- Perimeter Fence
- Crushed Asphalt

Figure 5.7-2

Exposure Rate Measurement Location Outside Satellite Facility

Dewey-Burdock Project

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DATE	14-Jun-2013
FILENAME	SPP-ExposeRateLocOut.dwg

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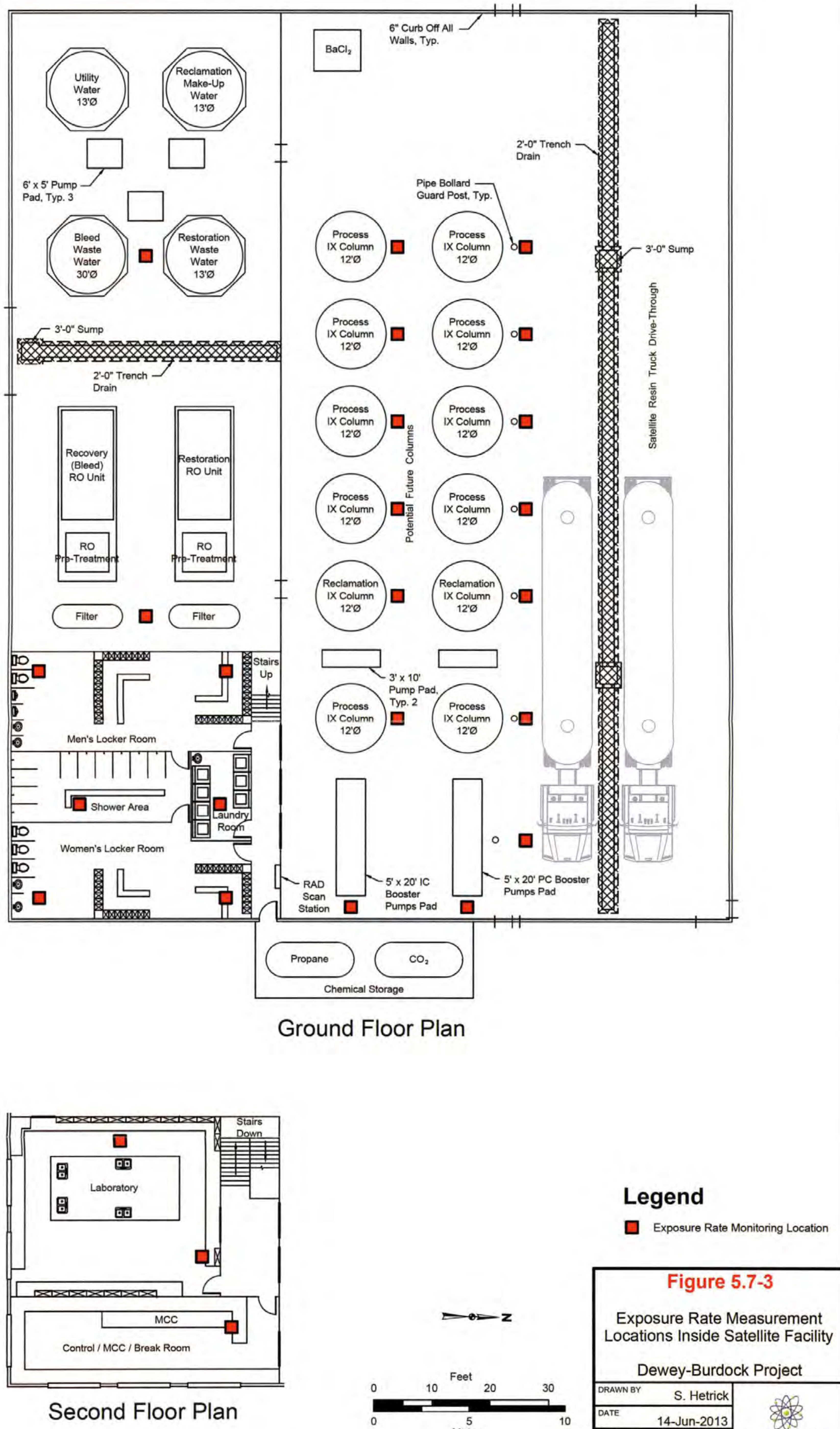

Figure 5.7-3

Exposure Rate Measurement Locations Inside Satellite Facility

Dewey-Burdock Project

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DATE 14-Jun-2013
FILENAME SPP-RadDecayProdIn.dwg

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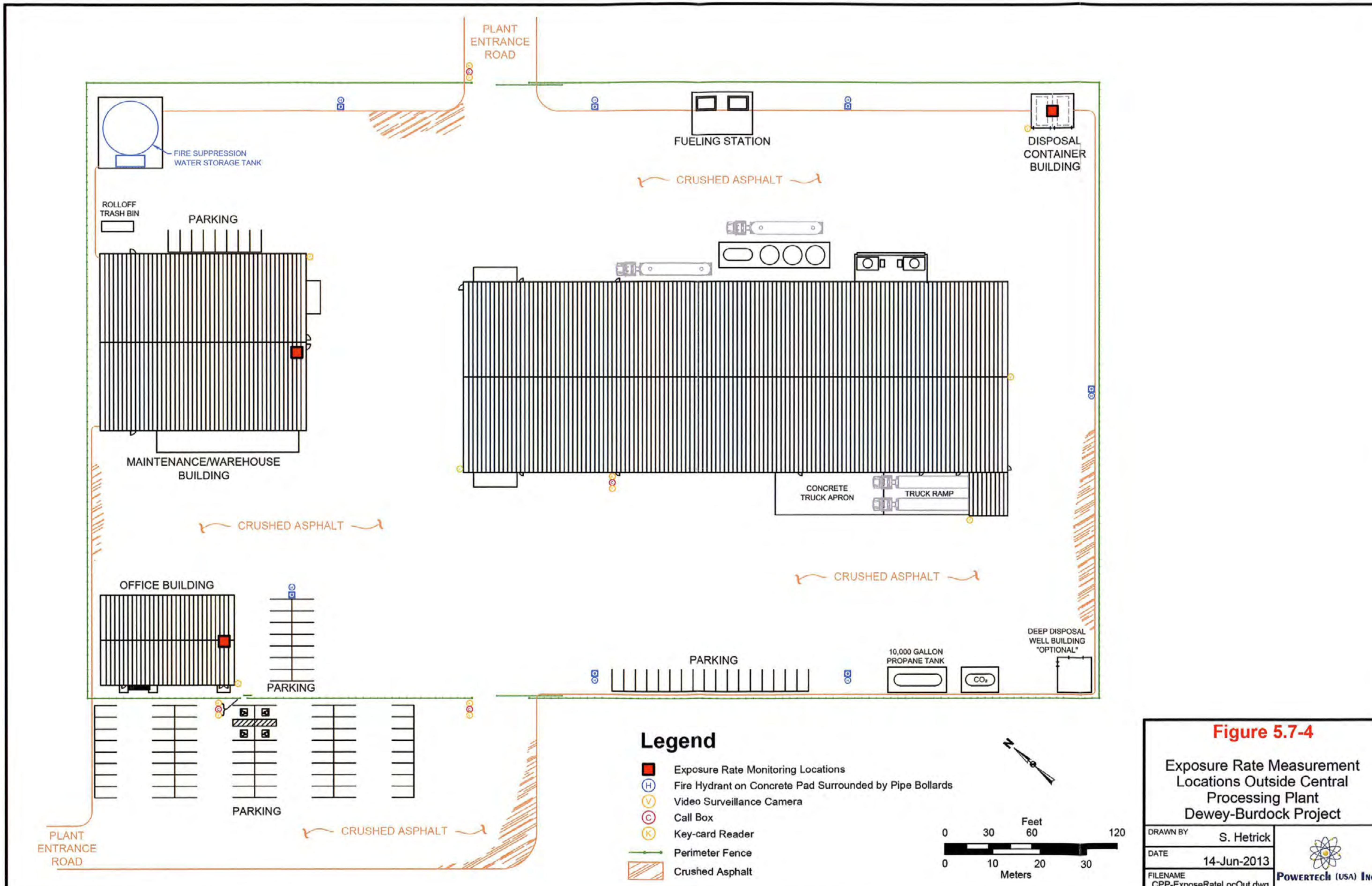

Figure 5.7-4

Exposure Rate Measurement Locations Outside Central Processing Plant Dewey-Burdock Project

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DATE	14-Jun-2013
FILENAME	CPP-ExposeRateLocOut.dwg

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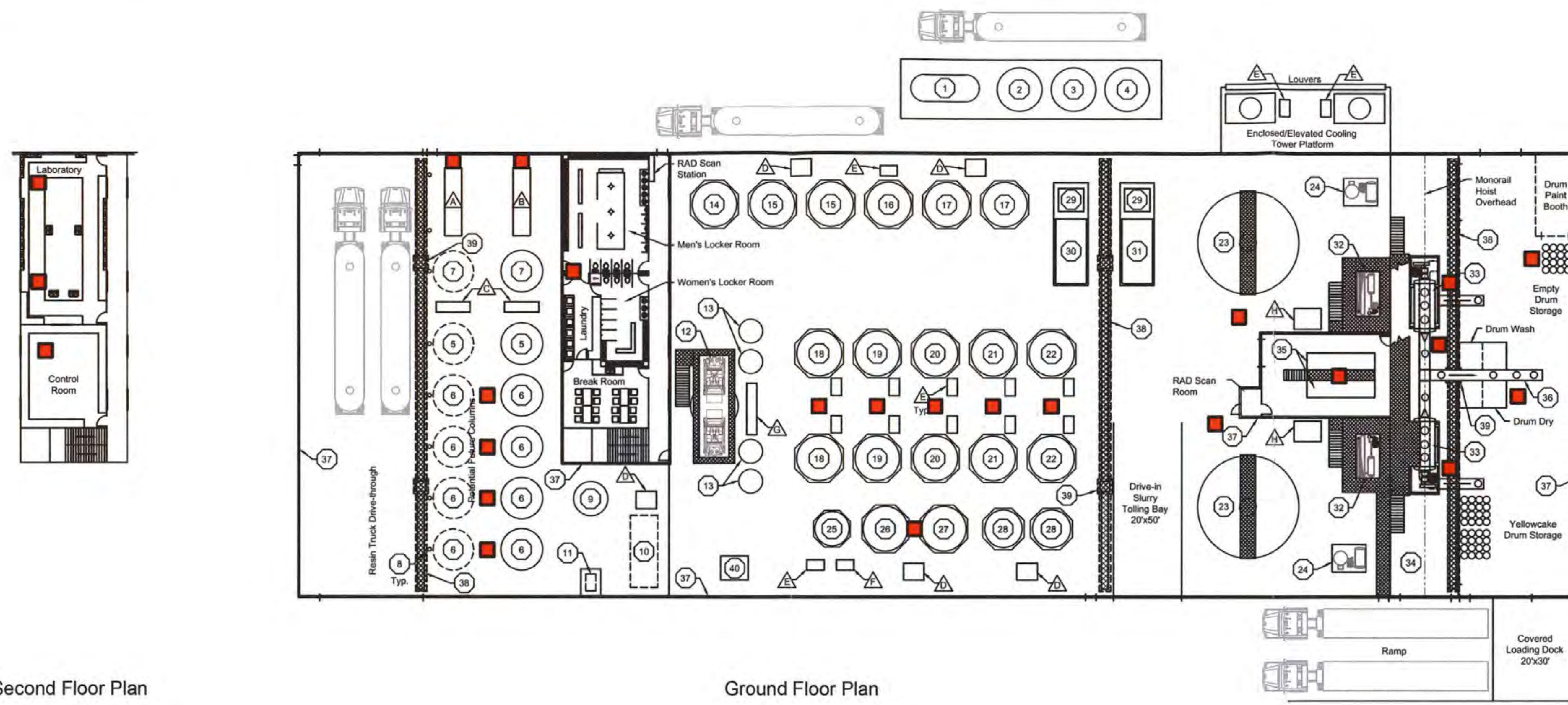

Second Floor Plan

Ground Floor Plan

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'Ø
6. Process IX Column 12'Ø
7. Bleed IX Column 12'Ø
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'Ø
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'Ø
14. Reclamation Make-up Water 13'Ø
15. NaCl 13'Ø
16. Na_2CO_3 13'Ø
17. Utility Water 13'Ø
18. Fresh Eluant 13'Ø
19. Lean Eluant 13'Ø
20. Intermediate Eluant 13'Ø
21. Rich Eluant 13'Ø
22. Precipitation 13'Ø
23. 30'Ø Thickener, 5'Ø Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'Ø
26. High TDS Wastewater Tank 13'Ø
27. Low TDS Wastewater Tank 13'Ø
28. Solids Removal Tank 11'Ø
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A: 5'x20' - PC Booster Pumps
- B: 5'x20' - IC Booster Pumps
- C: 3'x10' - Pump
- D: 6'x5' - Pump
- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump

Feet: 0 15 30 60

Meters: 0 5 10 20

Legend

■ Exposure Rate Monitoring Locations

Figure 5.7-5

Exposure Rate Measurement Locations Inside Central Processing Plant Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2013
FILENAME	CPP-ExposeRateLocIn.dwg

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cumulative internal and external EDEs for the year are unlikely to exceed 5 rem, and that the doses are ALARA.

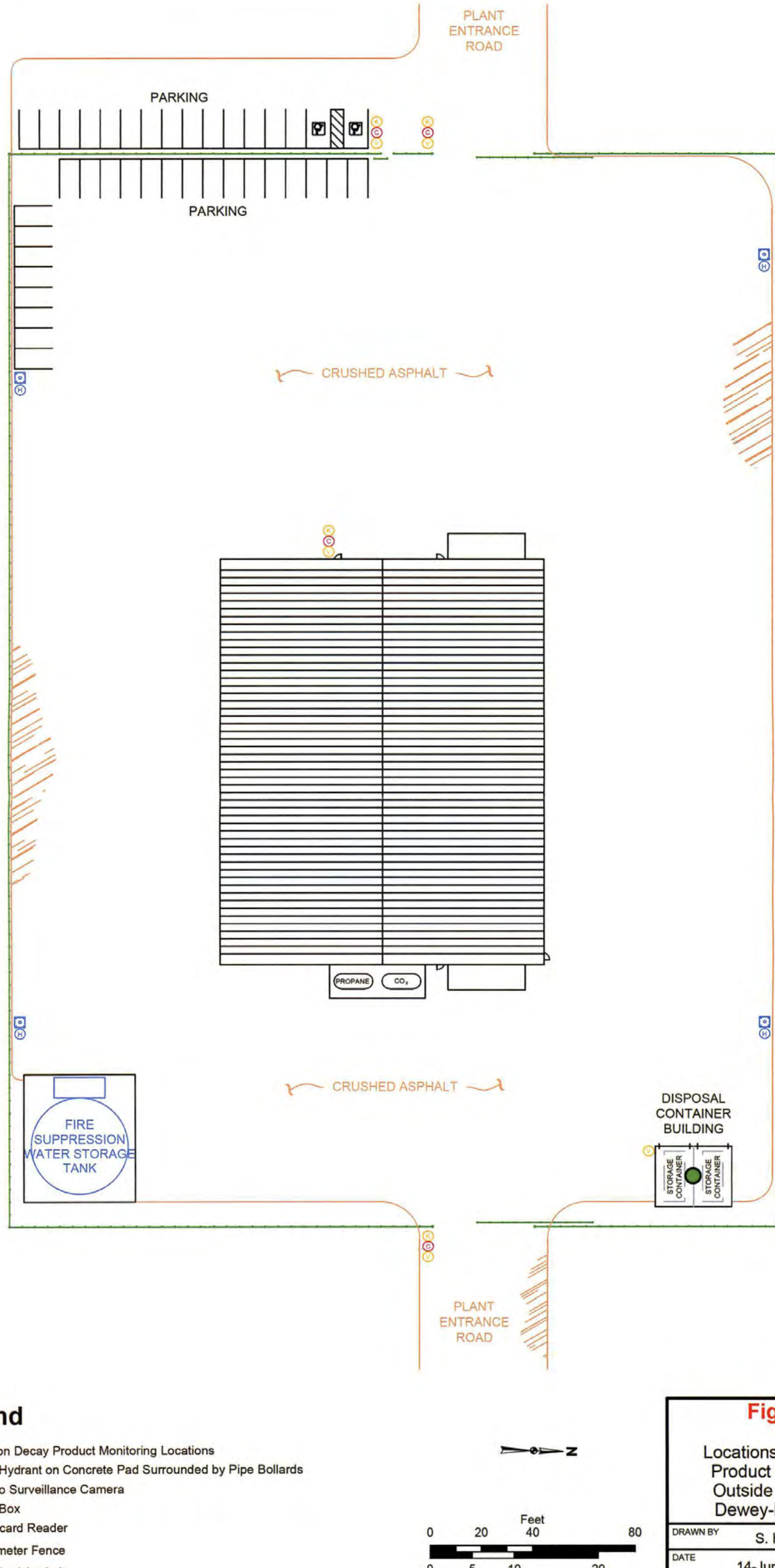
5.7.3 Airborne Radiation Monitoring Program

Powertech (USA) will conduct an airborne radiation monitoring program at the project facility which is consistent with the recommendations contained in RG 8.30. The facility will not process ore. However, the facility will precipitate, dry (at low temperatures), and package yellowcake. Therefore, the monitoring program will consist of monitoring radon decay products, as well as airborne particulate monitoring. During the first year of operation an extensive air particulate program will be implemented in order to evaluate and determine area concentrations of key particulates to which workers may be exposed.

5.7.3.1 Monitoring of Radon and Radon Decay Products

According to RG 8.30, measurements of radon decay products are a better measure for worker dose than measurements of radon. Therefore, measurements of radon decay products will be made in the facility.

Working level (WL) measurements for radon decay products will be made on a monthly basis in areas where radon decay product concentrations are likely to exceed the LLD of 0.03 WL as described in RG 8.30. Figures 5.7-6 to 5.7-9 present the monitoring locations where radon decay products could possibly exceed 0.03 WL. Additionally, areas where the radon decay product concentration exceeds 0.08 WL, as indicated by the monthly WL measurements, will be measured for radon decay products on a weekly basis. For these areas, investigations will be conducted to determine the source and corrective action will be taken if determined necessary by the RSO. If four consecutive weekly measurements in an area show the concentration of radon decay products to be at or below 0.08 WL, then the frequency of measurements in that area will return to monthly. Areas proximal to radon sources that do not exhibit radon decay product concentrations above 0.03 WL, as indicated by monthly WL measurements, will have WL measurement frequency reduced to quarterly. The time, date, and state of operation of the equipment in the vicinity of the measurement will be recorded. Areas that do not exhibit radon decay product concentrations above 0.03 WL but are proximal to radon sources will be evaluated on a quarterly basis. In addition, areas where workers routinely work and may be exposed to radon decay products will be evaluated at the discretion of the RSO.



Legend

- Radon Decay Product Monitoring Locations
- (H) Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- (V) Video Surveillance Camera
- (C) Call Box
- (K) Key-card Reader
- Perimeter Fence
- Crushed Asphalt

Figure 5.7-6

Locations of Radon Decay Product Monitoring Sites Outside Satellite Facility Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2013
FILENAME	SPP-RadDecayProdOut.dwg

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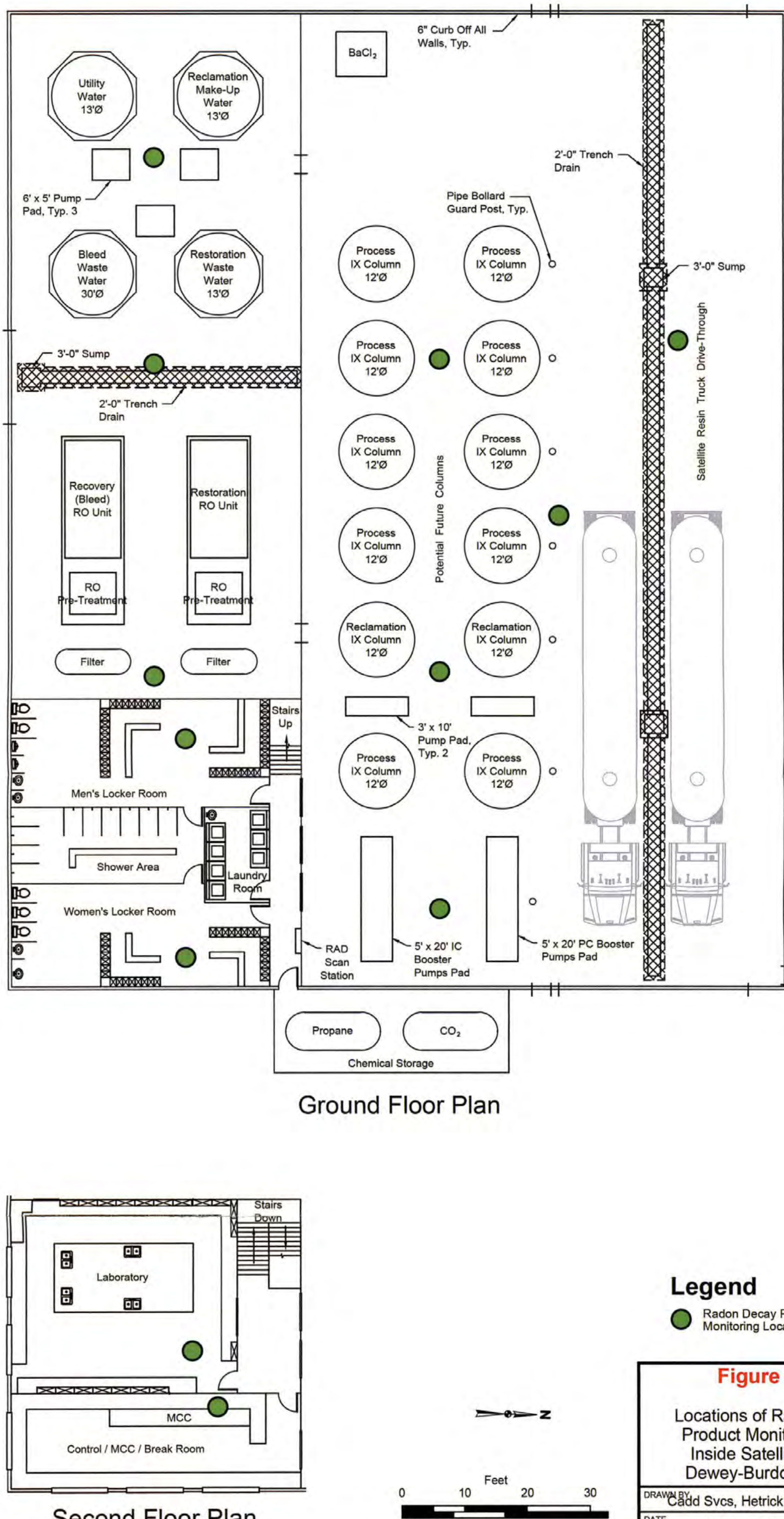

Legend

Radon Decay Product Monitoring Locations

Figure 5.7-7

Locations of Radon Decay Product Monitoring Sites Inside Satellite Facility Dewey-Burdock Project

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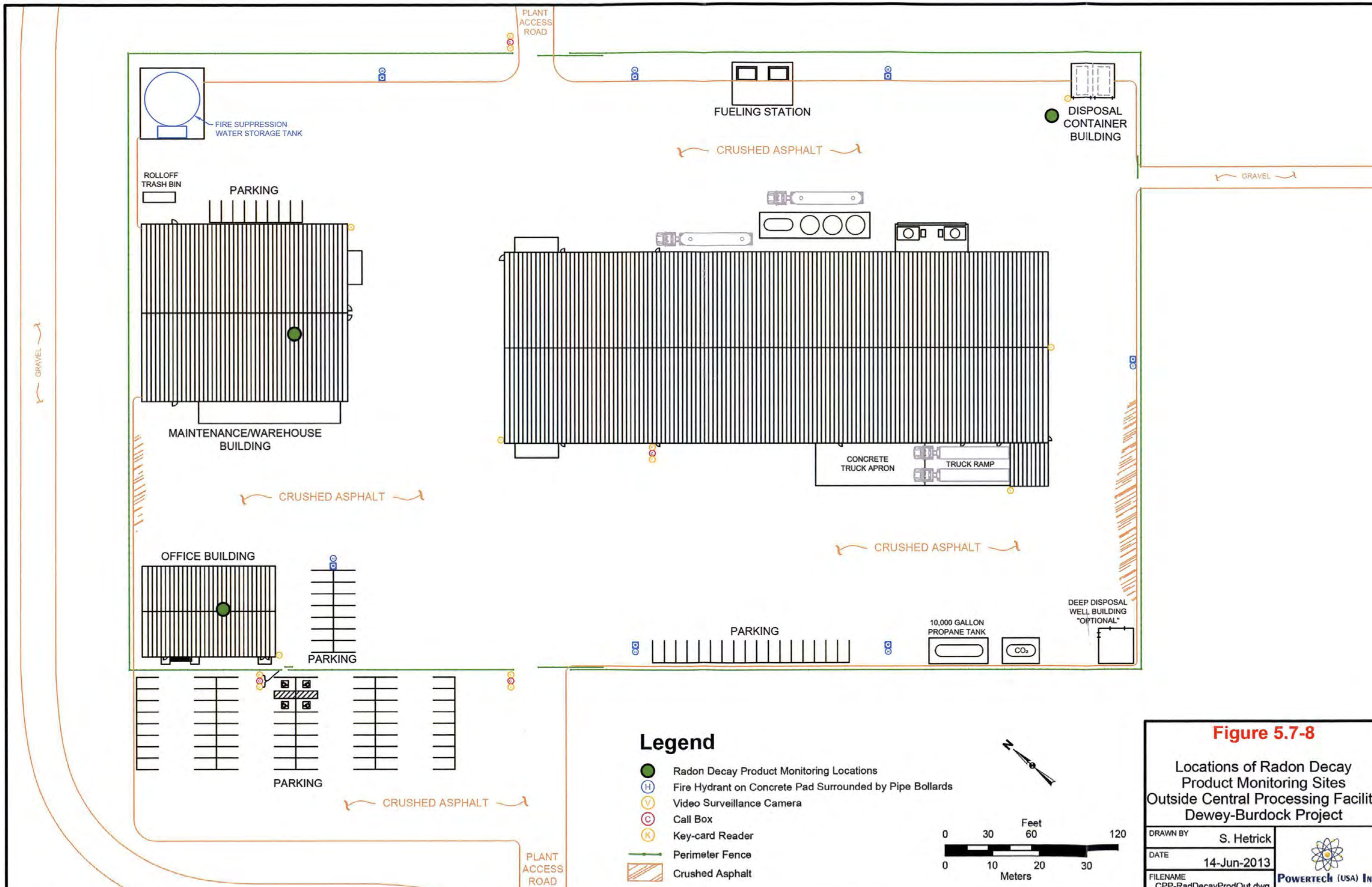

Figure 5.7-8

Locations of Radon Decay Product Monitoring Sites Outside Central Processing Facility
Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2013
FILENAME	CPP-RadDecayProdOut.dwg

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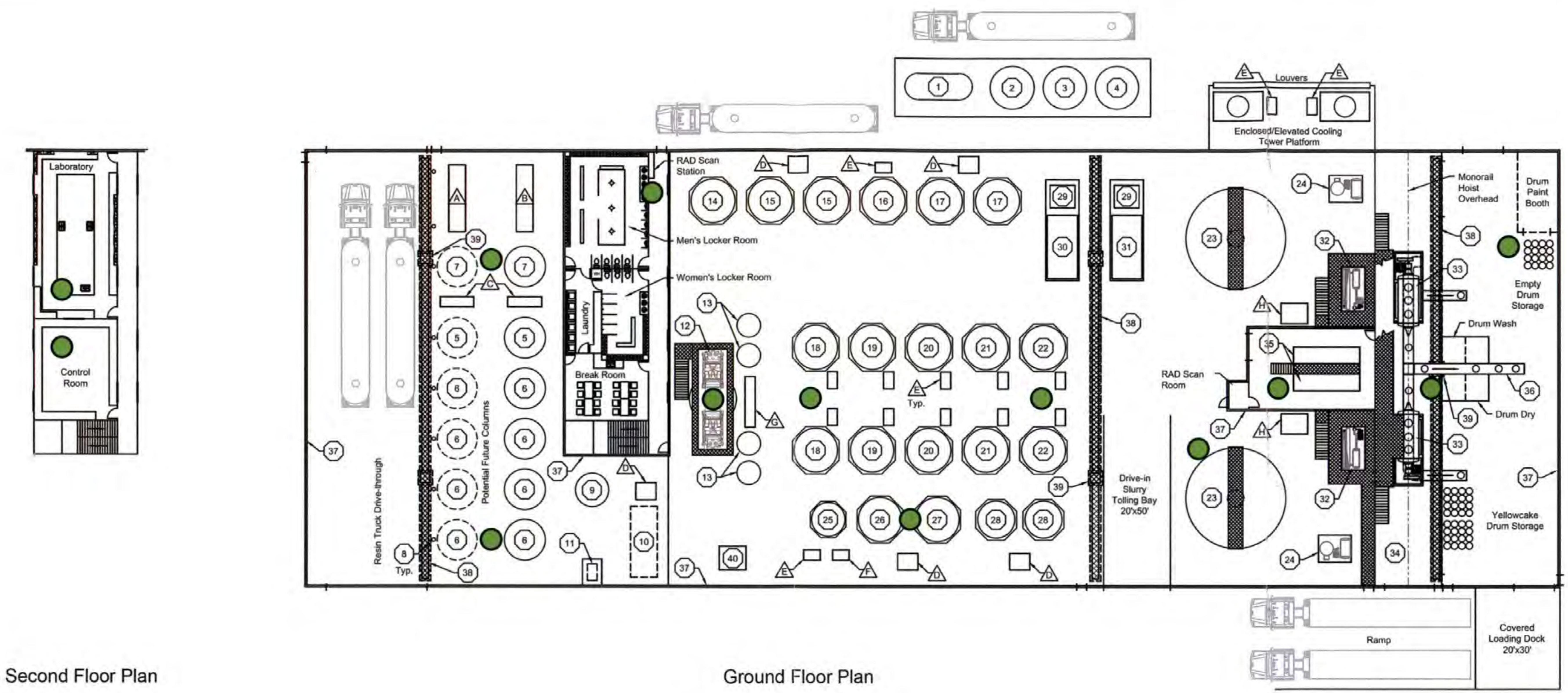

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'Ø
6. Process IX Column 12'Ø
7. Bleed IX Column 12'Ø
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'Ø
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'Ø
14. Reclamation Make-up Water 13'Ø
15. NaCl 13'Ø
16. Na_2CO_3 13'Ø
17. Utility Water 13'Ø
18. Fresh Eluant 13'Ø
19. Lean Eluant 13'Ø
20. Intermediate Eluant 13'Ø
21. Rich Eluant 13'Ø
22. Precipitation 13'Ø
23. 30'Ø Thickener, 5'Ø Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'Ø
26. High TDS Wastewater Tank 13'Ø
27. Low TDS Wastewater Tank 13'Ø
28. Solids Removal Tank 11'Ø
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A: 5'x20' - PC Booster Pumps
- B: 5'x20' - IC Booster Pumps
- C: 3'x10' - Pump
- D: 6'x5' - Pump
- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump

Feet: 0 15 30 60
Meters: 0 5 10 20

Legend

● Radon Decay Product Monitoring Locations

Figure 5.7-9

Locations of Radon Decay Product Monitoring Sites Inside Central Processing Facility Dewey-Burdock Project

DRAWN BY: Cadd Svcs, Hetrick
DATE: 14-Jun-2013
FILENAME: CPP-RadDecayProdIn.dwg

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The measurements will be performed by collecting samples on filter paper with a low-volume air sampler and analyzing the filter paper with an alpha counter using the Modified Kusnetz method described in ANSI N13.8-1973 or an equivalent method. The LLD for radon decay product measurements will be 0.03 WL, as described in RG 8.30, Section 2.3. The air sampler and alpha counter will be calibrated at the manufacturers' suggested time interval.

Airflow patterns in the facilities will be determined based on location of air inlets and exhausts relative to sources of airborne radioactive materials. Neutrally buoyant markers may be used to determine airflow patterns. Airflow patterns for workers will also be observed and monitored. If any worker areas are altered in size or location the air flow will be re-evaluated in those areas. If there is any reason to suspect a change in flow or pattern due to process or equipment changes, the area will be evaluated for airflow pattern changes, and sampling locations will be changed accordingly. Radon decay product samples will be collected at a height of 3 to 6 feet between the source and the area occupied by the workers.

During favorable weather conditions, open doorways and convection vents may change release points and air patterns of radon slightly, but the amount of radon released will remain the same. The concentration of radon gas being emitted under this scenario is expected to be lower compared to radon that is collected in the ventilation system and transported via duct work to an external release point. During plant operation, measurements will be made of radon emission from the plant ventilation system as well as measurements of radon decay products exposure at occupied areas in and around the plant. With these data, analyses of exposure to employees and radon effluent airflow will be conducted to determine if exposure is ALARA. In addition, a radon decay products concentration action level will be established. If the action level is exceeded, an analysis will be conducted to determine if the radon and radon decay products concentration and potential employee exposures are ALARA. Powertech (USA) will implement changes if and when necessary to ensure levels are ALARA. Results of monitoring obtained during initial plant operation will be used to adjust monitoring programs and upgrade ventilation and/or other effluent control equipment as necessary.

Powertech (USA) will implement these monitoring programs to provide sufficient information to demonstrate that radon effluent and worker exposure to radon decay products will be maintained at levels that are ALARA in accordance with the requirements in 10 CFR Part 40, Appendix A, Criterion 8 and 10 CFR § 20.1101(b) and the recommendation in NUREG-1569, Acceptance Criterion 4.1.3(5).

5.7.3.2 Airborne Particulate Monitoring

Since there will be no ore grinding at the facility, no monitoring of airborne uranium ore dust will be necessary. However, airborne yellowcake will be monitored at the facility. The facility will be drying yellowcake under low temperature (approximately 250°F). No stack monitoring will be required. According to the footnotes of 10 CFR 20 Appendix B, yellowcake dried under low temperature should be considered soluble on the following basis. There is no specific reference in 10 CFR 20 that describes hydrogen peroxide precipitated yellowcake as "soluble" for radiation protection purposes. Footnote 3 to 10 CFR 20, Appendix B, Table 1 addresses soluble mixtures of U-238, U-234, and U-235. Regulatory Guide 8.30, Section 2.2 suggests that "yellowcake dried at low temperature, which is predominantly composed of ammonium diuranate, or in the new processes uranyl peroxide, both are more soluble in body fluids than yellowcake dried at higher temperature; and a relatively large fraction is rapidly transferred to kidney tissues." Regulatory Guide 8.30 suggests that uranyl peroxide (i.e., hydrogen peroxide precipitated yellowcake) is soluble. Therefore, Powertech (USA) proposes that footnote 3 to 10 CFR Part 20, Appendix B, Table 1 applies to uranyl peroxide.

Nevertheless, consistent with the NRC staff guidance presented at the November 2009 uranium recovery workshop in Denver, CO, Powertech (USA) will consider hydrogen peroxide precipitated yellowcake dried at < 400° C as a Class W compound for radiation protection purposes until either the solubility class specific to the product produced in the process has been measured or the specific process has been shown to be comparable to similar processes for which the solubility class of the product has been measured.

The limiting factor for health considerations for soluble uranium is chemical toxicity and not radiation dose. According to the footnotes for the radionuclide tables in 10 CFR Part 20 Appendix B, "the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) µCi-hr/ml, where SA is the specific activity of the uranium inhaled." Also in the foot notes, the specific activity for natural uranium is 6.77E-7 Ci/g.

When the limit in footnote 3 to 10 CFR 20, Appendix B, Table 1 is divided by 40 hours and the specific activity of natural uranium is taken into account, the 40-hr time-weighted average uranium concentration limit is 1×10^{-10} µCi / mL. Assuming all the uranium sampled is soluble, this limit is consistent with the soluble uranium intake limit of 10 mg/week specified in 10 CFR 20.1201.2(e). Therefore, the soluble uranium intake (in mg/week) can be calculated from the airborne uranium concentrations to which the worker was exposed.

All measurements and calculations will be done and recorded using standard operating procedures. Typically, airborne particulate concentrations are recorded on an airborne particulate monitoring form, which includes lapel or air particulate sampling flow rates and time of operation, gross alpha measurements, and associated calculations.

Analysis of air filters using gross alpha and alpha spectroscopy methods will yield known concentrations of uranium, 100 percent of which will be converted to mass using the natural uranium specific activity of 677 µCi/g.

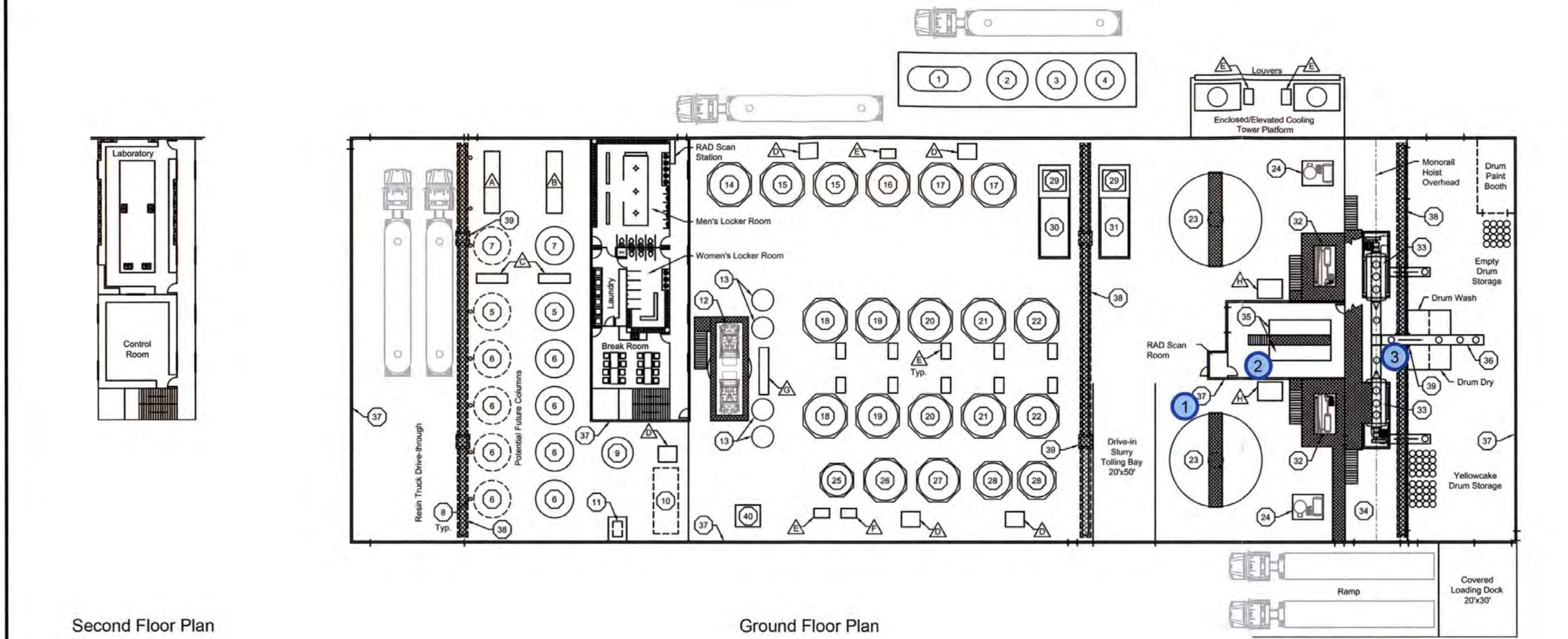
Records will be maintained as described in Section 5.2.5.

