POWERTECH (USA) INC.

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

February 2009

Prepared for

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List of Acronyms and Abbreviations

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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
BNRR	Burlington Northern Railroad
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
DENR	Department of Environmental 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
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 Climactic Data Center
NEPA	National Environmental Policy Act
NFF	National Flood Frequency
NFS	National Forest Service
NIST	National Institute of Standards and Technology
NPDES	National Pollution 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
PAA	Proposed Action Area
PABJh	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

RTV	Restoration Target Value
RWP	Radiological Work Permit
SA	specific activity
SAR	Sodium Absorption Ratio
SCFM	standard cubic feet per minute
SD	South Dakota
SDAR	South Dakota Administrative Rules
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 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 solid
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
WDW	Waste Disposal Well
WL	working level
WLM	working level months
WoUS	Waters of the United States
yr	year

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1.0 Proposed Activities

1.1 Licensing Action Requested

Powertech (USA) Inc. (Powertech (USA)) submits this Technical Report (TR) to the United States Nuclear Regulatory Commission (NRC) as part of a Uranium Recovery License (i.e., combined source material/11e.(2) byproduct material license) application to construct and operate the proposed Dewey-Burdock Project (hereinafter the "Proposed Action") using in situ leach (ISL) methods. The Proposed Action Area (PAA) will be located near Edgemont, South Dakota in Custer and Fall River Counties and will consist of a series of sequentially developed well fields, a satellite ion exchange (IX) facility (SF) at the Dewey portion and the central processing plant and associated process facilities (hereinafter the "CPP") to recover and process the final uranium product.

This TR has been prepared in accordance with:

Regulatory Programs

- 10 CFR Part 40 Appendix A as relevant and appropriate
- 29 CFR Part 1926.55 Gases, vapors, fumes, dusts, and mists
- 29 CFR Part 1910.119 and 1910.120 Hazardous Waste Operations and Emergency Response
- 40 CFR Part 68, 302.4, and 355 Emergency Planning and Community Right to Know Act
- 40 CFR Part 144 Underground Injection Control Program
- 40 CFR Part 146 Underground Injection Control Program Criteria and Standards
- 43 CFR §3809.401 BLM Plan of Operations

- Department of Transportation “Radioactive Materials Shipping Regulations,” CFR Titles 49 and 10
- South Dakota Codified Laws Rule 45:6B and Administrative Rules 74:29 and 74:29:11

Nuclear Regulatory Commission Documents

- NRC Regulatory Guide 3.46 “Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining” (NRC, 1982).
- NUREG-1569 “Standard Review Plan for In Situ Leach Uranium Extraction License Application” (NRC, 2003).
- NUREG-1748 “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs” (NRC, 2003).
- NUREG-1910 “Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities (Draft Report)” (NRC, 2008).
- NUREG-1757, Vol. 3 “Consolidated NMSS Decommissioning Guidance-Financial Assurance, Recordkeeping, and Timeliness (Final Report)” (NRC, 2003).
- NUREG-1623 “Design of Erosion Protection for Long-Term Stabilization” (NRC, 2002).
- NUREG/CR 6733 “A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees” (NRC, 2001).
- NUREG/CR-6870 “Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities” (NRC, 2007).
- NRC Regulatory Guide 8.30 “Health Physics Surveys in Uranium Recovery Facility,” Revision 1 (NRC, 2002).
- NRC Regulatory Guide 4.14 “Radiological Effluent and Environmental Monitoring at Uranium Mills,” Revision 1 (NRC, 1980).

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 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 PAA, 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 PAA. 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 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 which includes a table summarizing all historical exploration drilling.

1.3 Corporate Entities

This TR is submitted by Powertech (USA), which is the United States based wholly owned subsidiary of the Powertech Uranium Corp., a Corporation registered in British Columbia. Powertech Uranium Corp. shares are publicly traded on the Toronto Stock Exchange (TSX) as PWE and the Frankfurt Stock Exchange as P8A. Powertech Uranium Corp. owns 100 percent of the shares of Powertech (USA). The corporate office of Powertech Uranium Corp. is located in Vancouver, British Columbia. Powertech (USA) is a United States based Corporation registered in the State of South Dakota.

Currently, 10 CFR Part 40 regulations and Appendix A criteria do not prohibit the issuance of a uranium recovery license to a United States based corporation that is a wholly owned subsidiary of a foreign entity (10 CFR § 40.38). For purposes of the Proposed Action, Powertech (USA) and not Powertech Uranium Corp. intends to serve as the licensee for the Proposed Action. Powertech (USA) owns and will operate all of the company's uranium properties in the United States, including the Proposed Action. Powertech (USA)'s headquarters office is located in Greenwood Village, Colorado, and other offices are located in Hot Springs, South Dakota, Albuquerque, New Mexico, Wellington, Colorado and Edgemont, South Dakota.

1.4 Site Location and Description

The PAA 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 PAA boundary encompasses approximately 10,580 acres (4,282 ha) of mostly private land on either side of Dewey Road (previously 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.

As proposed, PAA 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.

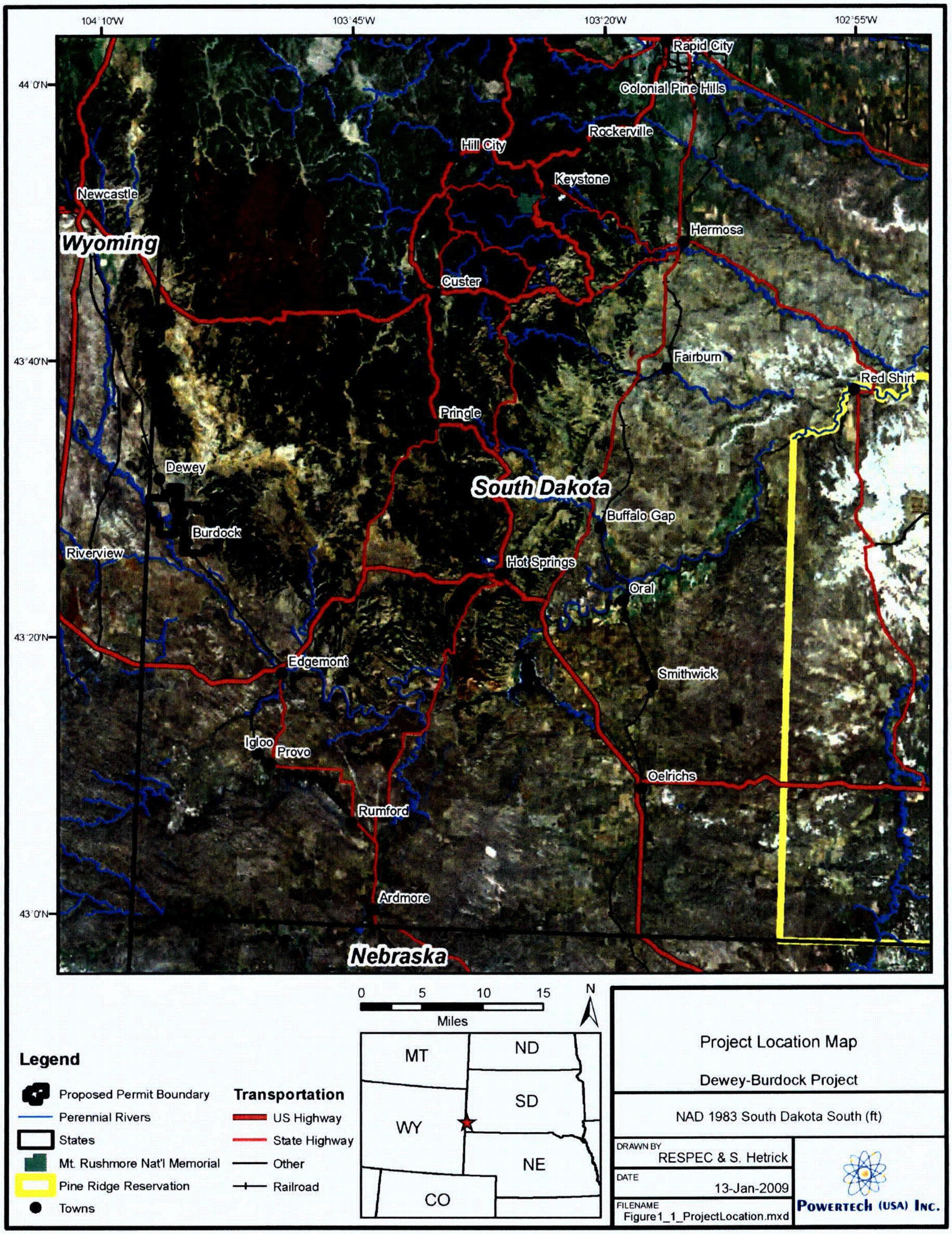

Figure 1.4-1: Proposed Project Location and Boundary

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 proposed project.

1.6 Orebody Description

The Proposed Action uranium deposit occurs in both the Fall River and Lakota formations of the lower Cretaceous age that make up the Inyan Kara Group. The Fall River and Lakota formations consist of permeable sandstones deposited in a major sand channel system that makes up a groundwater aquifer. The identified uranium orebody 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-solublization 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 solublization 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 PAA, 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 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

The Proposed Action will utilize uranium ISL production facilities at both the Dewey and Burdock sites with a CPP located at the Burdock site. The IX process and well fields are designed for a nominal flow rate of 2000 gpm at each site. Total production from both sites is expected to produce approximately 1,000,000 pounds of U_3O_8 per year.

1.9 Project Schedule

Following the issuance of an NRC uranium recovery license and other relevant permits it is anticipated that construction of the Burdock Well Field 1, CPP and ancillary facilities including storage ponds and land application pivots will commence. The construction of the Dewey Well Field 1 and ancillary facilities will follow shortly thereafter. 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 Proposed Action well fields. The CPP may continue to process uranium 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.

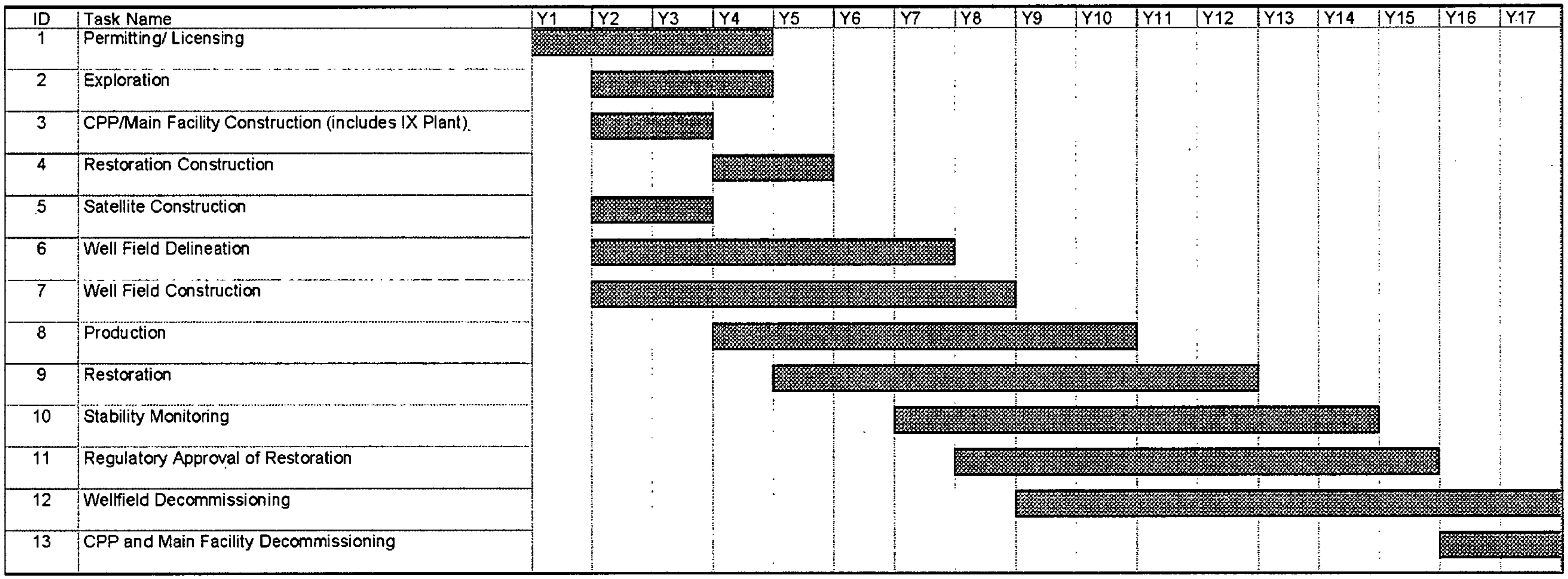

Figure 1.9-1: Projected Construction, Operation, Restoration and Decommissioning Schedule

1.10 Waste Management and Disposal

Wastewater from the Proposed Action ISL operations will consist primarily of spent CPP elution brines, production well field bleed, and restoration flows; these wastewaters will be disposed of by injection in Class I or V injection wells, or by treatment and subsequent 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

As part of the wastewater management plan, there may be periodic releases of water from storage ponds for the beneficial use of crop irrigation.

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 approved NRC 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 municipal 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 goal of the groundwater restoration program will be to return water quality within the exempted aquifer consistent with pre-operational baseline quality conditions or other NRC approved standard in accordance with NRC's application of 10 CFR Part 40 Appendix A Criterion 5(b)(5) to ISL operations. 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 approved 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

In accordance with 10 CFR Part 40, Appendix A, Criterion 9, related NRC guidance, and existing Commission administrative case law, ISL operators are required to submit detailed financial assurance cost estimates to NRC Staff for approval prior to the issuance of a license for ISL operations. Pursuant to these requirements, an ISL operator must submit a detailed, line-item cost estimate (breakdown) of the activities and their associated costs that are necessary to complete site-specific D&D, including groundwater restoration, and to release the project site for unrestricted use. As part of this license application, Powertech (USA) has prepared a detailed, line-item financial assurance cost estimate for the Proposed Action, including the mandatory minimum fifteen (15) percent contingency over and above the costs associated with site D&D. This financial assurance cost estimate is provided in Section 6.6.