The primary ALARA goal for uranium intake will initially be set to less than 25% of the DAC values presented in 10 CFR Part 20, Appendix B, Table 1. In addition, Powertech (USA) will establish a corollary ALARA goal to limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity (see footnote 3 to 10 CFR Part 20, Appendix B, Table 1). After review of the first ALARA audit, modifications determined to be necessary to the facilities, procedures or ALARA program will be developed and implemented in order to further reduce exposures.

Areas meeting one of two criteria will be designated as airborne radioactivity areas. The first criterion is airborne yellowcake concentrations greater than 1 x 10-10 □Ci / mL. The second criterion is potential for personnel to be exposed to 25 percent of that concentration, averaged over the number of hours exposed in a week (as recommended in RG 8.30).

Static monitoring stations for airborne radionuclide areas within the CPP are shown on Figure 5.7-9a. For non-airborne radioactivity areas within the CPP, Powertech (USA) will conduct monthly and weekly monitoring for in-plant airborne radionuclides via breathing zone monitoring devices assigned to workers performing specific routine tasks on a random basis. No static monitoring stations for non-airborne radioactivity areas will occur unless required by an RWP. Non-routine task monitoring requirements will be documented in an RWP.

Fixed-location sampler locations will be evaluated annually to confirm that their locations are still appropriate. Included in this evaluation will be the assessment of air flow patterns including potential seasonal variations, changes in worker and equipment locations, and changes in process. Breathing zone samples (lapel samples) for specific tasks are presumed to be representative without further assessment provided the intake of the lapel sampler is within one foot of the worker's head.



Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'Ø
6. Process IX Column 12'Ø
7. Bleed IX Column 12'Ø
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'Ø
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'Ø
14. Reclamation Make-up Water 13'Ø
15. NaCl 13'Ø
16. Na_2CO_3 13'Ø
17. Utility Water 13'Ø
18. Fresh Eluant 13'Ø
19. Lean Eluant 13'Ø
20. Intermediate Eluant 13'Ø
21. Rich Eluant 13'Ø
22. Precipitation 13'Ø
23. 30'Ø Thickener, 5'Ø Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'Ø
26. High TDS Wastewater Tank 13'Ø
27. Low TDS Wastewater Tank 13'Ø
28. Solids Removal Tank 11'Ø
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
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Housekeeping Pads

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- D: 6'x5' - Pump
- E: 3'x5' - Pump
- F: 3'x5' - Disinfectant
- G: 3'x15' - Pump
- H: 6'x8' - Pump

Feet: 0, 15, 30, 60
Meters: 0, 5, 10, 20

1. Precipitation Area
2. Filter Press Room
3. Dryer and Packaging Area

Figure 5.7-9a

Proposed Quarterly Air Particulate Sampling Locations

Dewey-Burdock Project

DRAWN BY: Cadd Svcs, Hetrick
DATE: 14-Jun-2013
FILENAME: CPP-QtrAirPartSamp.dwg

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In lieu of weekly 30 minute grab samples specified in RG 8.30, weekly low volume breathing zone samples will be taken from representative workers in airborne radioactivity areas. Breathing zone samples provide a better estimate of airborne particulate concentrations to which workers are exposed, resulting in a more representative estimate of actual intakes. The sensitivity of this method shall be at least 1×10^{-11} µCi / mL.

Breathing zone samples will be taken during non-routine operations with potential for a worker to receive exposure to airborne yellowcake above 1×10^{-10} µCi / mL. The monitoring type and frequency for non-routine tasks will be described in the job-specific RWP as described in Section 5.2.2

All air samples will be analyzed for uranium within two working days after sample collection. The lower limit of detection (LLD) of all analyses of air samples will be no greater than 1×10^{-11} µCi / mL. The calculation of LLDs for measuring concentration of uranium in air is derived from the method to calculate minimum detectable activity (MDA) shown in NRC Regulatory Guide 8.25 "*Air Sampling in the Workplace*".

The technical justification for using the LLD equation in RG 8.25, rather than LLD specified in RG 8.30, is contained in NUREG-1400, Air Sampling in the Workplace (NRC, 1993a), as discussed below.

RG 8.30 uses the following formula to calculate LLD.

$$LLD = \frac{3 + 4.65S_b}{3.7 \times 10^4 EVYe^{-\lambda t}} \qquad \text{(Equation 5.1)}$$

where:

LLD = the lower limit of detection (µCi/ml)
S_b = the standard deviation of background count rate (counts per second)
3.7×10^4 = the conversion from disintegrations per second to µCi
E = the counting efficiency (counts per disintegration)
V = the sample volume (ml)
Y = the fractional radiochemical yield if applicable
λ = the decay constant for the particular radionuclide
t = the elapsed time between sample collection and counting(s)

When performing gross alpha counts on a filter for natural uranium, all counts above background are assumed to be from natural uranium. Thus, the Y variable in the above equation is not applicable and the exponential term in the denominator goes to 1 due to the long effective half life of natural uranium. Equation 5.1 can then be simplified to the following:

$$LLD = \frac{3 + 4.65S_b}{3.7 \times 10^4 EV} \qquad \text{(Equation 5.2)}$$

S_b is the standard deviation of background count rate (counts per second) and is calculated using Equation 5.3.

$$S_b = \frac{\sqrt{R_b T_s \left(1 + \frac{T_s}{T_b}\right)}}{T_s} \qquad \text{(Equation 5.3)}$$

where:

S_b = the standard deviation of background count rate (counts per second)
T_s = the gross counting time or sample counting time (s)
T_b = the background counting time (s)
R_b = the background count rate

The equation proposed in the application to calculate LLD for uranium concentrations in air is shown as Equation 5.4.

$$LLD = \frac{2.71 + 3.29\sqrt{R_b T_s \left(1 + \frac{T_s}{T_b}\right)}}{VEKT_s} \qquad \text{(Equation 5.4)}$$

where:

LLD = the lower limit of detection (µCi/ml)
T_s = the gross counting time or sample counting time (s)
T_b = the background counting time (s)
R_b = the background count rate
K = the conversion from disintegrations per second to µCi (3.7×10^4)
E = the counting efficiency (counts per disintegration)
V = the sample volume (ml)

Substituting the variable S_b for the standard deviation of background count rate into Equation 5.4 yields Equation 5.5 below.

$$LLD = \frac{2.71 + 3.29S_b}{KEV} \qquad \text{(Equation 5.5)}$$

A special case of S_b where the background counting time (T_s) equals the sample counting time (T_b) results in the following relationship (Equation 5.6) for S_b:

$$S_b = \frac{\sqrt{R_b T_s}}{T_s}\sqrt{2} = 1.41\ \frac{\sqrt{R_b T_s}}{T_s} \quad \text{(Equation 5.6)}$$

Substituting Equation 5.6 into Equation 5.5 results in Equation 5.7

$$LLD = \frac{2.71 + 4.65\sqrt{R_b T_s}}{VEKT_s} \quad \text{(Equation 5.7)}$$

A more rigorous formulation for extreme low-level counting using the exact Poisson distribution was given in Currie, 1972. Here, 2.71 (the Poisson-Normal approximation) is replaced by the exact Poisson value of 3.

Using this value, Equation 5.7 becomes:

$$LLD = \frac{3 + 4.65\sqrt{R_b T_s}}{VEKT_s} \quad \text{(Equation 5.8)}$$

Powertech (USA) will use Equation 5.8 in the simplified case where the background counting time is equal to the sample counting time if the exact Poisson distribution is used. The effect of using 2.71 versus 3 on the LLD is small and both are appropriate in estimating the LLD for air concentrations. Equation 5.8 is similar to Equation 5.2 (the simplified Regulatory Guide 8.30 equation) in form; however, Equation 5.8 accurately addresses S_b.

5.7.3.3 Respiratory Protection

The respiratory protection program at the facility will be conducted in accordance with NRC Regulatory Guide 8.15 "*Acceptable Programs for Respiratory Protection*" and NRC Regulatory Guide 8.31 "*Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable*", Section 2.7 and 10 CFR 20 subpart H.

PPE in the form of respiratory protective equipment will be mandatory for workers in areas where the use of process and engineering controls may not be adequate to maintain regulated exposure levels to airborne radioactive and/or toxic materials. This protection program will be carried out in accordance with RG 8.15 and RG 8.31 and will be administered by the RSO. The work areas that may have the potential for overexposure are limited to the drying and packaging areas under normal operating conditions.

Criteria for determining when respirators will be required for special job situations or a credible emergency are summarized here. The use of respiratory protection devices will be contemplated only after other measures to limit intake have been considered (10 CFR § 20.1701). If the ALARA evaluation determines process and/or engineering controls are not practicable, Powertech (USA) will increase monitoring and limit intake by controlling access and exposure time; if it is determined the use of respirators will optimize the sum of internal dose and other potential risk, use of a respirator will be implemented in order to keep TEDE ALARA in conformance with RG 8.15. The level of detail addressed during a TEDE ALARA evaluation will be dictated by the potential radiological and physical risk that may be associated with the special job or emergency.

5.7.3.4 Air Monitoring during First Year of Operations

Powertech (USA) will conduct an airborne radiation monitoring program at the project facility that is consistent with the recommendations contained in RG 8.30. The monitoring program will consist of monitoring radon decay products as well as airborne particulate monitoring. During the first year of operation an extensive air particulate program will be implemented in order to evaluate and determine area concentrations of key particulates to which workers may be exposed. Since no conventional ore processing is conducted at an ISR facility, the program will be designed to measure areas where workers may theoretically be exposed to radiological and non-radiological particulates during the daily work routines specific to ISR operations. Breathing zone and particulate monitoring programs are proposed in areas of the CPP where yellowcake is present (Figure 5.7-9a). Upon analyzing the results from the air particulate measurements, determinations will be made as to the assurance that process and engineering controls are maintaining the concentrations to which workers may be exposed ALARA. Other precautions will be considered based on the data from the primary monitoring program, such as access control to some areas, restrictions on working time within specific areas, and the use of PPE for respiratory protection.

5.7.3.5 Action Levels for Air Sampling Locations

A facility action level of 25% of the DAC for particulate radionuclides and 0.08 WL for radon-222 decay products will be established. If an airborne radionuclide sample exceeds the action level for radioparticulates or radon-222, the RSO will investigate the cause and increase the sampling frequency as appropriate until airborne radionuclide concentration levels do not exceed the action level. An administrative action level will be set at 130 DAC-hours for exposure to radioparticulates and/or radon decay products for any calendar quarter. If the action level is exceeded, the RSO will initiate an investigation into the cause of the occurrence, determine any corrective actions that will reduce future exposures, and document the corrective actions taken. Results of the investigation will be reported to management and the SERP and will be available for NRC inspection. The results of the bioassay program also will be used to evaluate the adequacy of the respiratory protection program at the facility. An abnormally high urinalysis will be investigated to determine the cause of the high result and if the exposure records adequately reflect that such an exposure may have actually occurred.

5.7.3.6 *Monitoring for Areas Not Designated as Airborne Radioactivity Areas*

Consistent with RG 8.30, Powertech (USA) will implement an air sampling program for areas in the process facility not designated as airborne radioactivity areas. The air sampling program will include quarterly radon decay product grab samples and monthly uranium grab samples. With respect to airborne particulate monitoring, a demonstration that the volume of air sampled is accurately known will be performed via one monthly sample for 30 minutes, or 5-minute weekly grab samples via a high-volume air sampler running at 30 cfm. Powertech (USA) reserves the right to incorporate one or both of these methods into air sampling procedures depending on which method may be most appropriate for a given space not designated as an airborne radioactivity area.

5.7.4 *Exposure Calculations*

In accordance with 10 CFR 20.1202, the total effective dose equivalent for all radiation workers will be determined by summing the DDE from external radiation and the committed effective dose equivalent (CEDE) from internal radiation.

5.7.4.1 *Internal Exposure*

CEDEs due to inhalation of yellowcake will be determined by either using the stochastic annual limits of intake (ALIs) listed in Table 1 of 10 CFR 20 or using the derived air concentrations (DACs) listed in the same table. These two methods are described as follows.

Method 1: Use of Stochastic Inhalation ALIs from 10 CFR Part 20

The CEDE for each radionuclide may be calculated using the estimated radionuclide intake, by Equation 2 of RG 8.30 as follows:

$$H_{i,E} = \frac{5I_i}{ALI_{i,E}} \qquad \text{Equation 2 from RG 8.30}$$

where:

$H_{i,E}$ = CEDE from radionuclide i (rem)

I_i = Intake of radionuclide i by inhalation during the calendar year (µCi). (If multiple intakes occurred during the year, is the sum of all intakes)

$ALI_{i,E}$ = Value of the stochastic inhalation ALI (based on the CEDE) from Column 2 in 10 CFR Part 20, Appendix B, Table 1 (µCi)

5 = CEDE from intake of 1 ALI (rem). The intake of natural uranium will be determined using the equation listed above in the response to TR RAI 5.7.4-1(a).

If intakes of more than one radionuclide occur, the CEDE will be the sum of the CEDEs for all radionuclides as described below. The intake of natural uranium will be determined using the equation listed below.

Method 2: Use of DACs from 10 CFR Part 20

The CEDE also may be calculated from exposures expressed in terms of DAC-hours. Equation 4 of RG 8.30 demonstrates how the CEDE may be calculated from exposures expressed in terms of DAC-hours.

$$H_{i,E} = \frac{5C_i t}{2000\,DAC_{stoc,i}} \qquad \text{Equation 4 from RG 8.30}$$

where:

$H_{i,E}$ = CEDE from radionuclide i (rems)

C_i = The airborne concentration of radionuclide i to which the worker is exposed (μCi/ml)

t = The duration of the exposure (hours)

2000 = The number of hours in a work year

5 = CEDE from annual intake of 1 ALI or 2000 DAC-hours (rems)

Exposures to airborne natural uranium will be compared to the stochastic ALI or DAC for the "W" class of natural uranium from Table 1 of 10 CFR 20, Appendix B until the actual lung clearance class of the product has been determined.

These methods will be used in non-routine operations, maintenance, and cleanup activities as well as during routine activities where appropriate. For non-routine operations involving an accident scenario, the worker breathing rate assumed in each of the above methods may not be appropriate. If at some point in time alternate methods to evaluate exposure to natural uranium not contained in RG 8.30 or 8.34 are determined to be more appropriate or applicable, these methods will be submitted to the NRC for review and approval prior to use.

The calculation of the committed effective dose equivalents, using either method, will be performed according with RG 8.30, Section C. These calculations will also be supported by the facility's bioassay program described in Section 5.7.5.

The potential intake due to inhalation of natural uranium by personnel in work areas where airborne radioactive materials could exist will be determined using the following formula:

$$I_u = BR \sum_{i=1}^{n} X_i \times t_i \times \frac{1}{PF}$$

where:

I_u	=	Intake of natural uranium for the monitoring period (µg or µCi)
X_i	=	The average air concentration of natural uranium in breathing zone during exposure period (i) (µg or µCi per milliliter)
BR	=	Breathing rate of the worker (2.0×10^{-4} milliliters per minute)
t_i	=	Time of exposure period (i) (minutes)
PF	=	The protection factor based on type of respiratory protection
N	=	Number of exposure periods during monitoring period

Based on industry experience, it is expected that there will only be natural uranium in air, not a mixture of radionuclides. Air samples will be analyzed using gross alpha measurements and, potentially, supported via alpha spectroscopy. Knowing the concentrations of long-lived alpha emitting radionuclides for various processes, no unknown mixtures of radionuclides in air are expected.

If encountered, exposure calculations will account for mixtures in air using the unity rule as follows:

$$\frac{C_{Th-230}}{DAC_{Th-230}} + \frac{C_{U-nat}}{DAC_{U-nat}} + \frac{C_{Ra-226}}{DAC_{Ra-226}} > 1$$

where:

C	=	airborne concentration, µCi/ml
DAC	=	derived air concentration, µCi/ml

The DAC for the mixture will be exceeded if the sum of fractions exceeds unity. If a condition occurs where the radionuclide and mixture of radionuclides are unknown, the DAC for Th-230(W) will be assumed since this is the most restrictive.

It is estimated that airborne uranium concentrations will be well below 25 percent of the derived air concentrations in 10 CFR Part 20 when the plant is at maximum production capacity. This estimate is supported by Section 2.8.4 of NUREG/CR-6733, which states:

"The vacuum dryer has an efficiency in excess of 99 percent for removal of uranium particulates prior to release to the atmosphere. The particles that result from the control system are returned to the drying chamber, thus recovering any uranium particulates. This particulate control system captures virtually all escaping particles."

5.7.4.2 Radon Decay Product Exposure

The amount of radon decay products exposure an employee received in a year will be calculated using the following equation:

$$E_{rd} = \frac{1}{170}\sum_{i=1}^{n}\frac{C_i \times t_i}{PF_i} \qquad \text{Equation 5.9}$$

where E_{rd} is the exposure to radon decay products in working level months (WLM) the employee received in a year, C_i is the average concentration, or working level (WL), of radon decay products of each exposure, t_i is the time of each exposure in hours, PF_i is the respiratory protection factor of each exposure, and n is the number of exposures the employee had during the year.

According to 10 CFR 20 Appendix B, 4 WLM equates to 5 rem CEDE.

Consistent with NUREG-1569, Acceptance Criterion 5.7.4.3(6), the parameters used to evaluate inhalation exposure to radon-222 decay products and to natural uranium will be representative of site conditions as they relate to the maximum production capacity. The calculations will incorporate occupancy time and average airborne concentrations; consequently, both full- and part-time employees (if any) will be considered in these exposure calculations.

5.7.4.3 Prenatal and Fetal Exposure

RG 8.13, Instruction Concerning Prenatal Radiation Exposure (NRC, 1999) provides information to pregnant women and other personnel to help them make decisions regarding radiation exposure during pregnancy, and also provides the definition of a "declared pregnant woman" as stated in Section A of the document. Consistent with RG 8.13, Powertech (USA), in Section 5.5.1, commits to providing this information to workers as appropriate. The information below describes some of the specific information that will be included within Powertech (USA)'s prenatal radiation exposure program consistent with RG 8.13.

- In order for a pregnant worker to take advantage of the lower exposure limit and dose monitoring provisions specified in 10 CFR Part 20, the woman must declare her pregnancy in writing to the licensee.
- The woman's immediate supervisor should receive the written declaration of pregnancy.

- Once a woman has declared a pregnancy in writing, the applicant has the obligation to take steps, including potentially changing the woman's job function, in order to keep doses to the embryo/fetus below regulatory limits contained in 10 CFR § 20.1208 and to levels that are ALARA.
- The RSO is to be consulted if the declared pregnant worker needs additional information.
- The dose to the embryo and fetus is calculated as the sum of the deep-dose equivalent of the declared pregnant worker and the dose to the embryo/fetus from radionuclides in the embryo/fetus and the declared pregnant worker. The calculations will be done according the NRC Regulatory Guide 8.36 *"Radiation Dose to the Embryo/Fetus"*.

5.7.4.4 Reporting and Recordkeeping of Worker Doses

Records showing the results of surveys and calibrations will be maintained for a minimum of three years after the record is made.

Records of all dose assessments, including surveys, measurements, bioassays and calculations used in the dose assessments, will be maintained through license termination in accordance with recommendations in RG 8.7 and in formats necessary to demonstrate compliance with 10 CFR § 20.2102, 20.2103, 20.2106, and 20.2110.

5.7.5 Bioassay Program

A urinalysis bioassay program will be established at the facility in order to detect employee intakes of uranium. The program will be consistent with the recommendations contained in NRC Regulatory Guide 8.22 "*Bioassays at Uranium Mills*" (RG 8.22). The justification for relying on urinalysis as a primary bioassay technique is provided as follows. Two bioassay techniques are considered in RG 8.22: urinalysis and in-vivo lung measurements. RG 8.22 discusses two triggers for in-vivo lung measurements: 1) when air monitoring or exposure calculations call for in vivo measurement, and 2) when urinalysis results call for in vivo measurements.

The first trigger is when air sampling results indicate an exposure exceeding that resulting from exposure to the more insoluble component of yellowcake at an average airborne concentration of 10^{-10} µCi/ml in a period of 1 calendar quarter. Powertech (USA) will consider the dried yellowcake produced at the Dewey-Burdock Project as Class W natural uranium for radiation protection purposes until determined otherwise. The DAC for Class W natural uranium is 3×10^{-10} µCi/ml. The action level for airborne radionuclide concentrations measured minimally on a weekly basis is 25% of the DAC, or in the case of Class W natural uranium an airborne concentration of 7.5×10^{-11} µCi/ml. Since controls will be implemented to mitigate airborne concentrations at the established action level, airborne natural uranium concentrations exceeding the air monitoring trigger for in-vivo measurement are unlikely.

Since quarterly average airborne natural uranium (Class W) concentrations are unlikely to exceed the in-vivo lung measurement trigger, urinalysis will be used as the primary bioassay technique. However, in-vivo lung measurement will be considered on a case-by-case basis if urinalysis results indicate that it would be appropriate.

All employees that will handle yellowcake will give a urine sample prior to starting employment and upon termination of employment. During operation of the facility, each employee that has the potential to ingest or inhale yellowcake will give a urine sample on a monthly basis. At a minimum, mechanics/general maintenance workers (7 employees), dryer operators (2 employees), and CPP operators (8 employees) will be sampled on a monthly basis (17 total employees).

Additionally, urine samples will be collected from workers who were exposed to airborne yellowcake suspected of exceeding the 40-hr weekly limit of 1×10^{-10} µCi / mL.

All urine samples will be analyzed for uranium content by a contract laboratory that can achieve a minimum sensitivity of 5 µg/L.

Dose Calculations

The dose from the intake will be estimated by multiplying the estimated intake by the appropriate dose conversion contained in Federal Guidance Report No. 11 (EPA, 1988).

Intakes of uranium will be estimated using the methods described in RG 8.9 (NRC, 1993b). The methods used below apply to the inhalation pathway since it is by the far the most important pathway for potential worker exposure. The following equation will be used to estimate intakes for urine samples collected over a 24-hour period:

$$I = \frac{A(t)}{IRF(t)}$$ Equation 5.10 (RG 8.9)

where:

I = Estimate of intake with units the same as A(t)
A(t) = Numerical value of the bioassay measurement obtained at time t (µCi)
IRF(t) = Intake retention fraction corresponding to type of measurement for time t after estimated time of intake

The IRF(t) for Class D and Class W, given a 30-day urine bioassay monitoring interval, is 4.7E-3 and 1.3 E-3, respectively (ICRP, 1988).

If the total urine sample is not collected over a 24-hour period, the following formulas will be used to estimate the intake:

$$\Delta A_i = C_i E_i \, (t_i - t_{i-1})$$ Equation 5.11

$$A_t = \Delta A_1 + \Delta A_2 + \ldots \Delta A_i \qquad \text{Equation 5.12}$$

where:

ΔA_i	=	Amount of uranium in sample (μCi)
i	=	The sequence number of the sample
C_i	=	The uranium concentration in urine of sample i (μCi/L)
E	=	Daily urine excretion rate (1.4 and 1.0 L/d for standard man and standard woman, respectively)
t_i	=	time (d) after intake that sample i is collected
A_i	=	Total amount (mg) excreted up to time t

Using the calculated A_i, the worker intake will be estimated using Equation 5.10 and the IRF(t) given above.

Corrective Actions

The following corrective actions, which are consistent with Table 1 in RG 8.22, will be taken if positive bioassay results are confirmed. If a monthly urinalysis is less than 15 μg/L uranium, no action will be taken. If the monthly urinalysis is 15 to 35 μg/L uranium, the cause of the elevated uranium will be identified and corrected. A determination will be made as to the potential for other workers' exposure and bioassays conducted as necessary. Work assignment limitations and/or respiratory protection will be considered. Uranium effluent controls will be also be reviewed for possible improvements. If the amount of uranium detected in a monthly urinalysis is greater than 35 μg/L, and has been confirmed in two consecutive specimens, then the actions mentioned above will be taken. Additionally, the urine specimen will be tested for albuminuria, and an in vivo count may be obtained. Work restrictions will be considered for affected employees until urinary concentrations are below 15 μg/L uranium and laboratory tests for albuminuria are negative. Further uranium effluent controls or respiratory protection requirements will also be considered. NRC will be notified as required.

Reporting and Recordkeeping

Consistent with Acceptance Criterion 5.7.6.3(5) of NUREG-1569, Powertech (USA) will conduct record keeping and reporting for the bioassay program in accordance with 10 CFR Part 20, Subparts L and M. Records of all dose assessments will be maintained through license termination. All bioassay results, including negative (i.e., < action level of 15 μg/l) results, will be retained in employee personnel files. For results confirmed in excess of action levels, an internal dose assessment will be performed including information obtained from follow-up actions and investigations including follow-up bioassay results, if applicable. Powertech (USA) will submit a written report to NRC within 30 days after confirmation of results in excess of action levels. The report will contain estimates of each individual's dose, the levels of radiation and concentrations of radioactive material involved, the cause of the elevated exposures, dose rates or concentrations, and corrective steps taken or planned to ensure against a recurrence. Sections 5.2.5 and 5.2.6 contain additional information regarding reporting and recordkeeping.

5.7.6 Contamination Control Program

Powertech (USA) will conduct a contamination control program at the project facilities consistent with recommendations contained in RG 8.30. The purpose of the program is to prevent contamination from spreading to unrestricted areas and needlessly exposing people to radiation. The contamination control program will address potential contamination spreading from restricted areas (process areas as well as general plant areas), from personnel working in those areas, and from equipment and PPE used in those areas. Areas will be classified as restricted based on the potential for risks to workers from exposure to radiation and radioactive materials (10 CFR Part 20). This potential for risks from radiation exposure encompasses airborne radiation as well as radioactive materials on surfaces. The program will also address the survey equipment used to locate contamination. The ALARA goal for contamination control is to reduce the residual contamination on personnel and equipment to be released from the controlled area to as low as reasonably achievable.

5.7.6.1 Areas

Restricted areas include those with surface contamination above 5,000 dpm alpha per 100 cm^2 (averaged over no more than 1 m^2), spots of contamination above 15,000 dpm alpha per 100 cm^2 (averaged over no more than 100 cm^2), or removable contamination above 1,000 dpm alpha per 100 cm^2.

To meet the ALARA concept, surfaces in restricted areas exposed to the air will be limited to having surface contamination of 220,000 dpm alpha per 100 cm^2.

Unrestricted areas will be spot checked weekly for removable surface contamination. If a spot check finds an area of removable surface contamination above background in an unrestricted area, that area will be cleaned and resurveyed for removable surface contamination.

The limits established for alpha and beta-gamma radiation shall apply independently where surface contamination by both alpha and beta-gamma radiation exists. Beta contamination surveys will be performed in those areas of operations that involve direct handling of large quantities of aged yellowcake. Unrestricted area surveys (areas where food is allowed, change rooms, and offices) will be conducted weekly. The total beta-gamma contamination limit for these surveys will be 1,000 dpm/100 cm^2. After facilities have been built, each area will be monitored and a background level established. After background has been established, the action levels for each area will be determined. The beta-gamma surveys for contamination within controlled areas (e.g., well fields) will be conducted monthly; the limit for these surveys will be 1,000 dpm/100 cm^2.

5.7.6.2 Personnel

Personnel working in restricted areas as described in Section 5.7.6.1 will wear protective clothing to mitigate the potential for skin contamination.

Personnel exiting restricted areas with potential removable surface contamination will be monitored for skin and clothing contamination in order to prevent the spread of contamination to unrestricted areas and to keep doses ALARA. Areas of skin measured to be above background will be washed until they no longer read above background. Clothing measured to have alpha contamination above background will be laundered or properly disposed. Soles of shoes reading higher than background alpha levels will be washed and scrubbed until they are no longer above that value. Each survey of personnel leaving a restricted area and the subsequent decontamination will be documented.

Since any beta–gamma contamination at a uranium ISR facility must be associated with alpha emitting nuclides, no special monitoring or survey for beta–gamma emitters will be used for contamination monitoring for personnel. The lack of detectable alpha contamination assures no beta–gamma contamination.

The individual(s) with skin contamination will conduct self-decontamination if physically able to do so. If necessary, the RSO, the RST or a qualified and trained radiation worker will conduct the skin decontamination and verify that background levels have been achieved. The RSO will verify that correct procedures were followed and follow up with an investigation, if appropriate.

Additionally, random surveys of personnel by a member of the radiation protection staff will be conducted quarterly to ensure that the contamination control program is performing adequately.

5.7.6.3 Equipment

Equipment leaving restricted areas with removable contamination will undergo decontamination followed by a survey for removable contamination in order to prevent the spread of contamination to unrestricted areas. Radiation surveys for alpha radiation and beta-gamma radiation in restricted areas will be conducted by the RSO, the RST, or a qualified and trained radiation worker under the supervision of the RSO. Equipment found to have average radiation levels at or below 5,000 dpm alpha (or beta-gamma) per 100 cm^2 (averaged over no more than 1 m^2), removable contamination at or below 1,000 dpm alpha (or beta-gamma) per 100 cm^2, and spots (areas 100

cm^2 or smaller) at or below 15,000 dpm alpha (or beta-gamma) per 100 cm^2 will be cleared for unrestricted use. Equipment that exceeds the contamination limits will undergo further decontamination until the contamination is below the limits or until decontamination yields no reduction in contamination. Equipment with contamination above any of the limits after attempts of decontamination will be properly disposed. Each survey of equipment leaving a restricted area and the subsequent decontamination will be documented.

Consistent with NUREG-1569, Acceptance Criterion 5.7.6.3(7), the radioactivity of the interior surfaces of pipes, drain lines, or duct work used to convey radionuclides will be determined by making radioactivity measurements at all accessible traps, drains and other appropriate access points that would likely be representative of the radioactivity on the interior of the pipes, drain lines or duct work. If a representative surface cannot be accessed, the pipe, drain line, duct work used to convey radioactive material or similar item will be considered contaminated and not released for unrestricted use from the site.

Consistent with NUREG-1569, Acceptance Criterion 5.7.6.3(6), Powertech (USA) will make a reasonable effort to minimize any radioactive contamination before the use of any covering. Radioactivity on equipment or other surfaces will not be covered with paint, plating, or other covering material unless contamination levels, as determined by a radioactivity survey and properly documented, are below the limits specified in Enclosure 2 to Policy and Guidance Directive FC-83-23, as updated (NRC, May 28, 2010, pg. 41, Section 6.3, Item #2).

5.7.6.4 Respirators

Respirator hoods and face pieces will be surveyed for removable surface contamination before each reuse. Any pieces that have removable surface contamination above background will be decontaminated or replaced. Each survey of respirator hoods and face pieces and the subsequent replacement will be documented.

5.7.6.5 Survey Instrumentation

For tests of removable alpha contamination, swipes or wipes will be used and then counted with an alpha detector designed for sample counting. The same method will be used for testing for removable beta-gamma radiation except the counting will be done with a beta-gamma detector designed for sample counting.

For other measurements for surface contamination, a battery-operated portable alpha detector will be used to directly measure the surface for alpha contamination and a battery-operated portable beta-gamma detector will be used to directly measure the surface for beta-gamma contamination.

In each scenario, the alpha detector used will be able to detect alpha radiation ranging from 100 to 220,000 dpm per 100 cm^2 and the beta-gamma detector used will be able to detect beta-gamma radiation ranging from 1,000 to 15,000 dpm per 100 cm^2.

The instrumentation will be calibrated according to the manufacturer's specifications annually or at the manufacturer's recommended interval, whichever is more frequent.

5.7.6.6 Reporting and Recordkeeping

Consistent with NUREG-1569, Acceptance Criterion 5.7.6.3(5), Powertech (USA) will record and maintain contamination control program information and data as required by 10 CFR Part 20, Subpart L. The records will be retained for 3 years after the records are made. Powertech (USA) will immediately report any event involving source and byproduct materials possessed by Powertech (USA) that may have caused or threatens to cause any of the conditions listed in 10 CFR § 20.2202. Powertech (USA) will submit a written report to NRC within 30 days after confirmation of any of the reportable events listed in 10 CFR § 20.2203. The report will describe the extent of exposure of individuals to radiation and radioactive material and other information as described in 10 CFR § 20.2203. Sections 5.2.5 and 5.2.6 contain additional information on reporting and recordkeeping.

5.7.7 Airborne Effluent and Environmental Monitoring Program

Powertech (USA) will conduct an airborne effluent and environmental monitoring program during operations consistent with recommendations in NRC Regulatory Guide 4.14 "*Radiological Effluent and Environmental Monitoring at Uranium Mills*" (RG 4.14). The program will consist of sampling air, water, vegetation, livestock, and surface soil. Powertech (USA) will develop, implement and maintain monitoring and quality assurance/quality control programs that ensure consistency for purposes of comparison of data results within and between phases of pre-operation, operations and restoration and reclamation activities where applicable.

Operating philosophies in Regulatory Guide 8.10 will be implemented to determine that concentrations of radon and decay products will be maintained ALARA. Administratively, action levels of 25% of the DAC for airborne radionuclides will be established. Exceedances of the action levels will trigger an investigation to evaluate the performance of existing controls and potentially implement new controls to mitigate airborne radionuclide concentrations.

Additionally, Section 4.1.1 states that results of monitoring obtained during initial plant operations will be used to adjust monitoring programs and upgrade ventilation and/or other effluent control equipment as necessary.

Monitoring results will also be evaluated in routine audits conducted by the RSO and third parties. Included in these audits will be an evaluation of spatial and temporal trends for these monitoring results. These audits provide another opportunity to evaluate whether concentrations of radon and decay products are ALARA.

Throughout the application Powertech demonstrates through commitments for implementing management controls, engineering controls, radiation safety training, radon monitoring and sampling, and auditing programs that there are multiple methods by which concentrations of radon and radon decay products will be determined to be ALARA.

5.7.7.1 Air Monitoring

Operational air monitoring locations (air particulate and radon-222 track-tech detectors) are shown in Figure 5.7-10. This figure includes an updated annual wind rose. The five proposed operational monitoring locations are the same as the corresponding pre-operational monitoring locations, allowing the comparison of operational data with pre-operational data. Section 2.9.6 provides information regarding placement of pre-operational air particulate sampling stations as they apply to Regulatory Guide 4.14. Since the placement of pre-operational air monitoring stations is consistent with recommendations contained in Regulatory Guide 4.14, the placement of operational air monitoring stations is also consistent with Regulatory Guide 4.14.

The filters from air samplers operating continuously will be analyzed quarterly for natural uranium, thorium-230, radium-226, and lead-210. Samplers will have sensors to measure total air flow within a sampling period. The maximum LLDs for the analyses will be consistent with the recommendations of RG 4.14.

Powertech (USA) will change filters from the operational air samplers bi-weekly or more frequently if required for dust loading. The operational air particulate samplers will be brushless, automatic flow control hi-vol air samplers similar to those used during pre-operational monitoring. Each air sampler will be equipped with a variable speed motor, controlled by a programmable logic controller (PLC). The PLC will receive input from a mass air flow sensor placed in the air flow path downstream of the filter paper. Any changes in the pre-set flow rate due to dust loading, barometric pressure or temperature will be detected by the air flow sensor. The PLC will compensate for the change by adjusting the motor speed to maintain the pre-set flow rate.

Air samplers will also be equipped with air flow totalizers, which will be recorded and reset during each filter change. Based on the use of modern, automatic flow control air samplers, the recommendation in Regulatory Guide 4.14 to change filters weekly is obsolete. When Regulatory Guide 4.14 was issued, automatic flow control air samplers were unavailable, resulting in the need for weekly filter changes. As described in Section 2.9.6, use of automatic flow control air samplers along with visual observations and flows recorded during each filter change confirmed that the bi-weekly filter changes was sufficiently frequent to avoid reduction in performance due to dust loading during pre-operational monitoring. Similarly, Powertech (USA) will monitor air sampler performance during operational monitoring and change filters bi-weekly or more frequently if required for dust loading.

There will be no stacks at the Dewey-Burdock Project. There will be release points (e.g., vents) that will be sampled quarterly. The grab samples will be isokinetic in nature and will be analyzed for natural uranium, thorium-230, radium-226, and lead-210. The maximum LLDs for the analyses will be consistent with recommendations of RG 4.14.

Powertech (USA) will sample for radon-222 using passive track-etch detectors located at each air monitoring station on a monthly basis, which is consistent with Regulatory Guide 4.14 and NUREG-1569, Acceptance Criterion 5.7.7.3(1).

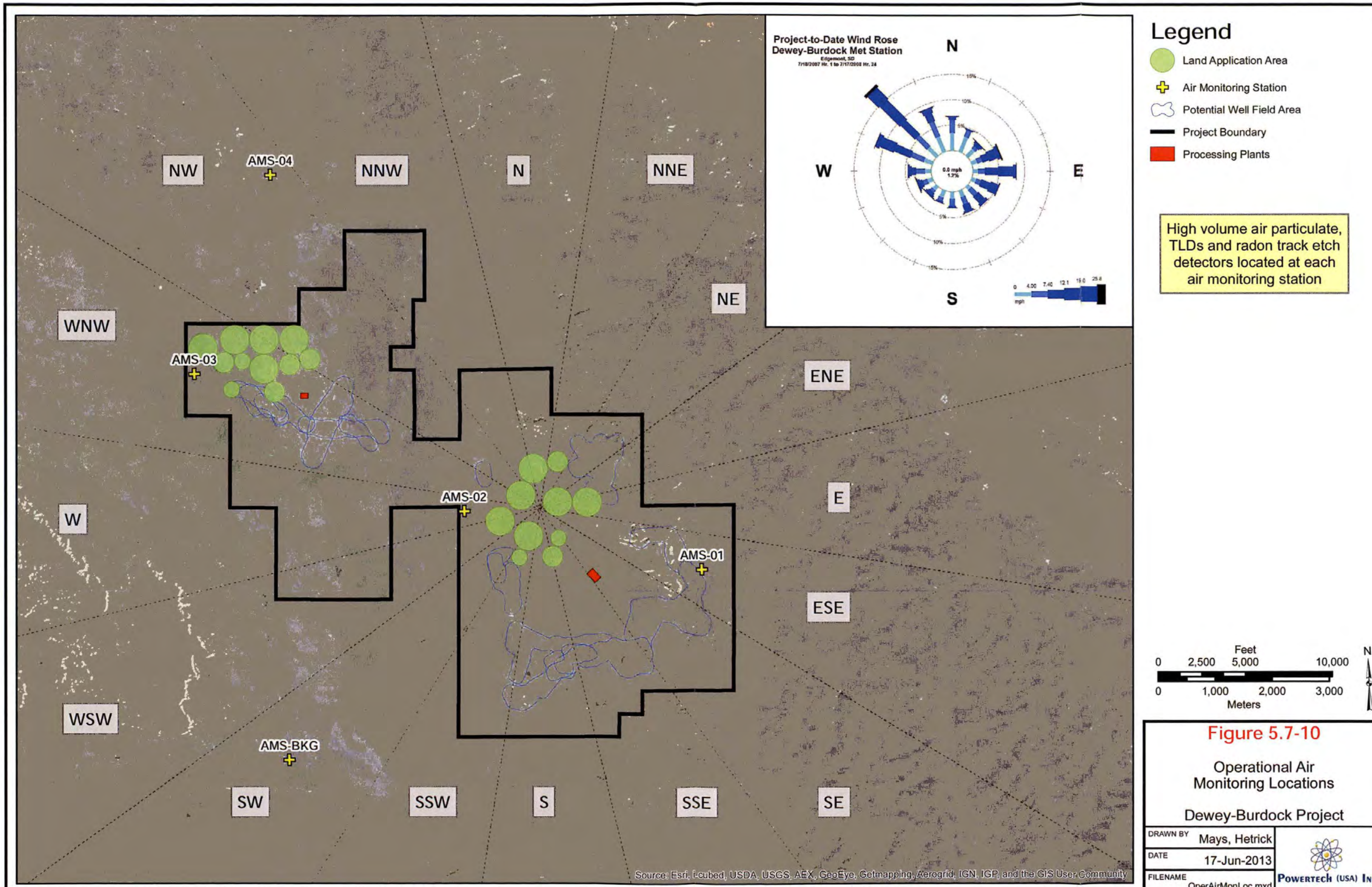

Figure 5.7-10
Operational Air Monitoring Locations

5.7.7.1.1 Estimating Airborne Release of Radon

The airborne release of radon (the principal radionuclide potentially released) from process operations will be estimated using the methods described in Section 7.3 and in Regulatory Guide 3.59, Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (NRC, 1987). Important parameters used to estimate the airborne releases will be monitored as part of routine process performance parameters. These parameters include but are not limited to the following:

- Average production lixiviant flow rate
- Average restoration flow rate
- Average bleed rate
- Radium-226 concentration of pregnant lixiviant
- Uranium concentration of pregnant lixiviant
- Number of operating days
- Land application rate
- Radionuclide concentration of land application solutions
- Radionuclide soil concentrations of land application areas
- Identification of potential point and diffuse source locations.