However, while NRC regulations and requirements require NRC approval of such cost estimates, such regulations and requirements do not require identification of Powertech (USA)'s specific financial assurance mechanism (e.g., surety bond, letter of credit, etc.) that will be used to provide such financial assurance nor do they require posting of the required funding until the operator is prepared to commence licensed operations at its project site. As a result, Powertech (USA) submits that it will identify and supply a financial assurance mechanism for the amount of funding approved by NRC in accordance with 10 CFR Part 40, Appendix A, Criterion 9 and NUREG-1757, Volume 3 prior to the commencement of licensed operations.

In addition, Powertech (USA) recognizes that NRC's application of Criterion 9 to ISL operations requires annual financial assurance updates to account for potential changes in the approved financial assurance cost estimate such as inflation, increased workforce wages, and cost increases for materials. Powertech (USA) commits to this requirement and will submit annual financial assurance updates for NRC Staff approval in accordance with Criterion 9 and NUREG-1569 on a timely basis.

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 PAA 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 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 T7S, R1E, and Section 10. This access road joins with several pre-existing roads that traverse through the Burdock Section of the proposed action area (PAA). Further to the north is the access road for the section of the PAA. This road joins with several other pre-existing roads. These pre-existing roads within the Burdock and Dewey sections of the PAA 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. Figure 2.1-1 displays the potential location of facilities for the proposed project. Also displayed on this figure are the utilities, roads, and potential land application sites.

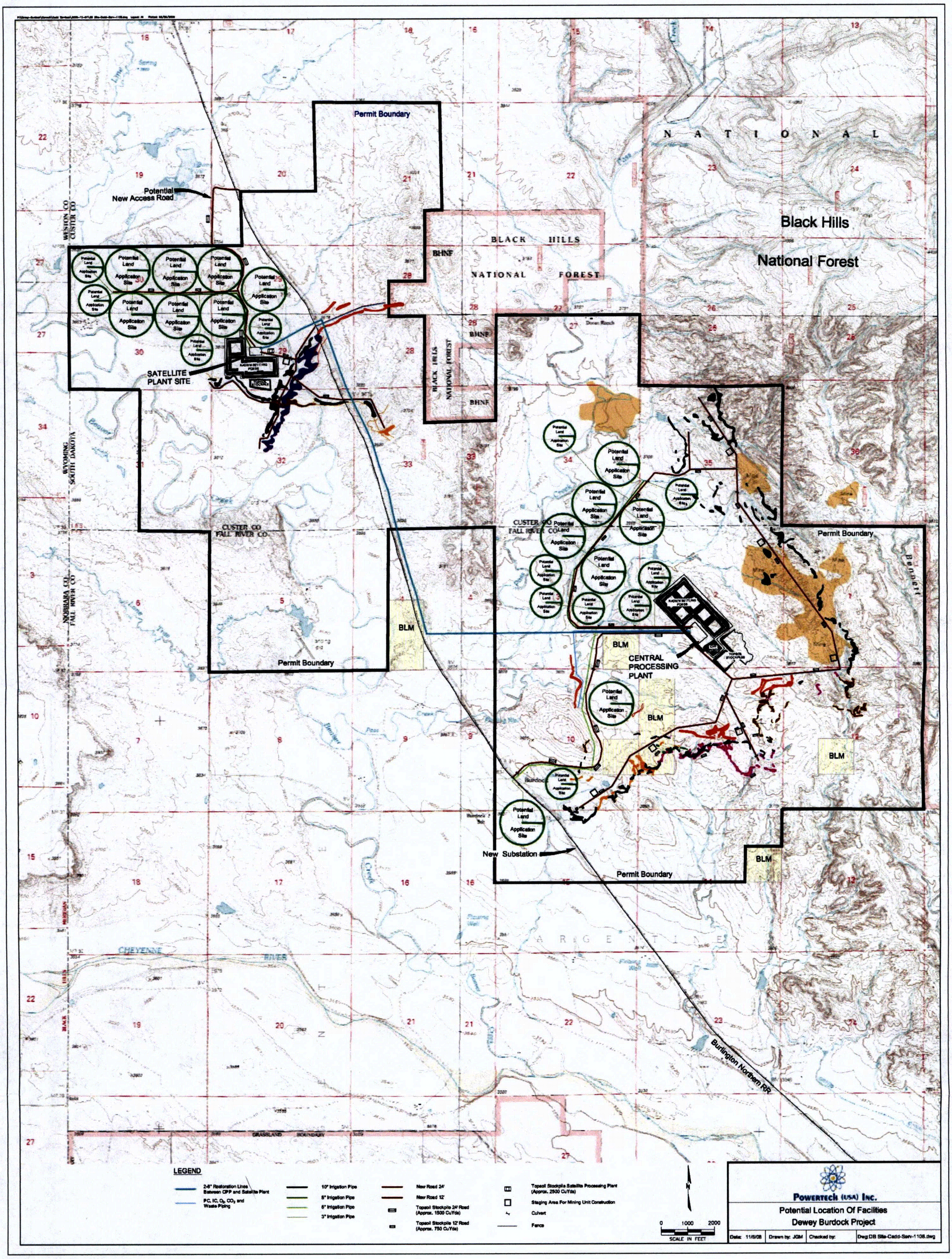

Figure 2.1-1: Potential Location of Facilities for the Proposed Project

2.2 Uses of Adjacent Lands and Waters

2.2.1 General Setting

The PAA straddles the western county border between Custer and Fall River, South Dakota. Land within the project boundary is predominantly privately owned (97.5 percent) and the remaining 2.5 percent is managed by the Bureau of Land Management (BLM).

2.2.2 Land Use

Land use within the proposed 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. There is no commercial crop production within the permit area, although approximately 388.79 acres of land are irrigated in Sec. 32, T 6S, R. 1E along Beaver Creek. The majority of agricultural production is related to grazing. Most land serves as grazing land for cattle that are sold as food, as well as a small number of horses.

According to the United States Department of Agriculture's (USDA) 2002 census, Custer County generated $11,536,000 and Fall River County generated $49,003,000 from the selling of livestock, poultry and their products. The results from the 2007 Census will not be available until February 4, 2009. According to the National Agriculture Statistics Service, in 2008 the two counties had a combined total 78,000 head of cattle (No data was available for poultry, pig, or sheep inventories). Table 2.2-1 shows the 2008 livestock inventory for Custer and Fall River Counties.

Table 2.2-1: 2008 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	17,000	45,000	22/58%
All Cattle and Calves – excluding Beef Cows	1,000	15,000	1/19%
Sheep and Lamb	N/A	N/A	N/A
Hogs and Pigs	N/A	N/A	N/A
Total Animals	18,000	60,000	100%

Source: USDA, 2008.

Recreation lands are present in Custer, Fall River and Pennington counties within a 50-mile radius of the PAA (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 PAA 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, belonging to the BLM.

Recreational use within the project boundary is limited primarily to large game hunting. Within the PAA, hunting is currently open to the public on approximately 5,689 acres. Approximately 240 acres are owned by the BLM; the South Dakota Game Fish and Parks (SDGFP) lease around 3,069 acres annually of privately owned land and currently designate this acreage as walk-in hunting areas. Prior to commencement of operations, all hunting will be prohibited within the Permit Boundary.

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

Name of Recreational Facility	Managing Agency	Distance From PAA (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	0.25
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)

Table 2.2-3 lists the distance to the nearest resident from the PAA according to 22.5-degree sectors centered on the 16 cardinal compass points. The nearest resident is 0.9 miles to the west south-west of the PAA.

Table 2.2-3: Distance to Nearest Resident from Center of the Proposed 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 PAA 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. The 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 Railroad that runs north through Edgemont towards Newcastle, Country Road 6463 that parallels the Burlington Northern Railroad (BNRR) to the town of Dewey and overhead electricity lines and several gravel access roads.

2.2.2.2 Transportation and Utilities

The PAA will generally be accessed north from Edgemont along County Road 9. 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 PAA do not exist. Powertech (USA) is in the process of ground truthing the location of any public utilities within the PAA.

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 NCR website there are no fuel cycle facilities within 50 miles of the PAA. 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 PAA. The nearest operational in situ facility is the Crow Butte ISL facility, SUA-1534, in Darrow County, near Crawford, Nebraska (NRC, 2008).

2.2.3 Uses of Adjacent Waters

2.2.3.1 Surface Water

The PAA 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 PAA is drained by the Cheyenne River (Figure 2.2-1). Beaver Creek and Pass Creek pass through the proposed permit area and empty into the Cheyenne River downstream of the proposed permit 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 proposed permit area. These streams, including the Cheyenne River, often experience extended periods of no flow. During periods of flow, water quality varies considerably, mostly dependant 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 PAA. Pass Creek is a secondary surface water resource in the PAA, although the channel is almost always dry. The remaining surface water resources in the PAA are small intermittent stream channels and small ponds which are used by livestock when water exists. With the exception of a pond in the eastern section of the PAA, just south of the Custer-Fall River County line, no ponds are located in the PAA's primary facility zones. Several small, local drainage channels pass through the primary facility zone of the eastern site.

The approximate elevation of the PAA 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.

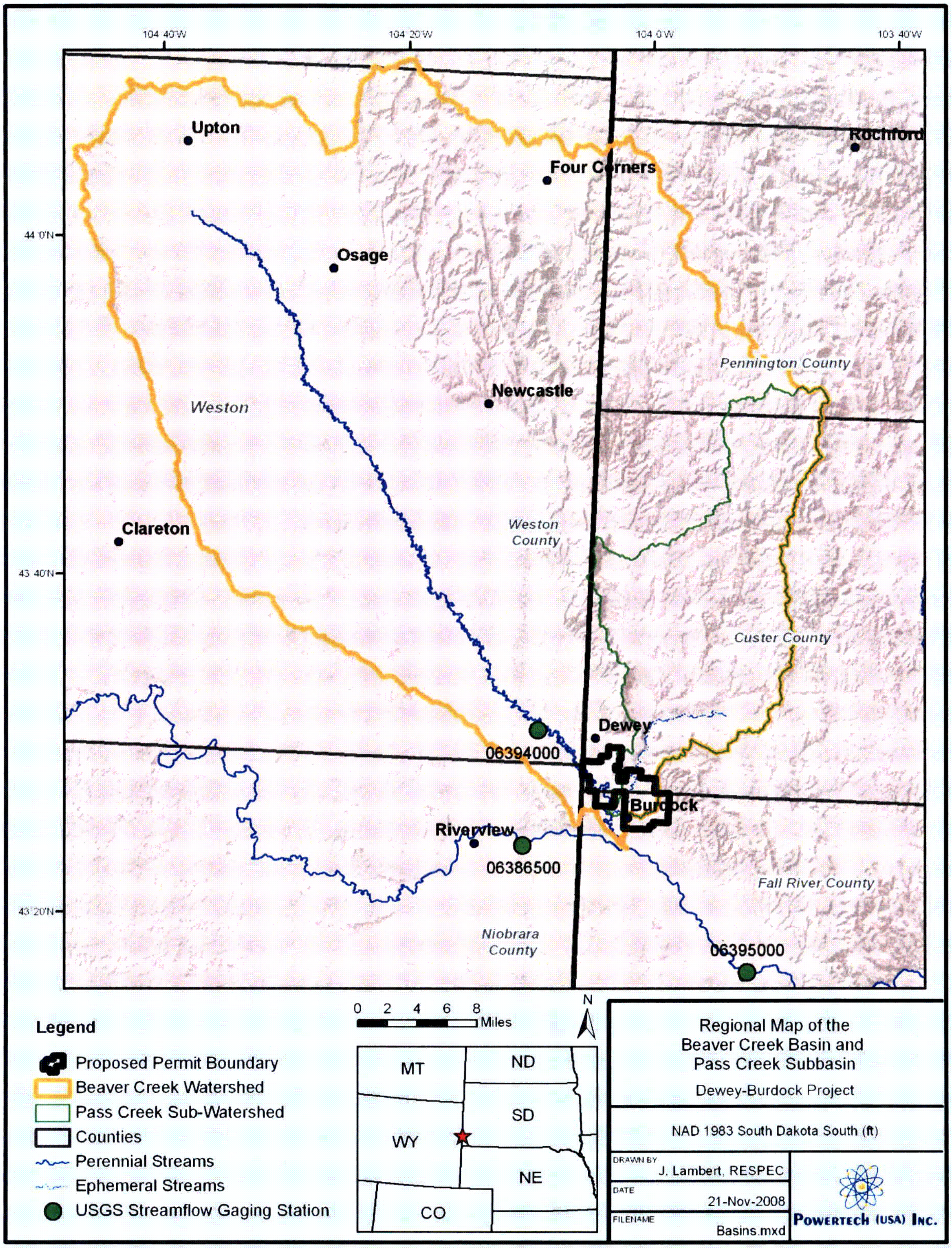

Figure 2.2-1: Regional Map of the Beaver Creek and Pass Creek Basins

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 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 proposed 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) has performed surface water quality sampling at eight monitoring locations at the project site on a quarterly basis since the third quarter of 2007. 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 groundwater hydrology is influenced by distribution and variation in recharge, leakage between overlying and underlying hydrogeologic units, lateral flow within the aquifers, and discharge to pumping wells, artesian wells, and springs.

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
- 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.