Although potential airborne uranium emissions to unrestricted areas are not expected, performance of the vacuum dryer and emission control systems for the dryer will be monitored as part of typical process performance parameters.

The results of airborne radionuclide release surveys, including location and strength (i.e., quantity of each radionuclide in Ci/yr) of point and diffuse airborne emissions, based on important parameter monitoring will be reported in the semiannual effluent reports required by 10 CFR § 40.65.

5.7.7.1.2 Estimating Public and Occupational Exposure to Radon Decay Products

The primary method to account for public exposure to radon decay products is to evaluate the dose from radon and its decay products at receptor locations in and around the project area using environmental monitoring data and Equation 5.13 below.

$$\boldsymbol{CEDE = DCF \times C_{net} \textstyle\sum_i OF_i \times EF_i} \qquad \text{(Equation 5.13)}$$

where:

CEDE = Annual committed effective dose equivalent from radon-222 (mrem/yr).

C_{net} = Net annual average radon-222 concentration (annual average concentration at location minus annual average concentration at background location) (pCi/L).

OF_i = Occupancy factor for location or conditions; in above equation will usually be 1 unless different equilibrium factors for indoor and outdoor radon-222 exposures are used.

EF_i = Radon-222 decay products equilibrium fraction; will assume indoor and outdoor fraction of 0.5. May adjust outdoor fraction based on MILDOS-AREA modeling.

DCF = Dose Conversion Factor of 500 mrem/pCi L^{-1} at 100% equilibrium (from 10 CFR 20, Appendix B, Table 2).

The member of the public likely to receive the highest dose from licensed operations is a resident at air monitoring station AMS-02. Locations of operational air monitoring stations are shown on Figure 5.7-10. Passive track-etch detectors will be deployed at each operational monitoring station for monitoring radon-222 on a quarterly basis.

The above method is a conservative approximation of dose from radon-222. Given the difficulty in measuring low-level radon-222 concentrations resulting from site activities within the varying background radon-222 concentrations in and around the project area, an alternate approach to the above method may be used as needed. The alternate approach would be to model the dose to the receptor of concern using MILDOS-AREA. Inputs into MILDOS-AREA will be the location and strength of source terms based on estimated airborne releases reported as required by 10 CFR § 40.65, the site-specific meteorological data updated as needed for the current year, and receptor location. An example of this approach using pre-operational meteorological data is provided below.

Consistent with the requirements of 10 CFR §20.1501, Figure 5.7-11 presents the results of modeling the annual total effective dose equivalent (TEDE) above background in and around the project area. The analysis was performed using MILDOS-AREA as a predictive model to estimate doses at regularly spaced (1 X 1-km grid spacing) arbitrary receptors within and around the project area using the same input parameters and source terms described in Section 7.3. Isodose contour lines were developed using kriging interpolation methods based on the results of the MILDOS-AREA modeling of the arbitrary receptors.

The isodose lines shown on Figure 5.7-11 are adult doses based on continuous occupancy. The highest predicted dose is around 6 mrem/year southeast of the Dewey portion of the project area. Assuming a worker is in the project area for 2,000 hours per year, the expected annual occupational dose from gaseous and particulate releases would be less than 2 mrem/year. If a

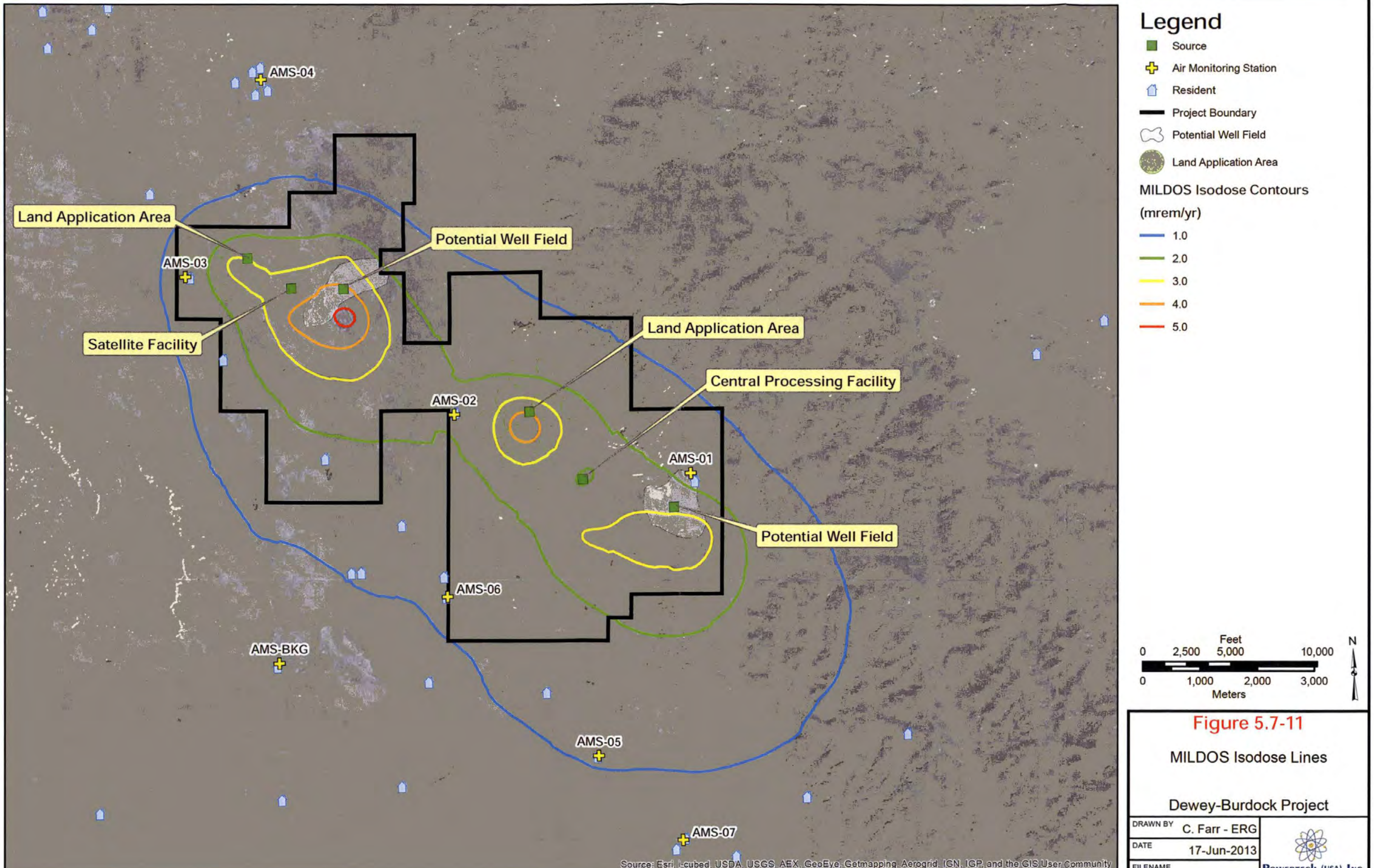

Figure 5.7-11

MILDOS Isodose Lines

Dewey-Burdock Project

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worker not associated with the Dewey-Burdock Project (i.e., a member of the public) were to work the entire year within the project area, no public dose limits will be exceeded.

Assuming a member of the public uses the project area for recreation or other purposes for 2 weeks per year, the expected annual public dose from gaseous and particulate releases would be less than 1 mrem/year. It is likely that any member of the public working or otherwise using the land within the project area would be there for a small fraction of time compared to a resident potentially living within the project area. Consequently, the member of the public likely to receive the highest dose from the licensed operation would be a resident living near the facility continuously during the year. The residence closest to and downwind from the facility is AMS-02 as described previously. The predicted TEDE at this location ranges from 2.21 mrem/year for an adult to 4.5 mrem/per year for an infant. The AMS-02 location is included in the proposed environmental monitoring program for radon-222, air particulate, and exposure rate monitoring.

This analysis is based on the use of best professional practices to ensure effluent limits are ALARA, including use of pressurized, downflow IX columns, modern vacuum dryer, building ventilation, and extensive control, alarm, and monitoring systems. This will ensure that ISR operations are conducted so that all airborne effluent releases, occupational doses, and doses to members of the public are reduced to levels that are ALARA in accordance with 10 CFR Part 40, Appendix A, Criterion 8, 10 CFR 20.1101(b) and NUREG-1569, Acceptance Criterion 4.1.3(5).

The analysis is also in agreement with NUREG-1910 (NRC, 2009), which states, "Doses for the various ISL facilities…are at least a factor of three below the regulatory limit and most are less than that. Based on operational history and dose-modeling results, doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and overall potential radiological impacts from ISL operations would be SMALL" (pg. 4.3-33). NUREG-1910 also provides information regarding typical employee exposure to radon decay products. For one ISR facility monitored over a 13-year period, maximum employee exposure to radon decay products ranged from 0.213 to 0.643 working-level months, or from 2.5 to 16 percent of the occupational exposure limit of 4 working-level months. NUREG-1910 concludes, "Because these average and maximum exposure levels range from 2.5 to 16 percent of the occupational exposure limit of 4 working-level months, doses from normal radon releases would be expected to have a SMALL impact on the workers" (pg. 4.2-55). Figure 5.7-11 supports the expectation that the areas with the highest potential for occupational doses occur within the confined structures of the facility where gaseous and particulate emissions potentially could concentrate.

5.7.7.2 Biota Monitoring

Following is a description of the operational monitoring programs for vegetation, crops, livestock and fish, and game animals. Powertech (USA) commits to attaining the LLDs in RG 4.14 or, at a minimum, alternate LLDs, if agreed to by the NRC in the operational monitoring phase of the project. Powertech (USA) commits to utilizing well trained field personnel and to working closely with contract laboratory personnel in order to ensure LLDs are consistent with NRC guidance in RG 4.14.

Vegetation

Samples of vegetation will be collected three times during the grazing season at each air monitoring station presented on Figure 5.7-10. These air monitoring locations are located in three different sectors having the highest predicted airborne radionuclide concentrations due to milling operations, which is a siting criterion for the air monitoring stations. Justification regarding the placement of these air monitoring stations as they apply to recommendations in RG 4.14 is provided in Section 2.9.6. The samples of vegetation will be analyzed for radium-226 and lead-210.

Based on MILDOS-AREA results that show the total effective dose equivalent (TEDE) from all pathways is less than 5% of the applicable radiation protection standard (the modeled dose to potential maximally exposed member of the public is approximately 3 mrem/year), Powertech (USA) does not believe that the ingestion pathways from grazing animals is a potentially significant pathway exceeding 5% of the applicable radiation protection standard. However, Powertech (USA) will sample vegetation during the first year of operations for comparison to baseline data. If analysis and MILDOS-AREA determine that there is not a significant pathway, Powertech (USA) will propose to modify the monitoring plan to not include the sampling of vegetation or forage as part of the operational monitoring program. This is consistent with the recommendations contained in RG 4.14.

Crops

Based on MILDOS-AREA results that show the TEDE from all pathways is less than 5% of the applicable radiation protection standard (the modeled dose to potential maximally exposed member of the public is approximately 3 mrem/year), the ingestion pathway from crops would not likely exceed 5% of the applicable radiation protection standard. If the pre-operational garden vegetable soil sample results described in Section 2.9.10 supported by MILDOS-AREA modeling demonstrate no significant exposure pathway, Powertech (USA) will not sample crops, including vegetable gardens, as part of the operational monitoring program. This approach is consistent with the recommendations contained in RG 4.14.

Livestock and Fish

Powertech (USA) commits to collecting livestock samples annually, consistent with guidance contained in RG 4.14. RG 4.14 focuses animal food sampling on grazing animals and fish. Poultry are not grazing animals. Fish will be collected semiannually provided they exist in water bodies that may be subject to seepage or surface drainage from potentially contaminated areas. Livestock and fish samples will be collected and analyzed for uranium (natural), thorium-230, radium-226, lead-210 and polonium-210.

Powertech (USA) commits to livestock sampling and analysis during the first year of operations for comparison to baseline. These annual grab samples taken at the time of harvest or slaughter will be analyzed for natural uranium, radium-226, thorium-230, lead-210 and polonium-210. Livestock samples will include cattle, pigs and other livestock present at the time of sampling; number and type will depend upon availability. Currently, cattle and pigs are the only livestock within the 3.3 km area. If the presence of other livestock is found during the annual land use survey, Powertech (USA) will seek the livestock owner's approval to collect tissue samples at the time of slaughter.

If the analysis of livestock tissue supported by the annual MILDOS-AREA modeling indicates grazing animals demonstrate no significant exposure pathway, Powertech (USA) will modify the monitoring program appropriately and submit to the NRC for approval. This is in accordance with Regulatory Guide 4.14, Table 2, footnote "o," which states, "Vegetation or forage sampling need be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway (an exposure pathway should be considered important if the predicted dose to an individual would exceed 5% of the applicable radiation protection standard)."

Powertech (USA) does not propose to sample poultry. While chickens also are currently present within 3.3 km of the project area, they are fed grains not originating from the project area and are not considered grazing animals.

Fish species with the potential for human consumption (green sunfish and channel catfish) have been recorded in the area will be sampled semiannually, if present in water bodies potentially affected by contamination.

Game Animals

Powertech (USA) does not propose to sample wild game due to the precedent from recently approved NRC license applications (e.g., Moore Ranch) that have not provided game animal tissue sample analyses due to the migratory nature and relatively large home range of game animals in relation to the size of the project area. These animals would not be a significant pathway to man, which Regulatory Guide 4.14 lists as a criterion for sampling in the operational monitoring program. This will be confirmed through annual MILDOS-AREA modeling.

5.7.7.3 Surface Soil Monitoring

Samples of surface soil (0-5 cm) will be collected annually at each of the air monitoring stations shown in Figure 5.7-10. The samples will be analyzed for natural uranium, radium-226, and lead-210. Powertech (USA) commits to attaining the LLDs in RG 4.14 or, at a minimum, alternate LLDs, if agreed to by the NRC in the operational monitoring phase of the project.

5.7.7.4 Direct Radiation Monitoring

Consistent with recommendations contained in RG 4.14, thermoluminescent dosimeters (TLDs) or equivalent dosimeters will be co-located with the air particulate samplers. Powertech (USA) will utilize environmental, low-level TLDs provided by a National Voluntary Laboratory Accreditation Program (NVLAP) approved provider. The dosimeters will be exchanged quarterly. The results will be used to assess quarterly gamma exposure rates at each of the sites.

5.7.7.5 Sediment Monitoring

During operations, Powertech (USA) will conduct annual sediment sampling at the operational surface water monitoring locations. Sections 2.7.3.1 and 5.7.8.1 describe the impoundments and stream sampling sites included in the operational monitoring program. All samples will be analyzed for natural uranium, Th-230, Ra-226, and Pb-210, which is consistent with Table 2 of Regulatory Guide 4.14.

5.7.8 Groundwater and Surface-Water Monitoring Programs

5.7.8.1 Surface Water Operational Monitoring Program

During ISR operations, 24 impoundments, identified during the 2007 field survey, and 10 stream sampling sites (depicted on Plate 5.7-1) will be monitored as part of the operational monitoring program. The location of each impoundment in relation to proposed activity was used to determine whether the impoundment will be included in the operational monitoring program.

Table 5.7.8-1 lists all of the impoundments and identifies which impoundments are located down-gradient (i.e., potentially subject to surface runoff) from proposed activity or within potential well field areas. The table also denotes the 24 impoundments included in the operational monitoring program, including 2 Darrow pits not included in the baseline monitoring program. Justification for the impoundments not included is provided in the table and is typically due to the impoundment not being located downstream of all proposed activities. All 24 impoundments identified for operational monitoring will be visited on a quarterly basis throughout construction and operation. In addition, Powertech (USA) will visit all 24 of the impoundments included in the operational monitoring program four times (including pre-operational samples already collected) prior to operations to satisfy the Regulatory Guide 4.14 pre-operational monitoring recommendations. Water samples will be collected, when available, and analyzed for constituents listed in Table 2.7-22, which is consistent with Table 2.7.3-1 of NUREG-1569 and Table 1 of Regulatory Guide 4.14.

The pre-operational stream sampling sites were evaluated against guidance in Regulatory Guide 4.14 to establish an operational monitoring program. Table 5.7.8-2 provides a list of the stream sampling sites proposed for operational monitoring. The table includes 10 stream sampling sites, including 6 new sites, as depicted on Plate 5.7-1. Four sites (BVC01, BVC04, PSC01, and PSC02) used for baseline monitoring will be replaced with operational monitoring sites that better meet the guidance in Regulatory Guide 4.14 as follows:

- BVC11 will be located where Beaver Creek exits the project area. This monitoring location will replace BVC01, which was approximately 2 stream miles further downstream, below the confluence with Pass Creek.
- BVC14 will be located where Beaver Creek enters the project area. This monitoring location will replace BVC04, which was approximately 12 stream miles upstream from the project area.
- PSC11 will be located where Pass Creek exits the project area. This monitoring location will replace PSC01, which was approximately 2 stream miles upstream from the PSC11 location, within the project area.
- PSC12 will be located where Pass Creek enters the project area. This monitoring location will replace PSC02, which was about 2 stream miles upstream from the project area.

In addition to the four new sites described above, Powertech (USA) will establish two additional sites on unnamed tributaries in the southeast portion of the project area.

Table 5.7.8-1: Impoundments Included in Operational Monitoring Program

Site	Type/Name	Down-Gradient of Proposed Activity*	Included in Operational Monitoring Program	Justification for Not Including in Operational Monitoring Program
Sub01	Stock Pond	No		Not down-gradient and outside of project area
Sub02	Triangle Mine Pit	No	**Yes**	
Sub03	Mine Dam	Yes	**Yes**	
Sub04	Stock Pond	Yes	**Yes**	
Sub05	Mine Dam	Yes	**Yes**	
Sub06	Darrow Mine Pit Northwest	Yes	**Yes**	
Sub07	Stock Dam	Yes	**Yes**	
Sub08	Stock Pond	Yes	**Yes**	
Sub09	Stock Pond	Yes	**Yes**	
Sub10	Stock Pond	Yes	**Yes**	
Sub11	Stock Pond	Yes	**Yes**	
Sub20	Stock Pond	Yes	**Yes**	
Sub21	Stock Pond	Yes	**Yes**	
Sub22	Stock Pond	Yes	**Yes**	
Sub23	Stock Pond	No		Not an impoundment, infrequent, small pool of water due to inadequate storm water control at county road crossing
Sub24	Stock Pond	No		Outside of project area, not located in a project area drainage
Sub25	Stock Pond	No		Outside of project area, not down-gradient
Sub26	Stock Pond	No		Outside of project area, not down-gradient
Sub27	Stock Pond	Yes		Outside of project area, downstream of Sub28
Sub28	Stock Pond	Yes		Outside of project area, downstream of Sub08 and Sub09 with no proposed activity between Sub08 or Sub09 and Sub28
Sub29	Stock Pond	Yes	**Yes**	
Sub30	Stock Pond	Yes	**Yes**	
Sub31	Stock Pond	Yes	**Yes**	
Sub32	Stock Pond	Yes	**Yes**	
Sub33	Stock Pond	Yes	**Yes**	
Sub34	Stock Pond	Yes	**Yes**	
Sub35	Stock Pond	Yes	**Yes**	
Sub36	Stock Pond	Yes	**Yes**	

Table 5.7.8-1: Impoundments Included in Operational Monitoring Program (cont.)

Site	Type/Name	Down-Gradient of Proposed Activity*	Included in Operational Monitoring Program	Justification for Not Including in the Operational Monitoring Program
Sub37	Stock Pond	Yes		Downstream of Sub36
Sub38	Stock Pond	No		Outside of project area, not down-gradient
Sub39	Stock Pond	No		Not down-gradient
Sub40	Darrow Mine Pit Southeast	Yes	**Yes**	
Sub41	Stock Pond	Yes		Only down-gradient of potential perimeter monitor wells
Sub42	Stock Pond	No		Not down-gradient
Sub43	Stock Pond	No		Not down-gradient
Sub44	Stock Pond	No		
Sub45	Stock Pond	No		Outside of project area, not down-gradient
Sub46	Stock Pond	No		Outside of project area, not down-gradient
Sub47	Stock Pond	No		Outside of project area, not down-gradient
Sub48	Stock Pond	No		Outside of project area, not down-gradient
Sub49	Darrow Mine Pit	Yes	**Yes**	
Sub50	Darrow Mine Pit	Yes	**Yes**	

* Potentially subject to surface runoff from Satellite Facility, CPP, ponds, potential land application areas, pipelines, or potential well field areas.

Table 5.7.8-2: Operational Stream Sampling Locations

Site ID	Name	Sample Type	Location in NAD 27, South Dakota State Plane South (feet)	
			Northing	Easting
BVC11	Beaver Creek Downstream	Grab	433,638	1,022,546
BVC14	Beaver Creek Upstream	Grab	446,829	1,012,976
CHR01	Cheyenne River Upstream	Grab	423,009	1,016,699
CHR05	Cheyenne River Downstream	Grab	405,925	1,047,227
PSC11	Pass Creek Downstream	Passive sampler	431,452	1,028,064
PSC12	Pass Creek Upstream	Passive sampler	446,470	1,031,222
BEN01	Bennett Canyon	Passive sampler	416,196	1,047,473
UNT01	Unnamed Tributary	Passive sampler	422,482	1,039,166
UNT02	Unnamed Tributary	Passive sampler	424,478	1,035,236
UNT03	Unnamed Tributary	Passive sampler	425,438	1,029,910

Prior to ISR operations, Powertech (USA) will sample each site monthly (including samples already collected) for 12 consecutive months in accordance with Regulatory Guide 4.14 pre-operational monitoring recommendations. Grab samples will be collected from sites BVC11, BVC14, CHR01, and CHR05. Passive samplers will be installed at the remaining sites to collect samples during ephemeral flow events. Water samples will be analyzed for constituents listed in Table 2.7-22, which is consistent with Table 2.7.3-1 of NUREG-1569 and Table 1 of Regulatory Guide 4.14.

Operational Surface Water Sampling Methods and Parameters

Impoundments will be sampled quarterly by collecting grab samples. Prior to sampling, the sampler will conduct a visual survey of the impoundment to identify an appropriate sample location. This will include an area free of ice or floating debris and with sufficient water depth to permit sample collection without disturbing sediments. If necessary, a clean, long-handled dip sampler will be used. Typically the sample location will be near the impoundment embankment where the water is deepest. Grab samples will be collected in clean sample containers provided by the contract laboratory. Water will be obtained by filling the containers from the top 10 cm (4 in) of the water column. Samples will be field-preserved where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory. In the event that a sample cannot be collected from an impoundment during the quarterly visit, the reason will be stated on a field sheet and reported accordingly.

Streams will be sampled by quarterly grab sampling or with automatic samplers. Perennial stream sampling locations include those on Beaver Creek and the Cheyenne River. These will be sampled by collecting grab samples as described above. Passive samplers (single-stage samplers) will be installed at all other stream sampling sites from April through October. These will automatically collect samples when the flow rate in the channel reaches a field-adjustable minimum depth threshold. Following the runoff event the water will be manually transferred from the temporary sample container to clean sample bottles and submitted to the contract laboratory for analysis.

Representative water of that collected in the grab samples will be analyzed in the field for pH, conductivity and temperature. Impoundment and stream samples will be analyzed for the parameters presented in Table 5.7.8-3, which is consistent with Regulatory Guide 4.14.

Table 5.7.8-3: Operational Surface Water Monitoring Parameter List and Analytical Methods

Parameter	Units	Analytical Method
Uranium, dissolved	mg/L	E200.8
Uranium, suspended	mg/L	E200.8
Ra-226, dissolved	pCi/L	E903.0
Ra-226, suspended	pCi/L	E903.0
Th-230, dissolved	pCi/L	E907.0
Th-230, suspended	pCi/L	E907.0
Pb-210, dissolved	pCi/L	E909.0M
Pb-210, suspended	pCi/L	E909.0M
Po-210, dissolved	pCi/L	RMO-3008
Po-210, suspended	pCi/L	RMO-3008

5.7.8.2 Groundwater Operational Monitoring Program

The operational groundwater monitoring program will include domestic wells, stock wells, irrigation wells and wells located hydrologically upgradient and downgradient of proposed activity. This is an alternate operational groundwater monitoring program to what is recommended in Regulatory Guide 4.14. The operational monitoring program is designed to provide a comprehensive baseline evaluation of water supply wells located within 2 km of the potential well field boundaries. Wells proposed for operational monitoring include domestic and irrigation wells within 2 km of the potential well field boundaries, stock wells within the project area, and additional monitor wells in the alluvium, Fall River, Chilson and Unkpapa.

Prior to operations all domestic, stock, and irrigation wells within 2 km of the boundary of each proposed well field (provided the owner consents to the sampling and the well condition is suitable for sampling) will be sampled to establish baseline water quality. Domestic, stock, and irrigation wells are listed in Appendix 2.2-A of the approved license application and depicted on Plate 2.7-2. To meet the recommendations of Regulatory Guide 4.14, Powertech (USA) will ensure that all domestic, stock and irrigation wells within 2 km of the potential well fields are monitored quarterly for one year prior to operation (including monitoring already completed). All samples will be analyzed for constituents listed in Table 6.1-1, which meets the criteria listed in NUREG-1569 and Regulatory Guide 4.14.

<u>Operational Groundwater Monitoring - Domestic and Irrigation Wells</u>

Prior to operations, all domestic wells within the project area will be removed from private use. Depending on the well construction, location and screen interval, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well. During operations, Powertech (USA) will monitor all domestic and irrigation wells within 2 km of the boundary of each well field (as measured from the perimeter monitoring well ring). Samples will be collected annually and analyzed for the constituents listed in Table 6.1-1.

Operational Groundwater Monitoring - Stock Wells

During the design of each well field, all nearby stock wells will be evaluated for the potential to be adversely affected by ISR operations or to adversely affect ISR operations. At a minimum, all stock wells within ¼ mile of well fields will be removed from private use prior to operation of nearby well fields. Depending on the well construction, location and screen interval, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well. During operation, Powertech (USA) will monitor all stock wells within the project area. Samples will be collected quarterly and analyzed for water level and the three excursion indicators of chloride, total alkalinity, and conductivity.

Operational Groundwater Monitoring - Monitor Wells

As recommended in Regulatory Guide 4.14, Powertech (USA) will monitor wells located hydrologically upgradient and downgradient of proposed activity as part of the operational groundwater monitoring program. A list of the monitor wells included in the operational monitoring program is provided in Table 5.7.8-4. Monitor wells included in the operational monitoring program are depicted on Figures 5.7.8-1 through 5.7.8-6 and include wells completed in the alluvium, Fall River, Chilson, and Unkpapa. The monitor wells will be monitored quarterly and analyzed for constituents listed in Table 6.1-1.

Monitoring conducted as part of the operational monitoring program will be conditional upon land owner access and suitable conditions allowing proper collection of a sample. If access is not available during the time of monitoring, a second attempt will be made to collect a sample during the monitoring period. If a well cannot be accessed continually, Powertech (USA) will propose an alternate monitoring location or remove the well from the operational groundwater monitoring program.

Operational Groundwater Sampling Methods and Parameters

Groundwater sampling methods will be the same as the methods utilized for baseline characterization. Static water level will be measured before sample collection when access is available. Measurement techniques will include pressure transducers, a portable electronic water level meter, or an ultrasonic water level sensor. For flowing artesian wells, the shut-in pressure will be measured, where access is available, using a 15 or 30 psi NIST pressure gauge. Prior to

Table 5.7.8-4: Monitor Wells Included in Operational Monitoring Program

Well ID	Qtr-Qtr	Section	Township	Range	Relative Position
Alluvium					
676	SESW	34	6S	1E	Downgradient of Land App.
677	SWSW	27	6S	1E	Downgradient
678	SWNE	4	7S	1E	Downgradient
679	NESW	9	7S	1E	Upgradient
707	SWNE	34	6S	1E	Downgradient of Triangle Pit
708	SESW	3	7S	1E	Downgradient of Land App.
709	SENW	15	7S	1E	Downgradient of Well Field
TBD	NWNW	20	6S	1E	Upgradient
TBD	NENE	31	6S	1E	Downgradient of Well Field
TBD	NWSE	32	6S	1E	Downgradient of Well Field
TBD	NWNW	20	6S	1E	Downgradient of Land App.
Fall River					
631	SWSW	23	6S	1E	Upgradient
681	NWNE	32	6S	1E	Production Zone
688	NESW	11	7S	1E	Overlying Production Zone
694	NWNW	15	7S	1E	Upgradient
695	SESE	32	6S	1E	Downgradient
698	SENW	2	7S	1E	Downgradient
706	NENE	21	6S	1E	Upgradient
TBD	SWNE	34	6S	1E	Downgradient of Triangle Pit
TBD	NWSE	2	7S	1E	Downgradient of Darrow Pit
Chilson					
43	SWSE	34	6S	1E	Downgradient of Triangle Pit
680	NESW	11	7S	1E	Production Zone
689	NENW	32	6S	1E	Production Zone
696	NWNW	15	7S	1E	Downgradient
697	SESE	32	6S	1E	Downgradient
705	NENE	21	6S	1E	Upgradient
3026	SESE	12	7S	1E	Upgradient
TBD	SWSE	2	7S	1E	Downgradient of Darrow Pit
Unkpapa					
690	NESW	11	7S	1E	
693	NENW	32	6S	1E	
703	SWSE	1	7S	1E	

TBD – To be determined. Well not yet installed.

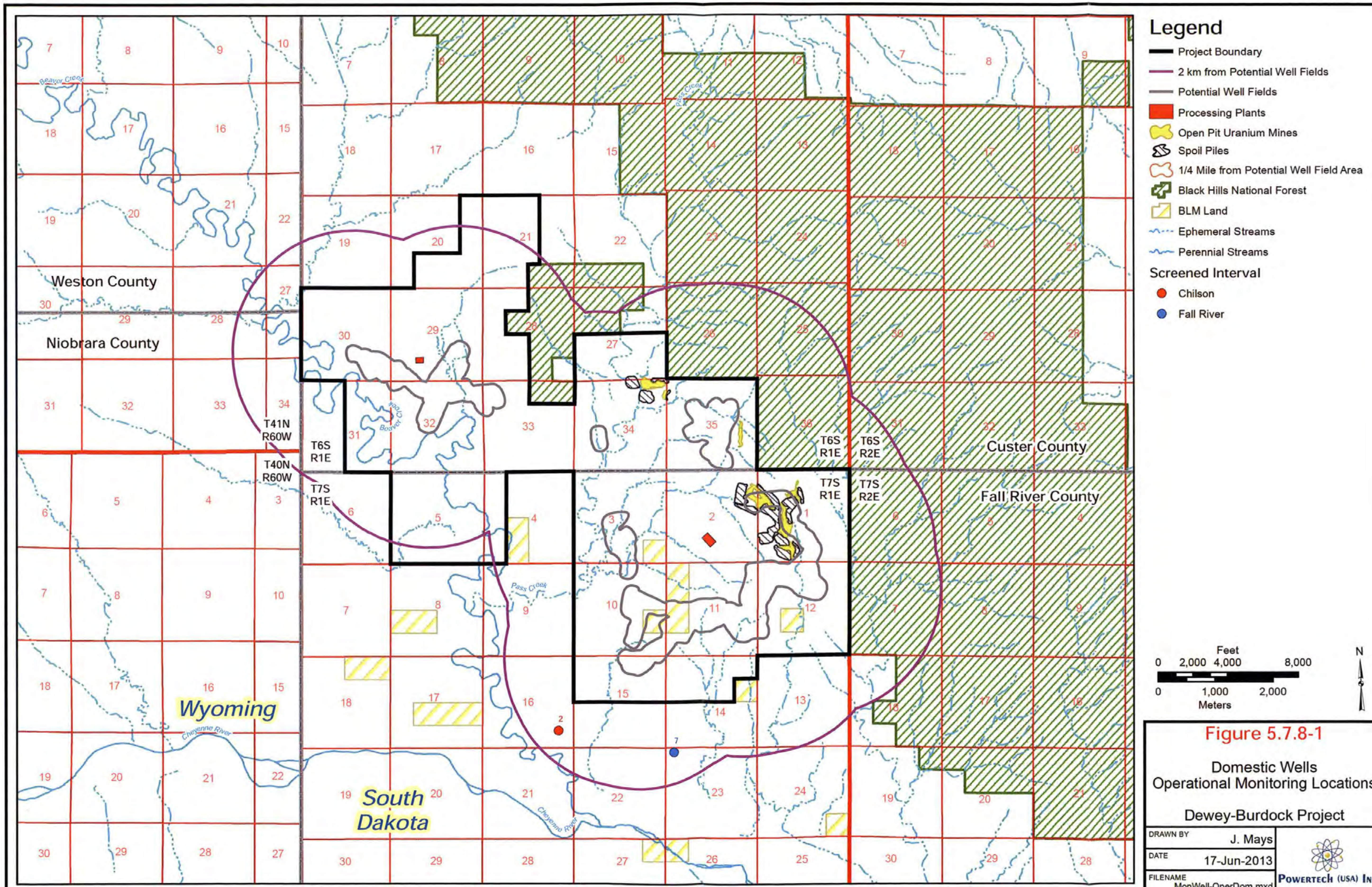


Figure 5.7.8-1

Domestic Wells Operational Monitoring Locations

Dewey-Burdock Project

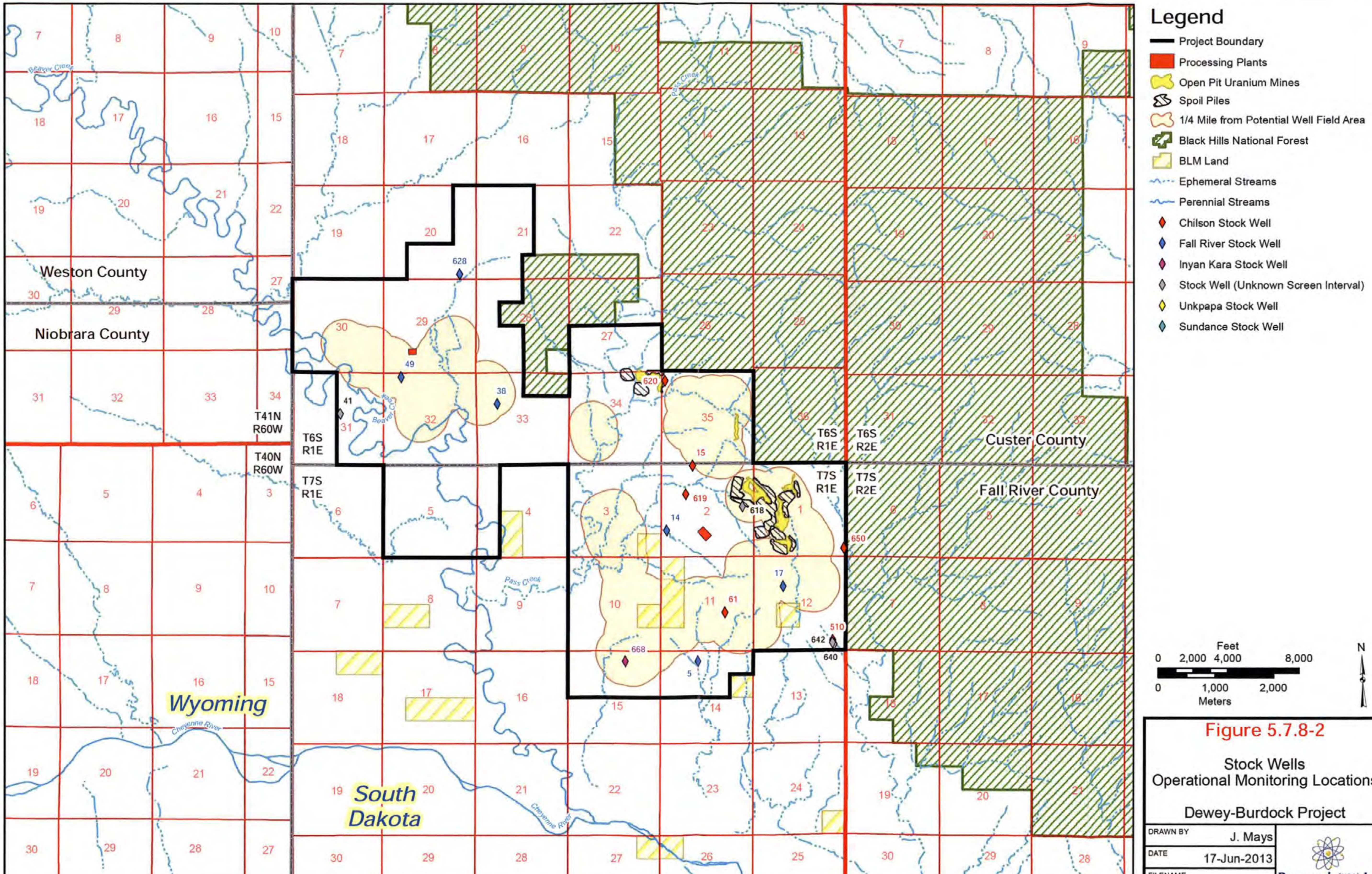


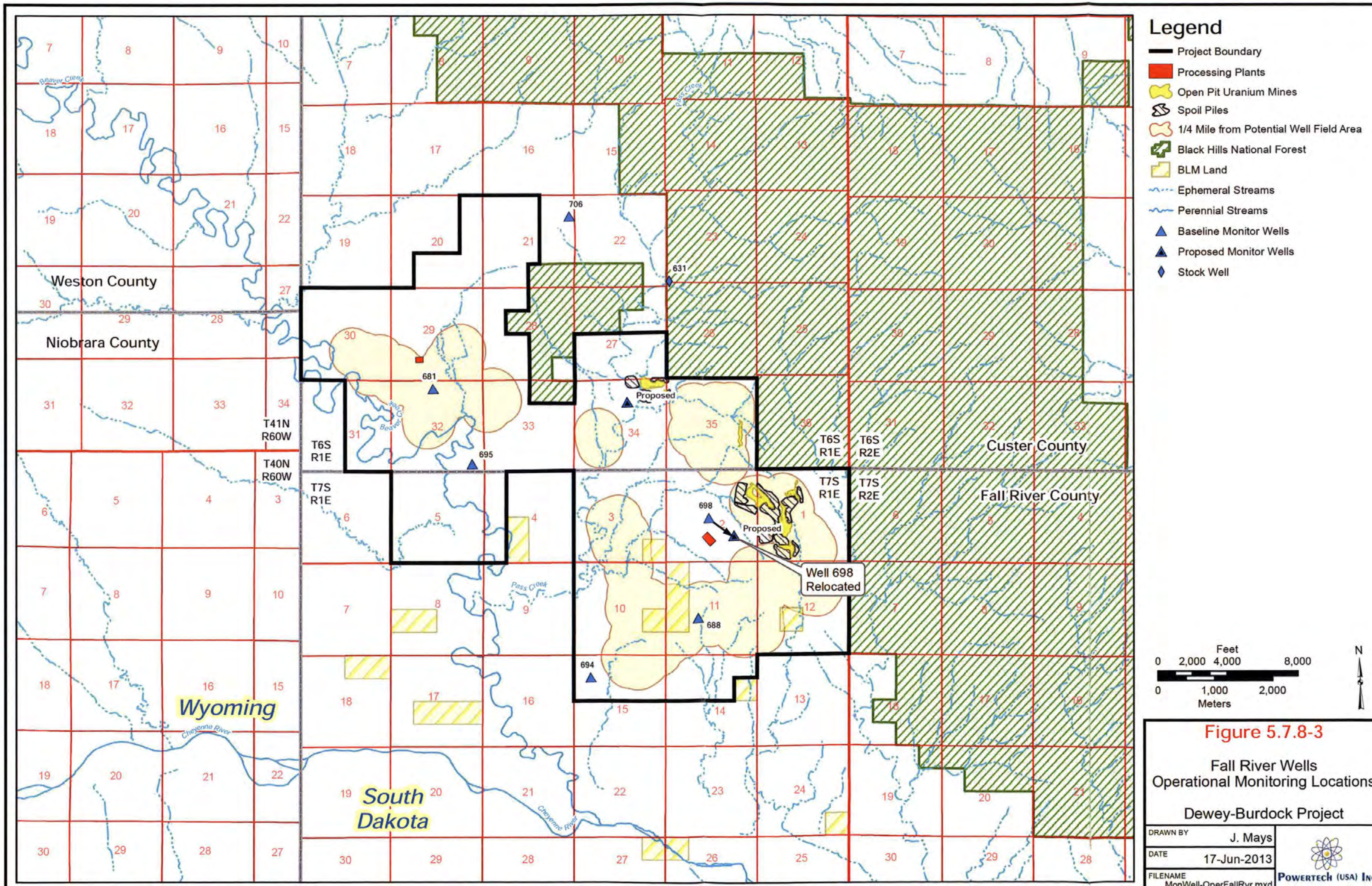
Figure 5.7.8-2

Stock Wells
Operational Monitoring Locations

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	MonWell-OperStock.mxd

POWERTECH (USA) INC.