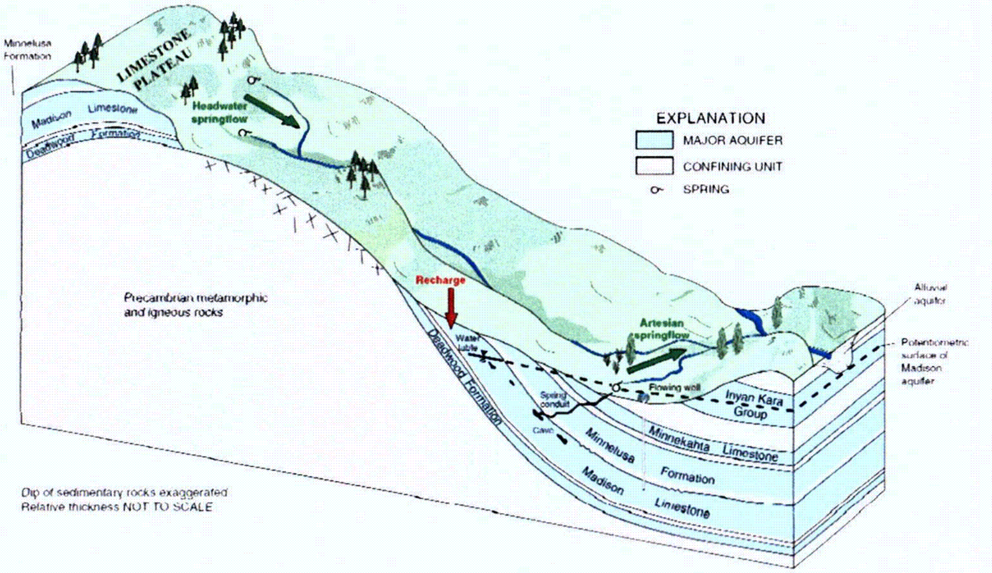

DIAGRAM SHOWING A SIMPLIFIED VIEW OF THE HYDROGEOLOGIC SETTING OF THE BLACK HILLS AREA (modified from Driscoll et al, 2002)

DEWEY-BURDOCK PROJECT

DRAWN	L. Tafoya
DATE	12-Nov-2008
SCALE	NONE
FILENAME	Figure 5.1.dwg

POWERTECH (USA) INC.

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

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	--	Includes 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 Orman 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 FM — 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 SS	0-225	Massive fine-grained sandstone.
			SUNDANCE FORMATION — Redwater Member, Lak Member, Hulett Member, Stockade Beaver Mem., 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.
	PERMIAN / 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.
	ORDOVICIAN	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.

†Modified based on drill-hole data

STRATIGRAPHIC COLUMN OF THE BLACK HILLS AREA
(from Driscoll et al.)

DEWEY-BURDOCK PROJECT

DRAWN	L. Tafoya
DATE	12-Nov-2008
SCALE	NONE
FILENAME	Figure 6.2.dwg

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Figure 2.2-3: Stratigraphic Column of the Black Hills Area

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

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 PAA, the Fall River and Lakota Formations, together forming the Inyan Kara aquifer, are the principal sources of water. An inventory of private water-supply wells within an approximate 2 km radius of the proposed permit boundary was conducted in June 2007, during which about 80 wells were located (see Appendix 2.2-A). Most wells within 2 km of the site serve as water supply for livestock (26), although some wells are used for domestic (10) or other purposes (47) including piezometers, mine dewatering wells, and garden watering.

Wells within 2 km of the site include 24 wells known to obtain water from the Fall River Formation, with 12 of these wells being flowing artesian wells. Based on measurements from flowing wells and estimates from others, an estimated 15 gpm is currently being consumed from the Fall River. Within this same 2 km radius, there are 39 wells currently obtaining water from the Lakota Formation, 14 of which are flowing artesian. The estimated flow from these Lakota wells is 46 gpm. Additionally, 10 wells are completed within an unknown formation of the Inyan Kara aquifer (Fall River, Lakota, or both). The total estimated flow from the Inyan Kara (including wells screened within the Fall River, Lakota, or both) within 2 km of the site is approximately 70 gpm. There are six wells completed in the Sundance/Unkpapa, with four that are flowing. Within 2 km, an additional eight wells are completed into an unknown aquifer. Wells within the project boundary that are currently in use are shown on Figure 2.2-4. Twenty-six wells in the vicinity of the project site were deemed abandoned because of the condition and inactivity of the well; these wells termed abandoned are not considered properly plugged and abandoned.

Well completion reports and other related data are found in Appendix 2.2-B.

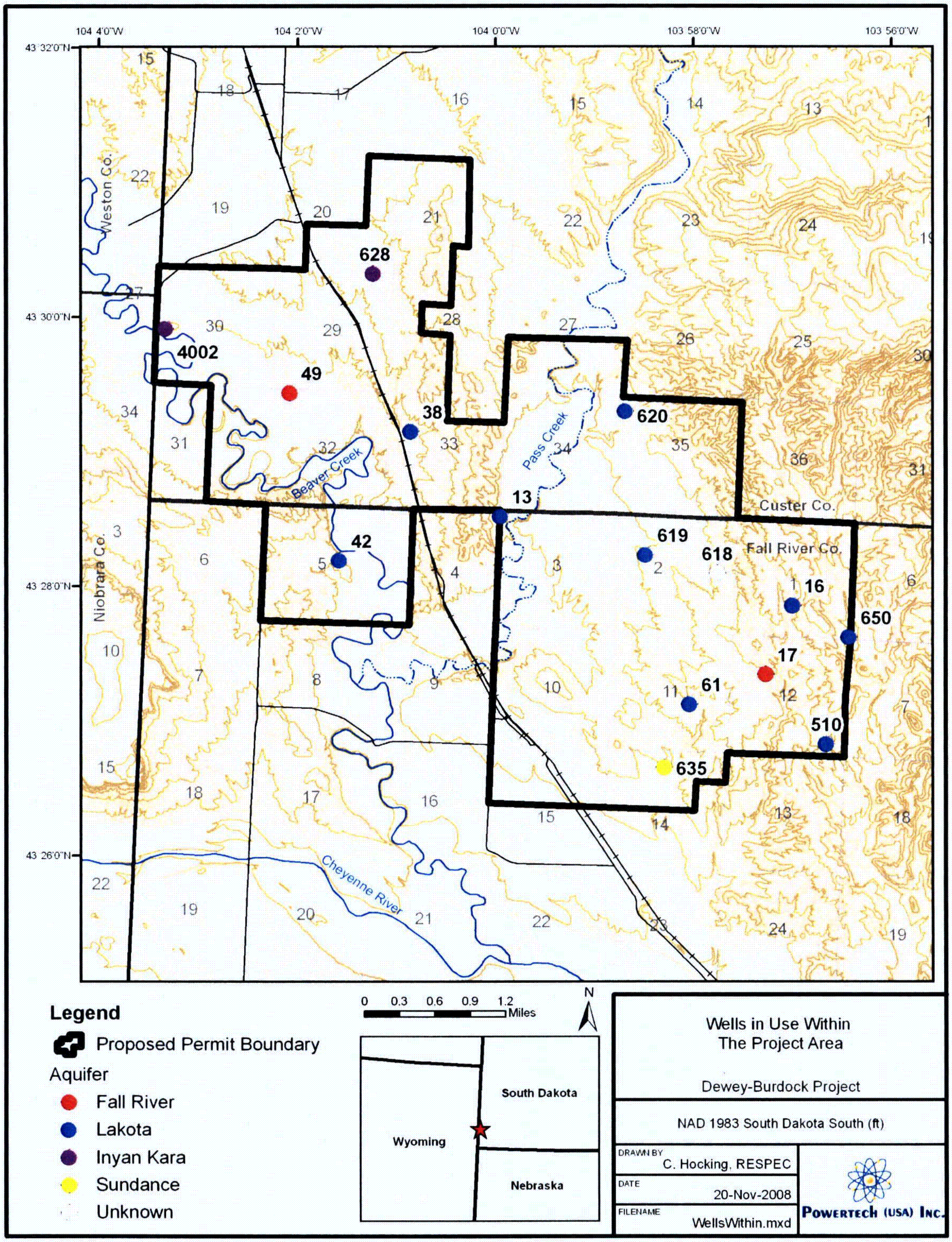

Figure 2.2-4: Wells in Use within the Proposed Action Area

Within a 2 km radius of the site, 24 wells are known to obtain water from the Fall River Formation, with 12 of these wells being flowing artesian wells. Based on measurements from flowing wells and estimates from others, an estimated 15 gpm are currently being consumed from the Fall River. Within this same 2 km radius, there are also 39 wells currently obtaining water from the Lakota Formation; 14 are flowing artesian. Estimated flow from these Lakota wells is 46 gpm. Additionally, 10 wells are completed within an unknown formation of the Inyan Kara aquifer (Fall River, Lakota, or both). The total estimated flow from the Inyan Kara (including wells screened within the Fall River, Lakota, or both) within 2 km of the site is approximately 70 gpm. There are six wells completed in the Sundance/Unkpapa, with four that are flowing.

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

2.2.4 References

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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 proposed 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 1.5 miles (2.4 km) of the project's western border follows the Wyoming / South Dakota state line south of Dewey, South Dakota. Therefore, the Wyoming locations of Newcastle and Osage[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 PAA'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

Rapid City, South Dakota, the closest urban area to the project, is approximately 100 miles (161 km) via road northeast of the PAA, 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 Census 2000 data and from the 2006 ACS, the most recent Federal demographic

[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.

survey. Other sources of demographic information include the U.S. Department of Commerce's Bureau of Economic Analysis (BEA), South Dakota Governor's Office of Economic Development (SD GOED), the University of South Dakota's Business Research Bureau, and county and city websites.

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.

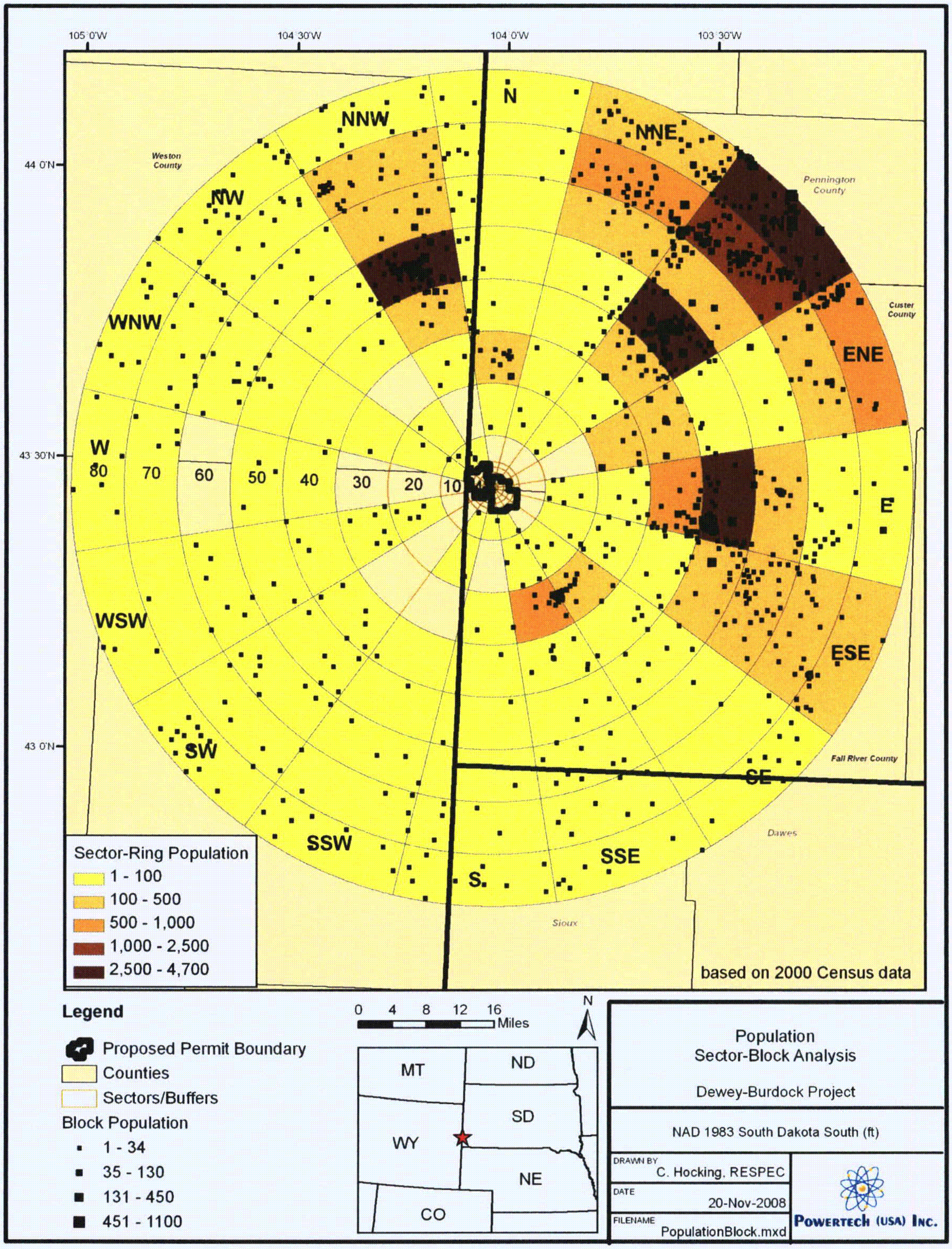


Figure 2.3-1: Population Sector-Block Analysis

In general, detailed information on population distribution and demographics is only provided for the towns within the proposed project's direct social zone of influence, as defined in the preceding section, with emphasis on the two South Dakota counties in which the proposed 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.