Legend
Project Boundary
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Baseline Monitor Wells
Proposed Monitor Wells
Stock Well
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
Well 698 Relocated
Proposed
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 5.7.8-3
Fall River Wells
Operational Monitoring Locations
Dewey-Burdock Project
DRAWN BY J. Mays
DATE 17-Jun-2013
FILENAME MonWell-OperFallRvr.mxd
POWERTECH (USA) INC.

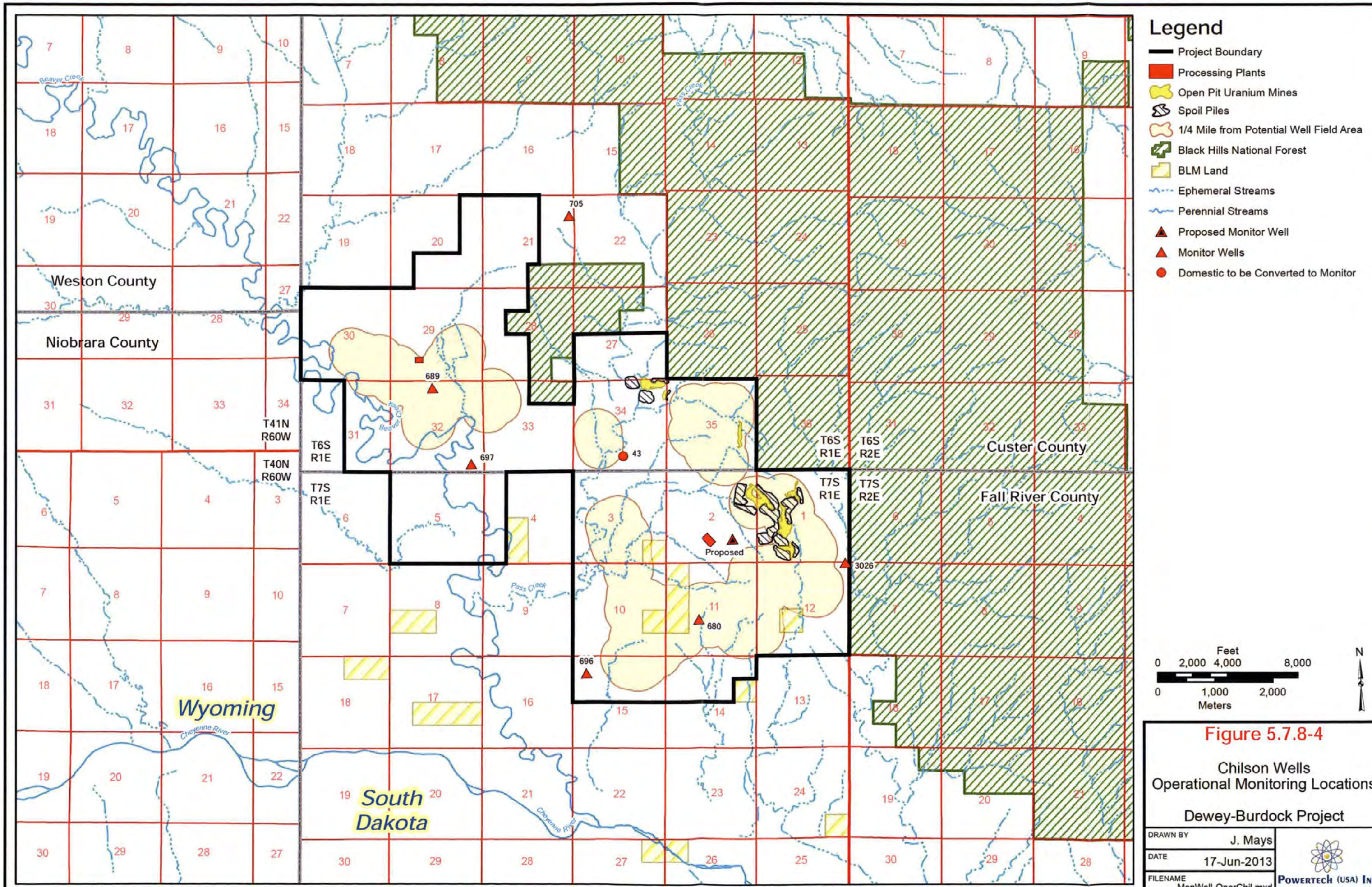


Figure 5.7.8-4

Chilson Wells Operational Monitoring Locations

Dewey-Burdock Project

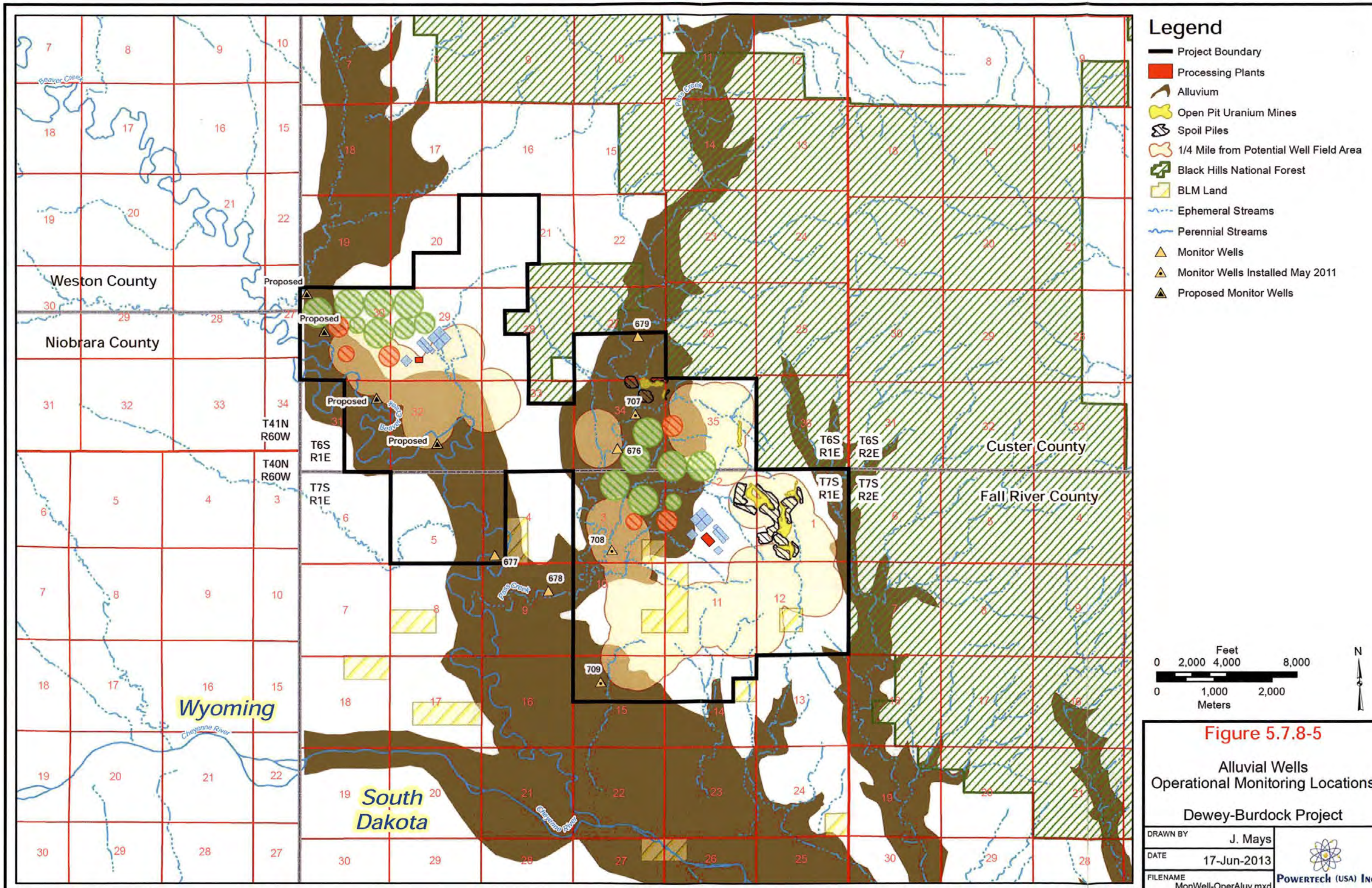
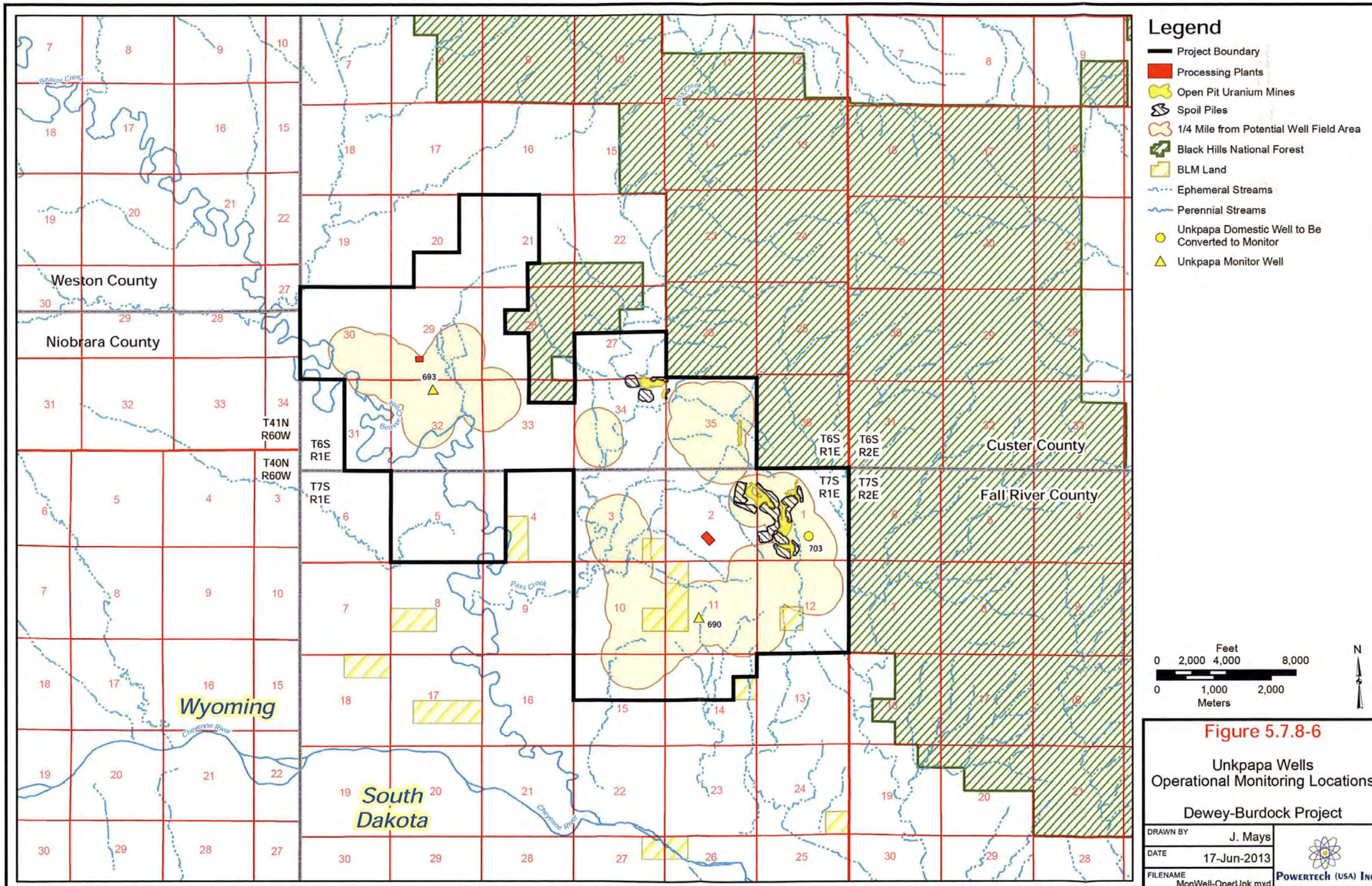


Figure 5.7.8-5

Alluvial Wells Operational Monitoring Locations

Dewey-Burdock Project


Legend
Project Boundary
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Unkpapa Domestic Well to Be Converted to Monitor
Unkpapa Monitor Well
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
Beaver Creek
Pass Creek
Cheyenne River
693
690
703
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 5.7.8-6
Unkpapa Wells Operational Monitoring Locations
Dewey-Burdock Project
DRAWN BY J. Mays
DATE 17-Jun-2013
FILENAME MonWell-OperUnk.mxd
POWERTECH (USA) INC.

measuring the pressure, the well will be shut in and the pressure allowed to stabilize before recording the hydrostatic pressure.

Three casing volumes will be purged prior to sample collection where possible, except that flowing artesian wells will be assumed to contain representative formation water without purging. In all cases, field parameters will be measured and recorded and samples will not be collected until field pH, conductivity and temperature have stabilized. The criterion used to assess stability will be three consecutive measurements of each of the field parameters with values for each parameter within 10%.

All groundwater samples will be collected in clean sample containers and field preserved, where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory. During operation, all domestic wells within the project area and all stock wells within ¼ mile of well fields will be removed from use. Domestic wells within 2 km of the project area will be sampled annually for the parameters in Table 6.1-1. Stock wells within the project area will be sampled quarterly for chloride, total alkalinity and conductivity. Monitor wells will be sampled quarterly for the parameters in Table 6.1-1.

5.7.8.3 Well Field Production Zone Baseline Groundwater Monitoring

Within each well field a subset of wells that will later serve as production wells will be identified for baseline water quality sampling. These subsets of wells will include at least one (1) well per four (4) acres of well field pattern area, or six (6) wells, whichever is greater. Should the pattern area be 6 acres or less, the maximum density will be one well per acre and a subset of less than six wells may be used. These wells will be sampled four times for baseline characterization, with a minimum of fourteen (14) days between sample events. The samples will be analyzed for all parameters identified in Table 6.1-1.

Prior to calculating baseline water quality statistics, the analytical results will be examined for differences within the production zone. Methods used to determine whether differences exist include visual screening such as the use of trilinear diagrams, and statistical analysis such as the Student's t-test or other accepted methods such as those described in "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance" (EPA, 2009). If heterogeneity exists, then baseline water quality will not be established for the entire production zone but will be separated into subzones. If no statistically significant differences in water quality are present, then baseline water quality will be established for the entire production zone of the well field.

Outliers, which are anomalously high or low values relative to the other values, will not be removed by quality control checks including visual screening and statistical analysis. Typically, an outlier will be defined as a value outside of the mean value, plus or minus three (3) standard deviations, of all values of that parameter within the production zone or subzone, if applicable. The mean value and standard deviation used to identify outliers will be calculated for the entire data set within the production zone or subzone minus the suspected outlier. Other accepted methods may be used to identify outliers including methods described within EPA (2009). Outliers will be examined for potential data transcription or other identifiable errors and corrected if possible. If they cannot be corrected, outliers will be removed from the data set prior to calculating baseline water quality.

For the production zone monitor wells, the baseline water quality will be established as the average on a parameter-by-parameter basis for the entire production zone, for each subzone, or on a well-by-well basis. Alternately, Powertech (USA) may propose the use of a statistical analysis tool such as EPA's ProUCL 4.0, which was described by NRC staff in the January 2011 NRC Uranium Recovery Workshop in Denver, Colorado, to establish baseline water quality based on the distribution of sample results on a parameter-by-parameter basis. The target restoration goals (TRGs) will be established as a function of the average baseline water quality and the variability in each parameter according to statistical methods approved by NRC. The methods used to establish baseline water quality, identify outliers, evaluate variability, and calculate TRGs will be described within the well field hydrogeologic data package for each well field.

5.7.8.4 Excursion Monitoring Program

5.7.8.4.1 Monitor Well Baseline Groundwater Monitoring

All monitor wells will be sampled four times for baseline characterization, with a minimum of fourteen (14) days between sample events. The water level in each monitor well also be recorded during each sampling event. All samples will be analyzed for the parameters listed in Table 6.1-1.

Prior to calculating UCLs, the analytical results will be examined for differences. Methods used to determine whether differences exist include visual screening, such as the use of trilinear diagrams and statistical analysis such as the Student's t-test. If heterogeneity exists, then the UCL for a particular monitor well will be established for that well. If no statistically significant differences in water quality are present, then the UCLs will be established to represent the entire monitoring zone of the well field.

Outliers, which are anomalously high or low values relative to the other values, will be removed by quality control checks including visual screening and statistical analysis. Specifically, an outlier will be defined as a value outside of the mean value plus or minus 3 standard deviations of all values of that parameter within the same zone. The mean value and standard deviation used to identify outliers will be calculated for the entire data set within the same zone minus the suspected outlier. Data values identified as outliers will not be included in the computation of statistical parameters used for determining the UCLs. Outliers will be examined for potential data transcription or other identifiable errors and corrected if possible. If they cannot be corrected, outliers will be removed from the data set prior to calculating baseline water quality.

5.7.8.4.2 Excursion Indicators and Upper Control Limits

Following characterization of well field baseline water quality, UCLs will be established for constituents that provide early indication of a potential excursion. The constituents proposed for use as UCLs are chloride, conductivity and total alkalinity. Chloride will be used as an excursion indicator because concentrations in the lixiviant are increased by the IX process. In addition, chloride is highly mobile in groundwater and is not influenced by pH changes or oxidation-reduction reactions. Conductivity will be used as an excursion indicator because it provides an overall indication of changes in groundwater quality and is more easily measured than TDS. Total alkalinity will be used as an excursion indicator since concentrations of bicarbonate are increased during ISR operations.

UCLs for each monitor well will be set at the baseline mean concentration of the individual unit or zone being monitored plus five (5) standard deviations for each excursion indicator. Because some aquifers exhibit low chloride concentration with a narrow statistical distribution, for chloride only the greater of the mean plus five standard deviations or the mean plus 15 mg/L will be used as the UCL.

5.7.8.4.3 Excursion Monitor Wells

Monitor Well Configuration

Refer to Section 3.1.3.1 for the monitor well configuration. Monitor wells completed in the perimeter of the production zone and in overlying and underlying hydrogeologic units will be used to monitor for potential excursions.

Perimeter Monitor Well Spacing

The perimeter production zone monitoring ring will be located at a maximum distance of 400 feet from the pattern area. This maximum distance is based on and consistent with standard monitoring practices at operating ISR facilities. As indicated in NUREG-1569, Acceptance Criterion 5.7.8.3(3), "Previously approved *in situ* leach excursion monitoring systems used monitor wells as far as 180 m [600 ft] and as near as 75 m [250 ft] from the well field edge…The licensee should be afforded some discretion in determining the appropriate distance of excursion monitor wells from the well field, but should provide justification for distances greater than about 150 m [500 ft]." The maximum distance also is supported by site-specific data and evaluation through numerical groundwater modeling.

Within the project area, the Fall River and Chilson hydrogeologic units have been extensively characterized, both historically by TVA and more recently by Powertech (USA). Numerous monitor wells have been installed for determination of the potentiometric surfaces. Pumping tests conducted by TVA (Appendix 2.7-K of the approved license application) and by Powertech (USA) (Appendix 2.7-B of the approved license application) have provided site-specific aquifer properties for the Fall River and Chilson. Data derived from the hydrologic testing have been incorporated into numerical models to evaluate well field scale issues related to ISR operations, including monitor ring spacing and excursion control.

Additional numerical modeling will be performed to evaluate well spacing and control of potential excursions for the Chilson well fields. The aquifer properties of the Chilson are similar to those of the Fall River, based on pumping tests conducted by TVA and Powertech (USA). Therefore, results of the modeling for the Chilson well fields are anticipated to be similar to those already completed for the Fall River well fields.

In support of the perimeter monitor ring spacing, numerical modeling has been undertaken to evaluate groundwater conditions related to ISR at the Dewey-Burdock Project (Appendix 6.6-B of the approved license application). The results from the rigorous numerical simulations demonstrate that the maximum spacing of 400 feet is adequate to detect an excursion and that the excursion can be controlled. Petrotek Engineering Corporation's 2010 report, "Numerical Modeling of Groundwater Conditions Related to In-Situ Recovery at the Dewey-Burdock Uranium Project, South Dakota," is included in Appendix 6.6-B of the approved license application.

The model simulations are based on the site-specific hydrogeological conditions and aquifer properties determined for the Dewey well field area from the 2008 pumping test in the Lower Fall River (Appendix 2.7-B of the approved license application). The result from the 2008 pumping test indicated the average transmissivity to be 255 ft^2/day with an average storativity 4.6×10^{-5}. Assuming a 75-foot thickness for the Lower Fall River, the hydraulic conductivity is calculated to be 3.4 ft/day. Total porosity of the Lower Fall River was estimated, based on analysis of core samples, to be 29 percent. These values were the initial values used in the model calibration. Using the site-specific aquifer properties and the observed hydraulic gradient of 0.006 ft/ft, the average groundwater flow velocity was calculated to be 0.07 ft/day, or 26 ft/yr.

Assuming the anticipated production rates to be approximately 20 gpm per well pattern, with a net bleed of approximately 1 percent, the model simulations were conducted to evaluate well field-scale issues related to ISR production. The horizontal well field flare was determined to be 1.19 and the 400-foot well spacing demonstrated through modeling to be adequate to detect a potential excursion at this distance. Model simulations were also used to demonstrate that hydraulic control of the simulated excursion can be established by changing well field operational rates to reverse the hydraulic gradient at a distance of 400 feet and change the direction of groundwater travel back to the well field.

Powertech (USA) anticipates conducting ISR operations concurrently for "stacked" roll front deposits within one hydrogeologic unit. In such cases the perimeter monitor well ring will be located within 400 feet horizontally from the larger production zone, and the monitor wells will be screened across the full thickness of the hydrogeologic unit.

For example, the L2 and L3 ore bodies are within the Lower Chilson sand unit and are separated vertically by approximately 10 feet. Although the L2 and L3 ore horizons will be produced with separated systems of injection and recovery wells, they will be treated as a single production zone for monitoring purposes. There is no evidence that a laterally continuous shale of clay confining unit is present between the L2 and L3 ore bodies that would restrict hydraulic communication between these ore bodies, so they are considered together as one hydrologic unit. The perimeter monitor well ring will be located within 400 feet horizontally from the larger production zone. The monitoring wells in that perimeter monitor ring encompassing the L2 and L3 ore horizons will be screened across the full thickness of the Lower Chilson sand unit, which is estimated to average approximately 65 feet thick.

It is anticipated that ISR operations for these "stacked" roll front deposits will be conducted concurrently. Therefore, monitoring of the entire Lower Chilson sand unit is appropriate to ensure that any potential excursion is detected.

5.7.8.4.4 Excursion Monitoring

All monitor wells will be sampled for excursion indicators at least twice per month and no more than 14 days apart in any given month during ISR operations.

The monitoring program for excursion detection has been designed to comply with NRC guidance of NUREG-1569, Acceptance Criterion 5.7.8.3(5) (NRC, 2003a). An excursion will be deemed to have occurred if two or more excursion indicators in any monitor well exceed their UCLs. A verification sample will be taken within 48 hours after results of the first analyses are received. If the results of the verification sampling are not complete within 30 days of the initial sampling event, then the excursion will be considered confirmed for the purpose of meeting the reporting requirements described below. If the excursion is not confirmed by the verification sample, a third sample will be taken within 48 hours after the second set of sampling data are received. If neither the second nor the third sample confirms the excursion by two indicators exceeding their UCLs, the first sample will be considered to have been in error, and the well will be removed from excursion status. If either the second or third sample exhibits two or more indicators above their UCLs, an excursion will be confirmed, the well will be placed on confirmed excursion status, and corrective action will be initiated.

5.7.8.4.5 Corrective Actions to Control Excursions

Corrective action to retrieve an excursion will include adjusting the flow rates of the pumping and injection wells to increase the aquifer bleed in the area of the excursion. The sampling frequency will be increased to weekly. The NRC will be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions taken and the corrective action results will be submitted to NRC within 60 days of the excursion confirmation.

If wells are still on excursion status when the report is submitted, the report will also contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In accordance with NUREG-1569, p. 5-44, if an excursion is not corrected within 60 days of confirmation, Powertech (USA) will terminate injection of lixiviant into the affected portion of the well field until the excursion is retrieved, or provide an increase to the reclamation financial assurance obligation in an amount that is agreeable to NRC and that will cover the expected full cost of correcting and cleaning up the excursion. The financial assurance increase will remain in force until the excursion is corrected. The written 60-day excursion report will state and justify which course of action will be followed. If wells are still on excursion status at the time the 60-day report is submitted to NRC, and the financial assurance option is chosen, the well field restoration financial assurance obligation will be adjusted upward. To calculate the increase in financial assurance for horizontal excursions, it will be assumed that the entire thickness of the confined operating horizon between the well field and the monitor well(s) on excursion contains lixiviant. The width of the excursion is assumed to be the distance between the monitor wells on excursion status plus one monitor well spacing distance on either side of the excursion. When the excursion is corrected, the additional financial assurance obligations resulting from the excursion will be removed.

5.7.9 Quality Assurance Program

After license issuance but prior to operations, Powertech (USA) will prepare a Quality Assurance Project Plan (QAPP) 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 QAPP is to ensure that all radiological and nonradiological measurements that support the radiological monitoring program are reasonably valid and of a defined quality. The QAPP is 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 outline of the QAPP is provided in Figure 5.7-12.

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. 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.).

Dewey-Burdock Project
Quality Assurance Project Plan – Outline

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Figure 5.7-12: Quality Assurance Project Plan Outline

5.7.10 References

Energy Metals Corporation, U.S., *"Application for USNRC Source Materials License Moore Ranch Uranium Project, Campbell County, WY";* Vol 1 Technical Report (2007).

NRCP Report No. 127, "*Operational Radiation Safety Program*", (June 12, 1998).

USNRC Regulatory Guide 4.14, *"Radiological Effluent and Environmental Monitoring at Uranium Mills"*, (Revision 1, April 1980).

USNRC Regulatory Guide 4.15, *"Quality Assurance for Radiological Monitoring Programs (Normal Operations) – Effluent Streams and the Environment"*, (Revision 1, February 1979).

USNRC Regulatory Guide 8.13, *"Instruction Concerning Prenatal Radiation Exposure"* (Revision 3, June 1999).

USNRC Regulatory Guide 8.15, *"Acceptable Programs for Respiratory Protection"*, (Revision 1, October 1999).

USNRC Regulatory Guide 8.22, *"Bioassay at Uranium Mills"*, (Revision 1, August 1988).

USNRC Regulatory Guide 8.25, *"Air Sampling in the Workplace"*, (Revision 1, June 1992).

USNRC Regulatory Guide 8.29, *"Instruction Concerning Risks From Occupational Radiation Exposure"*, (Revision 1, February 1996).

USNRC Regulatory Guide 8.30, *"Health Physics Surveys in Uranium Recovery Facilities"*, (Revision 1, May 2002).

USNRC Regulatory Guide 8.31, *"Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as is Reasonably Achievable"*, (Revision 1, May 2002).

USNRC Regulatory Guide 8.36, *"Radiation Dose to the Embryo/Fetus"*, (July 1992).

6.0 Groundwater Quality Restoration, Surface Reclamation, and Facility Decommissioning

6.1 Plans and Schedules for Groundwater Quality Restoration

Groundwater restoration, reclamation of disturbed land and decommissioning of the well fields, plant and associated facilities will be conducted in a manner that will protect human health and the environment. The methods for achieving this objective are discussed in the following sections.

6.1.1 Groundwater Restoration Criteria

Groundwater restoration at the project site will be performed pursuant to NRC requirements to protect underground sources of drinking water (USDW) adjacent to the site. Prior to recovery, a Class III Underground Injection Control (UIC) Permit that includes an aquifer exemption from the EPA must be issued. This exemption will be based on historical and existing water quality, the demonstration that the ore zone is commercially producible and that the ore zone has not historically nor will it now or in the future be an underground source of drinking water.

The groundwater restoration program for all well fields will be conducted pursuant to 10 CFR Part 40, Appendix A, Criterion 5, which sets forth groundwater quality standards for uranium milling facilities. Currently, Criterion 5 states that groundwater quality at such facilities shall have primary goals of baseline (background) or an MCL, whichever is higher, or an ACL. Powertech (USA) recognizes that an ACL is a site-specific, constituent-specific, risk-based standard that demonstrates that maintaining groundwater quality at the requested level at a designated point of compliance (POC) will be adequately protective of human health and the environment at the point of exposure (POE) and that groundwater quality outside the boundary of the aquifer exemption approved by EPA would meet background (baseline) levels or MCLs. Powertech (USA) understands that satisfaction of prior class-of-use can be proposed as a factor in demonstrating justification for an ACL.

Powertech (USA) understands that, in the event that the primary goal of groundwater restoration (i.e., baseline or an MCL, whichever is higher) cannot be met after engaging in all practicable (reasonably achievable) efforts, it will be required to submit an ACL application to NRC staff in accordance with its regulatory rights under 10 CFR Part 40, Appendix A, Criterion 5(B)(5). Powertech (USA) understands that any ACL application will be in the form of a license amendment application that addresses, at a minimum, all of the relevant factors in 10 CFR Part 40, Appendix A, Criterion 5B(6), including but not limited to:

(a) Potential adverse effects on ground-water quality, considering—

  (i) The physical and chemical characteristics of the waste in the licensed site including its potential for migration;

  (ii) The hydrogeological characteristics of the facility and surrounding land;

  (iii) The quantity of ground water and the direction of ground-water flow;

  (iv) The proximity and withdrawal rates of ground-water users;

  (v) The current and future uses of ground water in the area;

  (vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground-water quality;

  (vii) The potential for health risks caused by human exposure to waste constituents;

  (viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

  (ix) The persistence and permanence of the potential adverse effects.

(b) Potential adverse effects on hydraulically-connected surface water quality, considering—

  (i) The volume and physical and chemical characteristics of the waste in the licensed site;

  (ii) The hydrogeological characteristics of the facility and surrounding land;

  (iii) The quantity and quality of ground water, and the direction of ground-water flow;

  (iv) The patterns of rainfall in the region;

  (v) The proximity of the licensed site to surface waters;

  (vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;

  (vii) The existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality;

  (viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and

(x) The persistence and permanence of the potential adverse effects.

Powertech (USA) intends to follow any and all relevant NRC guidance and policy in effect at the time that an ACL would be requested, including the NRC staff Technical Position on Alternate Concentration Limits for Title II Uranium Mills (NRC, 1996), which is the most current ACL guidance available to date.

Prior to operation, the baseline groundwater quality will be determined through the sampling and analysis of water quality indicator constituents in wells screened in the mineralized zone(s) across each well field. Section 5.7.8.3 describes the methods used to select baseline wells, sample the wells, and calculate baseline water quality statistics. The baseline samples will be analyzed for all parameters identified in Table 6.1-1. The target restoration goals (TRGs) will be established as a function of the average baseline water quality and the variability in each parameter according to statistical methods approved by NRC. The methods used to establish baseline water quality, identify outliers, evaluate variability, and calculate TRGs will be described within the well field hydrogeologic data package for each well field.

Table 6.1-1: Baseline Water Quality Parameter List

Test Analyte/Parameter*	Units	Analytical Method
Physical Properties		
pH ≠	pH units	A4500-H B
Total Dissolved Solids (TDS) +	mg/L	A2540 C
Conductivity	µmhos/cm	A2510 B
Common Elements and Ions		
Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Bicarbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B (as HCO_3)
Calcium	mg/L	E200.7
Carbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Chloride, Cl	mg/L	A4500-Cl B; E300.0
Magnesium, Mg	mg/L	E200.7
Nitrate, NO_3^- (as Nitrogen)	mg/L	E300.0
Potassium, K	mg/L	E200.7
Sodium, Na	mg/L	E200.7
Sulfate, SO_4	mg/L	A4500-SO4 E; E300.0
Trace and Minor Elements		
Arsenic, As	mg/L	E200.8
Barium, Ba	mg/L	E200.8
Boron, B	mg/L	E200.7
Cadmium, Cd	mg/L	E200.8
Chromium, Cr	mg/L	E200.8
Copper, Cu	mg/L	E200.8
Fluoride, F	mg/L	E300.0
Iron, Fe	mg/L	E200.7
Lead, Pb	mg/L	E200.8
Manganese, Mn	mg/L	E200.8
Mercury, Hg	mg/L	E200.8
Molybdenum, Mo	mg/L	E200.8
Nickel, Ni	mg/L	E200.8
Selenium, Se	mg/L	E200.8, A3114 B
Silver, Ag	mg/L	E200.8
Uranium, U	mg/L	E200.7, E200.8
Vanadium, V	mg/L	E200.7, E200.8
Zinc, Zn	mg/L	E200.8
Radiological Parameters		
Gross Alpha††	pCi/L	E900.0
Gross Beta	pCi/L	E900.0
Radium, Ra-226[§]	pCi/L	E903.0

*Analyte list based on NUREG-1569, Table 2.7.3-1. As noted on pg. 6 of NUREG-1569, Powertech (USA) may provide the rationale for the exclusion of water quality indicators/ parameters in a license application or amendment request if operational experience or site-specific data demonstrate that concentrations of constituents such as radium-228 are not significantly affected by ISR operations.

≠ Field and Laboratory

+ Laboratory only

††Excluding radon, radium, and uranium

§ If initial analysis indicates presence of Th-232, then Ra-228 will be considered within the baseline sampling program or an alternative may be proposed.

6.1.2 Estimate of Post-Production Groundwater Quality

In order to estimate post-production water quality from ISL operations at the site, Powertech (USA) has reviewed operational restoration water quality data from six ISL operations in the western United States. These sites include:

- Irigaray/Christensen Ranch (Wyoming)
- Crownpoint (New Mexico)
- Crow Butte (Nebraska)
- Bison Basin (Wyoming)
- Smith Ranch/Highland (Wyoming)
- Ruth (Wyoming)

Based on this review, the Crow Butte site was selected for the estimate because of the proximity and similar geologic conditions to the project site, available water quality data, reasonable pore volume estimates to achieve restoration and overall restoration success. The water quality data for the Crow Butte site is extensive with baseline, post-production, post-restoration, and stabilization period data. Baseline water quality, post-production water quality, post-restoration average water quality and stabilization period average water quality data are provided in Table 6.1-2 for the Crow Butte Mine Unit No.1. Powertech (USA) may expect similar baseline and post-production water quality results at the project site.

6.1.3 Groundwater Restoration Methods

During aquifer restoration, Powertech (USA) will restore groundwater quality consistent with the groundwater protection standards contained in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis using best practicable technology. The technology selected will depend on the liquid waste disposal option as described below. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. In either case, Powertech (USA) proposes to remove at least six (6) pore volumes during aquifer restoration.

Table 6.1-2: Crow Butte Post Mining Water Quality Data Summary

Parameter	Baseline Water Quality	Post-Mining Water Quality	Post-Restoration Average Water Quality	Stabilization Period Average Water Quality
BULK PROPERTIES				
Specific Cond.	1947	5752	1620	1787
pH	8.5	7.35	7.95	8.18
TDS	1170.2	3728	967	1094
CATIONS/ANIONS				
Alkalinity	293	875	321	347
Chloride	204	583	124	139
Sulfate	356.2	1128	287	331
TRACE METALS				
Manganese	0.11	0.075	0.01	0.02
Arsenic	0.002	0.021	0.024	0.017
Iron	0.044	0.078	<0.05	0.09
Lead	0.031	<0.05	<0.05	<0.01
Uranium	0.092	12.2	0.963	1.73
Vanadium	0.066	0.96	0.26	0.11
RADIONUCLIDES				
Radium-226	229.7	786	246.7	303

Notes: All units in mg/L except for pH (standard units), radium (pCi/L), and specific conductivity (μmhos/cm).

6.1.3.1 Deep Disposal Well Option

In the deep disposal well liquid waste disposal option, the primary method of aquifer restoration will be RO treatment with permeate injection. In this method, water will be pumped from one or more well fields to the CPP or Satellite Facility for treatment. Treatment will begin with removal of uranium and other dissolved species in IX columns. The water will then pass through the restoration RO unit, which will remove over 90% of dissolved constituents using high pressure RO membranes. The treated effluent, or permeate, will be returned to the well field(s) for injection. The RO reject, or brine, will undergo radium removal in radium settling ponds and will then be disposed in one or more deep disposal wells.

The RO units will operate at a recovery rate of approximately 70%. Therefore, about 70% of the water that is withdrawn from the well fields and passed through the restoration RO unit will be recovered as nearly pure water, or permeate. In order to avoid excessive restoration bleed and consumptive use of Fall River and Chilson groundwater, permeate will be supplemented with clean makeup water from Madison Formation water supply wells. Permeate and Madison Formation water will be reinjected into the well field(s) at an amount slightly less than the amount withdrawn from the well field(s). This will be done to maintain a slight restoration bleed, which will maintain hydraulic control of the well field(s) throughout active aquifer restoration. The restoration bleed will typically be 1% of the restoration flow rate unless groundwater sweep is used in conjunction with RO treatment with permeate injection, in which case the restoration bleed will average approximately 17%. Refer to the "Optional Groundwater Sweep" discussion in Section 6.1.3.3.