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	0	26	165	54	25	25	39	58
N, cumulative	*0*	*26*	*191*	*245*	*270*	*295*	*334*	*392*
NNE	0	12	8	59	64	229	780	386
NNE, cumulative	*0*	*12*	*20*	*79*	*143*	*372*	*1,152*	*1,538*
NE	0	10	15	494	3,852	391	1,825	3,427
NE, cumulative	*0*	*10*	*25*	*519*	*4,371*	*4,762*	*6,587*	*10,014*
ENE	0	0	154	282	21	73	268	539
ENE, cumulative	*0*	*0*	*154*	*436*	*457*	*530*	*798*	*1,337*
E	0	24	47	501	4,651	278	70	95
E, cumulative	*0*	*24*	*71*	*572*	*5,223*	*5,501*	*5,571*	*5,666*
ESE	0	21	26	76	329	183	143	136
ESE, cumulative	*0*	*21*	*47*	*123*	*452*	*635*	*778*	*914*
SE	0	12	342	18	32	12	13	34
SE, cumulative	*0*	*12*	*354*	*372*	*404*	*416*	*429*	*463*
SSE	2	18	649	52	7	30	20	30
SSE, cumulative	*2*	*20*	*669*	*721*	*728*	*758*	*778*	*808*
S	11	1	7	6	18	2	17	44
S, cumulative	*11*	*12*	*19*	*25*	*43*	*45*	*62*	*106*
SSW	3	7	0	2	2	25	21	48
SSW, cumulative	*3*	*10*	*10*	*12*	*14*	*39*	*60*	*108*
SW	0	0	0	29	18	21	23	61
SW, cumulative	*0*	*0*	*0*	*29*	*47*	*68*	*91*	*152*
WSW	6	19	14	15	4	28	8	9
WSW, cumulative	*6*	*25*	*39*	*54*	*58*	*86*	*94*	*103*
W	0	0	0	2	10	0	22	18
W, cumulative	*0*	*0*	*0*	*2*	*12*	*12*	*34*	*52*
WNW	8	6	2	2	18	57	58	33
WNW, cumulative	*8*	*14*	*16*	*18*	*36*	*93*	*151*	*184*
NW	6	2	0	10	22	30	50	72
NW, cumulative	*6*	*8*	*8*	*18*	*40*	*70*	*120*	*192*
NNW	2	0	35	234	4,129	121	316	77
NNW, cumulative	*2*	*2*	*37*	*271*	*4,400*	*4,521*	*4,837*	*4,914*
Ring Population, all Sectors	**38**	**158**	**1,464**	**1,836**	**13,202**	**1,505**	**3,673**	**5,067**

Data from: US Census Bureau, 2006 American Community Survey population estimates.

The distance to the nearest resident within each sector was calculated from querying the geographic data in Figure 2.3-1 and is presented in Table 2.3-2.

Table 2.3-2: Distance to Nearest Residents

Sector	Number of Residents	Distance from Project Center	
		Miles	Km
N	38	7.2	11.6
NNE	112	8.3	13.3
NE	423	6.7	10.8
ENE	154	13.1	21.1
E	24	6.8	11.0
ESE	110	10.7	17.3
SE	69	7.5	12.1
SSE	88	5.9	9.4
S	23	0.9	1.4
SSW	23	3.4	5.5
SW	39	21.0	33.7
WSW	27	1.7	2.7
W	14	20.3	32.6
WNW	39	6.2	10.0
NW	49	3.5	5.6
NNW	250	4.2	6.7

Data from US Census Bureau, 2000 Census.

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. Demographic data was collected from the Census 2000 statistical pool at both the county and state levels to provide a descriptive picture of the populations within the immediate PAA in comparison to that of the State of South Dakota as a whole.

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.

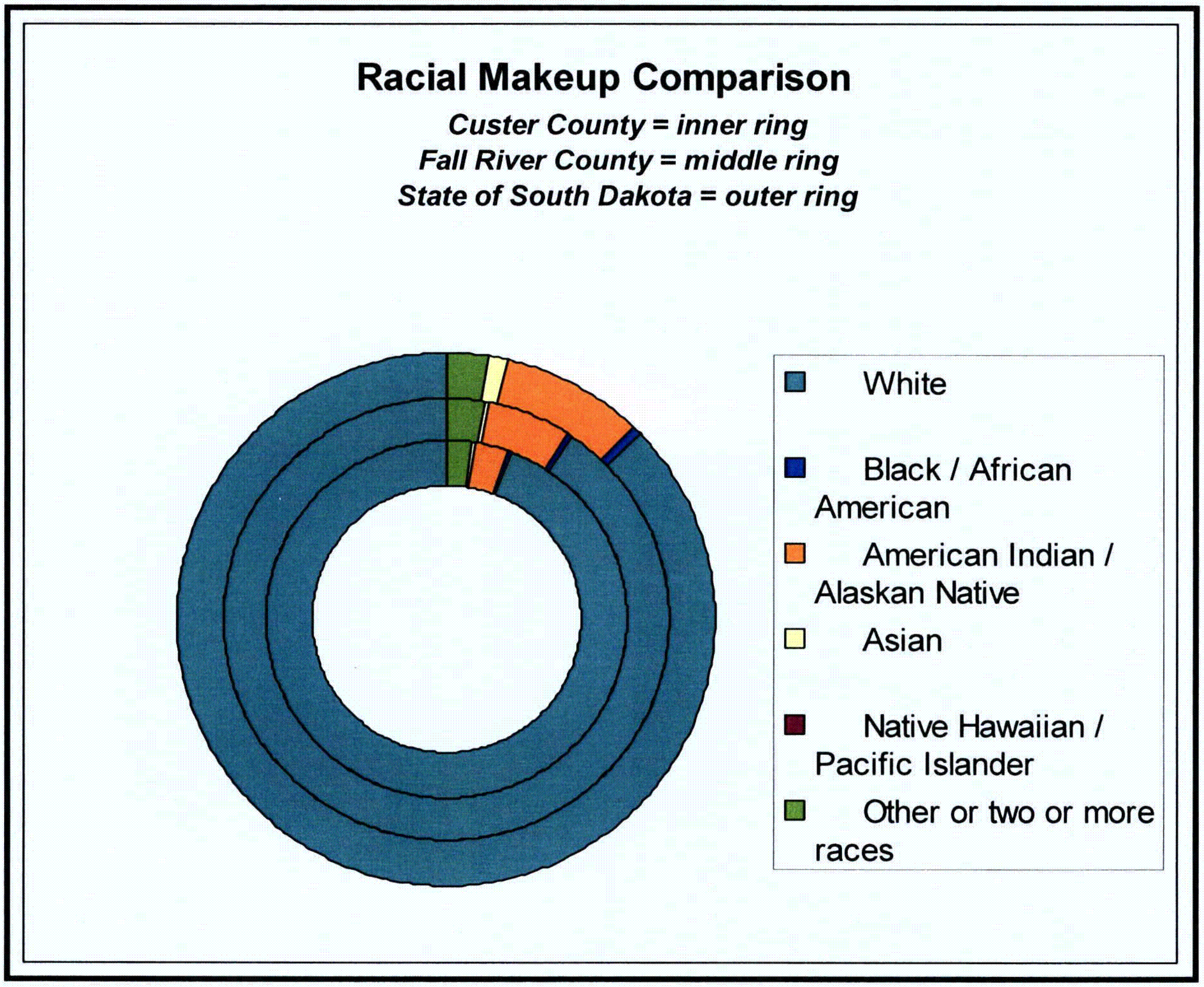
Table 2.3-3: Proposed Action Area Demographic Data, South Dakota

Data Type	Custer County	Fall River County	South Dakota
Male / female ratio, %	51.1 / 48.9	52.3 / 47.7	49.6 / 50.4
Median age, years	43.2	45.5	35.6
Average household size, people	2.35	2.23	2.50
Average family size, people	2.80	2.82	3.07
Households with individuals under 18 years, %	29.1	25.9	34.8
Households with individuals 65 years and over, %	27.4	33.4	25.0
Female householder with no husband present, %	6.6	8.5	9.0
Above, with own children under 18 years, %	4.0	5.2	6.1
Race, %			
White	94.2	90.5	87.2
Black / African American	0.3	0.3	0.7
American Indian / Alaskan Native	3.1	6.1	8.6
Asian	0.2	0.2	0.9
Native Hawaiian / Pacific Islander	0.0	0.1	0.0
Other or two or more races	2.2	2.8	2.6
Hispanic / Latino (of any race)	1.5	1.7	2.0

Data from Census 2000, US Census Bureau

Female-headed households with no husband present accounted for 6.6 percent and 8.5 percent of the total households during the 2000 Census for Custer and Fall River counties, respectively, somewhat lower than the State average of 9 percent. In both counties, 61 percent (4.0 out of 6.6 in Custer County, and 5.2 out of 8.5 in Fall River County) of these households included children under the age of 18 years; lower than the State average of 68 percent (6.1 out of 9.0 in the State of South Dakota) of female-headed households.

Racial data for the two counties show that the local population is predominantly white, with American Indian/Alaskan Native the predominant minority group. At 6.1 percent, the percentage of American Indians in Fall River County is roughly twice that of Custer County, but still below the State average of 8.6 percent. A graphic depiction of the area's racial makeup is shown in Figure 2.3-2 below, again compared to the State average.



Data from US Census Bureau, Census 2000.

Figure 2.3-2: Racial Makeup Comparison

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, this time 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, lower proportions of children in the home, and higher percentage of senior citizens. The percentage of female-headed households was also similar to the PAA counties, and lower than the State-wide average. Both Wyoming counties also have lower percentages of Native American populations than the State average, and substantially lower than either Custer or Fall River counties.

Table 2.3-4: Proposed Action Area Demographic Data, Wyoming

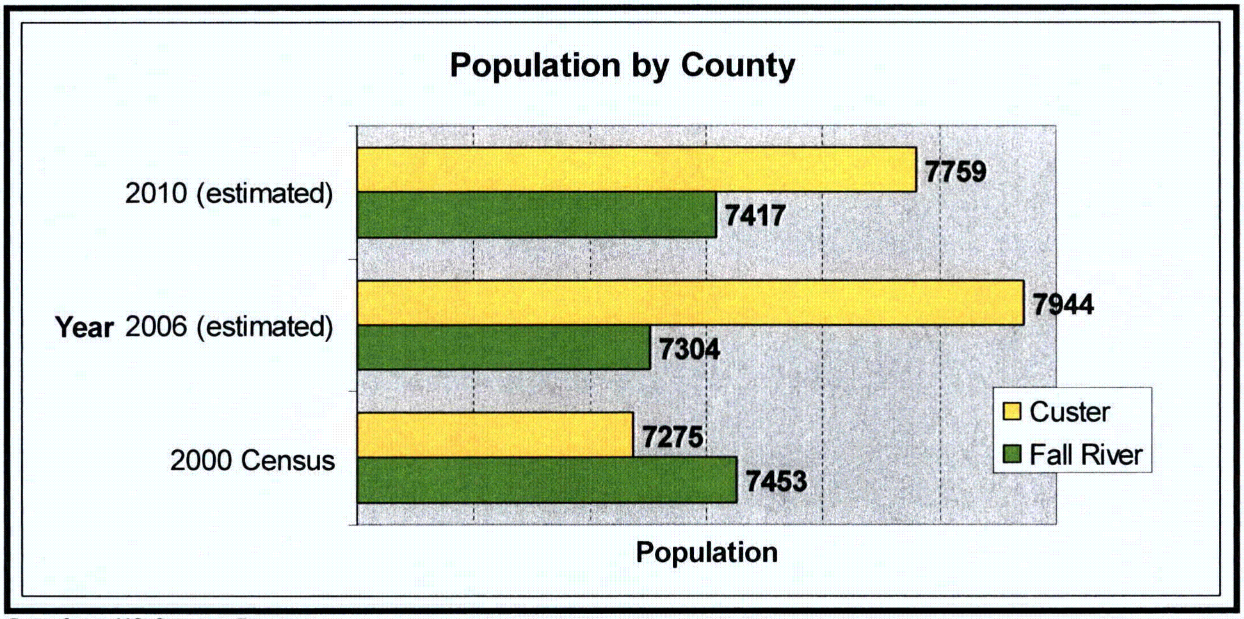
Data Type	Niobrara County	Weston County	Wyoming
Male / female ratio, %	48.8 / 49.1	50.8 / 49.2	50.3 / 49.7
Median age, years	42.8	40.7	36.2
Average household size, people	2.28	2.42	2.48
Average family size, people	2.81	2.88	3.00
Households with individuals under 18 years, %	28.7	33.0	35.0
Households with individuals 65 years and over, %	33.1	26.9	20.8
Female householder with no husband present, %	6.0	7.3	8.7
Above, with own children under 18 years, %	4.2	4.6	6.0
Race, %			
White	98.0	95.9	92.1
Black / African American	0.1	0.1	0.8
American Indian / Alaskan Native	0.5	1.3	2.3
Asian	0.1	0.2	0.6
Native Hawaiian / Pacific Islander	0.0	0.0	0.1
Other or two or more races	1.2	2.4	4.3
Hispanic / Latino (of any race)	1.5	2.1	6.4

Data from US Census Bureau, Census 2000.

2.3.2.1 Population Projections

The most recent verifiable population data for Fall River and Custer counties comes from the last Federal census, in 2000. Estimations of population changes for South Dakota counties were calculated by the USCB for 2006 and by the SD GOED (based on the USCB's projections) for 2010. As Figure 2.3-3 below shows, Fall River is projected to have lost almost 2 percent of its population between 2000 and 2006, in comparison to a 9 percent gain in population in Custer County over the same time period.

Projections for the 2010 county populations show a 1.5 percent gain for Fall River County and a slight decrease of 2.3 percent for Custer County, both over the 2006 estimates.



Data from US Census Bureau.

Figure 2.3-3: Population by County

A breakdown of population per town within each county is shown in Table 2.3-5, based again on Census 2000 data and 2006 USCB population projections. Custer City and Hot Springs, the county seats of Custer and Fall River counties, respectively, are also the largest towns in each county.

Table 2.3-5: Population Change, Custer and Fall River Counties, 2000 – 2006

County / Town	Population	
	2000 Census	2006 (estimate)
Custer		
Buffalo Gap	164	161
Custer City	1860	1984
Fairburn	80	78
Hermosa	315	354
Pringle	125	118
Fall River		
Edgemont	867	810
Hot Springs	4129	4102
Oelrichs	145	143

Data provided by US Census Bureau, 2000 and 2006

General population trends within both counties are shown Figure 2.3-4, and indicate that while Custer County overall is projected to gain in population, the three smallest towns in the county (Fairburn, Pringle, and Buffalo Gap) were estimated to lose between -1.8 percent (at Buffalo Gap) to -5.6 percent (at Pringle) of their populations between 2000 and 2006.

The two larger towns, Hermosa and Custer City, both were projected to gain in population over the same time period, with Hermosa's rate of increase nearly twice as high as that of Custer City. In keeping with the general county population trend, all three towns in Fall River County show estimated population decreases from 2000 to 2006, with the highest percent decrease in Edgemont (the closest town to the project site), at -6.6 percent.

Rapid City, the largest urban area nearest to the project, had a 2000 population of 59,607, projected to increase by 5.2 percent to 62,715 by 2006.

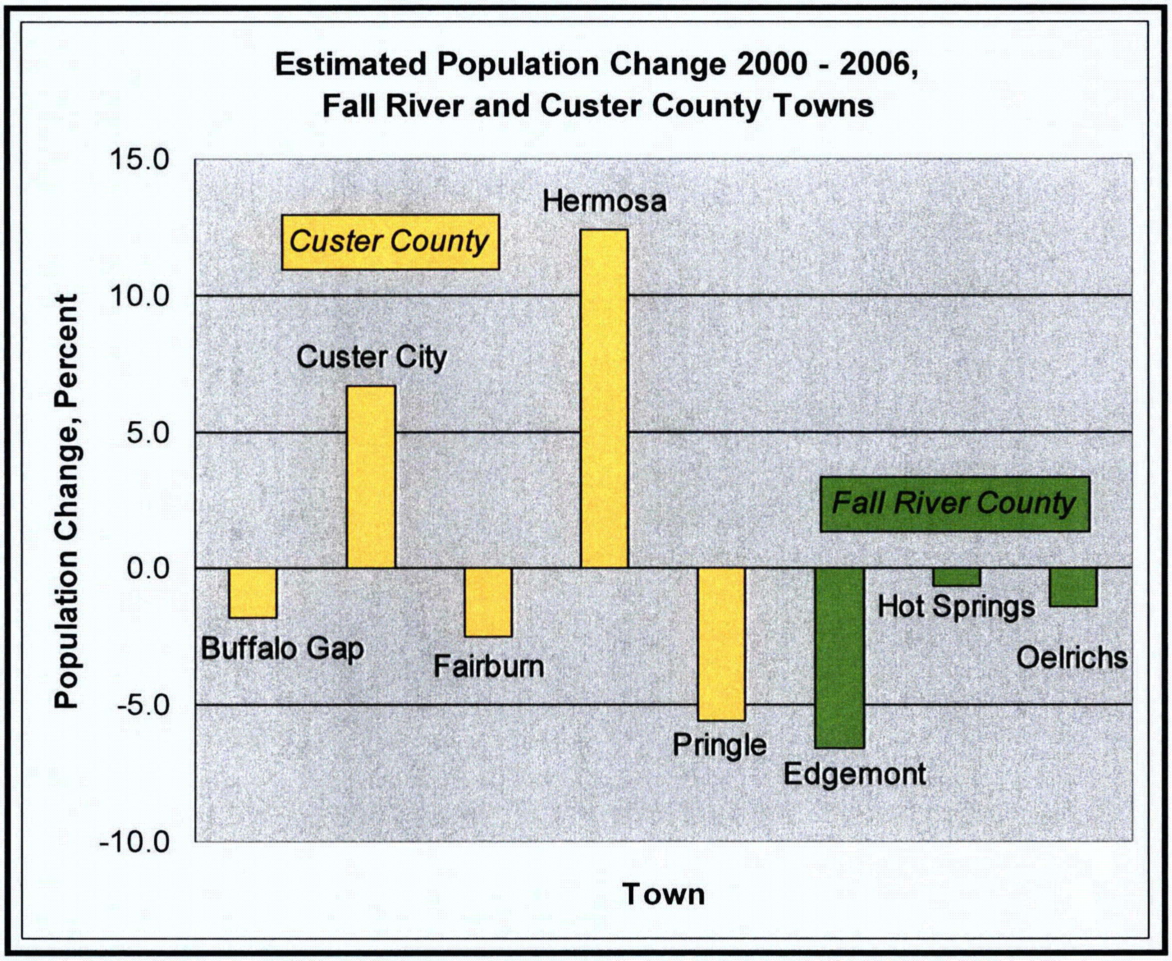


Figure 2.3-4: Estimated Population Change 2000 – 2006, Fall River and Custer Counties

Estimated 2006 population densities for both Custer and Fall River counties were quite low, at approximately four to five people per mi^2 (two people/ km^2). In comparison, the state average population density estimate for 2006 was approximately 10 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 2.3-6: Population Data for Other Areas of Interest, 2000-2006

County, State / Town	Population		
	2000 Census	2006 (estimate)	*% Change*
Pennington Co, SD			
Hill City	780	871	+ ***11.7***
Keystone	311	315	+ ***1.3***
Weston Co, WY			
Newcastle	3065	3272	+ ***6.8***
Osage	215	n/a	***n/a***

Data provided by US Census Bureau, 2000 and 2006; "n/a" = inter-census data not available.

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 the PAA and their attendant schools and age levels are:

- **Custer School District:**
  - Custer Elementary, Pre-Kindergarten (PK) - 5th
  - Custer Middle, 6th – 8th
  - Custer High, 9th – 12th
  - Hermosa Elementary, PK – 8th
  - Fairburn Elementary, Kindergarten (K) – 8th
  - Spring Creek Elementary, K – 8th
- **Elk Mountain School District:**
  - Elk Mountain Elementary, K – 6th
- **Hot Springs School District:**
  - Hot Springs Elementary, PK - 5th
  - Hot Springs Middle, 6th - 8th
  - Hot Springs High, 9th – 12th

- **Edgemont School District:**
  - Edgemont Elementary, K – 6th
  - Edgemont Junior High, 7th – 8th
  - Edgemont High, 9th – 12th
- **Oelrichs School District:**
  - Oelrichs Elementary, K – 6th
  - Oelrichs Junior High, 7th – 8th
  - Oelrichs High, 9th – 12th

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 – 5th.

Primary and secondary school attendance rates in Custer and Fall River counties were higher than the State-wide rates from kindergarten onward and typically higher in Fall River than in Custer County (Table 2.3-7). However, the percentage of the population of either county attending college or graduate school in 2000 was less than half the State attendance rate

Table 2.3-7: Primary and Secondary School Attendance Rates, 2000 & 2006

School Category	Percent of Population ≥ 3 Years Old Attending School		
	Custer County (1)	Fall River County (1)	South Dakota (1), (2)
Nursery, pre-kindergarten, and pre-school	4.0	5.92	6.1, 6.7
Kindergarten	4.8	6.1	5.4, 4.9
Elementary (grades 1st – 8th)	42.7	51.8	44.6, 41.9
High (grades 9th – 12th)	37.7	27.4	23.4, 21.5
College or graduate school	10.7	8.8	20.6, 25.0

Data from US Census Bureau: (1) Census 2000, (2) 2006 American Community Survey estimates.

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).

The WDTI is one of four State-run technical institutes in South Dakota, and offers 25 career programs leading to the Associate of Applied Science degree, as well as many non-credit classes, workshops, short-term training programs, and online courses. Approximately 850 full-time students are currently enrolled at WDTI, with over 4,000 students participating in full-, part-time, or non-credit courses annually.

The SDSMT is one of the six state public universities governed by the South Dakota Board of Regents, and offers undergraduate (Associate of Arts, Bachelor of Science) and graduate degrees (Master and Doctor of Science) in various science and engineering fields. Current enrollment is 1,572 full-time and 498 part-time students.

The Rapid City campus is one of NAU's 20 campuses in six states, including an on-line campus also based in Rapid City. NAU is a private institute of higher learning, offering regionally accredited and degree programs in a variety of fields, both at its campuses and on-line. Current enrollment at NAU's Rapid City campus is 1,005, including 646 full-time and 359 part-time students.

2.3.3 Local Socioeconomic Baseline Conditions

2.3.3.1 Major Economic Sectors

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 developed solely by SD DOL, as provided in Table 2.3-8.

Table 2.3-8: Proposed Action Area Labor Statistics, December 2007

	Custer County	Fall River County	South Dakota*
Labor force, persons	3,955	3,680	440,085
Labor force, % of total population	49.8	50.4	56.3
Employed, persons	3,810	3,520	426,815
Unemployed, persons	145	160	13,270
Unemployment rate, annual %	3.2%	3.6%	3.1%
Labor supply, persons	470	535	67,570
Labor supply, % of labor force	11.9	14.5	15.4

Data from Labor Market Information Center, South Dakota Department of Labor
*State-wide data is seasonally adjusted

The percentage of the total county populations represented by their labor forces is roughly the same for Custer and Fall River counties, but lower than the State-wide rate, potentially due to the older populations in the area, as noted in Section 2.3.2. Annual unemployment rates in both counties were higher than the State-wide rate of 3.1 percent, with unemployment higher in Fall River County.

The majority of workers between the ages of 25 to 64 in both counties have only 12 years of formal education (high-school level), as shown in Table 2.3-9.

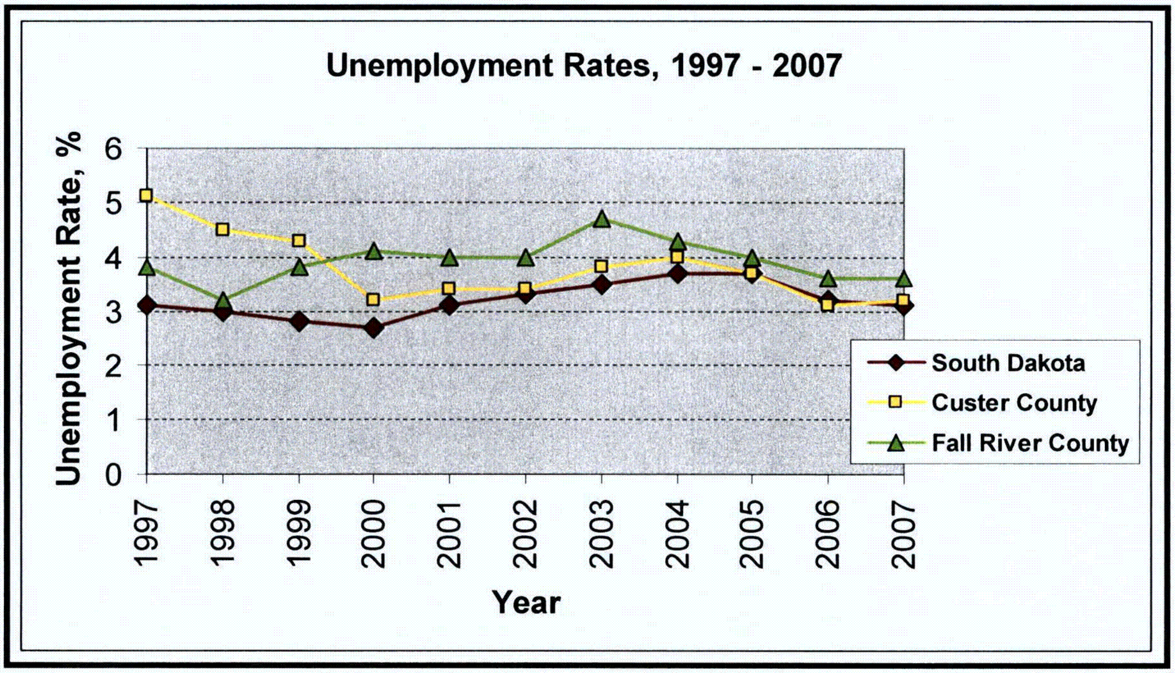
Table 2.3-9: Labor Force Educational Attainment (25 to 64 Years of Age), 2000

	Custer County, %	Fall River County, %	South Dakota
Less than 12 years of school	6.3	12.1	15.5
High school (12 years of school)	31.1	35.0	32.9
Some college (no degree)	27.1	28.6	23.0
Associate degree	7.5	3.8	7.1
Bachelor's degree	20.3	13.1	15.5
Graduate degree	7.7	7.4	6.0

Data from South Dakota Governor's Office of Economic Development and the US Census Bureau, 2000

2.3.3.2 Unemployment Trends

Unemployment trends for Custer and Fall River counties and South Dakota's state-wide rate over the last decade are shown in Figure 2.3-5, which plots the average unemployment rate for each year determined from monthly county and state data from the SD DOL's Labor Market Information Center.



Data from South Dakota Department of Labor, Labor Market Information Center

Figure 2.3-5: Unemployment Rates, 1997 - 2007

As the chart shows, the disparity between county and State unemployment rates has been decreasing, so that since 2005 Custer and Fall River county unemployment rates are closely matched to that of the State. This trend adjustment has been most pronounced for Custer County, which had an unemployment rate of nearly twice the State average in 1997, but which now is within 4 percent of the State average. Fall River County's 2007 average unemployment rate was approximately 16 percent higher than the State-wide rate of 3.1 percent.

2.3.3.3 Employment

Employment data from 2006 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 2.3-10 and illustrated in Figure 2.3-6. "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.

According to correspondence (email, 7 March 2008) with Ron Meier, Senior Economic Analyst with the SD DOL's Labor Market Information Center, covered worker data will be updated to reflect the 2007 annual statistics in late June / early July 2008.

Table 2.3-10: Proposed Action Area Covered Worker Employment by Sector, 2006

Employment Sector	Custer County, % Employed (1)	Fall River County, % Employed (1)	South Dakota, % Employed (2)
Construction	6.59	4.62	5.69
Education / Health Services	9.62	10.36	13.6
Financial Activities / Insurance	3.31	2.75	7.61
Information	NR	1.43	1.81
Leisure / Hospitality	25.15	16.26	11.06
Manufacturing	1.52	0.96	10.78
Natural Resources / Mining	2.44	1.79	1.07
Other Services	1.12	1.71	2.69
Professional / Scientific / Technical Services	1.64	4.07	6.66
Trade / Transportation / Utilities	14.89	14.55	20.66
% Total, Private Ownership (3)	***66.28***	***58.50***	***82.00***
Local government	11.30	15.34	11.47
State government	11.26	5.74	3.63
Federal government	8.22	20.49	2.90
% Total, Government (3)	***30.78***	***41.57***	***18.00***
Total Covered Workers:	**2505**	**2509**	**383,856**

Data from South Dakota Governor's Office of Economic Development and South Dakota Department of Labor, Labor Market Information Center, 2006.
Notes: (1) County data are from 2007; (2) State data are from 2006; (3) Totals exceed 100% due to rounding; NR = not reported

Government (local, state, or federal) was the largest employment sector for both Custer and Fall River counties. In 2006, slightly under half of all covered workers in Fall River County were employed by some form of government, in comparison to 31 percent of the covered workforce in Custer County and 18 percent of the workforce State-wide. Major private enterprise sectors of employment for both counties were leisure/hospitality (including arts, entertainment, recreation, food service, and accommodations) and trade/transportation/utilities (including retail, wholesale, transportation, warehousing, and utilities), see Figure 2.3-6.