6.1.3.2 Land Application Option

In the land application liquid waste disposal option, the primary method of aquifer restoration will be groundwater sweep with Madison Formation water injection. This method will begin the same as the method described above for RO treatment with permeate injection; water will be pumped to the CPP or Satellite Facility for removal of uranium and other dissolved species in IX columns. The partially treated water will undergo radium removal in radium settling ponds and will then be disposed in the land application system. Powertech (USA) refers to this portion of the aquifer restoration method as "groundwater sweep," since none of the water recovered from the Fall River or Chilson will be reinjected into the well field(s).

RO will not be used if there are no deep disposal wells available to accept the RO brine. Instead, clean makeup water from the Madison Formation will be injected into the well field(s) at a flow rate sufficient to maintain the restoration bleed. As before, the restoration bleed will typically be 1% of the restoration flow rate unless the optional groundwater sweep method is used as described in Section 6.1.3.3.

The water quality of the Madison Formation is expected to be equal to or better than the baseline ore zone water quality, and injection of Madison Formation water will therefore be similar to injection of permeate under the deep disposal well option.

6.1.3.3 Optional Groundwater Sweep

Although a 1% restoration bleed will be adequate to maintain hydraulic control of well fields undergoing active aquifer restoration, additional bleed may be required at times. For example, additional restoration bleed may be used to recover flare of lixiviant outside of the well field pattern area. In addition to the restoration methods described above, Powertech (USA) may withdraw up to one (1) pore volume of water through groundwater sweep over the course of aquifer restoration. This will result in an average restoration bleed of approximately 17%.

6.1.3.4 Flare Control and Capture

Flaring will be controlled by maintaining balanced well fields and adequate bleed during uranium recovery and aquifer restoration. Powertech (USA) will maintain hydraulic control of each well field from the first injection of lixiviant through the end of active aquifer restoration. During uranium recovery, the groundwater removal rate in each well field will exceed the lixiviant injection rate, creating a cone of depression within the well field. During aquifer restoration, the groundwater removal rate in each well field will exceed the injection rate of permeate and clean makeup water from the Madison Formation. If there are any delays between uranium recovery and aquifer restoration, production wells will continue to be operated as needed to maintain water levels within the perimeter monitor rings below baseline conditions. This activity may be intermittent or continuous.

Verification of hydraulic control will be performed through water level measurements in perimeter monitor wells. Water levels will be measured continuously using pressure transducers and recorded at a frequency appropriate to confirm hydraulic well field control.

Flaring will be captured by maintaining adequate restoration bleed. If necessary, the restoration bleed may be increased to provide up to one (1) pore volume of groundwater sweep as discussed above. The results of a numerical modeling potential impact analysis for the Inyan Kara under aquifer restoration with and without one (1) pore volume of groundwater sweep are provided in Appendix 6.1-A of the approved license application.

6.1.4 Restoration Schedule

The proposed project schedule, Figure 6.1-1, shows the estimated schedule for restoration. This is a preliminary schedule based on current knowledge of the area, and is based on completion of the production activities for both the Dewey and Burdock sites. As the project is developed, the restoration schedule will be further refined. As illustrated on Figure 6.1-1, it is expected that the aquifer restoration phase for each well field will be completed in less than two years. Powertech (USA) will notify the NRC in writing, in accordance with 10 CFR 40.42, within 60 days of the cessation of recovery operations in any individual well field. Should restoration efforts indicate a period longer than 24 months is necessary for groundwater restoration of a particular well field, Powertech (USA) will request NRC approval for an alternate schedule in accordance with 10 CFR 40.42.6.1.5 Effectiveness of Ground Water Restoration Techniques

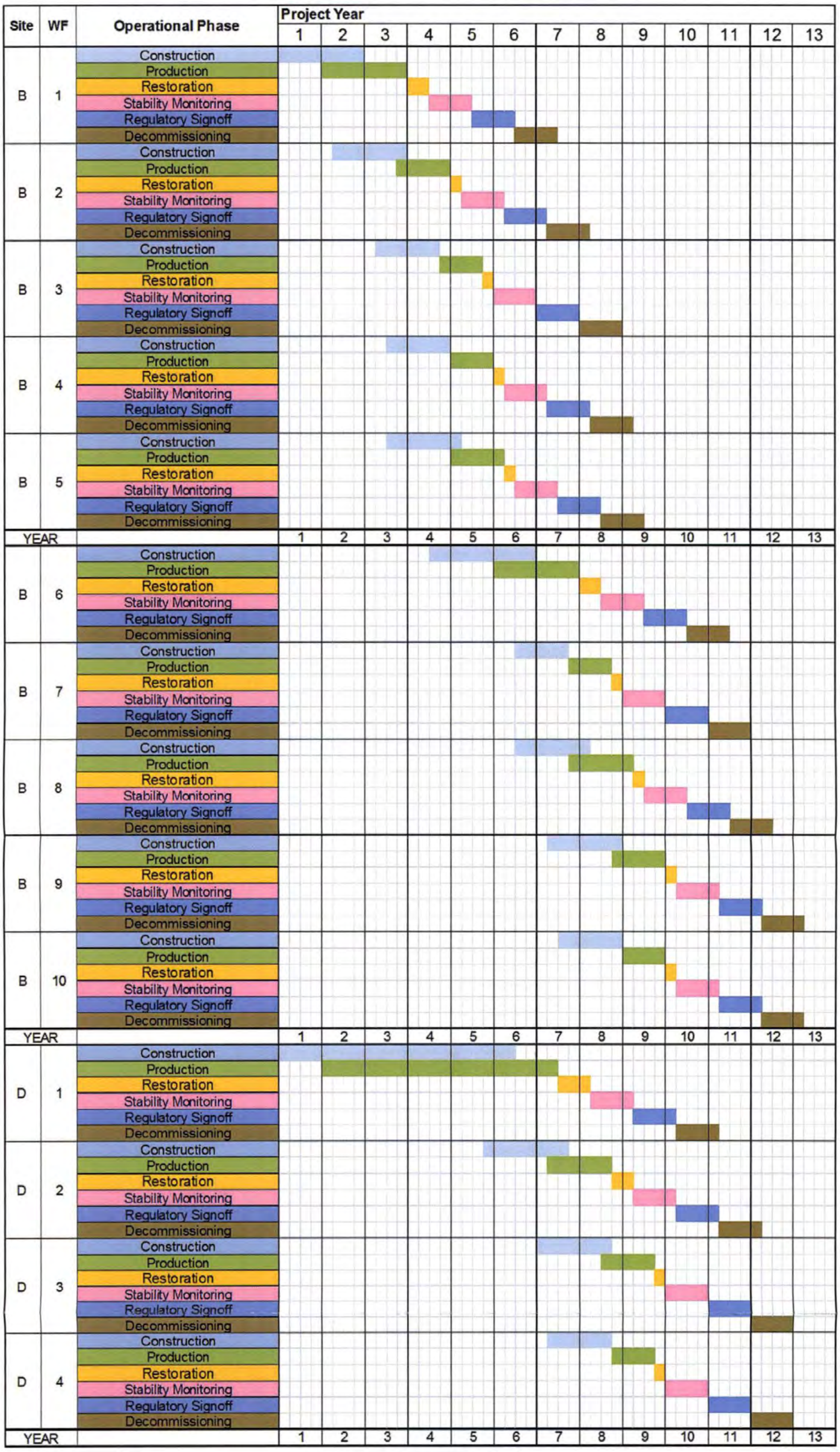

Figure 6.1-1

Proposed Project Operations and Restoration Schedule

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	18-Jun-2013
FILENAME	OpRestSched.dwg

POWERTECH (USA) INC.

The preferred aquifer restoration method is RO treatment with permeate injection. This is the aquifer restoration method that will be used if deep disposal wells are used to dispose liquid waste. As described in Section 2.5.3 of the ISR GEIS (NUREG-1910), this method of aquifer restoration is responsible for returning "total dissolved solids, trace metal concentrations, and aquifer pH to baseline values." RO treatment with permeate injection has proven effective at achieving successful aquifer restoration as described below.

> "Results of the effectiveness of groundwater sweep (or lack of it) were clearly demonstrated in the Christensen Ranch Wellfield Restoration report (CRWR) (COGEMA 2008). Example plots from that report of mean well field water quality at the end of mining, groundwater sweep, RO and stabilization monitoring... indicate minimal improvement following groundwater sweep at MU3 and MU5 and an actual increase [in dissolved constituents] at MU6. Following application of RO, the TDS values at MU5 and MU6 decreased to levels below the target Restoration Goal. Uranium increased in MU5 and MU6 following groundwater sweep...and then was significantly lowered during RO. Approximately 1.8, 4.8 and 1.5 PVs of groundwater were removed from MU3, MU5 and MU6, respectively, during groundwater sweep. This water removal was totally consumptive by design, in that none of it was returned to the aquifer.
>
> "Based on the results, minimal benefit, if any, was derived from [the groundwater sweep] phase of restoration. Eliminating groundwater sweep, an unnecessary, ineffective and consumptive step in the restoration process, will reduce the number of PVs required to reach restoration goals.
>
> "Terminating RO once water quality has stabilized will minimize the consumptive use of groundwater and reduce the number of PVs of treatment." (Uranium One, 2008)

The following analogues demonstrate the effectiveness of RO treatment with permeate injection as an effective aquifer restoration technology:

The Ruth R & D Project was a Wyoming pilot test conducted by Uranerz USA, Inc. in the early 1980s. The ore body represented a typical roll front type deposit with the target ore zone approximately 500 feet below ground surface. Groundwater restoration began in February 1984. Groundwater sweep was initially the primary restoration method, but it was terminated due to excessive water consumption. Groundwater restoration continued using RO treatment with permeate injection. By September 1984, TDS was successfully lowered, but the concentrations of a few metals remained above target restoration goals. A reductant phase was initiated in November 1984 and continued for six weeks. This combination of treatment was deemed successful, and by the end of December 1984 restoration activities were terminated. At the end of the stability period, regulatory agencies deemed the water quality was stable and aquifer restoration efforts by Uranerz were successful. (Catchpole and Kuchelka, 1993)

The Crow Butte R&D Project also used RO treatment with permeate injection to achieve successful aquifer restoration. According to Catchpole and Kuchelka (1993), RO treatment with permeate injection "restored the quality of the groundwater in the mined out well field to a level acceptable to the agencies and, following the successful completion of the six month stability monitoring period, the agencies deemed that Ferret Exploration Company of Nebraska had demonstrated the capability of restoring an aquifer affected by ISR mining operations."

The Bison Basin Commercial ISL Uranium Mine is another example of a successful restoration project using RO treatment with permeate injection. According to Catchpole and Kuchelka (1993), "This action returned all water quality parameters to levels acceptable to the regulatory agencies and, following the successful completion of a 12 month stability monitoring period, the aquifer was deemed restored. The Bison Basin case represented the first successful aquifer restoration of a commercial sized ISL well field in the United States."

As described in Section 6.1.3, clean makeup water from the Madison Formation will be used to supplement permeate and maintain the restoration bleed in the deep disposal well option. In the land application option, all of the water reinjected into the well fields during active aquifer restoration will come from the Madison Formation. The water quality of the Madison Formation is expected to be equal to or better than the baseline ore zone water quality, and injection of Madison Formation water will therefore be similar to injection of permeate under the deep disposal well option.

Refer to Section 6.1.3.3 for a discussion of the optional groundwater sweep that Powertech (USA) may use with either the deep disposal well or land application options. In order to recover flare of lixiviant outside the well field pattern area, up to one (1) pore volume of groundwater sweep may be employed over the course of aquifer restoration.

6.1.5 Pore Volume Calculations and Restoration Pore Volumes

The formulas for determining the pore volume and the volume of restoration composite (RC) to be withdrawn during aquifer restoration are as follows:

Pore volume = (well field pattern area) x (thickness) x (porosity) x (flare factor)

RC volume = (pore volume) x (number of pore volumes for aquifer restoration)

The thickness is the average thickness of the mineralized zones as determined by down-hole radiological logging. The average thickness in the Dewey-Burdock project area is 4.6 feet. Pore volumes will be calculated based on the actual screen lengths of injection and production wells and not by the ore zone thickness.

The porosity of the ore zone within the project area was determined by laboratory analysis of core samples. Based on 11 measurements of ore zone porosity from core samples of the Fall River and Chilson host sands, the average porosity of the ore zone sands within the project area is 0.30.

The proposed flare factor is 1.44, accounting for both horizontal and vertical flare of lixiviant during ISR operations. Support for the flare factor is contained in the numerical groundwater modeling results presented in Appendix 6.6-B of the approved license application, "Numerical Modeling of Groundwater Conditions Related to In situ Recovery at the Dewey-Burdock Uranium Project, South Dakota." Appendix 6.6-B of the approved license application describes how horizontal flare from a modeled balanced well field was determined to be 1.19. Vertical flare is expected to be similar to or less than the horizontal flare since the horizontal conductivity is greater than vertical conductivity. An overall flare factor of 1.44 is supported by the numerical modeling results presented in Appendix 6.6-B of the approved license application.

The flare factor and number of pore volumes required for aquifer restoration are both a function of the properties of the particular sandstone formations and ore deposits, as well as the operational factors of aquifer bleed rates, the balancing of pattern flow rates, the use of RO during aquifer restoration and the timeliness of beginning aquifer restoration operations following cessation of recovery operations. For the Dewey-Burdock Project, the values of the flare factor and the number of pore volumes removed for aquifer restoration are comparable to those that have been recently approved for other ISR facilities and are consistent with the best practicable technology for aquifer restoration.

The overall (horizontal and vertical) flare factor for ISR uranium projects has varied from 1.44 at Irigaray/Christensen Ranch (COGEMA, 2008 and COGEMA, 2005) to 1.95 at Churchrock/Crownpoint (HRI, 2001). The overall well field flare factor for the Dewey-Burdock Project is estimated to be 1.44, which is equal to the flare factor in approved license applications at ISR facilities located nearby in the State of Wyoming and is supported by numerical groundwater modeling.

The number of pore volumes, including flare, of groundwater to be removed to achieve aquifer restoration is estimated to be 6.0. This figure is consistent with the best practicable technology that includes the following operational practices:

(i) Daily balancing of injection and extraction flow rates during production. This flow rate balancing is designed to ensure that a proper aquifer bleed is maintained both at the well field level and also within each 5-spot pattern within the well field.
(ii) Timeliness of beginning restoration operations. For any particular well field, aquifer restoration operations will begin as soon as is reasonably possible following the cessation of recovery operations.
(iii) Maintenance of aquifer bleeds. Hydraulic control of well fields through the net withdrawal of the aquifer bleed stream will be continuously maintained from the beginning of recovery operations until the end of active aquifer restoration.

While the number of pore volumes required for aquifer restoration has historically proven to have been significantly higher for some of the early ISR uranium projects, the methods and timing of restoration likely contributed to these larger numbers. The following information was obtained from the Moore Ranch license application (Uranium One, 2008)

> "The average number of PVs extracted and treated/reinjected/or disposed was 13.6 for Irigaray and 12.4 for Christensen … Circumstances at both those ISR projects resulted in increased PVs to achieve restoration goals including the following:
>
> - Production and restoration were not conducted sequentially, and were plagued with extended periods of shut-in and standby, with delays of up to several years in some cases;
> - Groundwater sweep, the initial phase of restoration, was often largely ineffective and in some cases may have exacerbated the problem; and
> - RO was continued in some well fields after it was apparent that little improvement in water quality was occurring.
>
> "Restoration was not performed immediately following the completion of production, and in some cases, there were long periods of inactivity during the production and restoration phases. At Irigaray, production was interrupted for a period of almost six years in MU1 through MU5 … Similarly, there was a three-year break in production in MU6 through MU9, when the operation was in standby status. Restoration did not commence at MUl through MU3 until a year after production had ended. At MU4 and MU5, restoration operations did not begin until two years following production. Restoration commenced shortly after the end of production at MU6 through MU9. However the project was on standby status between the completion of groundwater sweep and the beginning of the RO phase of production, resulting in a break of one to two years, depending on the MU.

> Restoration was initiated sooner after the end of production at Christensen Ranch, with the exception of MU3 and MU4. However, there were periods of standby between groundwater sweep and RO treatment/injection of up to a year. These delays between and during production and restoration operations most likely increased the number of PVs required to complete aquifer restoration."

For the financial assurance calculations, the pore volume affected in the first year of production is estimated to be approximately 13 million gallons, corresponding to an active well field area of approximately 20 acres. The restoration composite, or volume of groundwater to be extracted during groundwater restoration, is estimated to be approximately 78 million gallons. Calculations are presented in Appendix 6.6-A of the approved license application.

6.1.6 Environmental Effects of Groundwater Restoration

Based on the success of groundwater restoration at other ISL facilities, Powertech (USA) expects that the proposed groundwater restoration techniques will be successful at returning the production zones within the PA to restoration target values. The purpose of restoring the groundwater to these indicator parameters is to protect USDWs adjacent the aquifer exemption boundary. Powertech (USA) believes that by using proven best practicable technology for groundwater restoration combined with federal and state regulatory requirements will ensure that potential impacts to groundwater quality outside the production zone are mitigated.

The preferred method of restoration consists of using the groundwater treatment method with RO reject brines being treated for radium removal and disposed in Class V disposal wells. This method minimizes the amount of groundwater that will be consumed during restoration, and minimizes the surface disturbance to land within the permit boundary. Disposal of wastewater in deep disposal wells is the best practicable technology and is the standard method used at most ISL uranium mines. The alternate method of land application would consume more groundwater since none of the restoration water would be recycled to the well field, but would be used in a once-through process leading to land application.

The proposed restoration methods will consume groundwater. Groundwater recovered during groundwater restoration is typically disposed of directly in the wastewater system. Consumption of groundwater is an unavoidable consequence of groundwater treatment; potential impacts and water usage during operations is discussed in more detail in Section 7.2.5.1.

6.1.7 Groundwater Restoration Monitoring

6.1.7.1 Monitoring During Active Restoration

During active aquifer restoration, monitoring wells will be sampled every 60 days and analyzed for the indicator UCL parameters. If the concentration of two 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 samples 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 nor third sample confirm the first sample results.

Corrective Action and Monitoring

Corrective actions following the confirmation of an excursion will include: sampling frequency will be increased to weekly; pumping rates of production wells in the area of the excursion will increase; the net bleed will be increased; individual wells will be pumped to enhance recovery of ISR solutions; and an excursion report will be prepared for NRC. If actions taken are not effective at retrieving the excursion within 60 days, Powertech (USA) will suspend injecting lixiviant into the production zone adjacent to the excursion until the excursion is retrieved and the UCL parameters are not exceeded.

Notification

In the event of an excursion Powertech (USA) will notify the NRC within 24 hours by telephone or email, and in writing within 30 days, and begin corrective actions.

Monitoring the Progress of Active Restoration

Powertech (USA) will implement an active aquifer restoration monitoring program to document the progress of aquifer restoration. During active aquifer restoration, each well field will be monitored on a frequency sufficient to determine the success of aquifer restoration, optimize the efficiency of aquifer restoration and determine if any areas of the well field need additional attention. At the beginning of aquifer restoration, water level will be measured and groundwater analyzed for all parameters listed in Table 6.1-1 for the subset of production zone sampling wells used in baseline. Thereafter, samples will be collected and analyzed for all or selected parameters as needed.

The success of aquifer restoration will be demonstrated during the well field stabilization period.

The results of the active restoration monitoring will be used to evaluate potential areas of flare or hot spots. If potential flare or hot spots are identified, appropriate corrective measures will be taken. These may include adjusting the flows in the area, changing wells from injection to production or vice-versa, or adjusting the restoration bleed in specific areas. Additional information on statistical methods used to identify hot spots is provided in Section 6.1.8.2.

6.1.7.2 Restoration Stability Monitoring

A groundwater stability monitoring period will be implemented to show that the restoration goal has been adequately maintained. The stability monitoring period will consist of twelve (12) months with quarterly sampling. Over the 12-month minimum stability monitoring period, there will be at least five (5) sample events, including one at the beginning of the stability monitoring period and following each of the following four quarters. The criteria to establish restoration stability will be based on well field averages for water quality, except that hot spots will be evaluated based on the results from individual wells.

During the restoration stability period, the following monitoring program will be utilized:

Monitoring wells in the perimeter ring and those wells in the overlying and underlying aquifers will continue to be sampled once every 60 days for the UCL indicator parameters of chloride, total alkalinity (or bicarbonate), and conductivity. The NRC will be contacted if any of the wells cannot be sampled within 65 days of the last sampling event due to unforeseen conditions such as snowstorms, flooding, or equipment malfunctions.

Quarterly, the production-zone wells that were sampled to determine well field baseline will be sampled and analyzed for the water quality parameters listed in Table 6.1-1. The criteria to establish successful stability will be that, for each sampling event, the mean constituent concentration of each water quality parameter meets the target restoration goal established for that parameter from baseline sampling, as described in Section 5.7.8.3.

Linear regression analysis will be performed on each monitored constituent measured in the production zone baseline wells. This statistical method will assist in determining if the concentration of a given constituent exhibits a significantly increasing trend during the stability period. If a constituent exhibits a strongly increasing trend, or in the case of pH a strongly increasing or decreasing trend, Powertech (USA) will take action to resolve the situation. The action taken will depend on the constituent and the status of the restored groundwater system. Due to the complexity of the aqueous geochemical groundwater systems involved, these statistical techniques will not be relied on as the sole determinant when evaluating the effectiveness of groundwater restoration. Therefore, Powertech (USA) will consider which constituent(s) shows an increasing trend in concentration and base the decision on further action on the status of the production zone groundwater geochemistry. These actions may include extending the stability period or returning the well field to a previous phase of active restoration to resolve the issue. The phase of active restoration that will be used will be determined by the constituent and the process required to bring it to stability.

If the analytical results from the stability period continue to meet the target restoration goals and do not exhibit significant increasing trends, then Powertech (USA) will submit supporting documentation to the regulatory agencies showing that the restoration parameters have remained at or below the restoration standards and will request that the well field be declared restored.

For one or two parameters, localized, elevated concentrations above the restoration criteria may remain in the production zone following restoration. These isolated, residual elevated concentrations are referred to as "hot spots." The primary indicator of a hot spot for a specific constituent or parameter will be the mean production zone concentration plus two standard deviations. For pH, the indication of a hot spot will be plus or minus two standard deviations. If a constituent or parameter at a production zone baseline sampling well exceeds that criterion during the stability period, the location of the well will be identified as a hot spot. Once a hot spot is identified, additional evaluation will be conducted to determine potential impacts that such a hot spot could have on water quality outside of the exempted aquifer. The additional evaluation may include collection of additional water samples, analysis of added parameters, trend analysis, or flow and transport modeling. Based on the results of the evaluation, additional stability monitoring or restoration may be conducted as needed to ensure the protection of water quality outside the exempted aquifer. If hot spots are sufficiently demonstrated not to have the potential to affect water quality outside of the exempted aquifer and the restoration criteria are otherwise met without increasing trends, then no additional action will be taken and Powertech (USA) will submit supporting documentation to the regulatory agencies showing that the restoration parameters have remained at or below the restoration standards and will request that the well field be declared restored.

6.1.8 Well Plugging and Abandonment

Prior to plugging, each well will undergo mechanical integrity testing (MIT) to demonstrate the integrity of casing and cement that will be left in the ground after closure. Alternatively, cementing records or other evidence (such as cement bond logs) will be used to show that an adequate quantity of cement is present to prevent upward fluid movement within the borehole outside of the casing.

Powertech (USA) will plug all wells with bentonite or cement grout. The weight and composition of the grout will be sufficient to control artesian conditions and meet the well abandonment standards of the State of South Dakota, including Chapter 74:02:04:67 (Requirements for Plugging Wells or Test Holes Completed into Confined Aquifers or Encountering More than One Aquifer) of the South Dakota Administrative Rules. Cementing will be completed from total depth to surface using a drill pipe. Records will be kept of each well cemented including at a minimum the following information:

- well ID, total depth, and location
- driller, company, or person doing the cementing work
- total volume of cement placed down hole
- viscosity and density of the slurry used

Powertech (USA) will remove surface casing and set a cement plug to a depth 6 ft below the ground surface on each well or borehole plugged and abandoned.

6.1.9 Restoration Wastewater Disposal

As noted earlier, the method of wastewater disposal is closely linked to the choice of groundwater restoration methods. The preferred option is to dispose of wastewater by injection into Class V disposal wells. The alternate option is land application of treated wastewater. Additional details and water balance figures are provided in Section 4.2.

6.1.10 References

Catchpole, G. and R. Kuchelka, Groundwater Restoration of Uranium ISL Mines in the United States, January 1993, available from website on the Internet in June 2011: <http://www.uranerz.com/i/pdf/Uranium_Paper_Groundwater_Restoration.pdf>

COGEMA, 2008, Wellfield Restoration Report, Christensen Ranch Project, Prepared by COGEMA Mining, Inc. and Petrotek Engineering Corporation, March 5, 2008, NRC ADAMS Accession No. ML081060131.

_____, 2005, Response to LQD/DEQ January 10, 2005 Comments and Irigaray Wellfield Restoration Report, TFN 4 1/170, Prepared by COGEMA Mining, Inc., Petrotek Engineering Corporation, and Resource Technologies Group, May 4, 2005, NRC ADAMS Accession No. ML053270037.

HRI, 2001, Hydro Resources Inc. Unit 1 Restoration Action Plan, HRI Crownpoint Uranium Project, NRC License No. SUA-1580, September 14, 2001.

NRC, 1996, NRC Staff Technical Position: Alternate Concentration Limits for Title II Uranium Mills, January 1996.

Uranium One, 2008, Responses to NRC Request for Additional Information, Moore Ranch Uranium Project Source Material License Application, October 2008, NRC ADAMS Accession No. ML090370542.

6.2 Plans and Schedules for Reclaiming Disturbed Lands

At the completion of the project, all disturbed lands will be returned to their pre-production land use of livestock grazing and wildlife habitat. The objective of the surface reclamation effort is to return the disturbed lands to equal or better condition than pre-production. All buildings and structures will be decontaminated to regulatory standards and demolished and trucked to an approved disposal facility. Baseline soils, vegetation, and radiological data will be used as a guide in evaluating the final reclamation. A final decommissioning plan will be submitted to the NRC for review and approval at least 12 months prior to the planned decommissioning of a well field or PA.

6.2.1 Pre-Reclamation Radiological Surveys

Consistent with NUREG-1569, Acceptance Criterion 6.2.3(2), Powertech (USA) will implement a pre-reclamation radiological survey program to identify areas for cleanup operations. The instruments and techniques for pre-reclamation radiological surveys to identify areas of the site that need to be cleaned up to comply with NRC concentration limits will be the same or similar to those used to survey the project area for pre-operational radiological conditions. The instruments used for the pre-operational survey are described in Section 2.9 and include unshielded Ludlum Model 44-10 2" x 2" sodium iodide (NaI) detectors coupled to Ludlum Model 2221 rate meter/scalers (set in rate meter mode) and a Trimble Pro XRS GPS receiver with Trimble TSCe data logger.

Consistent with NUREG-1569, 6.2.1 Areas of Review, Powertech (USA) will provide the NRC and SD DENR with maps and data that document the post-operational condition. The techniques to be used during the pre-reclamation radiological survey include putting special emphasis on those areas with the highest potential for surface contamination, including diversion ditches, surface impoundment areas, well fields (particularly those areas where potential spills or leaks may have occurred), process structures, storage areas, on-site transportation routes for contaminated material and equipment, and areas associated with liquid waste disposal. Powertech (USA) will also consider results from operational monitoring and any other information that provides insight to areas with the greatest potential to be contaminated. Powertech (USA) will use a sampling grid of 100 m^2 for soil and other specifications to ensure that radium and other radionuclides will not exceed the standards in 10 CFR Part 40, Appendix A, Criterion 6(6). Guidance for sample size and other techniques provided in NUREG-1575 will be used as reference for the pre-reclamation radiological survey.

The following general procedures for interpretation of the pre-reclamation survey results will be used to identify areas for cleanup operations:

1) Pursuant to 10 CFR Part 40, Appendix A, Criterion 6(6), the radium-226 content in soils, averaged over areas of 100 m^2, will not exceed the background concentration by more than (i) 5 pCi/g of Ra-226 averaged over the first 15 cm (5.9 in) below the surface, and (ii) 15 pCi/g of radium-226 averaged over 15 cm thick layers more than 15 cm below the surface.

2) The background radionuclide concentrations have been determined using appropriate methods as described in Section 2.9. There are two areas within the project area where the gamma survey recorded levels higher than the majority of the project area. These are the surface mine area in the northeast portion of the project area and a naturally anomalous area in the northern portion of the project area. These areas may warrant a different background concentration. Should Powertech (USA) determine that use of a different background radionuclide concentration is warranted, it will propose one with its final decommissioning plan.

3) For areas that meet the radium cleanup criteria, but that still have elevated thorium-230 levels, Powertech (USA) proposes to provide in its final decommissioning plan an acceptable cleanup criterion for thorium-230, one that when combined with residual concentrations of radium-226, would result in the radium concentration (both radium residual and from thorium decay) that would meet the radium cleanup standard in 1,000 years.

4) Likewise, Powertech (USA) will propose acceptable criteria for uranium in soil, such as those found in Appendix E of NUREG-1569.

5) Lastly, the survey method for cleanup operations will be designed to provide 95% confidence that any residual radionuclides on the project area will be identified and

cleaned up. Powertech (USA) will apply appropriate statistical tests for analysis of survey data.

6.2.2 Surface Disturbance

Due to the nature of ISL production, minimal and intermittent surface disturbance will be associated with the project, and will be mainly associated with the CPP, maintenance and office areas. Additional intermittent disturbance occurs in the well fields, which includes well drilling, pipe installations, and road construction; however, disturbances associated with the well field impact a relatively small area and have short-term impacts.

Surface disturbances associated with the construction of the CPP, office and maintenance buildings, and well field header houses will be for the life of those activities. Topsoil will be stripped and stockpiled from these areas prior to construction. Disturbances associated with the well field drilling and pipeline installation are limited and will be reclaimed as soon as possible after these components are completed. Surface disturbance associated with the development of access roads will occur at the project site; topsoil will be stripped from the road areas and stockpiled prior to construction.

While, the PA encompasses 10,580 acres, the land potentially disturbed by the PA will be approximately 68 acres (facilities, piping, ponds, well fields and roads) the year proceeding operation. The disturbed area during the life of the project (production to restoration) is estimated to increase over time to a maximum of 108 acres. The maximum potential disturbance at any given time is expected to be 463 acres.

6.2.3 Topsoil Handling and Replacement

Topsoil will be salvaged from any building sites, permanent storage areas, access roads, and chemical storage areas prior to construction in accordance with SD DENR requirements. Typical earth moving equipment such as rubber tired scrapers and front end loaders will be used for topsoil stripping. In the well field, topsoil removal will be limited to headerhouse locations and access roads. A total of an estimated 13 acres of topsoil will be stripped, stockpiled, and replaced during the life of the project.

Salvaged topsoil will be stored in designated topsoil stockpiles. These stockpiles will be located such that losses from wind erosion are minimized. Additionally, topsoil stockpiles will not be located in any drainage channels or other locations that could lead to a loss of material. Berms will be constructed around the perimeter of stockpiles and the stockpile will be seeded with an approved seed mix to help minimize sediment runoff. Additionally, all topsoil piles will be identified with highly visible signs per SD DENR requirements.

During excavations of mud pits associated with well construction, exploration drilling, and delineation drilling activities, topsoil is separated from the subsoil with a backhoe. First the topsoil is removed and placed at a separate location and then the subsoil is removed and deposited next to the mud pit. Usually within 30 days of the initial excavation use of the mud pit is complete; the subsoil is redeposited in the mud pit followed by the replacing of topsoil. Pipeline ditch construction follows a similar procedure storing topsoil and subsoil separately and depositing the topsoil on the subsoil after the ditch has been backfilled.

6.2.4 Final Contouring

Due to the nature of ISL production, there will be very few construction activities that will require any major contouring during reclamation. Surface disturbances that do occur will be contoured to blend in with the natural terrain.

6.2.5 Revegetation Practices

Revegetation practices will be conducted in accordance with NRC and DENR regulations and the methods outlined in the SD DENR mining permit. In order to help reduce wind and water erosion, topsoil stockpiles and other various disturbances in the well field area will be seeded throughout the PA. Per SD DENR regulations, the seed mix will be chosen to be compatible with the post-production land use. The local conservation district, landowners and the SD DENR will be consulted when selecting the seed mix.

A reference area may be used to measure the success of reclamation. The reference area will be selected in a location that will not be affected by future production and is representative of the post-production land use. It will be managed such that there are no significant changes in cover, productivity, species diversity and composition of the vegetation.

Seeding may be done with a rangeland drill or with a broadcast seeder where practical. After topsoil preparation is completed affected lands will be seeded during the first normal period of favorable planting conditions unless an alternative plan has been approved. Any gullies or rills that would preclude the successful establishment of vegetation or achievement of the post-production land use will be removed or stabilized as part of the revegetation and reclamation process.

6.3 Procedures for Removing and Disposing of Structures and Equipment

The procedures for removing and disposing of structures and equipment include the establishment of surface contamination limits, preliminary radiological surveys of process building surfaces, equipment and piping systems; strategic cleanup and removal of process building materials and equipment, sorting materials according to contamination levels and salvageability, and preparing materials for transport and offsite use or disposal. Although not mentioned hereafter, the procedures also apply to tools and other equipment, such as backhoes.

All decommissioning activities will be done in accordance with the NRC license, Titles 10 and 49 of the CFR, and other applicable regulatory requirements.

6.3.1 Establishment of Surface Contamination Limits

Powertech (USA) will use surface contamination release limits contained in Enclosure 2 to Policy and Guidance Directive FC-82-23 (as updated) to release material and equipment that has potentially come into contact with licensed material.

Surface contamination release limits for surfaces on structures intended for unrestricted release following decommissioning are subject to Criterion 6(6) of Appendix A to 10 CFR 40. Acceptable dose-based surface contamination release limits will be established using the RESRAD-Build model or an equivalent model and will be provided in the final Decommissioning Plan, which will be submitted 12 months prior to any planned decommissioning. In the Decommissioning Plan, Powertech will assume that all premises, equipment, or scrap likely to be contaminated in excess of limits, but that cannot be measured, is contaminated in excess of limits and will be treated accordingly.

6.3.2 Preliminary Radiological Surveys and Contamination Control

Powertech (USA) will develop one or more characterization plans that it will follow to demonstrate compliance with the surface contamination limits for building materials, systems, and equipment. The characterization plan(s) will include guidance and SOPs to conduct the preliminary surveys and control contamination. Powertech (USA) will prepare procedures for performing radioactivity measurements on the interior surfaces of pipes, drain lines, and ductwork, and include the procedures in the Decommissioning Plan. Such plans will include measurements at all traps and other access points where contamination is likely to be representative of system-wide contamination.

Areas within buildings showing evidence of possible penetration of process solutions will be evaluated for possible subsurface contamination. If building materials, slabs and soils beneath the slabs are not contaminated, the buildings shall be released for unrestricted use, provided the building surfaces meet the release criteria and radiological monitoring requirements of the characterization and verification plans. Otherwise, the buildings will be demolished, the slabs removed, and the underlying soils removed (if contaminated). All materials contaminated above release limits will be prepared for offsite disposal at a licensed disposal facility. Contamination control will be addressed using operational SOPs, in conjunction with radiological surveys.

Concrete slabs will be surveyed and if found to contain radionuclides in excess of the release limits, an attempt will be made to decontaminate the concrete slab(s). If after a second survey radionuclides are in excess of the release limits, the concrete will be broken up and disposed of at a licensed 11e.(2) disposal site. If the survey results indicate that the concrete is not contaminated above release limits, it may be disposed in an appropriately permitted landfill, used for fill elsewhere, or left in place for use by the landowner.

6.3.3 Removal of Process Building and Equipment

Powertech (USA) will develop plans for the strategic removal of process building and equipment, based on inventory, the results of the radiological surveys, decontamination options and available methods, reuse/disposal pathways, and information obtained during the effort. To the extent possible, Powertech (USA) intends to decontaminate salvageable equipment for unrestricted release. Decontamination methods may include a combination of washing, high pressure sprays, or steam cleaning. Cleaned surfaces will be air-dried prior to radiological monitoring. The ALARA principle applies to decommissioning activities. As such, surface contamination will be reduced to levels as far below applicable limits as practical.

Powertech (USA) will document the results of radiological surveys for all building materials, systems, and equipment. These items will be sorted as follows:

- Salvageable and contaminated above release limits (not releasable but potentially disposable or transferrable)
- Salvageable and contaminated below release limits (releasable) for unrestricted use
- Not salvageable and contaminated above release limits (offsite disposal at a facility licensed to accept 11e.(2) byproduct material)
- Not salvageable and contaminated below release limits (offsite disposal at a permitted facility)

In the first case, the item may be transferred to another NRC or Agreement State licensee. If it cannot be transferred or decontaminated to be released for unrestricted use, it will be disposed of at a licensed disposal facility. In all cases, Powertech (USA) will strictly maintain an inventory of all process building and equipment and the results of radiological surveys.

6.3.3.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Powertech (USA) will develop an approved standard operating procedure for release of items to unrestricted use and thoroughly document all items eligible for release to unrestricted use. To the extent possible, releasable items having a salvageable value will be sold on the industrial market. Releasable items having no net salvageable value will be sent to a municipal landfill.

6.3.3.2 Preparation for Disposal at a Licensed Facility

All materials and plant equipment unsuitable for unrestricted release will be prepared for offsite disposal at a licensed facility. Building materials, tools, and equipment destined for offsite disposal will be prepared for transportation and disposal in accordance with 49 CFR and other applicable requirements.

6.3.4 Waste Transportation and Disposal

Waste transportation will be performed in accordance with 49 CFR and all other applicable regulations. Offsite shipments will be properly prepared, in terms of packaging, marking and labeling, dose rate measurements, shipping papers, and emergency contact information. Offsite disposal will be conducted in accordance with disposal facility licensing requirements, including waste characterization and profiling.

Powertech (USA) will maintain a strict inventory of materials sent for disposal in a municipal landfill, i.e., those that are both non-salvageable and meet the requirements of unrestricted release. In all cases, Powertech (USA) will couple the ultimate destinations of all items to its origin, date of generation, and the results of radiological surveys.

6.3.5 Plans for Decommissioning Non-Radiological Hazardous Constituents

Consistent with NUREG-1569 and 10 CFR Part 40, Appendix A, Criterion 6(7), Powertech (USA) will ensure that non-radiological hazards are addressed in the planning and implementation processes of decommissioning and closure. Section 1.10 includes a discussion of non-radiological wastes and their disposition at closure. Non-radiological cleanup concerns related to the land application option are addressed in Section 7.3.3.8.2.

Any non-radiological hazardous waste that is determined to be 11e.(2) byproduct material will be disposed of offsite at a licensed 11e.(2) waste disposal site in accordance with NRC's directive in 10 CFR Part 40, Appendix A, Criterion 2. Any non-radiological hazardous waste that is not 11e.(2) byproduct material will be disposed offsite at a permitted hazardous waste disposal facility. As described in Section 1.10, potentially hazardous liquid wastes such as used oil, hydraulic fluid, cleaners, solvents and degreasers will be recycled or disposed offsite at an appropriately permitted hazardous or solid waste disposal facility. In addition, as described in Section 7.3.3.8.2, residual non-radiological metal concentrations in land application areas are not expected to exceed their respective EPA soil screening levels (SSLs). Powertech (USA) will include more details on decommissioning non-radiological hazardous constituents in its final decommissioning plan, which will be submitted 12 months prior to any planned reclamation.

6.4 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

6.4.1 Cleanup Criteria

Powertech (USA) will conduct land cleanup in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and South Dakota DENR regulations. Powertech (USA) commits to removal of all 11e.(2) byproduct material for disposal in a licensed 11e.(2) disposal facility (including all affected soils, liners, equipment, filters, etc.) or, if liquid, using an appropriately permitted deep disposal well and/or land application. Any non-11e.(2) byproduct material will be disposed off-site in an appropriately permitted solid or hazardous waste disposal facility.

Surface soils will be cleaned up in accordance with requirements contained in 10 CFR Part 40, Appendix A, including considerations of ALARA goals and the chemical toxicity of Uranium. On April 12, 1999, the U.S. NRC issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. The amendment to Criterion 6 (6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site reclamation plan or included in license applications. This report documents the modeling and assumptions made by Powertech (USA) to derive a standard for U-nat in soil for the project ISL facility.

Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance (NRC, 2003) was published as Appendix E to the Standard Review Plan for In Situ Leach License Applications (NUREG-1569). This guidance discusses acceptable models and input parameters. This guidance from the RESRAD Users Manual (ANL, 2001), the Data Collection Handbook (ANL, 1993) and site-specific parameters were used in the modeling as discussed in the following sections.

6.4.1.1 Determination of Radium Benchmark Dose

RESRAD Version 6.4 computer code (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 6.4.1.2) is attached in the Appendix 6.4-A of the approved license application (Radium Benchmark Dose Assessment, ERG, Inc., Oct., 2008):

- The RESRAD Data Input Basis (Attachment 1 of Appendix 6.4-A of the approved license application) 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 6.4-A of the approved license application).
- 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 6.4-A of the approved license application). 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 6.4-A of the approved license application).

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/yr. This dose was based upon the 5 pCi/g surface (0 to 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/yr 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.

6.4.1.2 Determination of Natural Uranium Soil Standard

RESRAD was used to determine the concentration of natural uranium (U-nat) in soil distinguishable from background that would result in a maximum dose of 38.1 mrem/yr. 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/yr. at time, t = 0 years. The printout of the RESRAD data summary is provided in Attachment 3.1 of Appendix 6.4-A of the approved license application and the dose figures generated with RESRAD are provided in Attachment 4.1 of Appendix 6.4-A of the approved license application.

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.

6.4.1.3 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 6.4-A of the approved license application and the figures generated with RESRAD shown in Attachment 4.1 of Appendix 6.4-A of the approved license application.

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 6.4-1 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 6.4-A of the approved license application 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 6.4-1 is equal to the product of the parameters given in the subsequent columns. Table 6.4-1 shows that the total annual uranium intake from all food sources from the site is 52.4 mg/yr.

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 6.4-1: 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 yrs*365 days/yr)

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/liter. Assuming water intake of 2 liters/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/liter 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 potential 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 presence 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) 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.

6.4.2 Excavation Control Monitoring

The purpose of excavation control monitoring will be to guide the removal of contaminated material to the point where it is highly probable that an area meets the cleanup criteria.

Gamma surveys will be relied on to guide soil remediation efforts. At least 12 months prior to commencing reclamation, Powertech (USA) will submit a decommissioning plan that will contain descriptions of methodology for both pre- and post-reclamation gamma ray surveys. The gamma ray surveys for excavation control monitoring and final cleanup status will be designed to be consistent with NUREG-1569, Acceptance Criteria 6.4.3(1), 6.4.3(3) and 6.4.3(5), including the use of a methodology for gamma-ray surveys for excavation control monitoring and final status surveys that will provide 95% confidence that the survey units will meet the cleanup guidelines.

The post-operation (pre-decommissioning) radiological survey will consist of an integrated area gamma survey and confirmation soil sampling and analysis to verify that the required cleanup standard(s) are met. The areas that will receive particular attention are those that are expected to have higher readings than surrounding areas and include diversion ditches, surface impoundment areas, well fields (particularly those areas where spills or leaks may have occurred), process structures, storage areas, and on-site transportation routes for contaminated material and equipment. Areas associated with liquid waste disposal will also receive close attention. The surveys will identify soil contamination that exceeds the cleanup criteria and will be used to guide the cleanup efforts. After cleanup, the surveys will be used, in conjunction with surface soil sample analyses, to verify cleanup to the site cleanup criteria.

Two methods are proposed for conducting site gamma surveys, the first is the use of the GPS-based radiological survey system and the second is the use of the equivalent conventional method using a Ludlum 2221 rate-meter/scaler and Model 44-10 detector.

Since the methods differ only by data recording and management, there will be no apparent differences in the accuracy of the results.

Gamma Action Level

A gamma action level, defined as a gamma count-rate level corresponding to the soil cleanup criterion, is used in the interpretation of the data. Normally the action level is conservatively developed to allow only a five percent error rate of exceeding the cleanup criteria at the 95 percent confidence level. The gamma action level may change as contaminated soil and associated gamma "shine" is removed. Thus, several action levels may be established. A particular action level will correspond to a gamma-ray count rate that conservatively predicts that the radium-226 in soil may be above the cleanup criterion. In addition, one action level will be required where radium-226 is the principal contaminant, such as in the well fields. Another action level will be required for areas affected by uranium releases, such as in plant areas.

The methods to determine gamma action levels will be determined prior to decommissioning.

For areas exhibiting contamination below the top 6 inches, excavation control monitoring will be done using the same detector deployed to determine the action level. Subsurface excavation control monitoring will consider the appropriate action level, adjusting for geometry factors.

After the remediation, the area will be resurveyed and the new data added to the database. Remediation will continue in areas not meeting action levels. This iterative procedure will be applied until all areas are determined to meet the action levels.

6.4.3 Surface Soil Cleanup Verification and Sampling Plans

Powertech (USA) will comply with the cleanup standard of Criterion 6(6) of 10 CFR Part 40, Appendix A: 11e.(2) byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, will not result in a TEDE exceeding the dose from cleanup of radium-contaminated soil to the above standard (benchmark dose), and will be at levels which are ALARA. If more than one residual radionuclide is present in the same 100 m^2 area, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed 1 (unity).

In areas that meet the Ra-226 cleanup criteria post-reclamation but that still have elevated Th-230 levels, Powertech (USA) will propose an acceptable protocol for Th-230 cleanup. Powertech (USA), in its final decommissioning plan, which will be submitted 12 months prior to any planned reclamation, will propose a concentration for Th-230 that, when combined with the residual concentration (residual thorium and products from thorium decay) that would be present in 1,000 years, meets the radium cleanup standard. In addition, Powertech (USA) will consider other potentially acceptable criteria before selecting and proposing a final cleanup criterion for Th-230 in the decommissioning plan.

Compliance with cleanup criteria will be evaluated in terms of soil concentrations, which will be supplemented by field surveys employing gamma-ray measurements. A final gamma survey of the affected area and buffer zone will be performed using the GPS-based equipment or conventional equipment. Affected areas are those areas that have greater potential to be impacted by uranium solutions, dried uranium product (yellowcake) or liquid or solid waste streams that contain uranium or other radionuclides associated with uranium recovery operations. The areas that are most likely to be considered affected areas include diversion ditches, surface impoundment areas, well fields (particularly those areas where potential spills or leaks may have occurred), process structures, storage areas, on-site transportation routes for contaminated material and equipment, and areas associated with liquid waste disposal. Consistent with NUREG-1569, Acceptance Criterion 6.4.3(5), the survey method for verification of soil cleanup will be designed to provide 95% confidence that the survey units will meet the cleanup guidelines.

A calculation of the potential peak annual total effective dose equivalent (TEDE) within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site will be submitted to NRC for approval. Details will be provided in the decommissioning plan to be submitted for review at least 12 months prior to decommissioning activities. A key component of the plan will be that 11e.(2) byproduct material containing concentrations of radionuclides, other than radium in soil, and surface activity on remaining structures, must not result in a TEDE exceeding the dose from cleanup of radium contaminated soil to the radium benchmark dose, and must be at levels which are ALARA. Powertech (USA) is aware that the use of decommissioning plans with radium benchmark doses which exceed 100 mrem/yr, before application of ALARA, requires the approval of the Commission after consideration of the recommendation of the NRC staff.

6.4.4 Quality Assurance

After license issuance but prior to operations, Powertech (USA) will prepare a QAPP in accordance with Regulatory Guide 4.15 as described in Section 5.7.9. The QAPP will establish the quality assurance and control measures for field measurement, sample collection, and laboratory analysis for all decommissioning activities. The QAPP will also establish performance criteria for field and laboratory data precision, accuracy, completeness, and representativeness. The program will be designed to ensure that the project area is closed in a manner that permits release for unrestricted (i.e., any) use.

Powertech (USA) management will check all aspects of data collection and input to verify that procedures are being followed. The collection and handling of samples from the plant decommissioning, soil cleanup, and other radiological cleanup areas will be reviewed and approved by management. Laboratory results for these samples will be evaluated and validated to requirements in the QAPP. Other aspects of the reclamation including adherence to the SOPs and adherence to the decommissioning plan will be evaluated periodically by Powertech (USA) management. The construction process will be monitored to confirm that appropriate physical and radiological safety procedures are followed. Excavation processes will be monitored to ensure that contaminated materials are not handled carelessly and that any spillage is collected and contained. The conveyance of contaminated materials through the site, e.g., to stockpiling areas, will be monitored to prevent dispersal of these materials in the environment. Construction and sampling activities will be documented and reviewed throughout the reclamation process.

6.5 Decommissioning Health Physics and Radiation Safety

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels will be kept as low as reasonably achievable during decommissioning. The Radiation Safety Officer, Radiation Safety Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Section 5 will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of Regulatory Guide 8.30 or other applicable standards at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC. Records of all contaminated materials transported to a licensed disposal site will be maintained for five years, or as otherwise required by applicable regulations at the time of decommissioning.

6.6 Financial Assurance

In compliance 10 CFR Part 40 Appendix A criteria and NUREG-1569 and 1757, Powertech (USA) will maintain financial assurance instruments to cover the cost of reclamation including the costs of groundwater restoration, the cost of decommissioning, dismantling and disposal of all buildings and other facilities, and the reclamation and revegetation of affected areas for the project.

In accordance with SUA-1600 LC 9.5, Powertech (USA) commits to supplying a financial assurance mechanism in a form and in an amount approved by NRC staff in accordance with 10 CFR Part 40, Appendix A, Criterion 9 prior to the commencement of operations. Powertech (USA) is required to supply financial assurance cost estimates for NRC staff approval for construction and the first year of operations based on best available information, including contractor and material costs, using standard industry practices (Hydro Resources, Inc., 51 NRC 227, May 25, 2000). However, based on the Commission's decision, Powertech (USA) is not required to commit to a specific financial assurance instrument during the license application review process, nor is it required to supply the actual financial assurance instrument for the proposed cost estimates prior to the commencement of licensed activities.

Table 6.6-1 summarizes the financial assurance cost estimates for the Dewey-Burdock Project based on 2009 information. Detailed cost factors and tables are provided in Appendix 6.6-A of the approved license application. Pages 3 and 4 of Attachment RAP-2 of this appendix provide a summary of costs by year for the deep disposal well option and the land application option, respectively. The financial assurance model is based on the Dewey-Burdock Project being in operation for one full year prior to a third party taking over reclamation of the facility. Reclamation would include facility decommissioning, groundwater restoration, stability monitoring, well field reclamation, soil reclamation, and radiological surveys. The by-year costs are based on year 1 being the pre-operational construction phase, year 2 the full year of ISR operations, and year 3 the beginning of the financial assurance-funded reclamation activities. Groundwater restoration and stability monitoring would be conducted in years 3-4. Final decommissioning, including building demolition and soil reclamation, would be conducted during years 5-6.

Table 6.6-1: Summary of Financial Assurance Amounts

Financial Assurance Estimate - Dewey-Burdock Project No. Description			Table Referenced in App. 6.6-A (RAP-2)	Disposal Option	
				Disposal wells	Land application
1	Facility Decommissioning				
	A	Salvageable equipment	9	$ 242,000	$ 242,000
	B	Non-salvageable building & equipment disposal	9,13	$ 710,080	$ 1,123,580
	C	11e.(2) byproduct material disposal	6	$ 466,609	$ 527,831
	D	Restore contaminated areas	9	$ 570,300	$ 1,429,100
2	O&M - Aquifer Restoration and Stability Monitoring				
	A	Method: RO treatment with permeate injection	O&M	$ 897,873	
	B	Method: Groundwater sweep with Madison injection	O&M		$ 555,700
3	Well Field Reclamation				
	A	Well plugging & closure	8, 14	$ 751,300	$ 751,300
	B	Remove surface equipment & reclaim	9	$ 975,050	$ 975,050
4	Radiological Survey and Environmental Monitoring		10	$ 10,300	$ 24,400
5	Project Management Costs & Miscellaneous		12	$ 968,700	$ 968,700
6	Labor, 35% overhead + 10% contactor profit		11	$ 1,337,000	$ 1,337,000
7	Contingency @ 15%			$ 1,039,382	$ 1,190,199
Total Financial Assurance Amount				$ 7,968,594	$ 9,124,861

The financial assurance cost estimate reflects costs as of 2009. The cost factors found in Appendix 6.6-A of the approved license application, Attachment RAP-2, Table 2 and elsewhere were obtained from vendor quotes, from the 2009 RS Means cost estimating handbooks, from recent ISR license applications, and from calculations as described. All electrical power costs are conservatively based on a per kWh hour cost of $0.07; the results of a power study (Lyntek, 2010) showed estimated 2013 power costs of $0.0595 to $0.0691 per kWh, depending on the supplier. The costs of 11e.(2) byproduct material disposal, as listed in Appendix 6.6-A of the approved license application, Attachment RAP-2, Table 2 and as utilized in Table 6, are based on the assumption that Powertech (USA) will secure a byproduct disposal contract with Denison Mines Corporation for disposal at their byproduct disposal facility at White Mesa, UT. The cost estimate is based on a transportation distance of 785 miles from the project area to the White Mesa facility near Blanding, UT. Transportation costs to alternate 11e.(2) byproduct material disposal facilities will be similar or less. For example, the Pathfinder Mines Corporation Shirley Basin Facility is approximately 250 miles away, the Energy Solutions LLC Clive Disposal Site near Clive, UT is approximately 700 miles away, and the Waste Control Specialists LLC facility near Andrews, TX is approximately 900 miles away.

Powertech (USA) proposes use of a flare factor of 1.44 and the restoration estimate of 6 pore volumes of groundwater for its financial assurance. Basis for the flare factor is found in Appendix 6.6-B, "Numerical Modeling of Groundwater Conditions Related to In Situ Recovery at the Dewey-Burdock Uranium Project, South Dakota." Refer to Section 6.1.6 for justification of the flare factor and total number of restoration pore volumes. As explained in more detail in Section 6.1.6, the flare factor is based on experience gained from ISR operations in Wyoming and on numerical groundwater modeling. The number of PVs necessary for restoration is also based on experience from other ISR operations after allowing for improvements in technology, including reduced groundwater sweep, which was found to be ineffective at some other operations, and elimination of long delays, sometimes up to several years, which proved to be less effective than completing restoration soon after uranium recovery was completed.

While it is likely that the facility buildings will have a salvage value, the demolition cost estimate assumes that all buildings will be shredded and disposed at an appropriate landfill. Decommissioning costs include a final gamma survey.

Labor costs associated with the reclamation operations will be a combination of contract labor and direct hires, listed in Appendix 6.6-A of the approved license application, Attachment RAP-2, Table 11. A full-time Radiation Safety Officer will be employed through final decommissioning.

All of the financial assurance information contained in the license application as well as the information in Table 6.6-1 has been consolidated into a restoration action plan (RAP), which is provided as Appendix 6.6-A of the approved license application.

Powertech (USA) will revise these financial assurance cost estimates after license issuance based on NRC approval of the methodologies for cost estimate calculations. In the event that additional factors are utilized for adding or subtracting from NRC-approved cost estimates, Powertech (USA) will provide a written explanation of such factors when submitting revised cost estimates after license issuance.

Powertech (USA) commits to providing annual financial assurance updates to NRC staff, including any revisions to financial assurance cost estimates based on a series of factors including, but not limited to: (1) inflation; (2) changes in contractor costs; (3) changes in material costs; and (4) changes in restoration elements such as pore volumes. Pursuant to NUREG-1757, Volume 3, Powertech (USA) also commits to (i) automatically extend the financial assurance instrument for the previously approved financial assurance amount until NRC approves the revised financial assurance cost estimates if NRC staff has not approved its proposed revisions thirty (30) days prior to the expiration date of the existing financial assurance instrument; (ii) revise the financial assurance instrument within ninety (90) days of NRC approval of any revised decommissioning plan if the revised cost estimate exceeds the amount of existing financial assurance costs; (iii) submit for NRC staff review an updated financial assurance package to cover any planned expansion or operational change not included in the previous annual financial assurance update at least ninety (90) days prior to beginning such associated construction; and (iv) provide NRC staff with copies of financial assurance-related information submitted to the State of South Dakota and/or EPA, including a copy of the financial assurance review or final financial assurance package.

6.7 References

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Code of Federal Regulations, 10 CFR 40, "Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content".

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NRCS, 2007, "*2003 Annual National Resources Inventory*", Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, DC.

TVA, 1979, "*Draft Environmental Statement – Edgemont Uranium Mine*", Tennessee Valley Authority, Knoxville, Tennessee.

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7.0 Potential Environmental Effects

This section discusses potential direct and indirect environmental impacts (effects) that may be temporary (short term) or permanent (long term) in nature, and are associated with the construction and operation of the Dewey-Burdock Project. After a complete site specific analysis of the potential impacts of the Proposed Action, NRC concluded that such potential impacts fall within the scope of the analysis and conclusions in NUREG-1910 regarding the South Dakota-Nebraska Region as described in NUREG-1910 Supplement 4.

7.1 Potential Environmental Effects of the Site Preparation and Construction

Site preparation and construction activities associated with the project facilities include site characterization, drilling wells, clearing and grading related to building and road construction, installation of pipelines, and construction of evaporation ponds. Construction at an ISL site is phased and iterative as new well fields are developed throughout the life of the project.

7.1.1 Potential Air Quality Effects of Construction

ISL facilities typically do not affect air quality drastically (NUREG-1910, 2008). The potential 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. Due to the isolated location (13 miles northwest of Edgemont) and the atmospheric conditions of the PA, the potential cumulative air quality impacts will be negligible. The generation of dust and emissions will be limited to the brief construction phase.

The construction phase of ISL projects and facilities 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 EPA and 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.

7.1.2 Potential Land Use Effects of Construction

Rangeland and pastureland are the primary land uses within the PA and the surrounding 2 km review area. While, the Proposed Action site encompasses 10,580 acres, the land potentially disturbed by the Proposed Action will be approximately 68 acres (facilities, piping, ponds, well fields and roads) the year proceeding operation. The 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 approximately a maximum additional 355 acres would be affected by the Proposed Action for most of the project life. The maximum potential disturbance at any given time is expected to be 463 acres.

Under the proposed action, this land will be temporarily converted from its previous use as rangeland and pastureland to ISL use on a "phased" basis. The land will likely experience an increase in human activity also contributing to further land disturbance. The disturbance associated with drilling and 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.

Recreational use within the project boundary is limited primarily to large game hunting. Within the PA, hunting is currently open to the public on approximately 5,700 acres. Approximately 240 acres are owned by the Bureau of Land Management (BLM); the South Dakota Game Fish and Parks (SDGF&P) lease around 3,000 acres annually of privately owned land and currently designate this acreage as walk-in hunting areas. Prior to commencement of operations Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable.

Additional potential land use impacts could include the disruption to livestock grazing within the PA. 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 and eliminated prior to site closure.

7.1.3 Potential Surface Water Effects 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 potential 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 potential impacts. No direct disturbance to any wetlands or water sources is planned at this time. If, in the future, the project 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.

According to NUREG-1910, "*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 potential 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 USACE; the determination rendered 4 of the 20 evaluated as Jurisdictional sites (see Appendix 7.1-A of the approved license application). 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 PA and the rest of the natural water flow is ephemeral. Of the jurisdictional determinations within the PA, potential 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 directly impacted by the disturbance areas located along the old mine pits.

ISL operations do not involve 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.

7.1.3.1 Potential Surface Water Effects from Sedimentation

Increased sedimentation of water bodies due to construction activities may be a concern at the site. Land clearing for construction of roads, well pads, pipelines, and other various structures may result in soil exposure to water and wind erosion. Soil is often compacted by vehicle use during various construction activities, resulting in decreased soil permeability, and thus increased water runoff. The soil exposure and increased water runoff may cause sedimentation to be carried into surface water bodies.

7.1.4 Potential Population, Social, and Economic Effects of Construction

The construction phase of the project could result in moderate impacts to the local economy as a result of purchasing goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs are expected to be minor or non-existent and temporary in duration.

For the construction phase of the project, an estimated 86 payroll workers will be engaged directly in construction activities. An estimated 176 additional non-payroll positions will be created in Custer and Fall River Counties as a result of construction activities and non-payroll capital expenditures incurred by the project.

7.1.5 Potential Noise Effects 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 PA and the surrounding 2 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 well field construction should cause no off-site impacts, since the PA is not in close proximity to off-site receptors and will occur only during daylight hours.

7.2 Potential Environmental Effects of Operations

This section describes the environmental effects of operation at the ISL project. Operations activities include:

- Ongoing well field construction activities including well drilling and construction, construction of access roads, installation of pipelines and utilities, and headerhouse construction
- CPP and well field production operations
- Groundwater restoration activities associated with well field decommissioning
- Final site reclamation activities

Potential environmental concerns from the operation of the project are addressed in the following sections and include: air quality impacts, land use impacts, geological and soil impacts, impacts to cultural resources, water quality impacts, and ecological impacts.

7.2.1 Potential Air Quality Effects of Operations

The project site is not expected to be a major point source emitter and is not expected to be classified as a major source of emissions. New emissions are 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. This is the greatest air quality concern of ISL operations. Radon gas release is discussed further in Section 4.1.1. 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.

Yellowcake drying operations can also produce gaseous effluents, with the greatest concern being the release of uranium particles. As discussed in Section 3.2.5, the yellowcake will be dried at approximately 250°F in a rotary vacuum drying process. The off gases generated during the drying cycle are filtered through a baghouse, which is located on the top of the dryer, to remove particles down to approximately 1 micron in size. The gases are then cooled and scrubbed in a surface condenser to further remove the smaller size fraction particulates and the water vapor during the drying process. The potential impacts related to yellowcake drying are expected to be small due to the required filtration systems put in place.

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.

7.2.2 Potential Land Use Effects of Operations

The primary land use within the PA 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 PA will be returned to rangeland use.

The Proposed Action could temporarily impact recreational use, limited primarily to large game hunting, within the project boundary. Within the PA, hunting is currently open to the public on approximately 5,700 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 (SDGF&P) lease around 3,000 acres (1,241 ha) annually of privately owned land and currently designate this acreage as walk-in hunting areas. Prior to commencement of operations Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable.

Additional potential land use impacts could include the disruption to livestock grazing within the PA. Approximately 9.46 acres (3.828 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 and small prior to site closure. Given the relatively small size of the area impacted by operations, the exclusion of grazing from this area over the course of the project is expected to have minimal impact on local livestock production.

7.2.3 Potential Geologic and Soil Effects of Operations

The following section discusses the potential geological and soil impacts of operations at the project.

7.2.3.1 Potential Geologic Effects of Operations

Potential 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 2.6.7, the maximum magnitude earthquake estimated for the PA is a VII on the Modified Mercalli Scale, corresponding to a Richter magnitude of 6.1.

Due to the design of the project, no significant geologic impacts are anticipated, according to NUREG-1910.

7.2.3.2 Potential Soil Effects of Operations

There are two main drainage basins located in the PA; each of the drainages have different soil types. The soil mapping unit descriptions are in Section 2.6.6. 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 intermittent impacts include:

- Compaction
- Loss of productivity
- Loss of soil
- Salinity

- Soil contamination

These impacts could potentially occur via:

- 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 PA 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 PA, the soils are more susceptible to erosion from water than wind. See Table 2.6-7 for a summary of potential wind and water erosion hazards within the PA.

During land application disposal, there could be potential impacts to the soil from elevated TDS and electrical conductivity (EC) values in the water (Table 4.2-6) to be used to irrigate crops and salt tolerant wheat grasses. Irrigation water quality is commonly assessed in terms of soluble salt content, percentage of sodium, boron, and bicarbonate contents. In the case of the water used for irrigation the soluble salts are on the order of 3,000 to 4,000 µS/cm at 25 °C. 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 water erosion during the infiltration of rain or snowmelt. There could be some salt deposition at the surface, however maintaining maximum crop growth

Table 7.2-1: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Production Ground Water Quality([a])

Constituent	Dewey (mg/L)	Dewey (meq/L)	Dewey ESP[1]	Dewey RSC[2]	Dewey SAR[3]	Burdock (mg/L)	Burdock (meq/L)	Burdock ESP[1]	Burdock RSC[2]	Burdock 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-production water quality data from other ISL sites in Wyoming and Nebraska, with adjustments as necessary to account for planned post-production water treatment(s).

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

13.

14. 2. RSC = Residual Sodium Carbonate (n $RSC = ([CO_3] + [HCO_3]) - ([Ca] + [Mg])$

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

will reduce the possibility of undesirable species. During the irrigation season, water application rates will be determined to optimize both evaporation and crop production.

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 PA may be increased compared to areas outside the PA 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).

7.2.3.2.1 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).

7.2.3.2.2 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: waste disposal well 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.

7.2.3.2.3 Deep Disposal Wells

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 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 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 UIC regulations and, as such, the potential impacts will be negligible (NMA, 2007).

7.2.3.2.4 Well Fields

In addition, the injection of treated groundwater as part of uranium recovery or as part of restoration of the recovery 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 (USA)'s 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.

7.2.4 Potential Archeological Resources Effects of Operations

As discussed in Section 2.4.1, a Level III Cultural Resources Evaluation was conducted in the PA. 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 PA in relation to the Black Hills proper. The disparity existing between the number of historic and prehistoric sites observed in the PA 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 of ISL facilities 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, with which Powertech (USA) agrees, 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).

7.2.4.1 Potential Visual and Scenic Resources Effects

Short-term and temporary impacts to the visual resources produced during construction could 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 aerial extent affected during construction.

The sources of potential long-term impacts to the visual resources will be the presence of the CPP, 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 project.

The project could 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 project 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.

7.2.5 Potential Groundwater Effects on Operations

Consumption of groundwater and short-and long-term changes to groundwater are some of the potential groundwater impacts related to the operation of an ISL uranium operation.

7.2.5.1 Potential Drawdown

Based on numerical modeling developed from site-specific parameters and calibrated to historical pumping test data (Appendix 6.1-A of the approved license application), the estimated maximum drawdown outside of the project area resulting from projected ISR operations is approximately 12 feet in the Fall River aquifer and 10 feet in the Chilson aquifer. These simulations were for net extraction rates resulting from a gross production pumping rate of 8,000 gpm (or twice the maximum proposed pumping rate), a 1 percent production bleed rate, and the use of groundwater sweep during aquifer restoration. Since Powertech (USA) has committed to removing domestic wells within the project area from private using (refer to Section 5.7.1.3.2), these represent the maximum anticipated drawdown amounts for nearby domestic wells.

If Powertech (USA) were to use a bleed rate of 3 percent during the operations phase, drawdowns in the nearest domestic wells in the Fall River and Chilson aquifers may be greater than those estimated for a 1 percent bleed rate; however, as noted above, the maximum simulated drawdown was performed for a gross production pumping rate of twice that proposed and for the optional groundwater sweep during aquifer restoration. Therefore, it represents a conservatively high estimate of the potential drawdown resulting from operations and restoration.

Based on the numerical modeling in Appendix 6.1-A of the approved license application, water levels will recover to near pre-operational levels within 1 year after groundwater withdrawals cease.

7.2.5.1.1 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.

7.2.5.2 Potential Effects on Ore Zone Groundwater Quality

A potential environmental impact to groundwater as a result of ISL is the degradation of water quality in the ore zone within the well field areas. The impact, in and of itself, it is of limited, due to the fact that the groundwater quality is very poor prior to uranium ISL operations; this is due to the presence naturally occurring radionuclide levels that exceed EPA and/or state drinking water limits which serve as the base criteria for an UIC aquifer exemption and which 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 and chemical constituents of the aquifer results in an increase in trace elements and salinity during recovery due to a decrease in pH and IX. There is no conveyance of new constituent species from the recovery process into the groundwater. The recovery process may however raise levels of specific constituents that are present within the ore bearing zone and host aquifer pre-operations.

The reduced, insoluble form of uranium present in the ore zone pre-operations is solubilized as a direct result of oxidation via the ISL process when oxidized uranium is introduced to bicarbonate anions and become mobile for extraction. This is the most noticeable impact to the groundwater as a direct result of the ISL process. Although other trace constituents are mobilized during the ISL process, the concentrations of these constituents are dependent upon the specific mineralogy of each deposit and oxidation of trace elements for example: (1) iron sulfides would result in higher concentrations of sulfate; (2) ferroelite would result in higher selenium concentrations (NMA, 2007). If these minerals are present in the respective ore zone it would result in a change in the pH from alkaline range down to a range in the neutral scale, thus causing calcium carbonate to dissolve and result in another pH change moving upward to a more alkaline range due to the increase in calcium, chloride and carbonate.

During the IX above ground process, the uranium on the resin beads is exchanged for chloride. This chloride is introduced into the barren solution in the form of sodium chloride; therefore via the oxidation process which encourages pH adjustment and the IX process, the groundwater concentrations of constituents such as: calcium, sodium, carbonate, bicarbonate, sulfate, chloride, TDS, uranium, and pH are usually increased until the groundwater restoration is initiated within each well field (NMA, 2007).

7.2.5.3 Potential Groundwater Quality Effects from Excursions

Excursions have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized during the ISL process. 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 production zone of the orebody aquifer.

Vertical excursions can be caused by vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers. These head gradients can be caused by potential increases in pumping from either the underlying or overlying aquifers for water supply in the vicinity of the ISL facility. Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could also lead to vertical movement of solutions and excursions.

Another potential source of vertical excursions is potential well integrity failures during ISL operations. Inadequate construction, degradation, or accidental rupture of well casings above or below the uranium-bearing aquifer could allow lixiviant to travel from the well bore into the surrounding aquifer. Deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create pathways for vertical excursions as well.

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 helps minimize the chance of a horizontal excursion occurring. The potential impact of a horizontal excursion could be significant should a large volume of contaminated water leave the production zone and move downgradient within the production aquifer to a zone used for water production. To reduce the likelihood and minimize the consequences of potential horizontal excursions, a ring of monitoring wells will be installed within and encircling the production zone to enable early detection of excursions. If an excursion is detected corrective actions will be taken and the well will be placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

7.2.5.4 Potential Groundwater Effects from 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 leach fluid, 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. Refer to Section 3.2.12 for additional information.

7.2.5.5 Potential Groundwater Effects from Land Application

Land application of treated wastewater could potentially cause radiological or other constituents, such as Selenium or other metals, to accumulate in soils or infiltrate into shallow aquifers. NRC and state release limits for land application of treated wastewater are expected to mitigate the potential effects of land application of treated wastewater on shallow aquifers.

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. 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 licensed material to groundwater beneath the land application pivot sites, thereby eliminating any potential of exposure and risk to human health and the environment.

7.2.6 Potential Surface Water Effects

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. However, due to the relatively small size of these disturbances compared to the overall area and to the size of the watersheds, the increase is expected to be minimal. A slight increase in sediment yields and total runoff can be expected during final reclamation, however well field decommissioning and reclamation activities throughout the life of the project will help to reduce this increase.

In areas where surface structures including well fields and associated structures, access roads, office buildings, pipelines, facilities and other structures associated with ISL production and processing could affect surface water drainage patterns, diversion ditches and culverts will be used to minimize erosion and control runoff.

7.2.6.1 Potential Surface Waters and Wetlands

Powertech (USA) plans to construct several well fields atop the multiple disturbance areas located throughout the permit area. Process facilities are planned to be located adjacent to the uranium rollfront areas.

In the northwest section of the PA the ore bodies lie to the northeast of Beaver Creek, the wetlands along Beaver Creek will not be directly impacted by the disturbance areas. Erosion potential is present due to the construction of the wells near the drainage; however, disturbance is 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. The wetlands associated with old mine pits are not planned to be disturbed.

The remaining disturbance areas in the PA are located near a few small wetlands. These wetlands are likely not to have direct impacts from the wellfields presence but there may be indirect impacts due to the construction of the well fields.

Construction, operation, or reclamation activities, which cause disturbance or impacts to jurisdictional wetlands on the proposed Dewey-Burdock Project, will be performed in accordance with appropriate Nationwide Permits, if applicable. Nationwide Permit (NWP) 44 non-coal mining activities, which requires Pre-construction Notification (PCN) for all activities, NWP 12 utility line activities, which requires a PCN for an area where a section 10 permit is required, discharges that result in the loss of >1/10 acre, and NWP 14 linear transportation projects, which requires a PCN for 1/2 acre in non-tidal waters. NWP 44 has an acreage limit of half an acre for Waters of the United States (WoUS), NWP 12 and 14 also has a half an acre disturbance limit. Impacts to Other Waters of the United States (OWUS) are not considered under the acreage limit. (Federal Register V. 72, No. 47/ Monday, March 12, 2007 Notices) The wetlands found along Beaver Creek are recommended to be jurisdictional since Beaver Creek connects to the Cheyenne River which is a significant nexus. All other wetlands presented in this study are recommended to be non-jurisdictional since the wetlands are all isolated and do not support interstate commerce.

7.2.6.1.1 Wetland Survey Conclusions

The majority of the wetlands in the PA fall within Beaver Creek, the remaining wetlands are dispersed throughout the PA as small depressions and ponds, old mine pits, and an old open flowing well. The wetlands within the old mine pits are not planned to be disturbed and these areas are likely to be excluded from the disturbance areas. The remaining wetlands in the PA are likely not to suffer a direct impact due to the construction of the well fields. There may be some minimal indirect effects to a few of the small depressional wetlands.

The PA had 14.199 acres of wetland channel, 2.338 acres of isolated PEM, PEMC, PABJh, and PUSA ponds; 5.248 acres of PUB isolated depressions, 2.706 acres of PUS isolated depressions, and 10.623 acres of old mine pits classified as PUB, PEM, or OW. Wetlands found along Beaver Creek totaled 13.376 acres of wetland channel. These wetlands found along Beaver Creek are recommended to be jurisdictional because Beaver Creek connects to a significant nexus, the

Cheyenne River. The remaining wetlands are recommended to be non-jurisdictional as they are isolated and do not connect to a jurisdictional source.

Final determination of jurisdictional decision lies within the U.S. Army Corp of Engineers.

Powertech (USA) plans to construct several well fields and a CPP for the project. Where wetlands intersect the orebody, it has been assumed that impacts could occur from the presence of well fields. No wetland will be impacted due to the construction of the CPP. In the northwest section of the PA, the ore bodies lie to the northeast of Beaver Creek; therefore, the wetlands along Beaver Creek will not be directly impacted by the well fields. The remaining disturbance areas in the PA are located near a few small wetlands. These wetlands are not likely to have direct impacts from the presence of the well fields, but there may be indirect impacts due to the construction of the well fields. As noted in Section 2.8, the wetlands located within the PA are recommended as non-jurisdictional except for the wetlands located along Beaver Creek that are recommended to be jurisdictional. In the event that construction, operation, or reclamation activities cause disturbance or potential impacts to jurisdictional wetlands on the proposed project, appropriate Nationwide Permits will be followed, if applicable.

Drainages or surface waters within the PA will not be significantly impacted during construction or operations. In the northwest section of the of the PA near Beaver Creek, erosion potential is present due to the construction of the wells near the drainage; however, this disturbance will be short-term and disturbed areas will be reclaimed concurrently as the well field progresses.

7.2.6.2 Potential Surface Water Effects from Sedimentation

The disturbance associated with normal construction activities, and heavy use of roads and activities associated with the wellfields, pipeline and CPP, have the potential to increase sediment yields. The potential 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 square miles). Beaver Creek is the only perennial stream within the PA and the rest of the natural water flow is ephemeral. Preventative sedimentation measures will be taken for disturbances that have the potential to increase sediment yields; therefore, potential impacts to surface water will be limited to uncommon precipitation or runoff events.

The modification of the land surface that is associated with ISL operations including well fields, a CPP, offices, roads and other structures should have a negligible impact on the peak surface water flow because the relatively planar topography of the PA, low annual precipitation, and the comparatively small area of disturbance within the much larger Angostura Reservoir Basin.

7.2.6.3 Potential Surface Water Effects from Accidents

Potential impacts from accidents to surface water include the uncontrolled 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).

7.2.7 Potential Ecological Effects of Operations

The following section discusses the ecological potential impacts of operations at the project site.

7.2.7.1 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 aerial 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 PA. 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 PA; therefore, no impacts are anticipated.

7.2.7.2 Wildlife and Fisheries

ISL uranium production varies from typical open pit mining by using less intrusive extraction methods that are more efficient and, thus, have less impact on the surrounding area. In situ operations use a series of injection and production wells that extract the uranium from the orebody without physically removing the ore or overburden from the ground.

Despite the relatively limited surface disturbance associated with ISL uranium production, operations can have direct and indirect impacts on local wildlife populations. These impacts are both short-term (until successful reclamation is achieved) 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. 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. The likelihood for the impacts resulting in injury or mortality is greatest during the construction phase due to increased levels of traffic and physical disturbance during that period. Overall traffic will increase from current levels and will persist during production, but should occur at a reduced, and possibly more predictable level than during the construction phase. 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. 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 PA and input from local residents, indicate that the PA 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 PA during surveys conducted in 2007 and 2008. Two other species tracked by the SDNHP were confirmed or suspected to have nested in the PA in 2008, the long-eared owl and long-billed curlew, respectively. Eight additional SDNHP species were documented in or near the PA during baseline surveys. 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 PA during agency or project-specific surveys completed in recent years.

Suitable habitat (trees and native uplands) for all three nesting SDNHP species occurs in the PA. 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 PA and perimeter combine to minimizing 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 meters, 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 PA 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 License area. 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 PA, 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 project. It is possible that the potential implementation of center-pivot irrigation using treated wastewater 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 small percentage of projected surface disturbance within the PA 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 minimal 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.

7.2.7.3 Big Game

Big game could be displaced from portions of the PA 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 PA. 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 PA, 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 PA 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.

7.2.7.4 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 PA have shown an ability to adapt to human disturbance in varying degrees, as evidenced by their continued presence in other mining 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.

7.2.7.5 Raptors

ISL production in the PA 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 project 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 project-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 PA, 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 PA.

Eight intact raptor nests were documented within the project survey area (PA 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 PA, 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 PA (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 project 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 PA 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 production operations, and successfully executed state-of-the-art mitigation techniques to maintain viable raptor territories and protect nest productivity. Some individuals nest on active production 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 production 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 PA, 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 PA, 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.

7.2.7.6 Upland Game Birds

ISL production in the PA 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 PA, 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 PA (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 PA (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.

7.2.7.7 Other Birds

The project could potentially 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 would 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.

7.2.7.8 Waterfowl and Shorebirds

Construction and operation of the uranium project would have a negligible effect on migrating and breeding waterfowl and shorebirds. Existing habitat is limited and seasonally available in the PA, 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 the ponds. Any new treated water sources could enhance current habitat conditions for these species, though such effects may be temporary in nature.

7.2.7.9 Reptiles and Amphibians

As with waterfowl, potential habitat for aquatic and semi-aquatic amphibians and reptiles, is limited within the PA 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 PA and surrounding perimeter. Any impacts that would occur would affect individuals, but would not likely impact the population as a whole.