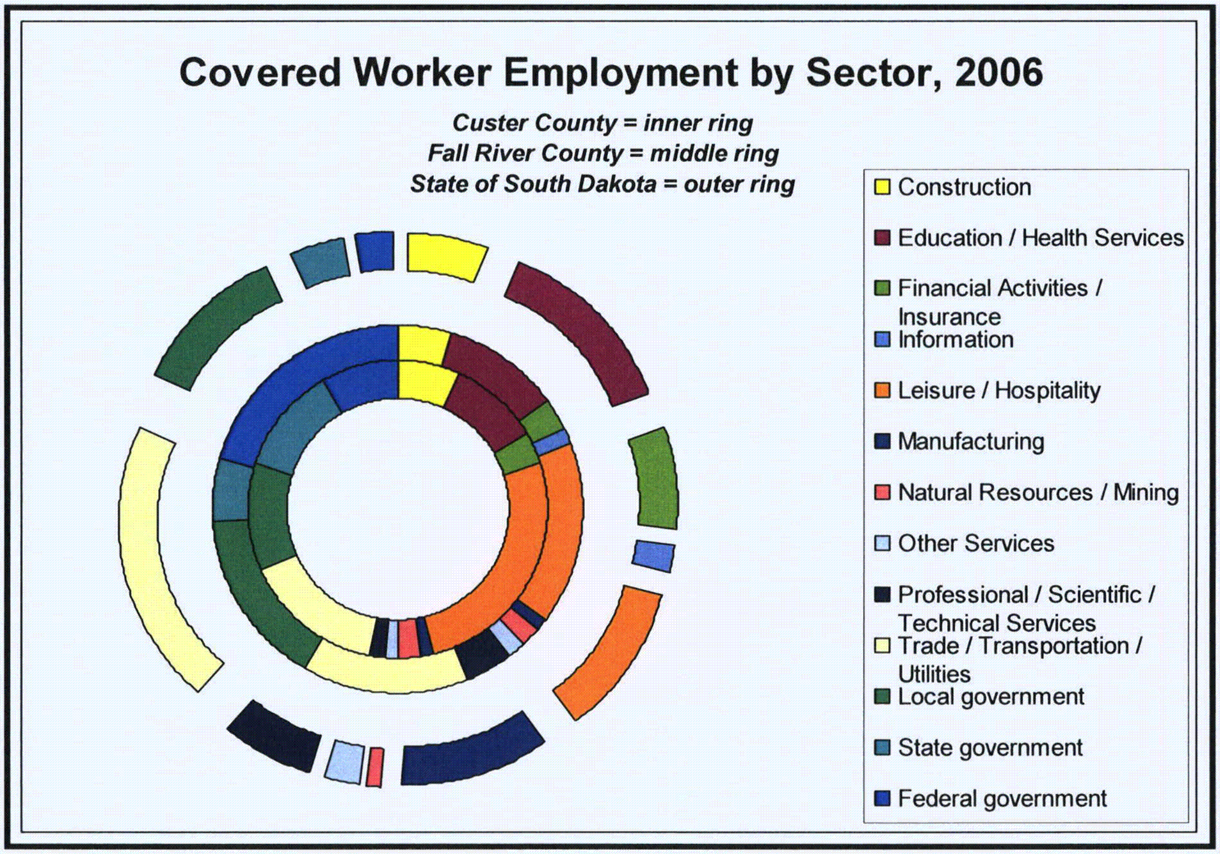


Figure 2.3-6: Covered Worker Employment by Sector, 2006

A more detailed breakdown of private and public sector employers for both counties is provided in Table 2.3-11, based on 2006 data collected by the SD GOED from local development corporations. Major employers in Custer County include the US Department of Agriculture Forest Service (whose Black Hills National Forest headquarters are in Custer City), local school districts, and various health care providers. Major employers in Fall River County include the US Department of Veteran's Affairs (which operates a VA Medical Center in Hot Springs) and the National Park Service, in addition to local school districts and health care providers.

Table 2.3-11: Major Employers, Custer and Fall River Counties, 2006

Employment Sector	Total Employed Custer / Fall River	Major Employers	Custer County # Employed – Town	Fall River County # Employed – Town
Construction	34 / 11	Jorgenson Log Homes	34 – Custer City	
		Barker Concrete Construction		11 - Edgemont
Education / Health Services	283 / 321	Custer Regional Senior Center	100 - Custer City	
		Custer School District	183 – Custer City	
		Cactus Hills Retirement Community		9 - Edgemont
		Edgemont School District		47 - Edgemont
		Castle Manor Nursing Home		140 – Hot Springs
		Hot Springs School District		125 – Hot Springs
Financial Activities	4 / -	Battle Creek Agency	4 - Hermosa	
Leisure / Hospitality	79 / 20	Cuny Table Café	4 - Buffalo Gap	
		Crazy Horse Memorial	60 – Custer City	
		Trails West	5 - Hermosa	
		Waterhole Restaurant & Bar	10 - Hermosa	
		Super 8 Motel		15 – Hot Springs
		State Line Club		3 - Oelrichs
		Horsehead		2 – Oelrichs
Natural Resources / Mining	33 / -	Pacer Corporation	33 – Custer City	
Other Services	- / 36	Black Hills Special Services		36 – Hot Springs
Trade / Transportation / Utilities	84 / 115	Black Hills Electric Cooperative	30 – Custer City	
		Buffalo Gap Repair	2 - Buffalo Gap	
		Rancher Feed & Seed	2 - Buffalo Gap	
		Lynn's Dakotamart	35 – Custer City	43 – Hot Springs
		Fresh Start	15 - Hermosa	
		Nelson's Oil & Gas		4 - Edgemont
		Maverick Junction		33 – Hot Springs
		Pamida		35 – Hot Springs
Local Government	74 / 7	Custer County	74 – Custer City	
		City of Edgemont		7 - Edgemont
State Government	30 / 106	Custer State Park	30 – Custer City	
		State Veterans' Home		106 – Hot Springs
Federal Government	583 / 504	Black Hills National Forest	583 - Custer City	
		VA Medical Center		402 – Hot Springs
		Wind Cave National Park		100 – Hot Springs
		U.S. Post Office		2 – Oelrichs

Data from South Dakota Department of Labor and Governor's Office of Economic Development

2.3.3.4 Income Levels

Information regarding median and per capita incomes and poverty statistics for Custer and Fall River counties is only available from the decennial federal census; state-level information is updated during the USCB's annual American Community Survey. Therefore, the county- and town-level information in Table 2.3-12 is presented in 1999 dollars, and has not been adjusted for inflation; State-wide data are for 2006 (2005 dollars).

Table 2.3-12: Proposed Action Area Income Levels

Location	Covered Workers, Annual Average Pay (1)	Median Household Income (2)	Median Family Income (2)	Per Capita Income (2)
Custer County	*$25,141*	*$36,303*	*$43,628*	*$17,945*
Custer County - Adjusted for inflation		*$41,917*	*$50,376*	*$20,721*
Buffalo Gap		$25,000	$28,750	$14,680
Custer City		$31,739	$41,313	$17,216
Hermosa		$23,750	$33,125	$20,832
Fall River County	*$26,727*	*$29,631*	*$37,827*	*$17,048*
Fall River County – Adjusted for inflation		*$34,214*	*$43,678*	*$19,685*
Edgemont		$24,919	$36,667	$17,273
Hot Springs		$27,079	$35,786	$16,618
Oelrichs		$27,222	$28,906	$13,454
South Dakota (3)	***$30,282***	***$42,791***	***$53,806***	***$22,066***

Data provided by South Dakota Department of Labor, Labor Market Information Center and US Census Bureau.
Note: (1) 2006 data; (2) Census 2000 data (1999 dollars) except State data; (3) State data = 2006 American Community Survey.

Median incomes at the household and family level were higher for both Custer and Fall River counties than for the individual towns within each county, indicating that unincorporated county residents contribute substantially to the area's gross income. Income values for both counties were lower than the comparable State-wide values, due in part to the time disparity of the available data. To facilitate comparison, the county-level data was adjusted for inflation to 2005 dollars (2006 data) using a web-based gross domestic product (GDP) deflator calculator (http://www.measuringworth.com/calculators/uscompare/result.php) based on the ration of nominal GDP to real GDP, a broad measure of inflation representing the price of all goods and services in the economy. The county adjusted median values are still lower than the comparable State-wide incomes in each category, but Custer County median income values range from 2 percent (household income) to less than 7 percent (family income) below their State analogs, while Fall River County median values are diverge by almost 11 percent (per capita income) to 20 percent (household income) from comparable State-wide values.

2.3.3.5 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 PAA are listed in Table 2.3-13 below.

Table 2.3-13: Proposed Action Area Municipal Tax Rates - 2007

Location	Municipal Tax Rate	Gross Receipts Tax Rate
Custer County		
Custer City	2 %	1%
Hermosa	2%	No
Pringle	2%	No
Fall River County		
Edgemont	2%	1%
Hot Springs	2%	1%

Data from South Dakota Department of Revenue and Registration, 2008.

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.

Table 2.3-14 presents the total taxable amounts for calendar year 2007 on sales and services for the larger towns in Custer and Fall River counties, and shows the amounts as a percent of South Dakota's total taxable sales over the same time period. The county total rates are approximate as they do not take into account any sales taking place in the unincorporated areas of the county.

Table 2.3-14: Total Taxable Sales for Project-Area Towns - 2007

Location	Total Taxable Sales	% of State Taxable Sales
Custer County		*~ 5.52*
Buffalo Gap	$404,188	0.03
Custer City	$79,332,055	5.08
Fairburn	$106,078	0.01
Hermosa	$5,768,664	0.37
Pringle	$552,539	0.04
Other cities	$351,520	0.02
Fall River County		*~ 4.2*
Edgemont	$6,863,927	0.44
Hot Springs	$57,148,891	3.66
Oelrichs	$714,584	0.05
Other cities	$704,086	0.05

Data from South Dakota Department of Revenue and Regulation, South Dakota Sales and Use Tax Report, Calendar Year 2007.

Figure 2.3-7 shows the percentage various business sectors contributed to the total taxable sales and use revenue for Custer City and Hot Springs, the respective county seats for Custer and Fall River counties, and the largest cities in each county. Businesses are grouped by standard industrial classification (SIC) as defined by SD DRR, and data reflect 2007 calendar year totals from SD DRR's annual report. The chart shows that the manufacturing, mining, transportation and public utilities, and services sectors were more important to Custer County than to Fall River, while agriculture, forestry, and fishing; construction; and retail trade were more important to Fall River County than to Custer. Wholesale trade and finance, insurance, and real estate sectors were approximately equal in terms of revenue generated for each county.

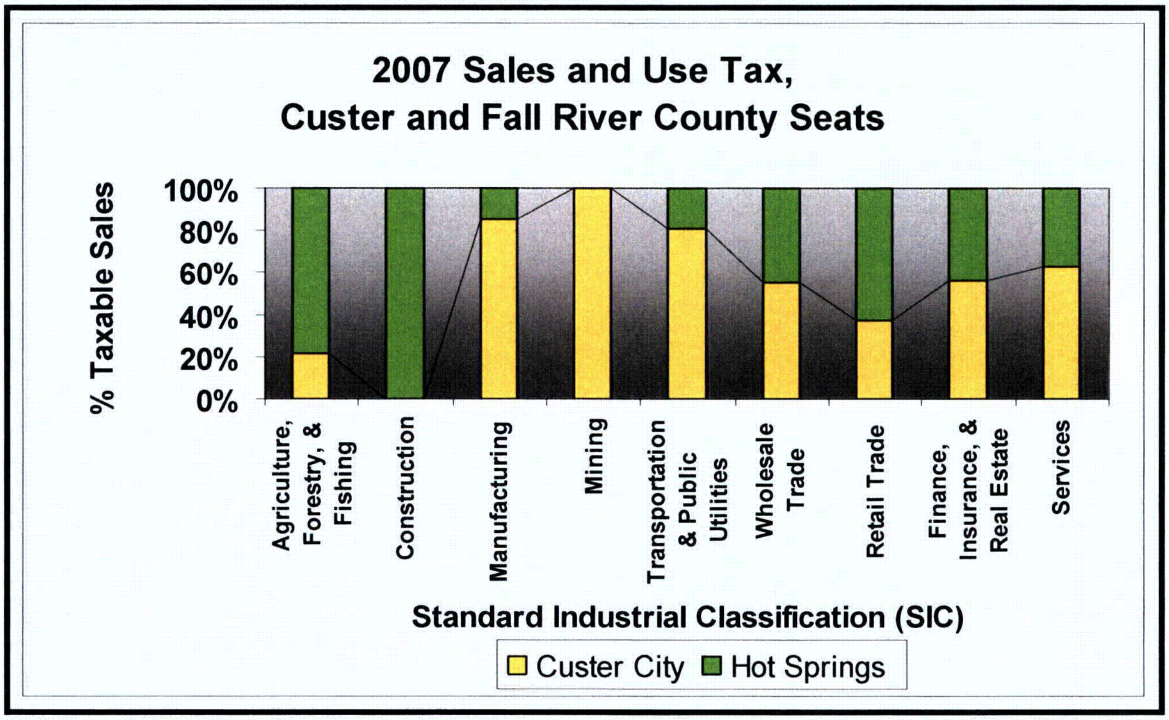


Figure 2.3-7: Sales and Use Tax for Custer and Fall River Counties, 2007

SIC categories generating the most taxable sales for Custer City in 2007 were services ($30,987,910), retail trade ($30,916,880), and transportation and public utilities ($12,340,925), accounting for 94.3 percent of the city's total sales and use tax revenue. SIC categories generating the most taxable sales for Hot Springs in 2007 were retail trade ($37,494,437), services ($12,989,107), and transportation and public utilities ($2,056,135), generating 94 percent of the city's total sales and use tax revenue.