7.2.7.10 Fish and Macro-Invertebrates

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 project facilities

(CPP, SF, 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 project 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. Some of the proposed land application sites west of the SF would be located in close proximity to Beaver Creek, the primary aquatic habitat in the project vicinity. Beaver Creek would not be directly affected by the well field operations or land application sites.

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

7.2.7.11.1 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 PA and 2 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 PA. Only one small black-tailed prairie dog colony was present in the PA 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.

7.2.7.11.2 State Listed Species

ISL production within the project may affect, but is not likely to adversely affect bald eagles, the only state listed species known to inhabit the PA. Bald eagles were documented at winter roosts and an active nest within the PA 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 2 or 3 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 PA. 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 would include the potential for injury or mortality to individual birds foraging in the PA 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 PA, 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 project 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 project 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 PA 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 PA (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 PA, the lack of otter sightings or sign in the PA 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.

7.2.7.11.3 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 PA, 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 PA. Three SDNHP species are known or suspected to have nested in the PA 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 PA could potentially experience the same type of direct and/or indirect impacts from construction and operation of the proposed operation 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, animals remaining in the PA would demonstrate an acclimation to those disturbances.

7.2.8 Potential Noise Effects of Operations

Because of the remote location and lack 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 project are not expected to result in any significant impacts to 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 project operation and reclamation should cause no off-site impacts, since the PA is not in close proximity to off-site receptors and will occur only during daylight hours.

7.2.9 Potential Cumulative Effects 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 PA is within the Nebraska – South Dakota – Wyoming Uranium Milling Region, which has a history of conventional uranium surface mining. According to the NRC GEIS 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 in situ uranium projects within fifty miles of the PA. The nearest operational in situ facility is the Crow Butte ISL facility, SUA-1534, in Dawes 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) 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 that have been submitted for any of these projects, therefore; Powertech (USA) can not accurately predict the cumulative impacts that potential projects that might have, should they be developed.

7.3 Potential Radiological Effects

This section includes an assessment of the radiological effects of the site, types of emissions the potential pathways present, and an evaluation of potential consequences of radiological emissions.

The site will consist of two facilities. One facility will be the CPP, located near Burdock. The other facility will be the SF, located near Dewey.

Since the site may dispose of treated process water via land application, emission of natural uranium, lead-210 (Pb-210), radium-226 (Ra-226), and thorium-230 (Th-230) is expected. The release estimates for natural uranium, Pb-210, Ra-226, and Th-230 are calculated using methods found in "MILDOS-AREA: An Update with Incorporation of In Situ Leach Uranium Recovery

Technology" by Faillace et al. and DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy.

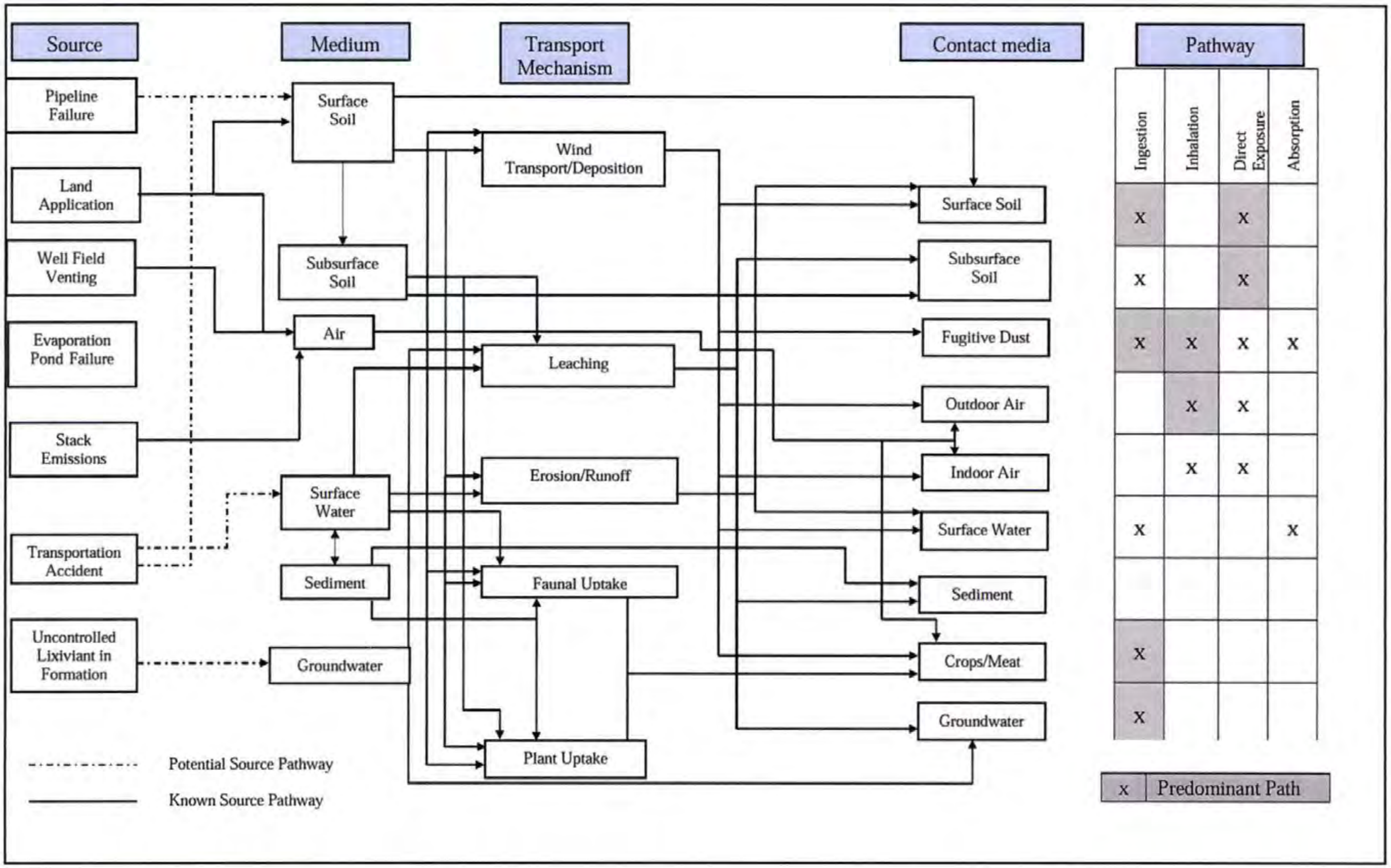
Due to the presence of Ra-226 in the soil from land application of wastewater, the land application areas will emit radon-222 (Rn-222), a decay product of Ra-226. The estimated release of Rn-222 is calculated using the previously mentioned methods as well as the methods found in Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers" (RG 3.64) by the US Nuclear Regulatory Commission. The details of and assumptions used in these calculations are found in Section 7.3.3.2.1.

Since the drying and packaging operation, to be conducted at the CPP, will be under vacuum, the only expected routine emission at the facilities and well fields will be Rn-222 gas. Radon-222 is dissolved in the lixiviant as it travels through the ore to a production well where it is brought to the surface. The concentration of Rn-222 in the production solution and estimated releases are calculated using the methods found in Regulatory Guide 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (RG 3.59) by the Nuclear Regulatory Commission. The details of and assumptions used in these calculations are found in Sections 7.3.3.2.2 through 7.3.3.2.5.

MILDOS-AREA is used to model potential radiological impacts on human and environmental receptors (e.g. air and soil) using site-specific radionuclide release estimates, meteorological and population data, and other parameters. The estimated radiological impacts resulting from routine site activities will be compared to applicable public dose limits as well as naturally occurring background levels.

7.3.1 Potential Exposure Pathways

Figure 7.3-1 presents potential exposure pathways from all potential sources in the site. The predominant pathways for planned and unplanned releases are identified. As mentioned earlier, atmospheric Rn-222 is expected to be the predominant pathway for impacts on human and environmental media. Impacts of Rn-222 releases can be expected in all quadrants surrounding the site, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, Rn-222 itself has very little radiological impact on human health or the environment. 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 7.3-1 shows, all exposure pathways, with the possible exception of absorption, can be important depending on the



Contact media	Ingestion	Inhalation	Direct Exposure	Absorption
Surface Soil	X		X	
Subsurface Soil	X		X	
Fugitive Dust	X	X	X	X
Outdoor Air		X	X	
Indoor Air		X	X	
Surface Water	X			X
Sediment				
Crops/Meat	X			
Groundwater	X			

Figure 7.3-1: Human Exposure Pathways

environmental media impacted. All of the pathways related to air emissions of radionuclides are evaluated by MILDOS-AREA.

7.3.2 Exposures from Water Pathways

The leach fluids in the ore zone will be controlled and monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

Two methods of waste disposal at the facility are being considered: Either treatment to remove radium and subsequent injection in a Class V disposal well, or by treatment followed by land application. Emission estimates from the land application processes are described in Sections 7.3.3.1 and 7.3.3.2.

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.

7.3.3 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 are also a source of Rn-222, as are the well fields and the resin transfers at the SF. 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 7.3-1.

7.3.3.1 Source Term Estimates – Natural Uranium, Pb-210, Ra-226, Th-230

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 7.3-1. In cases where site-specific information was not available, conservative values based on published information were used.

Table 7.3-1: Parameters Used to Estimate Radionuclide Releases from the Project Site

Parameter	Value	Unit	Variable Name	Source
Rate of land application - 1	1.27E-03	$m\ d^{-1}$	AR_1	Application
Rate of land application - 2	2.79E-3	$m\ d^{-1}$	AR_2	Application
Area of land application - Dewey	1.27E+06	m^2	LA_{Dewey}	Application
Area of land application - Burdock	1.27E+06	m^2	$LA_{Burdock}$	Application
Time of land application in a year - 1	80	d	t_{d1}	Application
Time of land application in a year - 2	137	d	t_{d2}	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	$g\ cm^{-3}$	ρ_{Dewey}	Application
Density of soil - Burdock	1.24	$g\ cm^{-3}$	$\rho_{Burdock}$	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

Table 7.3-1: Parameters Used to Estimate Radionuclide Releases from the Project Site (cont.)

Parameter	Value	Unit	Variable Name	Source
Respirable fraction of resuspended radionuclides in surface soil	1.0	unitless	RF	DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy
Soil porosity - Dewey	0.5429	unitless	n_{Dewey}	Application
Soil porosity - Burdock	0.5340	unitless	$n_{Burdock}$	Application
Lixiviant flow rate - production	1.49E+04	L min^{-1}	$M_{production}$	Application
Lixiviant flow rate - restoration	3.73E+03	L min^{-1}	$M_{restoration}$	Application
Lixiviant residence time	108	d	t	Application
Production days per year	360	d	D	Application
Formation porosity	0.34	unitless	n_{form}	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al. (coefficient for sandstone)
Content of radium in ore	592	pCi g^{-1}	$[Ra]_{ore}$	Application
Formation density	1.9	g cm^{-3}	ρ_{form}	Application
Storage time in mud pits	7	d	T	Application
Number of mud pits per year	725	y^{-1}	N	Application
Resin porosity	0.38	unitless	n_{resin}	Application
Resin transfers per day	0.5	d^{-1}	N_i	Application
Volume of resin per transfer	1.42E+04	L	V_i	Application
Average mass of ore material in mud pit	185	g	m	Application
Radon emanation coefficient	0.22	unitless	E	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.

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 grouped into one cluster called "Burdock." 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 ARRs 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:

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

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:

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

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.):

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

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:

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

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 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.):

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

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.):

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

Where:

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

Using the parameters in Table 7.3-1 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 7.3-2.

Table 7.3-2: 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	-6.02	3.80	10.8	0.0974	3.78	0.0325	2.27	0.0195	0.378	0.00325
Land Application - Burdock	-1.09	0.99	11.2	0.0974	3.91	0.0325	2.34	0.0195	0.391	0.00325

7.3.3.2 Source Term Estimates – Rn-222

Sources of radon releases 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 (Well Field 5) was modeled in MILDOS-AREA. Likewise, the well field in Burdock closest upwind to a receptor (Well Field 2) was modeled in MILDOS-AREA.

7.3.3.2.1 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 7.3-1:

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

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):

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

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):

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

Where:

n	=	Porosity

Using the parameters listed in Table 7.3-1 and Equations 7.8 through 7.10, the release rates of Rn-222 from land application are calculated. The Rn-222 release rates are 6.08 Ci y^{-1} for Dewey and 7.49 Ci y^{-1} for Burdock.

7.3.3.2.2 Production Releases

Plans are to have up to two areas which potentially could be operated 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:

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

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, 7.12 and the parameters listed in Table 7.3-1, 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 IX columns operating at atmospheric pressure in an open system is an appropriate conservative assumption. In cases where pressurized downflow IX 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 IX equipment, and maintenance of well field and ion exchange 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 IX circuit was assumed. Given these assumptions, the annual Rn-222 released from production in the well field and at the CPP is 212 and 191 Ci y^{-1}, respectively. Since the SF is planned to operate at the same parameters as the CPP, the annual Rn-222 released from production in the well field and at the SF 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 that may be treated or disposed of. Three percent of the Rn-222 released at the CPP and SF was attributable to deep well disposal at each facility.

7.3.3.2.3 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 and 7.12) but modified for the lower restoration flow rate listed in Table 7.3-1. The assumption of a 10 percent release in the well field and the CPP results in releases of 26.5 and 23.8 Ci y^{-1}, respectively. Since the SF is planned to operate at the same parameters as the CPP, the annual Rn-222 released from restoration in the well field and at the SF is also 26.5 and 23.8 Ci y^{-1}, respectively. Three percent of the Rn-222 released at the CPP and Satellite Facility was attributable to deep well disposal at each facility based on estimated restoration bleed rates.

7.3.3.2.4 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 Rn-222 released from 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 7.3-1, the yearly radon released from new well field development is 3.6E-05 Ci yr^{-1}.

7.3.3.2.5 *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 from resin transfers 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 through 7.16 and the parameters listed in Table 7.3-1, 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.

7.3.3.2.6 Radon-222 Release Summary

A summary of estimated radon-222 releases from the site is presented in Table 7.3-3. The source coordinates in Table 7.3-3 are relative to the CPP.

Table 7.3-3: 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 Well Field (5)	-3.86	3.48	212	26.5	3.6E-05	0	0	238.5
Production Well Field (2)	1.83	-0.56	212	26.5	3.6E-05	0	0	238.5
SF	-5.00	3.54	134	16.7	0	0.523	0	151.2*
SF Deep Well	-5.00	3.54	57	7.1	0	0	0	64.1*
Total SF			191	23.8		0.523		215.3
CPP	0	0	134	16.7	0	0	0	150.7*
CPP Deep Well	0	0	57	7.1	0	0	0	64.1*
Total CPP			191	23.8	0	0	0	214.8
Land Application - Dewey	-6.02	3.80	0	0	0	0	6.08	6.08
Land Application - Burdock	-1.09	0.99	0	0	0	0	7.49	7.49
Total			806	100.6	7.2E-05	0.523	14.0	921

* These estimated releases are included in the total SF and CPP estimated releases and are not added again in the Total of 921 Ci/y.

7.3.3.3 Receptors

The receptors used in the MILDOS-AREA simulations are presented in Table 7.3-4 and include the property boundary in 16 compass directions of the CPP and SF, 7 residences, and the town of Edgemont. The coordinates and distance values contained in Table 7.3-4 are in relation to the CPP.

Table 7.3-4: 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 - Andersen Ranch	-5.3	-3.0	6.0
Town - Edgemont	11.03	-18.59	21.62

7.3.3.4 *Miscellaneous Parameters*

The metrological data used in the MILDOS-AREA model is from the joint frequency distribution data presented in Section 2.5.2 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.

7.3.3.5 *Total Effective Dose Equivalent (TEDE) 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 recovery 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 7.3-4 are presented in Table 7.3-5. The output from the MILDOS-AREA simulation for the land application option is in Appendix 7.3-A of the approved license application. The output for the MILDOS-AREA simulation for the deep disposal well option is in Appendix 7.3-B of the approved license application.

An evaluation of the TEDE calculations follows:

- The maximum 40 CFR part 190 EDE of 6.69 mrem y^{-1}, located at an arbitrary receptor on the license boundary NNW of the SF, is 26.8 percent of the public dose limit of 25 mrem y^{-1}. There is no actual receptor at this location so someone would have to reside here for a full year to receive this estimated dose. 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 limits since these limits specifically exclude sources of radon-222.
- The maximum total TEDE of 7.88 mrem y^{-1}, located at an arbitrary receptor on the license boundary NNW of the SF, is 7.88 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 receptor. If the land application sources were excluded from the MILDOS_AREA model, the TEDE at this location would be 1.12 mrem y^{-1}.
- The maximum 40 CFR part 190 EDE at a potential residence is 3.06 mrem y^{-1}, located at the Spencer Ranch. This is 12.2 percent of the public dose limit of 25 mrem y^{-1}. 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 limits, since those limits specifically exclude sources of Rn-222.

Table 7.3-5: Estimated Total Effective Dose Equivalent (TEDE) and Effective Dose Equivalent (EDE) to Receptors Near the Project Site

Receptor	Distance from Main Plant (km)	40 CFR part 190 EDE* (mrem y^{-1})	TEDE* (mrem y^{-1})
Boundary - CPP - N	2.82	0.90	1.65
Boundary - CPP - NNE	2.96	0.58	1.23
Boundary - CPP - NE	1.65	1.43	2.48
Boundary - CPP - ENE	2.83	0.73	1.47
Boundary - CPP - E	2.60	0.96	2.10
Boundary - CPP - ESE	2.71	0.94	3.02
Boundary - CPP - SE	3.02	0.92	3.05
Boundary - CPP - SSE	2.41	0.97	2.99
Boundary - CPP - S	2.87	0.63	2.08
Boundary - CPP - SSW	3.04	0.60	1.77
Boundary - CPP - SW	3.44	0.52	1.43
Boundary - CPP - WSW	2.54	0.78	1.94
Boundary - CPP - W	2.32	1.37	2.72
Boundary - CPP - WNW	2.45	2.25	3.65
Boundary - CPP - NW	2.45	1.60	3.17
Boundary - CPP - NNW	3.96	0.88	1.61
Boundary - SF - N	7.22	0.84	1.71
Boundary - SF - NNE	6.74	0.65	1.51
Boundary - SF - NE	6.25	0.51	1.05
Boundary - SF - ENE	5.23	1.12	2.43
Boundary - SF - E	4.54	1.28	2.77
Boundary - SF - ESE	4.03	1.48	3.53
Boundary - SF - SE	3.10	2.03	3.70
Boundary - SF - SSE	3.55	1.08	2.36
Boundary - SF - S	4.92	0.66	1.70
Boundary - SF - SSW	5.86	0.99	2.37
Boundary - SF - SW	6.61	0.95	2.05
Boundary - SF - WSW	6.89	1.47	2.62
Boundary - SF - W	7.81	1.17	2.00
Boundary - SF - WNW	8.15	1.32	2.00
Boundary - SF - NW	7.81	2.16	2.93
Boundary - SF - NNW	7.14	6.69	7.88
Resident - Daniels Ranch	2.13	1.23	2.51
Resident - Spencer Ranch	2.34	3.06	4.49
Resident - BC Ranch	7.66	1.34	2.27
Resident - Puttman Ranch	8.88	0.41	0.85
Resident - Burdock School	2.98	0.62	1.64
Resident - Heck Ranch	6.61	0.30	1.04
Resident - Andersen Ranch	6.0	0.26	0.88
Town - Edgemont	21.61	0.10	0.30

* All doses reported in this table are infant dose. Dose estimates at the same location for children, teenagers and adults are lower than infant estimates.

- The maximum TEDE at a potential residence is 4.49 mrem y^{-1}, located at the Spencer Ranch. This is 4.49 percent of the 10 CFR 20 public dose limit of 100 mrem y^{-1}. If the land application sources were excluded from the MILDOS-AREA model, the TEDE at this location would be 1.37 mrem y^{-1}.

7.3.3.6 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 7.3-6 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 7.3-6. These calculations are also combined with the dose to the region within 80 km (50 mi) 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 0.000007 percent.

Table 7.3-6: 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	0.241
Dose received by population beyond 80 km of the facility	8.10
Total continental dose	8.35
Background North American dose	1.2E8
Fractional increase to background dose	7.0E-8

7.3.3.7 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 7.3-7 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 7.3-7: Highest Surface Concentrations of Radium-226 and its Decay Products Resulting from Project Operations

Radionuclide	Distance from site (km)	Direction	Surface concentration (pCi m^{-2})	Soil concentration in upper 15cm (pCi g^{-1})
Radium-226	1.5	WNW	60	2.7 E-4
Polonium-218	1.5	WNW	75	3.3 E-4
Lead-214	1.5	WNW	75	3.3 E-4
Bismuth-214	1.5	WNW	75	3.3 E-4
Lead-210	15.0	S	1.4	6.2 E-6

The largest increase in soil concentration is 2.7 E-4 pCi g^{-1} of radium-226. 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 uranium recovery 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.

7.3.3.8 Determination of Land Application Effects

7.3.3.8.1 Potential Radiological Effects

RESRAD Version 6.4 computer code (RESRAD) was used to model the site and calculate the maximum annual dose rate from the land application processes for a resident farmer scenario.

The soil concentration parameters used in the model were the soil concentrations calculated for the Dewey cluster in Section 7.3.3.1. The soil concentrations for Burdock were chosen because they are they are the most conservative (higher than) when compared to Dewey. The soil concentrations are 11.2 pCi g^{-1} for U-nat, 3.91 pCi g^{-1} for Th-230, 2.34 pCi g^{-1} for Ra-226, and 0.391 pCi g^{-1} for Pb-210. However, U-nat is composed of three isotopes of uranium: uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238).

The activity composition of U-nat is 49.2 percent U-234, 2.2 percent U-235, and 48.6 percent U-238. Therefore the 11.2 pCi g^{-1} of U-nat is composed of 5.51 pCi g^{-1} U-234, 0.246 pCi g^{-1} U-235, and 5.44 pCi g^{-1} U-238. These concentrations were used in the model.

The area of contamination used in the model was the area of the Dewey cluster, 450 acres. 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 described in Attachment 1 of Appendix 6.4-A of the approved license application and in Section 6.4.

The maximum annual dose rate from the land application areas, including radon, is 63.2 mrem y^{-1} at t = 0 years. Not including radon, the dose rate is 14.4 mrem y^{-1}. The major exposure pathways are radon, external, and plant (water independent). A full printout of the final RESRAD modeling results is in Appendix 7.3-D of the approved license application. This shows that the radiological impacts of the land application process are minimal and meet the license termination for unrestricted use criteria in 10CFR 20.1402 of 25 mrem per year to a critical group.

7.3.3.8.2 Potential Non-radiological Effects

Steady-state, non-radioactive metals concentrations in the land application area surface soils were determined using Equations 7.4 through 7.6. As it originally applied to radionuclides, the unit of concentration in Equation 7.4 was changed from pCi/L to mg/L. The mineral-water distribution (or fractionation) coefficient (K_d) for each metal was either adopted from default values in RESRAD v.6.4, Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil (Argonne 1993) or, if unavailable, the soil retention fraction (R_s in Equation 7.4) was conservatively assumed to be one. End of Production water quality estimates (Table 7.3-8) were used for the non-radiological parameter source term estimates.

The steady-state soil concentrations of metals are compared to EPA Region 9 generic Soil Screening Levels (SSLs) in Table 7.3-8. Each SSL represents a $1*10^{-6}$ excess cancer risk posed by non-additive ingestion of each of the metals or inhalation of chromium as chromium (VI).

The framework for EPA SSLs is presented in "Soil Screening Guidance: User's Guide," EPA/540/R-018, dated July 1996 (EPA 1996). The soil screening guidance states that the prevalent exposure pathway to metals in soil is direct ingestion. The guidance recommends that dermal contact need not be considered for metals and inhalation of fugitive dust need only be considered for chromium (VI).

The assumptions used to derive the generic SSLs appeared to be reasonable for the Dewey and Burdock land application areas. The equation used to determine the screening level for ingestion of non-carcinogenic contaminants in a residential use endpoint is:

$$ScreeningLevel(mg/kg) = \frac{THQ\,x\,BW\,x\,AT\,x\,RfD_o\,x\,365}{10^{-6}\,x\,EF\,x\,ED\,x\,IR}$$

Where:

THQ	=	Target hazard quotient, default value is 1
BW	=	Body weight, default value is 15 kilograms
AT	=	Averaging time, default value is 6 years
RfD_o	=	Oral reference dose, mg/kg-d, chemical specific
EF	=	Exposure frequency, default value is 350 d/yr
ED	=	Exposure duration, default value is 6 years
IR	=	Soil ingestion rate, default value is 200 mg/d

The equation used to determine the screening level for ingestion of carcinogenic contaminants in a residential use endpoint is:

$$ScreeningLevel(mg/kg) = \frac{TR\,x\,AT\,x\,365}{SF_o\,x\,10^{-6}\,kg/mg\,x\,EF\,x\,IF}$$

Where:

TR	=	Target cancer risk, default value is $1*10^{-6}$
AT	=	Averaging time, default value is 70 years
SF_o	=	Oral slope factor, $(mg/kg\text{-}d)^{-1}$, chemical specific
EF	=	Exposure frequency, default value is 350 d/yr
IF	=	Age-adjusted soil ingestion factor, default value is 114 mg-yr/kg-d

The equation to determine the screening level for inhalation of carcinogenic contaminants (chromium only) in a residential use endpoint is:

$$ScreeningLevel(mg/kg) = \frac{PEF\,x\,TR\,x\,AT\,x\,365}{URF\,x\,1000\,\mu g/mg\,x\,EF\,x\,ED}$$

Where:

PEF	=	Particulate Emission Factor, default value is $1.32*10^9$ m^3/kg
TR	=	Target cancer risk, default value is $1*10^{-6}$
AT	=	Averaging time, default value is 70 years
URF	=	Inhalation unit risk factor, $(\mu g/m^3)^{-1}$, 0.084 for chromium (VI) particulates

EF = Exposure frequency, default value is 350 d/yr
ED = Exposure duration, default value is 30 years

As shown in Table 7.3-8 no metals with steady state surface soil concentrations exceed their respective SSL at either location.

Table 7.3-8: Steady-State Metals Concentrations and Respective SSLs in Land Application Area Surface Soils

	Concentration in Applied Water (mg/L)		Concentration in Soil (mg/kg)		
Metal	**Dewey**	**Burdock**	**Dewey**	**Burdock**	**EPA Region 9 SSL (mg/kg)**
Arsenic	0.01	0.01	0.32	0.19	0.39 ca[a]
Barium	0.32	0.32	10.4	8.0	15,000
Cadmium	0.33	0.33	10.5	8.2	70[b]
Chromium	0.325	0.325	10.3	8.0	Chromium (III) insoluble salts: $1.2*10^5$ Chromium (VI) particulates: 39 ca[c] Chromium, Total (1:6 ratio Cr VI : Cr III): 280
Copper	0.272	0.272	8.8	6.8	3,100
Iron	1.1	0.2	35.6	27.6	55,000
Lead	10	10	324	251	400
Nickel	0.29	0.29	9. 4	7.2	1,600[d]
Selenium	0.2	0.2	6.5	5.0	390
Vanadium	10	6	324	151	390

Notes:
a. ca= cancer endpoint
b. dietary cadmium
c. exposure via inhalation
d. nickel as soluble salts

7.4 Potential Non-Radiological Effects

NUREG-1569 requires that estimates of concentrations of nonradioactive constituents in effluents at the points of discharge be compared to natural ambient concentrations with applicable discharge standards. There will be two effluents from the project; a gaseous airborne effluent and a liquid effluent.

The gaseous airborne effluent will consist of the ventilated air from the plant's ventilation system, originating from the process vessels and tanks. Radon gas will be present in this effluent as discussed in Section 7.2.1 above. No non-radiological effluents will be present in the gaseous airborne effluent. Non-radioactive airborne effluents from the project will be composed of fugitive dust from site roads and well field activities. Dust suppressants will be used to mitigate fugitive dust emissions if deemed necessary depending on-site conditions.

Powertech (USA) is currently considering two scenarios for liquid effluent disposal. The first involves management of liquid waste using Class V deep disposal wells. The second involves use of land application. As the project is moves forward, the feasibilities of either scenarios or some combination of two scenarios will be evaluated and a determination will be made based on effectiveness, implementability, and cost.

7.5 Potential Effects of Accidents

The NRC has determined that the effects of all accidents that are the most probable to occur at an ISL facility, are minor, provided that effective emergency procedures exist and are utilized in the event of an accident, and that personnel are properly trained to handle the situations. When compared with conventional underground and open pit mining methods, accidents associated with ISL uranium production typically have far less severe consequences. An assessment of potential accidents are discussed in the following sections.

7.5.1 Potential Chemical Risks

The chemicals to be utilized in uranium processing at the project are listed in Section 3.2.8 along with a description of chemical storage and spill containment. Chemicals have the potential to impact radiological and non-radiological safety. Chemicals that have the potential to impact radiological safety include hydrochloric acid, sulfuric acid, hydrogen peroxide, and sodium hydroxide. Oxygen, because of its ability to support combustion, also requires special handling. In all instances, process controls and preventative safety measures minimize the risk of increased radiological exposure or release. Each chemical storage and feeding system will be designed to safely store and accurately deliver process chemicals to the process delivery points. All chemical storage tanks will be clearly labeled to identify contents. Design criteria for chemical storage and feeding systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Powertech (USA) employees and members of the public, both with regard to the specific chemicals and with regard to the potential release of radioactive materials in the event of an accident.

Any negative impact to radiological safety from use of these chemicals would be due to accidents, improper use, or human error. Nevertheless, these chemicals would only indirectly cause a radiological hazard as they do not contain radiological materials themselves. Additional information on safe storage and use of chemicals with potential to impact radiological safety is provided in Section 3.2.8.

Potential non-radiological accident impacts include high consequence chemical release events for both workers and nearby populations. The likelihood of such release events would be low based on historical operating experience at NRC-licensed facilities, primarily due to operators following commonly-applied chemical safety and handling protocols. The overall potential impact to public and occupational health and safety of ISR operations that utilize these chemicals has been determined to be SMALL to MODERATE (NUREG-1910, v2, p. xliii).

7.5.1.1 Site-Specific Conditions Potentially Affecting Chemical Risk

Additional measures that address site-specific conditions are described below.

Freezing Temperatures
Outdoor winter temperatures at the project area will at times be below freezing. All tanks and pipelines that contain fluids subject to freezing will be heat traced to maintain the contents above the freezing point of the material. Header houses, valve vaults, and well head covers will contain electric heaters to prevent freezing temperatures from occurring in these structures.

Windstorms and Winter Storms
All facilities, including buildings, storage tanks, and well head covers, will be designed and constructed to withstand the highest wind velocities that are reasonably expected to occur within the project area. During winter months, storms with high winds and snowfall may cause blizzard conditions, but these events do not present a higher potential for chemical accidents. Delivery of chemicals will be delayed until safe driving conditions exist. Care will be taken not to let the amount of chemicals on hand be reduced to levels that make it urgent to obtain more chemicals.

7.5.2 Potential Groundwater Contamination Risks

Horizontal and vertical lixiviant excursions have the potential to contaminate the groundwater in the production aquifer or the overlying or underlying aquifers.

7.5.2.1 Potential Recovery Solution Excursions

Potential groundwater quality impacts from excursions are discussed in detail in Section 7.2.5.3. Excursions have the potential to contaminate adjacent non-exempt aquifers with constituents that have been mobilized during the ISL process. 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 production zone of the orebody aquifer.

The potential impacts of horizontal and vertical excursion could be significant. Monitoring wells will be installed within and around the production zone to ensure timely detection of horizontal excursions. Monitoring wells will be installed in the overlying and underlying aquifers to ensure timely detection of vertical excursions.

By properly designing and pump testing each well field and its associated monitor well network, including specifically addressing those areas having the greatest potential for excursions, Powertech (USA) will minimize the risk of excursions and minimize the potential impacts resulting from excursions. By routinely sampling monitor wells for changes in water level and concentrations of the highly mobile and conservative excursion parameters of chloride, total alkalinity and conductivity, Powertech (USA) will ensure that any potential excursions are identified and corrected quickly. As described on page B-75 of the Moore Ranch Final SEIS (NUREG-1910, Supplement 1, Appendix B), "An excursion is defined as an event where a monitoring well in overlying, underlying, or perimeter well ring detects an increase in specific water quality indicators, usually chloride, alkalinity and conductivity, which may signal that fluids are moving out from the wellfield…The perimeter monitoring wells are located in a buffer region surrounding the wellfield within the exempted portion of the aquifer. These wells are specifically located in this buffer zone to detect and correct an excursion before it reaches a USDW…To date, no excursion from an NRC-licensed ISR facility has contaminated a USDW."

7.5.3 Potential Well Field Spill Risks

The failure of a process pipeline within the well field could result in the discharge of pregnant or barren lixiviant or restoration fluid to the surface. In order to minimize the amount of liquid 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 CPP. Operating flow rates and pressures of all injection wells, production wells, and associated buried piping systems will also be monitored and recorded on a daily basis. The CPP and Satellite Facility control rooms will both receive the pressure and flow data transmitted from the well fields, trunklines, and header houses. This information will provide the plant operators access to instantaneous data on well field operating conditions, enabling them to respond appropriately to unexpected or upset conditions, and allow them to direct well field operators to specific locations where immediate attention is needed. Should a failure occur and the amount and/or concentration of the process fluid lost constitute an environmental concern, then the affected area will have the contaminated soil surveyed and removed for disposal. Pipeline failure is minimized by burying the pipeline below the frost line, approximately 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. As described in Section 3.2.12, each header house will also include a sump equipped with a water level sensor so that if a leak occurs, and the water level approaches a preset level, the sensors will cause an automatic shutdown of the header house. 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.

7.5.4 Potential Transportation Accident Risk

All shipments to and from the PA will be transported by only licensed and certified commercial 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.

Potential 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.

7.5.4.1 Potential Accidents Involving Yellowcake Shipments

The yellowcake will be transported in 55-gallon (208-L) drums to a conversion facility in Metropolis, Illinois or Port Hope, Ontario, Canada, for refining and conversion. A specialized third party transportation company (such as Tri-State freight service) will transport the yellowcake from the project to a conversion facility rather than Powertech (USA). Specific routes are to be determined upon agreements made within the transportation companies' contract. This company will meet all safety controls and regulations promulgated by 10 CFR 71.5. With a production rate of 1,000,000 lbs per year, 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 will be approved to leave the facility.

The potential environmental impacts from the shipment of yellowcake could result from an accident and impact primarily 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.

7.5.4.2 Potential Accident Involving Ion Exchange Resin Shipments

The project will have resin stripping facilities, therefore shipments involving uranium-loaded IX resin may be transported to the PA. 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. The same general shipping procedures outlined for the shipment of yellowcake (Section 7.5.4.1) will be followed for resin shipments.

The IX 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 SF to a CPP at 0.009 in any year (U.S. Nuclear Regulatory Commission, 1997a).

The potential environmental impacts from an accident involving the shipment of IX resin could impact primarily 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.

7.5.4.3 Potential Accidents Involving Shipments of Process Chemicals and Fuels

Over the course of the operational life of the facility a number of shipments of chemical, fuel, and supplies will be made each week. Process chemicals delivered to the project site 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. Analyses of documented accidents involving shipments have shown that secure containers have prevented spills (NMA, 2007).

7.5.4.4 Potential Accidents Involving 11e.(2) Byproduct Material

The disposal of all solid 11e.(2) byproduct waste generated during operations will be transported to an appropriately licensed disposal facility. Most of the solid waste shipping will occur during the site reclamation and decommissioning stage. The probability of an accident while transporting 11e.(2) waste for any given trip is similar to the probability discussed in Section 7.5.4.1. 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.

7.5.5 Potential Natural Disaster Risk

NUREG/CR 6733 evaluates potential risks associated with ISL facilities for the release of radioactive materials or hazardous chemicals due to the effects of an earthquake or tornado strike. The NRC determined that in the event of a tornado strike, chemical storage tanks could fail resulting in the release of chemicals. NUREG-0706 analyzed the risk from a tornado strike, which determined that ISL facilities were not designed to withstand tornado strength winds and assumed that an inventory of 45,000 kg of yellowcake was present on-site and that 15 percent (11,400 kg) or 26, 55-gallon drums of the yellowcake was dispersed by the tornado. The model assumes that all the yellowcake was in a respirable form and was carried by the tornado to the project's site boundary. According to the model, the maximum 50-yr. dose to an individual's lung would be 8.3×10^{-7} rem and located approximately 2.5 miles from the mill. NUREG-6733/CR concluded that the risk of a tornado strike on an ISL facility was very low and that no design or operational changes were necessary to mitigate the potential risks, but that it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident. Considering the relative remoteness of the proposed Dewey-Burdock Project, the potential consequences of a tornado strike would be considerably less than if the facilities were in a more populated area.

Nevertheless, there are risks to workers that must be addressed. Powertech (USA) will prepare and have available onsite for NRC inspectors an Emergency Response Plan that will contain emergency procedures to be followed in the event of severe weather or other emergencies. Included in the plan will be procedures for notification of personnel, evacuation procedures, damage inspection and reporting. It will also address cleanup and mitigation of spills that may result from severe weather. In advance of preparing the Emergency Response Plan, Powertech (USA) offers the following discussion on these issues.

Initially, Powertech (USA) will provide adequate training to its employees and visitors regarding communication systems used at the facilities. In the event of a report of a tornado sighting in the vicinity of the facility, the RSO, RST and/or Safety Engineer will ensure that the proper alarm (preset signal) has been sounded at both the Burdock and Dewey facilities. Additionally, all supervisors will be personally contacted via phone or radio and advised of the emergency. The supervisors and radiation safety staff will direct the employees' evacuation to one or more previously-specified nearby locations. Once it is safe to access the facilities, supervisory staff and radiation safety staff will begin the process of assessing potential damage to the facilities, including header houses and well heads. This process will include radiological surveys and assessment of potential non-radiological hazards as well. NRC, DENR, BLM and other regulatory agencies as appropriate will be notified and advised of the damage, if any was observed. After consultation with the regulatory agencies the cleanup and mitigation efforts will commence.

The NRC determined that the radiological consequences of materials released and dispersed due to earthquake damage at an ISL facility were no greater than for a tornado strike. NUREG-0706 determined that mitigation of earthquake damage could be attained following adequate design criteria. NUREG/CR-6733 concluded that risk from earthquakes is very low at uranium ISL facilities and that no design or operational changes were required to mitigate the risk, but that it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

All buildings, structures, foundations, and equipment will be designed in accordance with recommendations in the latest versions of the International Building Code and ASCE-7 published by the American Society of Civil Engineers. Maps published in ASCE-7, and the latest version of the USGS Earthquake Ground Motion Tool, along with information regarding soil characteristics provided by the project professional geotechnical engineer, will be used to determine seismic loadings and design requirements.

7.5.6 Potential Fire and Explosion Risk

Accident Consequences – Fires and Explosions

An explosion, although unlikely, could result from: a prematurely sealed drum of yellowcake, in a dryer, from the use of propane in the thermal fluid heater or space heaters, or from the mixing of oxygen gas with combustible materials. Of these, an explosion from the drum of yellowcake has the greatest potential to impact radiological safety of the workers. An explosion in a sealed drum would be contained within the dryer room. Powertech (USA) will develop an SOP for measuring the temperature in yellowcake drums prior to drum sealing.

According to the NRC, multiple hearth dryers pose a greater hazard than the vacuum dryers that will be used by Powertech (USA) (NUREG-1910). Multiple hearth dryers operate at higher temperatures and may be directly fed with gas. The vacuum dryers proposed for the Dewey-Burdock Project operate at lower temperatures and are not directly fed by gas. They therefore pose less of a hazard for explosion. In the unlikely event of an unmitigated explosion accident of a yellowcake dryer, doses to the workers could have a MODERATE impact depending on the type of accident, but exposure to the general public would result in a dose below the 10 CFR Part 20 public dose limit, resulting in only a SMALL impact to the public (NUREG-1910, pg. 4.2-56).