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. Table 2.3-15 below lists the property tax base for Custer and Fall River counties in 2007, and compares them to the State-wide totals. In 2007, agricultural land accounted for only 14 percent of the property tax base in Custer County, in comparison to 24.6 percent of the property tax base in Fall River County and 24.9 percent State-wide. Owner-occupied housing accounted for 47.9 percent of Custer County's tax base, compared to

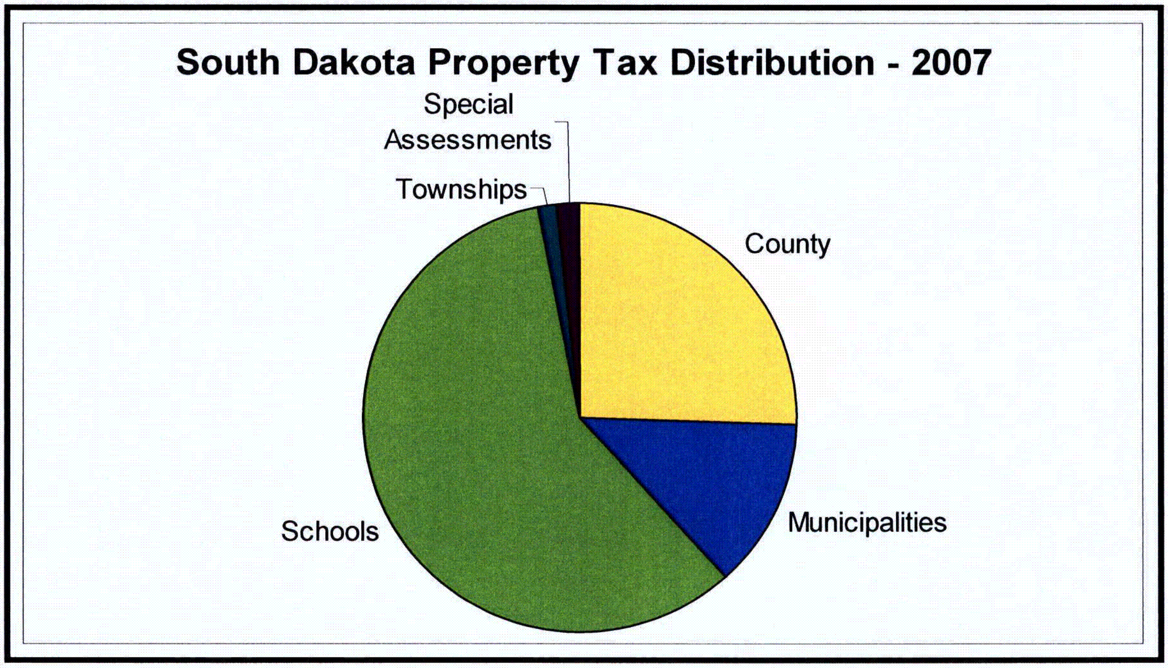
38.7 percent in Fall River County and 39.0 percent State-wide. Other valuation percentages for both counties were similar to the State-wide rate of 36.1 percent of total property taxes collected in 2007.

Table 2.3-15: Project-Area Property Tax Base - 2007

Property Tax Category	Custer County	Fall River County	South Dakota
Agricultural Real Valuation	$84,160,015	$96,691,027	$211,381,559
Owner-Occupied Real Valuation	$285,740,111	$152,274,225	$330,332,434
Other Valuation	$227,203,660	$144,165,093	$306,178,271
Total Valuation	**$597,103,786**	**$393,130,345**	**$847,892,264**

Data from South Dakota Department of Revenue and Regulation, 2007 Annual Report.

Figure 2.3-8 below shows that the majority (58.5 percent) of property taxes collected in South Dakota are used to fund local school districts. Another 38.4 percent of property tax revenue is used to fund county (25.4 percent) and municipality (13.0 percent) governments, with the remaining 3.1 percent used for funding townships and for special assessment purposes, generally for use by improvement districts for infrastructure (road, bridge, water, sewer, etc.) improvements (Goldman et al., 2001).



Data from South Dakota Department of Revenue and Regulation, 2007 Annual Report.

Figure 2.3-8: South Dakota Property Tax Distribution, 2007

South Dakota provides property tax relief for agricultural and owner-occupied property owners by using a portion of its General Fund ($120 M in 2007) to pay school taxes for these taxpayers.

2.3.3.6 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.

2.3.3.7 Dwelling Types

Census 2000 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 2000 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 2.3-16 summarizes the Census 2000 housing data for the PAA, including owner-occupied (generally equivalent to for sale) and rental unit vacancy rates and seasonal/recreational/occasional use unit vacancy rates. Custer County has the highest seasonal unit vacancy rate (more than double Fall River and the two adjacent Wyoming counties), indicative of its proximity to the many recreational and scenic areas in the Black Hills.

Table 2.3-16: Proposed Action Area Housing Unit Statistics - 2000

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	3624	100%	3812	100%	1338	100%	3231	100%
Single family homes	2358	65.0%	2429	63.7%	1096	81.9%	2186	67.6%
Multi-unit housing	261	7.2%	568	14.9%	104	7.8%	203	6.3%
Mobile homes	990	27.3%	807	21.2%	133	9.9%	823	25.5%
Other (boat, RV, van, etc.)	15	0.4%	8	0.2%	5	0.4	19	0.6%
Rental units	615	17.0%	901	23.6%	222	16.7%	549	17.0
Owner-occupied vacancy	-	2.3%	-	4.8%	-	7.5%	-	4.8%
Rental vacancy	-	9.1%	-	9.6%	-	18.2%	-	12.0%
Seasonal / recreational / occasional use vacancy	-	10.1%	-	7.5%	-	4.7%	-	4.4%
Units lacking complete plumbing	26	0.9%	47	1.5%	17	1.7%	11	0.4%
Units lacking complete kitchen facilities	51	1.7%	49	1.6%	4	0.4%	13	0.5%
No telephone service	77	2.6%	123	3.9%	44	4.4%	113	4.3%

Data from US Census Bureau, Census 2000 Summary File 3 Dataset

At the time of the last census, the majority of residencies in all four counties were single-family owner-occupied homes on less than 10 acres of land.

Periodic estimations are made by the USCB to update the total number of housing units available within a given geography, based on building permits issued, mobile home shipments, and estimates of housing unit loss since the last census. The most recent housing unit estimation at the county level in South Dakota was in 2006; however data is not divided into housing unit types. Fall River County had an estimated 4,007 housing units in 2006 (United States Census Bureau [USCB]), an increase of 5.1 percent over Census 2000 data, although the county suffered an approximate 2 percent population decline over the same period (Section 2.2.1). In comparison, Custer County posted a 16.5 percent increase in housing units since 2000, with a total of 4,223 units in 2006. These data support economic forecasting that lists Custer County as one of South Dakota's 10 fastest-growing counties (Business Research Bureau, 2007).

The 2006 estimation data for the bordering Wyoming counties showed a much more modest increase in housing units since the last census, with an increase of 1.1 percent (15 additional units) in Niobrara County and an increase of 2.5 percent (81 additional units) in Weston County.

2.3.4 Environmental Justice

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

As shown in Table 2.3-17, minorities make up less than 7.0 and 11.0 percent of the total population for Custer and Fall River Counties, respectively, which is less than the state average of 12.0 percent. No concentration of minorities was identified to reside near the PAA, which is located in a rural area, while most of the minority population lives urban centers such as Custer City (Census Tract 9952) or Hot Springs (Census Tract 9942).

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

2000 poverty level of $17,603 for a family of four, while the average of Custer Counties two census tracts was well above the State's average. The poverty rate in Custer County was 9.4 percent and 13.6 percent in Fall River County. Compared to the state-wide average of 13.2 percent, Fall River's poverty rate is only slightly higher, while Custer County is well below the state-wide 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 (USCB, 2000).

Table 2.3-17: Race and Poverty Characteristics for Areas Surrounding the Dewey-Burdock Project

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

Data from U.S. Census Bureau, Census 2000.

Per capita income level based on 1999 dollars was 17,945 for Custer County and $17,048 for Fall River County; these numbers are near the State average of $17,562. The median income in 2000 was $36,303 for Custer County and $29,631 Fall River compared with $35,282 for the State average, all well above the 2006 poverty level of $20,614 for a family of four members household. The poverty rate in Custer County was 9.4 percent and 13.6 percent in Fall River County. Compared to the state-wide average of 13.2 percent, Fall River's poverty rate is only slightly higher, while Custer County is well below the state-wide; therefore, there is not 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 proposed 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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2.4 Historic, Scenic and Cultural Resources

2.4.1 Historic Archeological, and Cultural Resources

A Level III Cultural Resources Evaluation was conducted for the PAA. 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).

Augustana documented 161 previously unrecorded archaeological sites and revisited 29 previously recorded sites within the PAA 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 PAA in relation to the Black Hills proper. The disparity existing between the number of historic and prehistoric sites observed in the PAA is also not unexpected; however, the sheer volume of sites documented in the area is noteworthy. The land evaluated as part of the Level III cultural resources evaluation has an average site density of approximately 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 PAA, 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 PAA 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 PAA. 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)

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 PAA 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 PAA 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.

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.

Table 2.4-2: Scenic Quality Inventory and Evaluation of the SQRU 001 for the Proposed Action Area

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 for the Proposed Action Area

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

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 PAA 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

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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 proposed 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 PAA 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 advected 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 PAA, 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. To determine whether this period of data collection (July 18, 2007, to July 17, 2008) was representative of long-term meteorological conditions, weather data from the nearest National Weather Service (NWS) site at Chadron, Nebraska, for the same period was compared to data collected at the site from years 1978–2007.

The data compiled from several sites (listed in Table 2.5-1 and shown in Plate 2.5-1) surrounding the PAA from the High Plains Regional Climate Center (HPRCC) and South Dakota State University (SDSU) was used to represent the long-term meteorological conditions of the project region. All the sites were used to characterize regional trends of temperature and precipitation along with growing, heating, and cooling degree days. Only the SDSU sites had sufficient data available to analyze regional patterns of humidity, and only the Oral, South Dakota, site had adequate data to characterize wind speed/direction and evapotranspiration.

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*	*Y*	*Z* (ft)	Years of Operation
Redbird	NCDC[(a)]	10,417	4,315	3,890	1948–2006
Oral	SDSU[(b)]	10,316	4,324	2,960	1971–2007
Oelrichs	NCDC	10,314	4,311	3,340	1948–2007
Newcastle	NCDC	10,414	4,351	4,380	1918–2006
Edgemont	NCDC	10,349	4,318	3,440	1948–2007
Custer	NCDC	10,336	4,346	5,330	1926–2007
Ardmore	NCDC	10,339	4,304	3,550	1948–2007
Angostura	NCDC	10,326	4,322	3,140	1948–2007
Jewel Cave	SDSU	10,349	4,343	5,298	2004–2008

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

(a) National Climatic Data Center.

(b) South Dakota State University Climate Web site.

2.5.2 Regional Overview

Meteorological data from the NWS site at Chadron, Nebraska, were collected from the HPRCC and analyzed to determine whether the past year's data (July 18, 2007, to July 17, 2008) was representative of long-term meteorological conditions (January 1, 1978, to July 17, 2008) in the area. The parameters analyzed were average daily temperature, wind speed, and precipitation.

The average daily temperature over the last (current) year was 47.8°F, which is slightly cooler than the 30-year average (historic) daily temperature of 50.5°F. Figure 2.5-1 displays a boxplot of the current and historic temperature data. The interquartile range for the current data is from 30.3°F to 64.5°F with a median value of 48.2°F, compared to the historic data that has an interquartile range from 35.3°F to 68.3°F and a median value of 50.5°F. When looking at the data on a month-by-month basis, the mean value of the current data lies within one standard deviation of the mean value of the historic data (see Appendix 2.5-A).

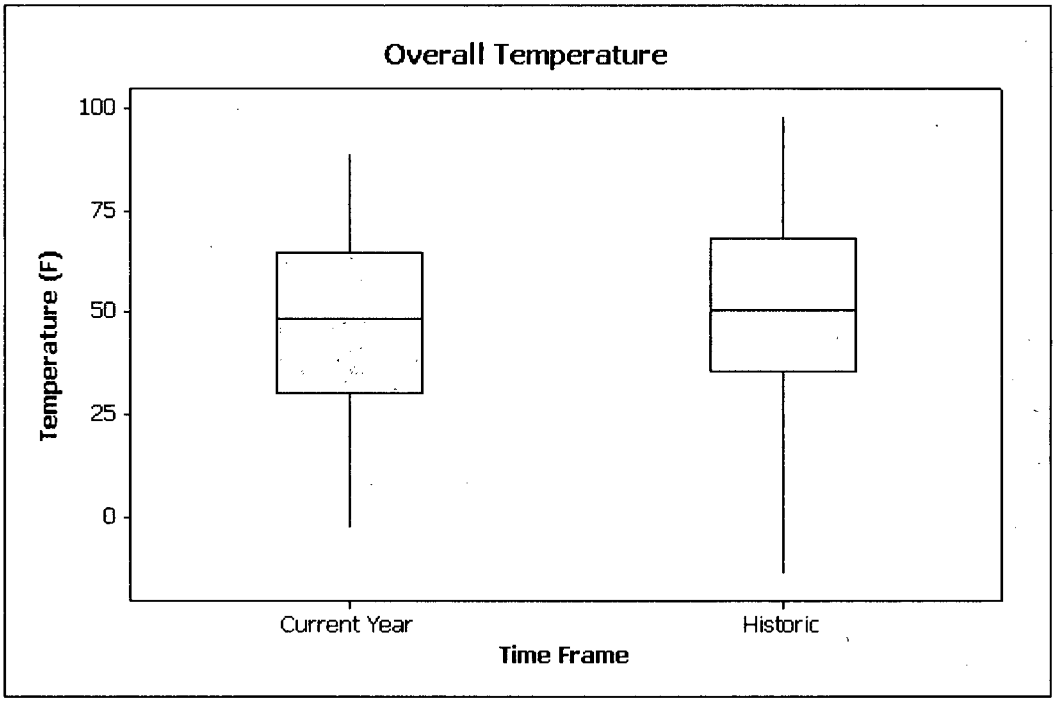


Figure 2.5-1: Temperature at Chadron, Nebraska, National Weather Service Site

The average daily wind speed over the current year was approximately 1 mile per hour (mph) less than historically (9.8 to 10.8 mph). Figure 2.5-2 displays a boxplot of monthly wind speed for the current and historic data. The median value lies with the interquartile range for all months.