Preventative and Mitigation Measures – Fires and Explosions

As noted in Section 3.2.8, the design criteria for chemical storage and feeding systems includes applicable sections of the International Building Code, International Fire Code, OSHA regulations, RCRA regulations, and Homeland Security regulations. Propane fired heating devices will be installed to meet applicable NFPA/FM safety standards. Additional measures for preventing fires and explosions within process facilities include:

- As noted in Section 3.2.8.6, the oxygen tanks will be located a safe distance from the CPP and other storage tanks and will be designed to meet industry standards of NFPA-50.
- Cleaning of equipment for oxygen storage and conveyance systems will follow the standards specified in CGA G-4.1.
- Powertech (USA) will develop emergency response procedures for oxygen accidents. All employees who may be exposed to hazards associated with oxygen will be properly trained with regard to the hazards, accident prevention and mitigation, and emergency response procedures.
- Header houses will be equipped with fans to provide continuous ventilation in order to prevent buildup of oxygen.
- The oxygen lines to each header house will be equipped with automatic low pressure shut-off valves to minimize the delivery of oxygen through a broken pipe or a valve stuck in the open position, which could potentially supply oxygen to a fire.
- Procedures will be in place for confined space work or hot work for monitoring of oxygen build-up prior to start of work.
- Fire extinguishers will be placed at accessible locations in all buildings and vehicles for quick response and training will be provided for appropriate personnel in use of fire extinguishers.
- Powertech (USA) personnel and local emergency responders will receive training for responding to a fire or explosion.
- The CPP facilities are designed to contain and reduce the exposures to individuals in the event of an accident. Emergency response procedures will be implemented and employees will be directed as to what actions to perform in the event of an accident. For instance, a respiratory protection program will be in place and will be executed as necessary for worker protection during accident assessment and cleanup phases. In addition to the above mentioned protections other safeguards and mitigatory protocols are always in place during operation of a CPP facility. For example, a bioassay program for worker safety and contamination control programs involving personnel survey, clothing survey and equipment survey before release to unrestricted areas are common practices workers are subject to on a regular basis. These types of protocols are also utilized to assess if an accidental exposure took place during the course of an unintentional incident.

Preventative and Mitigating Measures – Wildfire

In order to protect facilities from wildfires, all facility buildings will be located within an area that is maintained in a vegetation-free state by the use of a crushed aggregate or asphalt surface and by appropriate weed-control measures. The creation of this buffer zone is expected to prevent fire from damaging equipment that could lead to a chemical accident by acting as a firebreak.

Within the well fields, vegetation will be controlled around each header house and around each well head cover to reduce the amount of combustible material adjacent to these structures. In the event of an approaching wildfire, operators will be trained to shut down well field operations and, if necessary, to evacuate facilities until the danger to personnel has passed. Damage, if any, will be assessed and remediated prior to re-starting operations.

Powertech (USA) will maintain firefighting equipment on site and will provide training for local emergency response personnel in the specific hazards present in the project area.

The emergency response plan will include descriptions of the following provisions of 29 CFR Part 1910:

- Notification and evacuation procedures
- Personal protective equipment
- General firefighting safety rules
- Reporting procedures
- Electrical and gas emergencies

7.5.7 Potential Major Pipe or Tank Rupture Risk

Potential Major Pipe or Tank Rupture in the CPP or Satellite Facility

a. Preventative measures: Facilities will be designed and operated according to 40 CFR Part 68. In addition, Powertech (USA) will comply with 40 CFR Part 355 in disclosing the reportable quantities of sulfuric acid, hydrochloric acid and sodium hydroxide, the only chemicals used in the project area that are expected to be present in quantities greater than the minimum reportable amounts. Preventative measures will also include routine inspection, installation of safety devices to prevent over pressurization or excessive level, use of tanks and vessels that meet applicable ASME and/or ASTM codes, and proper engineering design of tanks and supporting structures, foundations, and footings.

b. Consequences: The rupture of a major pipe or tank within either the CPP or Satellite Facility would result in the release of process liquids onto the floor of the facility. The spilled material will be contained by concrete curbs and will flow to the trench drains and sumps (equipped with level alarms), where it will be pumped to the appropriate tank or disposal system. Alternatively, the spilled material will be transferred from the sumps to the Central Plant Pond for reprocessing prior to eventual disposal. In the event of a total electrical failure, such that no pumps would be operational, a spill due to a vessel failure will be contained within the building in which the vessel failure occurred.

c. Actions used to stop chemical accidents: Personnel will be trained in the hazards associated with process chemicals and solutions present at each facility and the proper procedure to follow in the clean-up of a spill of the materials within the plant facilities. In particular, for tank ruptures, operators will be trained to use personal protective equipment and to close valves on any pipelines connected to the ruptured tank. In the case of a pipe rupture, personnel will be trained to shut down pumps and close valves in order to isolate the section of pipe containing the rupture from other parts of the process. Powertech (USA) will also train local emergency response personnel in the potential hazards associated with the facility.

Capacities of Sumps and Curbed Areas

The CPP and Satellite Facility will be designed with trench drains, sumps, and a concrete curb at the perimeter of the floor designed to contain the contents of the largest vessel in the facility. For the CPP, the largest liquid-containing vessel is the yellowcake thickener, which will have an operating volume of 5,000 ft^3. For the Satellite Facility, the largest liquid-containing vessel will be the utility water tank, with a volume of 2,139 ft^3. For both facilities, a containment curb along the perimeter wall of each building slab with internal trench drains and sumps will be designed to contain a spill of at least 200% of the largest liquid-containing tank or vessel volume in each facility. Sumps and sump pumps will be operable for the removal of spilled materials to waste holding tanks or the Central Plant Pond and ultimately to the liquid waste disposal system. For additional information on the capacities of curbed areas, refer to Section 5.7.1.3.

7.6 Potential Economic and Social Effects of Construction and Operation

The following section highlights potential socioeconomic impacts of the project to Custer and Fall River Counties. A cost benefit analysis for the project is presented in section 9.0.

7.6.1 Construction

Assuming a peak workforce of about 86 payrolled 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 7,061 people working full and/or part-time jobs (US Bureau of Labor Statistics 2024). The impacts of worker influx will be mitigated by preferentially sourcing the labor force from the within the surrounding region.

Table 7.6-1 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, 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 7.6-1: Employment Effects of the Project in Custer and Fall River Counties

	Employment			
Years	Direct	Indirect	Induced	Total
1-2	86	45	126	257
3-9	84	36	35	155
10-16	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.

7.6.2 Operation 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 7,061 people working full and/or part-time jobs (US Bureau of Labor Statistics 2024). 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.

7.6.3 Effects to Housing

Because of the project's close proximity to the more populated communities of Custer and Hot Springs, South Dakota and Newcastle, Wyoming with a combined population greater than 15,000 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 project has the potential to sustain the creation of 257 new jobs for two years. During the following seven 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 3.04 as of 2020. This increase in population would account for an increase of 6.9 percent (2020 total population 15,291) 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 potential 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.

7.6.4 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.

7.6.5 Effects to Traffic

There are only a few residences in the vicinity of the project. Most of the land in the surrounding a 2 km 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 km area during operations. There will be some increased traffic, noise and dust on the county road between the project site and Edgemont during construction activities. However, these potential impacts will be of short duration.

7.6.6 Economic Impact Summary

According to the Cost-Benefit Analysis in Section 9, 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 7.6-2) as a result of the project.

Table 7.6-2 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 ISL project should present Custer and Fall River counties with net positive gain when compared to the no action alternative.

Table 7.6-2: 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 (2009-2010) during construction 155 jobs over seven years (2011-2017) during operation 24 jobs over seven years (2018-2024) 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

7.7 Environmental Justice

PAAs described in Section 2.3.4, minorities make up 11.1 and 15.9 percent of the total population for Custer and Fall River Counties, which is less than the state average of 19.4 percent and no concentration of minorities was identified to reside near the PA; therefore, no disproportionate impacts could occur to minority groups.

As described in Section 2.3.3.3, per capita income level is $35,677 for Custer County and $29,139 for Fall River County; these numbers are near the State average of $31,415. The median household income in 2020 was $64,556 for Custer County and $51,383 for Fall River compared with $59,896 for the State average. The percent of individuals below the poverty level in Custer County was 8.3 percent and 19.3 percent in Fall River County. Compared to the state-wide average of 12.3 percent, Fall River's poverty rate is higher, while Custer County is below the state-wide; therefore, there is not be a disproportionate concentration of low-income populations within the study area compared to the State as a whole.

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 project is not expected to generate any adverse environmental impacts to the area's natural resources, there will not be any disproportionate environmental consequences to minority groups or low income populations.

7.8 References

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8.0 Alternatives to Proposed Action

8.1 No-Action Alternative

Under the provisions of the National Environmental Policy Act (NEPA), one alternative that must be considered in each environmental review is the no-action alternative. In this case, the no-action alternative would be to deny the renewal of the license application for the Dewey-Burdock ISL facilities. This alternative will provide a baseline from which to compare the potential impacts of the other action alternatives.

8.1.1 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 energy production supply. In addition beneficial impacts resulting from stimulated economic growth, income and tax generation will not be realized. The project represents a significant new source of domestic uranium supplies that are essential to provide a continuing and economic source of fuel to power generation facilities. As discussed in the Cost-Benefit Analysis, Section 9, the Dewey-Burdock Project is expected to provide a significant beneficial economic impact to the local economy.

8.2 Proposed Action

While the PA encompasses 10,580 acres (4,282 ha), the land potentially impacted by the Proposed Action would be approximately 68 acres (27 ha) (facilities, piping, ponds, well fields and roads) in year one, and the potential impacts will be intermittent. The average disturbance per year for the life of the proposed project (production to restoration) is estimated at 77 acres (31 ha). If the maximum area for land application of treated wastewater is included in the footprint of the Proposed Action, then approximately 384 acres (155 ha) would be affected per year on average during the life of the mine. During the first year of the Proposed Action, approximately 110 acres (44 ha) would be affected. A description of the proposed ISL facilities is provided in Section 3.1.

8.3 Reasonable Alternatives

8.3.1 Location of Proposed Facilities

Locations of the proposed CPP and the SFs were strategically chosen based on specific site area, proximity to historical and current reserves within the northern Dewey and southern Burdock areas, environmental both historical disturbance, wildlife concerns and the geology of the area.

The CPP would be constructed in Section 2, T7S, R1E of the Burdock action area and the SF would be located in Section 29, T6S, R1E of the Dewey action area (see Figures 3.1-1and 3.1-2).

- Based on the TVA data and current Powertech (USA) data, the location of both the CPP and the SFs locations would be approximate to the center of ore reserves located within the action areas in locations that have little potential for ore beneath chosen locations.
- Environmental considerations were noted such as historical surface mines, nesting sites for raptors, drainage issues; the locations chosen do not have these issues.
- There were no issues with the surface or subsurface geology for either the CPP or the SF location.

8.3.1.1 Well Fields and Monitoring Wells

A well field consists of ISL amenable ore zones within a sandstone bounded by an upper and lower hydrologic barrier. In the simplest scenario, there is a single ore zone; and a monitor well ring radially bounds that ore zone, as one of the primary means of ensuring control of leach fluids within a well field. In more complex systems, there may be more than one ore zone stacked vertically within a sandstone, and there may be more than one sandstone, with multiple ore zones stacked vertically (Lost Creek Project, 2007).

Within the Dewey area, there exists at least one area where one production zone overlies another. Section 3.1.3 describes the monitoring well layout and design for this scenario, including monitoring all overlying hydrogeologic units for potential vertical excursions. Section 5.7.8.4.3 provides additional description of perimeter monitoring well spacing and layout for stacked roll fronts.

This monitoring scheme described in Sections 3.1.3 and 5.7.8.4.3 is preferred over other methods such as:

- Multiple Completions

  Completion of wells across multiple sands within the same horizon, using the same wells and the same monitor ring could be an alternative. However, this is not considered an appropriate alternative because of the difficulties of ensuring the injection and production fluids are being efficiently distributed to the various sands in the horizon and of monitoring the performance of the well field.

- Larger Rings Encompassing More Reserves

The wells are completed in the same manner as the preferred option. Because of the increase in scale, the construction time, evaluation of pump tests, and all other activities associated with installing and producing the well field would increase dramatically. Final restoration/reclamation of the well field would be delayed until all operations for the area were complete. Therefore, this option is not considered the most efficient approach (Lost Creek Project, 2007).

8.3.2 Process Alternatives

8.3.2.1 Lixiviant Chemistry

Powertech (USA) proposes to use gaseous oxygen and carbon dioxide to dissolve the uranium in the ore zone. Alternatives for lixiviant chemistry include ammonium carbonate or sodium bicarbonate/carbonate solutions and acidic leach solutions. While these lixiviant solutions have been used in previous ISL operations, they were rejected for the Dewey-Burdock Project, due to the fact that restoration and stabilization of groundwater to baseline conditions has been shown to be more difficult with these alternative systems.

8.3.2.2 Groundwater Restoration

The proposed groundwater restoration method for the proposed project is based on the successful programs implemented by other projects such as the Cogema Irigaray Restoration Project or Crow Butte Resources, Inc., which have both received regulatory approval for successfully restoring groundwater to previous class of use.

During aquifer restoration, the technology selected will depend on the liquid waste disposal option. In the deep disposal well liquid waste disposal option, RO treatment with permeate injection will be the primary restoration method. If land application is used to dispose liquid waste, then groundwater sweep with injection of clean makeup water from the Madison Formation will be used to restore the aquifer. Additional information about aquifer restoration methods is provided in Section 6.1.3.

An alternative groundwater restoration method includes the use of bioremediation. Bio-reductants are introduced to invigorate natural bacteria that re-reduce metals to an insoluble state. Bio-reduction has been used successfully to restore the Sweetwater Pit Lake, which originally had uranium concentrations of 8 to 10 mg/L and post remediation the levels were below 5 mg/L. This alternative was considered but eliminated because the effectiveness of this technology is not well documented for aquifer remediation post ISL operations as discussed in NUREG-1910.

8.3.2.3 Waste Management

There are several disposal options for the liquid waste generated during the production and restoration process including brine concentrators, discharge to surface waters, evaporation ponds, waste disposal well, land application, and waste disposal well off-site. The National Pollutant Discharge Elimination System (NPDES) permitting process allows for the discharge of treated liquid effluents to surface waters that meet state and federal water quality standards, but was determined to be a poor use of water resources in a water sensitive region. The sole use evaporation ponds was rejected because of the large surface impoundment area that would be required to evaporate the daily bleed water and the severe winters that would freeze the ponds for several months out of the year, thereby decreasing the evaporation rates. The transportation of liquid waste for disposal at an off-site deep well is another option that was considered but eliminated due to the transportation impacts and practicality of disposing waste out of state. Powertech (USA) considers the use of deep disposal wells and/or land application as the best alternatives to dispose of these types of liquid waste. The deep wells identified by Powertech (USA) will isolate liquid waste generated during the production and restoration processes from any underground source of drinking water (USDW). In both cases, the liquid waste will be treated with additional IX to remove residual uranium, followed by contact with barium chloride to remove radium. Other treatments may also be required before the liquid waste will be injected into Class V deep disposal wells or applied to the land through center-pivot irrigation systems.

Fresh water consumed during drilling, road maintenance, and other related activities will be disposed of appropriately.

Non-radioactive solid and liquid waste will be managed in accordance with existing regulations and disposed of in a landfill that has been permitted under subtitle D of RCRA. Materials that cannot be decontaminated will be disposed of at a licensed 11e.(2) disposal facility.

8.4 Eliminated Alternatives

As part of the alternatives analysis conducted by Powertech (USA) conventional uranium mining both open-pit and underground combined with milling were considered. However, due to economic, environmental, and recovery issues, a detailed analysis was not carried forward at this time.

8.4.1 Open Pit Mining Alternative

Open pit mining requires the removal of all material covering the orebody (overburden) and then the ore itself: The ore would then be transported to a conventional mill for further processing and extraction through grinding, leaching, purifying, concentrating, and drying. From an economic point of view, open pit mining of the relatively low grade and depth of the Dewey-Burdock ore bodies would require a much larger investment than ISL, especially in the early phase, when a significant investment would be required for acquisition of heavy equipment to perform the earthwork to expose the orebody. The overall footprint of the operation would be larger because of greater manpower and material handling requirements. Waste rock piles from excavation of the overburden and the mine pit would make permanent changes to the topography, with a disturbed area approximately three times the area of the orebody mined, in order to maintain slope stability. Potential personnel injury rates and potential radiological exposures at the PA would also be higher with open pit mining than what would be experienced with ISL. A mill tailings pond would be required to contain the millions of tons of waste produced from the uranium mill'. This tonnage would represent a large volume of radioactive tailings slurry covering a large area of ground surface. Conventional mill operation would involve higher risks of spillage and radiological exposure to both personnel and the environment than those associated with the proposed ISL operations. Open pit mining at the Proposed Action Area would also require dewatering of the pit to depress the potentiometric surface of all aquifers. Large quantities of groundwater would be discharged to the surface. Some of this groundwater contains naturally elevated radium-226 (Ra-226), radon, and uranium, which would have to be treated before discharge and the residue disposed of as radioactive solid waste (Lost Creek Project, 2007).

8.4.2 Underground Mining Alternative

Underground mining of the uranium resources at the Permit Area would involve sinking of shafts to the vicinity of the ore bodies, horizontally driving crosscuts and drifts to the ore bodies at different levels, physically removing the ore and transporting the mined ore to the conventional mill for further processing. Processes for milling and uranium extraction from underground mined ores would be the same as those for ores mined from the open pit. When one considers the alternative of underground mining, the economic and environmental disadvantage closely parallel those of an open pit mine. These, as stated above, include large amounts of initial investment, permanent changes to the topography (though in a smaller scale than open pit mining because less amounts of waste rock are being generated), generation of a significant amount of mine tailings, increased risks of injury and potential exposure to radioactive materials during mining and milling, and surface discharge of groundwater from mine dewatering with elevated radionuclide concentrations. One major concern for underground uranium mining is the potential exposure of miners to, radon gas if the gas is not continuously vented to the atmosphere. Subsequent land surface subsidence could also occur after the completion of underground mining.

Economic costs and potential environmental impacts associated with open pit and underground mining, clearly show that ISL is the more benign and viable uranium production method to use. The initial investment is lower; the tailings problem is completely eliminated; radiation exposure and potential environmental impacts are minimized; and the groundwater resource is preserved. In addition, because of the reduced costs, lower grade ores can be recovered through ISL than can be recovered from open pit and underground mines (Lost Creek Project, 2007).

The U.S. NRC conducted a comparison of the overall potential impacts of open pit and underground mining with ISL methods in NUREG-0925 and concluded that ISL methods generate lesser potential environmental and socioeconomic impacts. The relative advantages of ISL methods include:

- The degree and the quantity of disturbance to surface area are substantially less than with surface mining.
- No mill tailings are produced and the volume of solid waste is significantly less than conventional milling – typically more than 99 percent less waste is produced with ISL.
- The elimination of airborne emissions from overburden stockpiles or tailings stockpiles and the crushing and grinding processes, which are required for conventional mining.
- Exposure to radionuclides is markedly reduced with ISL methods because less than 5 percent of the radium in an orebody is brought to the surface compared with up to 95 percent with conventional mining techniques.
- Because of the lack of tailings and other significant sources of solid waste ISL facilities can readily be decontaminated and returned to unrestricted use within a relatively short time frame (12-15 years).
- ISL facilities typically consume much less water than conventional mining and milling, on the order of 1 percent of their production flow.
- The socioeconomic advantages of ISL include:
  - Lower grade ores can be mined
  - Requires less capital investment

- Provides a safer working environment for the miner
- Decreases amount of time before production begins and
- Requires a smaller workforce

8.5 Cumulative Effects

8.5.1 Future Development

Powertech (USA) has identified other potential ore bodies near the project region that may be developed. Development of these facilities is dependent upon further site investigations by Powertech (USA), as well as the viability of the uranium market. If the ore bodies and market prove to be favorable, Powertech (USA) may submit applications for permits to develop these additional resources.

8.6 Comparison of the Predicted Environmental Impacts

Table 8.6-1 outlines the predicted environmental impacts of the proposed project (Section 8.2) compared to the no-action alternative (Section 8.1), the process alternatives (8.3) and the mining alternatives (8.4). Potential environmental impacts are discussed in greater detail in Section 7.0.

Table 8.6-1: Comparison of Environmental and Socioeconomic Impacts based on Proposed Action and Alternatives

Impacts of Operation	Proposed Action	Process Alternatives		Mining Alternatives		No-Action Alternative
		Alternate Lixiviant Chemistry	Alternate Waste Management	Open-pit mining with a conventional mill	Underground mining with a conventional mill	
Land Surface Impacts	Minimal temporary potential impacts to the well field areas; significant temporary disturbance confined to a small portion of the proposed project site	Same as Proposed Action	Same as Proposed Action	Significant land disturbance with the potential for portions of the land surface to remain highly altered	Same as the open pit alternative	None
Land Use Impacts	Temporary loss of agricultural production (grazing livestock) and wildlife habitat within the PA for the duration of the proposed project	Same as Proposed Action	Same as Proposed Action	Land disturbance increases considerably and time required for reclamation is more extensive; Entire site may not return to unrestricted use	Same as the open pit alternative	None
Transportation Impacts	Minimal impact on current traffic levels	Same as Proposed Action	Same as Proposed Action	The traffic volume elevates substantially due to increased employment and vehicle requirements and considerable more opportunity for higher radiation exposure to the public due to transporting of uranium ores over public roads.	Same as the open pit alternative	None
Geology and Soil Impacts	No geologic impacts; temporary impacts to the soils from disturbance; possible impacts to soil from land application of treated wastewater	Same as the Proposed Action	Similar to the Proposed Action with minimal temporary soil impacts in disturbance areas from wind and water erosion	No geologic impacts; more potential land disturbance due to the possibility of long-term open pit mining	Same as the open pit alternative	None
Surface Water Impacts	None	None	None	Possible contamination of surficial water could result with the use of ponds	Possible contamination of surficial water could result with the use of ponds	None
Groundwater Impacts	Slight consumption of ore zone groundwater	Similar to Proposed Action but with increased difficulty in restoring water quality to baseline conditions	Same as the Proposed Action	Ore zone aquifer will be dewatered in order to mine	Ore zone aquifer will be dewatered in order to mine	None

Table 8.6-1: Comparison of Environmental and Socioeconomic Impacts based on Proposed Action and Alternatives (cont.)

Impacts of Operation	Proposed Action	Process Alternatives		Mining Alternatives		No-Action Alternative
		Alternate Lixiviant Chemistry	Alternate Waste Management	Open-pit mining with a conventional mill	Underground mining with a conventional mill	
Ecological Impacts	Would only disturb ~ 108 (without land application) to 463 (with maximum amount of land application) acres per year over the life of the proposed project with no substantial impact on the ecological or biological diversity	Same as the Proposed Action	Same as the Proposed Action	Similar to the Proposed Action, but considerably more time would be required for reclamation	Same as the open pit alternative	None
Air Quality Impacts	An increase of 10 tons per year of particulates due to increased traffic	Same as the Proposed Action	Same as the Proposed Action	Total dust emission would be increased significantly due to increased traffic and crushing and grinding processes	Same as the open pit alternative	None
Noise Impacts	Slight increase over background noise levels	Same as the Proposed Action	Same as the Proposed Action	Significant increase in noise levels due to explosions, excavation' and crushing and grinding of rock	Significant increase in noise levels due to crushing and grinding processes	None
Historical and Cultural Impacts	None	None	None	None	None	None
Visual/Scenic Impacts	Moderate and temporary impact; Well fields and Plants would negatively affect the aesthetics	Same as the Proposed Action	Same as the Proposed Action along with evaporation ponds that would further negatively affect the aesthetics	Large and temporary impact; open pit disturbs much more land area and requires much more heavy machinery that would negatively affect the aesthetics	Large and temporary impact; Mill, tailings pond, and increased use of heavy machinery would negatively affect aesthetics	None
Socioeconomic Impacts	Increased economic impact of $307M and the potential for 436 temporary and permanent jobs for Custer and Fall River Counties and the surrounding area	Same as the Proposed Action	Same as the Proposed Action	Similar to the Proposed Action but with an increase in economic impact and jobs created due to the larger workforce and required operation	Similar to the open pit alternative	Loss of positive economic impact of $307M along with potential for 436 temporary and permanent jobs for Custer and Fall River Counties and the surrounding area
Non-Radiological Health Impacts	None	None	None	None	None	None

Table 8.6-1: Comparison of Environmental and Socioeconomic Impacts based on Proposed Action and Alternatives (cont.)

Impacts of Operation	Proposed Action	Process Alternatives		Mining Alternatives		No-Action Alternative
		Alternate Lixiviant Chemistry	Alternate Waste Management	Open-pit mining with a conventional mill	Underground mining with a conventional mill	
Radiological Health Impacts	Estimated maximum TEDE at proposed project boundary is 7.88 mrem y^{-1} compared to the public dose limit of 100 mrem y^{-1} for the land application option; Estimated maximum TEDE at proposed project boundary is 1.12 mrem y^{-1} for the deep well disposal option.	Same as Proposed Action	Same as Proposed Action	Exposure to radioactive material is significantly increased because 95% of the radium in an orebody is brought to the surface	Same as open pit alternative	None
Waste Management Impacts	Generation of liquid and solid waste for disposal	Same as the Proposed Action, but potentially increased liquid waste due to the mobilization of additional hazardous elements in groundwater	Increased generation of 11e.(2) byproduct material for disposal	Waste generated is much greater than ISL and not all material can be removed from the site (e.g., tailings and waste rock)	Same as open pit alternative	None
Mineral Resource Recovery Impacts	Production of domestic energy resource	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action	Loss of domestic energy supply source; the current estimated reserves of uranium within the proposed permit area total 7.6 million pounds U_3O_8 currently valued at $456M (based on spot market price of $60)

8.7 References

Energy Information Administration, "*Summary Production Statistics of the U.S. Uranium Industry*", www.eia.doe.gov/cneaf/nuclear/dupr/usummary.html accessed July 1, 2008.

Energy Information Administration, "*2007 Uranium Market Annual Report*", www.eia.doe.gov/cneaf/nuclear/umar/umar.html accessed July 1, 2008.

Energy Information Administration, "*Uranium Mill Sites Under the UMTRA Project*", http://www.eia.doe.gov/cneaf/nuclear/page/umtra/edgemont_title1.html accessed July 3, 2008.

U.S. Nuclear Regulatory Commission, "*Draft Environmental Statement Related to the Operation of the Teton Project*", NUREG-0925, June 1982. Para. 2.3.5.

9.0 Cost-Benefit Analysis

9.1 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 Dewey-Burdock 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 impacts due to a change in economic activity on a regional or local economy. IMPLAN was originally developed by the United Stated Department of Agriculture (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 establishes that the proposed project is a cost-effective project and will provide a positive economic benefit to the 50 km radius impact area and the State of South Dakota.

9.2 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 impacts and non-monetary impacts.

9.2.1 Identification of Alternatives

This CBA evaluates the benefits and costs of the proposed 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.

9.2.1.1 No Action Alternative

Under this alternative, the proposed 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.

9.2.1.2 Proposed Action

The proposed action includes the construction and operation of a uranium in situ leach (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 ground water quality at the proposed project site.

9.2.2 Key Assumptions

Key assumptions involved in the cost and benefits of the proposed project include: (1) the operating life of the proposed 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.

9.2.2.1 Operating Life of the Project

The proposed project is considered as a single unit of analysis including the sequentially developed well fields, a CPP and other ancillary facilities. For this analysis, the total operating/production life of the proposed 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 CPP operations – includes continued well field construction and initiation of restoration
- Seven years of the site reclamation ground water restoration and decommissioning of well fields and ancillary facilities

9.2.2.2 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.

9.2.2.3 Scope of Impact

An important step in any cost-benefit analysis is establishing a viable scope of impact and establishing who will be affected by the proposed project (Zerbe and Bellas 2006). This analysis has been limited to the proposed project's direct zone of influence that is defined as the area within which the proposed project's impacts and benefits are reasonably anticipated to be concentrated, including the population areas most likely to contribute to the proposed 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 proposed project's cost-benefit analysis includes a radius of 80 km (50 miles) from the center of the PA and includes the townships, towns, and unincorporated areas within the two South Dakota counties surrounding the proposed project, Custer and Fall River. Approximately 1 mile (1.6 km) of the proposed 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 proposed project's direct zone of influence, but because the proposed project is located entirely within Custer and Fall River counties this cost-benefit analysis evaluates the proposed 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 proposed project on a regular basis. No areas of appreciable population size were located

[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.

within this radius (80 km) from the proposed project in other Wyoming counties or to the south in Nebraska.

Rapid City, South Dakota, the closest urban area to the proposed project is located approximately 100 miles (161 km) via highways northeast of the PA, in Pennington County. Rapid City may serve as a regional logistics hub and source of workers and supplies for the proposed project as well. Because of its greater distance from the proposed project, Rapid City is considered to be part of the proposed project's indirect zone of influence. Two other communities in Pennington County also fall within the proposed project's indirect zone of influence, Hill City and Keystone.

9.2.2.4 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.

9.3 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 proposed project. Economic benefits created from the proposed 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 proposed project on the local economies affected, the proposed 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 proposed 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 mining (IMPLAN code 29). IMPLAN does not have a specific uranium mining 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 mining sectors.

9.3.1 IMPLAN Input Data

For this analysis the initiation of the construction stage of the proposed project assumes a start date of 2009 continuing through 2010. Table 9.3-1 shows the input data for construction, operation and reclamation expenditures over the life of the proposed 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 CPP, 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 9.3-1: Input Data for the Project

Activities	IMPLAN Code	Per Year		
		Year 1–Year 2	Year 3–Year 10	Year 11-Year 18
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

9.3.2 Employment Benefits

Using the Input Data from Table 9.3-1, IMPLAN can generate the potential employment-related effects of the proposed 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 9.3-2 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 proposed project. For the initial construction phase in years one to two, 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 proposed project per year.

Table 9.3-2: Employment Effects of the Project in Custer and Fall River Counties

	Employment			
Years	**Direct**	**Indirect**	**Induced**	**Total**
1 - 2	86	45	126	257
3 - 10	84	36	35	155
11 - 18	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 the proposed 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 proposed project.

These results indicate that the proposed 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 proposed project. The economic impacts of the proposed 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.

9.3.3 State and Local Tax Revenue Benefits

In addition to the employment benefits of the proposed project, IMPLAN can calculate the expected State and Local taxes generated over the life of the proposed project. In order to remain consistent with the scope of impact, Federal taxes are not included in this analysis. The results presented in Table 9.3-3 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 9.3-3. 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 proposed 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 9.3-3, the results from the IMPLAN analysis indicate that the construction, operation and reclamation stages of the proposed project are expected to generate a net present value of approximately $13.54 million in total business tax revenue over the life of the proposed project. The total enterprise (corporate) tax was not analyzed because South Dakota does not levy a Corporate Income tax.

Table 9.3-3: 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% 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 mining operations (South Dakota Department of Revenue and Regulations – Special Tax Division 2008). Current resource estimates for the proposed project are 7.6 million lbs. (43-101 compliant). A total reserve estimate has not been included because it is still incomplete. Assuming that the identified 7.6 million lbs 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 proposed project, including indirect business taxes, are estimated to be approximately $35.1 million.

9.3.4 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 9.3-4, the results from the IMPLAN analysis indicate that the construction, operation and reclamation stages of the proposed project are expected to generate approximately $186.7 million in value added benefits over the life of the proposed project.

Table 9.3-4: 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

9.3.5 Benefits of Environmental Research and Monitoring

Due to the remoteness and low population of the PA, 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.

9.4 External Costs of Project Construction and Operation

This section of the BC analysis evaluates the external costs of the proposed 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 proposed project.

9.4.1 Short Term External Costs

9.4.1.1 Housing Shortages

Because of the proposed 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 project has the potential to sustain the creation of 257 new jobs for two years. During the following 7 year operation stage the proposed project has the potential to sustain the creation 155 jobs for seven years, and 23 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 proposed 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.

9.4.1.2 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 proposed project site as a result of the proposed 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 proposed project site; therefore the basic services required to support the proposed 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 proposed project, there are no significant changes or stresses anticipated for other public services, such as police, health care, or utilities.

9.4.1.3 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 a 2 km radius of the proposed 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 proposed project site, the anticipated limited use of large machinery and vehicles and the infrequent movement of transport vehicles to and from the proposed project site, no significant noise or congestion impacts are anticipated within the surrounding 2 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 of short duration.

9.4.2 Long Term External Costs

9.4.2.1 Impairment of Recreational and Aesthetic Values

While several opportunities for recreational activities exist in the Custer and Fall River counties surrounding the proposed project and within the proposed project's surrounding 2 km area, the current recreational use is limited to deer, elk, and antelope hunting. Prior to commencement of operations, Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the project area to the extent practicable. However, this activity will not be permanent as hunting will return following reclamation of the site.

Within a 50-mile radius of the proposed 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 proposed 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 proposed 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.

9.4.2.2 Land Disturbance

The land that encompasses the PA has been historically used for cattle grazing and open-pit uranium mining operations. Therefore, the proposed project site has been previously disturbed and impacted from agricultural and mining activities.

The in situ leach (well field) method of uranium mining 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 proposed project. Short-term surface disturbance impacts could result from the construction and operation of the 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 2.4-A of the approved license application) that includes a survey of archaeological sites within the entire permit boundary. Sites that may require additional data evaluation or recovery will be avoided as well field development progresses. More detail is provided in Section 2.4 on cultural resources within the PA.

9.4.2.3 Habitat Disturbance

The PA 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 proposed project operations. All of the disturbed land will be reclaimed after the proposed project is decommissioned and will become available for its pre-operational uses. Potential environmental impacts to vegetation and wildlife are discussed in Section 7.2.7.

9.4.3 Groundwater Impacts

Operational controls during production and groundwater restoration will assure that leach fluids are contained and will not impact nearby underground sources of drinking water. 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 production zones at the proposed project site to restoration target values, which will help protect underground sources of drinking water and allow the aquifers impacted to return to their pre-operational class of use. Potential impacts to groundwater resources are discussed in Section 7.2.5.

9.4.4 Radiological Impacts

The potential radiological impacts due to the proposed project during operation are small (as discussed in Section 7.3). The decommissioning of the Proposed project site and disposal of radioactive material will follow all applicable NRC requirements and/or license conditions and will be transported off site to an NRC or Agreement State licensed 11e.(2) disposal facility. The radiological effects including estimated exposures from the water and air pathways are discussed in Section 7.3.

9.5 Cost-Benefit Summary

The most significant benefits of the proposed project are its potential to sustain the creation of 257 new jobs during construction, 155 jobs during operation, and 23 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 project (Table 9.5-1) as a result of the proposed project.

Table 9.5-1 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 proposed project and minimal surface disturbance, impacts to recreational activities and aesthetic values within the area should be negligible.

This cost-benefit analysis indicates that the construction and operation costs including capital costs of this proposed 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 proposed project. The development of the proposed ISL project should present Custer and Fall River counties with net positive gain when compared to the no action alternative.

Table 9.5-1: 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 (2009-2010) during construction 155 jobs over seven years (2011-2017) during operation 23 jobs over seven years (2018-2024) 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

9.6 References

IMPLAN 2004, "*IMPLAN Professional Version 2.0 Manual Third Edition*", Minnesota IMPLAN Group, Inc., February.

U.S. Office of Management and Budget (OMB), 1992, Circular No. A-94, "*Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*".

Zerbe, R. O. and A. S. Bellas 2006, "*A Primer for Benefit-Cost Analysis*". Northampton, MA: Edward Elgar.

10.0 Environmental Approvals and Conclusions

In order for the Dewey-Burdock Project to operate, permits and approvals from numerous Federal and State agencies will be required. Section 10.1 identifies the issuing agencies, a description of the type of permit, license or approvals needed, and the current status of securing these approvals.

10.1 Applicable Regulatory Requirements, Permits, and Required Consultations

Necessary environmental approvals from Federal and State Agencies required for the proposed project are listed in Table 10.1-1. The NRC licensing process for a source materials license represents the longest lead-time approval. The majority of the remaining approvals are in-progress or will be initiated with in the next year. All necessary approvals must be secured prior to commencement of commercial production at the site.

Table 10.1-1: Permits and Licenses for the Dewey-Burdock Project

Issuing Agency	Description	Status
South Dakota Department of Environment and Natural Resources Joe Foss Building 523 E Capitol Pierre, SD 57501	Uranium Exploration Permit	Submitted/work completed
	Temporary Water Right for Testing	Submitted/work completed
	Temporary Discharge Permit for Testing	Submitted/work completed
	Scenic and Unique Lands Designation	Submitted/Designated not eligible for inclusion on the list of special, exceptional, critical, or unique lands on 2.19.2009
	Large Scale Mine Permit	Submitted/DENR recommended conditional approval 4.15.2013./ Pending outcome of Federal Litigation.
	Water Appropriation Permit	Submitted/Chief Engineer, Water Rights Department, DENR recommended approval of both applications (Inyan Kara & Madison) on 11.6.2012, Board approval pending outcome of Federal Litigation.
	Air Quality Permit	Pending major permit approvals.
	Groundwater Discharge Permit	Submitted/Discharge Plan was conditionally approval 12.12.2012. Board approval pending outcome of Federal Litigation.
	NPDES Water Discharge Permit	Pending major permit approvals.
US Nuclear Regulatory Commission Washington, DC 20555	Source Materials License	Byproduct Source Materials License SUA 1600 issued on April 8, 2014.

Table 10.1-1: Permits and Licenses for the Dewey-Burdock Project (cont.)

Issuing Agency	Description	Status
US EPA Region 8 8OC-EISC 1595 Wynkoop St Denver, CO 80202-1129	Aquifer Exemption	EPA Region 8 issued Aquifer Exemption on 11.24.2020, under appeal to 8th Circuit Court of Appeals.
	Class III Underground Injection Control Permit	EPA issued UIC Class III, and V permits on 11.24.2020, challenged to the EPA Environmental Appeals Board.
Custer County 420 Mount Rushmore Road Custer, SD 57730-1934	Building Permits	Pending major permit approvals
Fall River County County Courthouse Hot Springs, SD 57747-1309	Building Permits	Pending major permit approvals

10.2 Environmental Consultation

Over the course of license application preparation, consultations were conducted with several State and Federal agencies as listed in Table 10.2-1 below.

Table 10.2-1: State and Federal Agencies Contact Information

State Agency	Department	Location
South Dakota Game Fish and Parks	Wildlife	523 East Capitol Avenue Pierre, SD 57501
South Dakota State Archaeologist	Archaeologist	P.O. Box 1257 Rapid City, SD 57709-1257
SD Dept of Environment and Natural Resources	Minerals and Mining Program	523 E Capitol Ave Pierre, SD 57501
Federal Agency		
U.S. Geological Survey	Dakota Mapping Partnership Office	1608 Mountain View Road Rapid City, SD 57702
U.S. Army Corps of Engineers	Resource Management	441 G. Street, NM Washington, DC 20314-1000
U.S. Forest Service, South Dakota	Supervisor's Office in Custer, SD	25041 North US Highway 16 Custer, SD 57730-7239
Natural Resources Conservation Service	Pierre Service Center	1717 N Lincoln Ave Pierre, SD 57501-2398
U.S. Nuclear Regulatory Commission	Uranium Recovery Licensing Branch	Washington, DC 20555-0001
US EPA Region 8	8P-W-GW	1595 Wynkoop Street Denver, CO 80202-1129