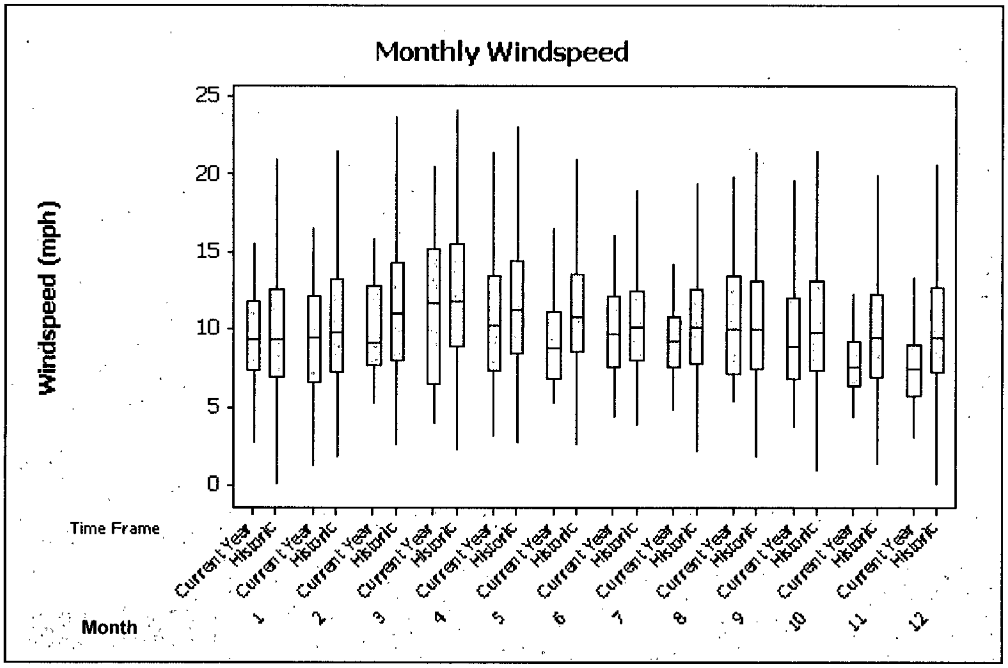
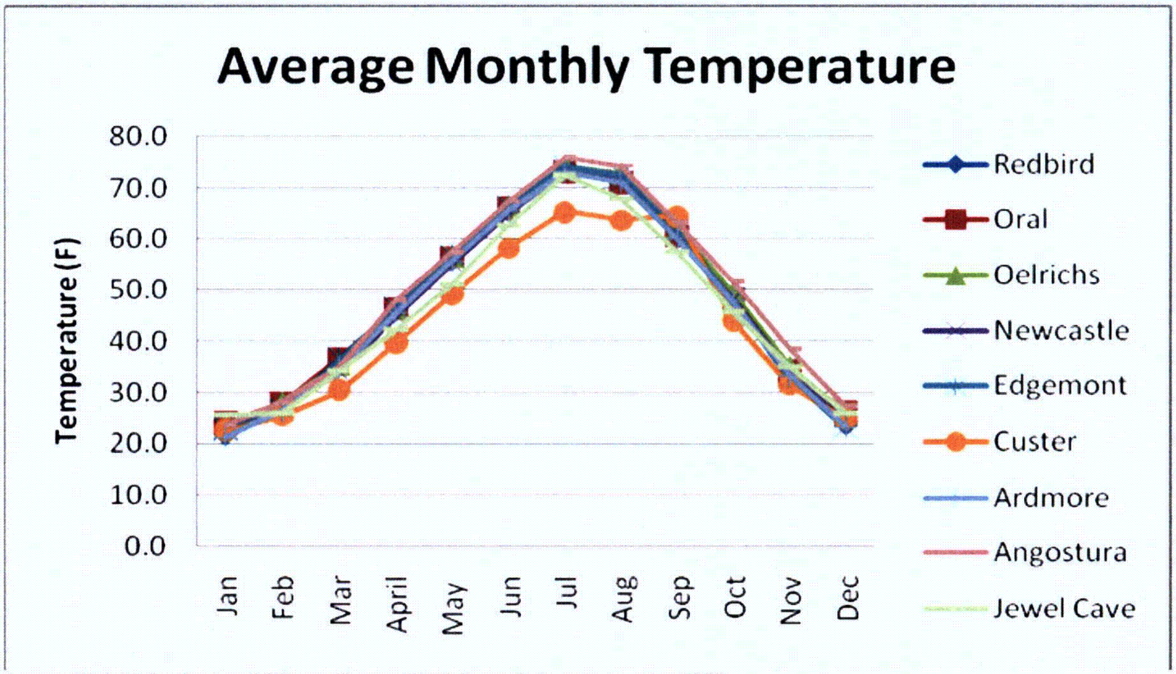


Figure 2.5-2: Monthly Wind Speed at Chadron, Nebraska, National Weather Service Site

The current year had well above the average amount of yearly precipitation. The current year had 32.8 inches of precipitation compared to the average yearly historic precipitation of 18.2 inches.

2.5.2.1 Temperature

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 University, 2008

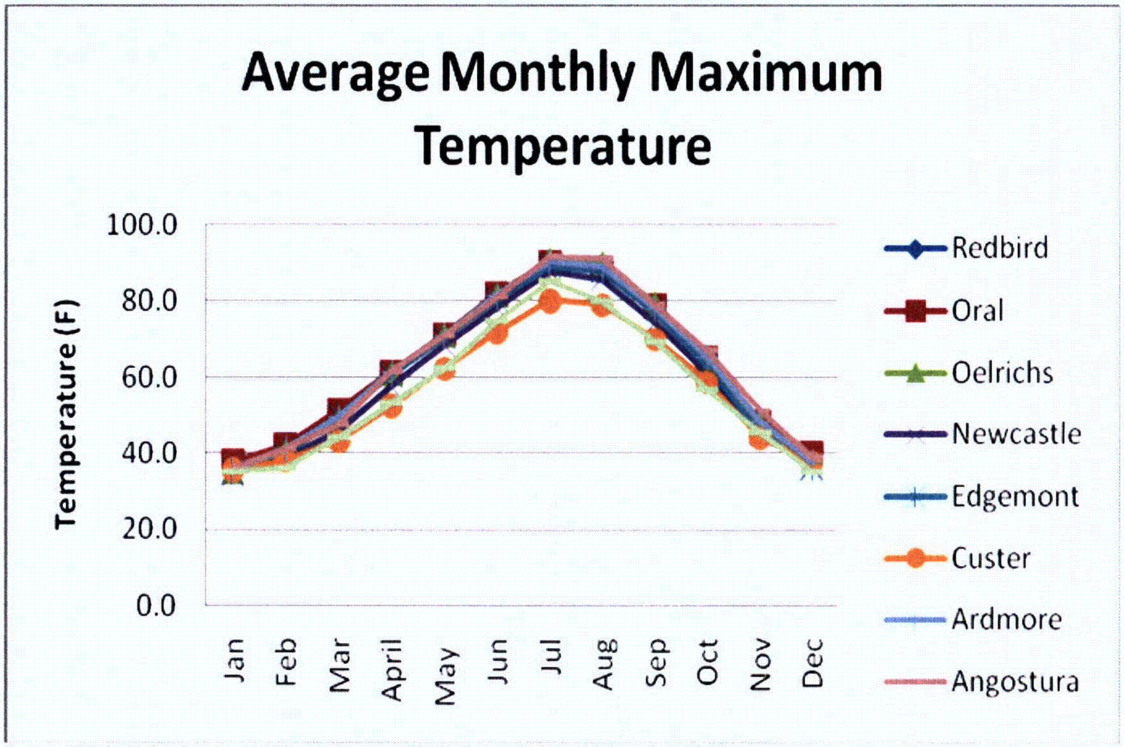
Figure 2.5-3: Average Monthly Temperatures for Regional Sites

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

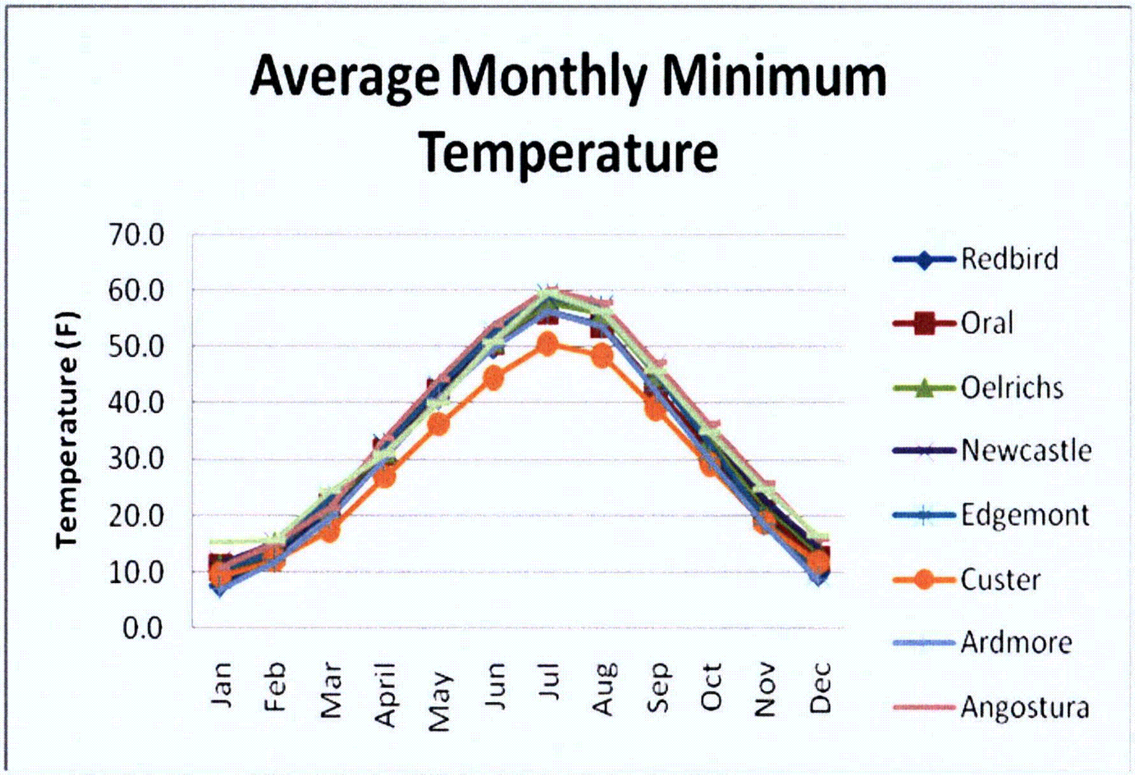
Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

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



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

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



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

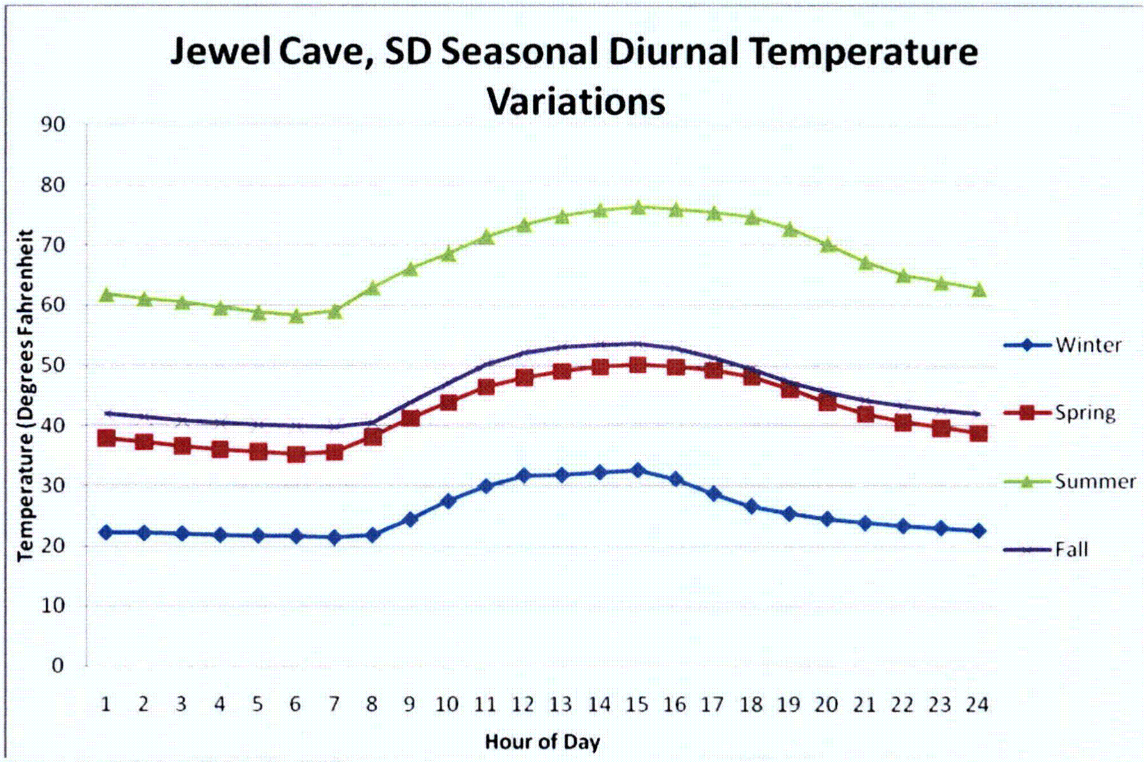
Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

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

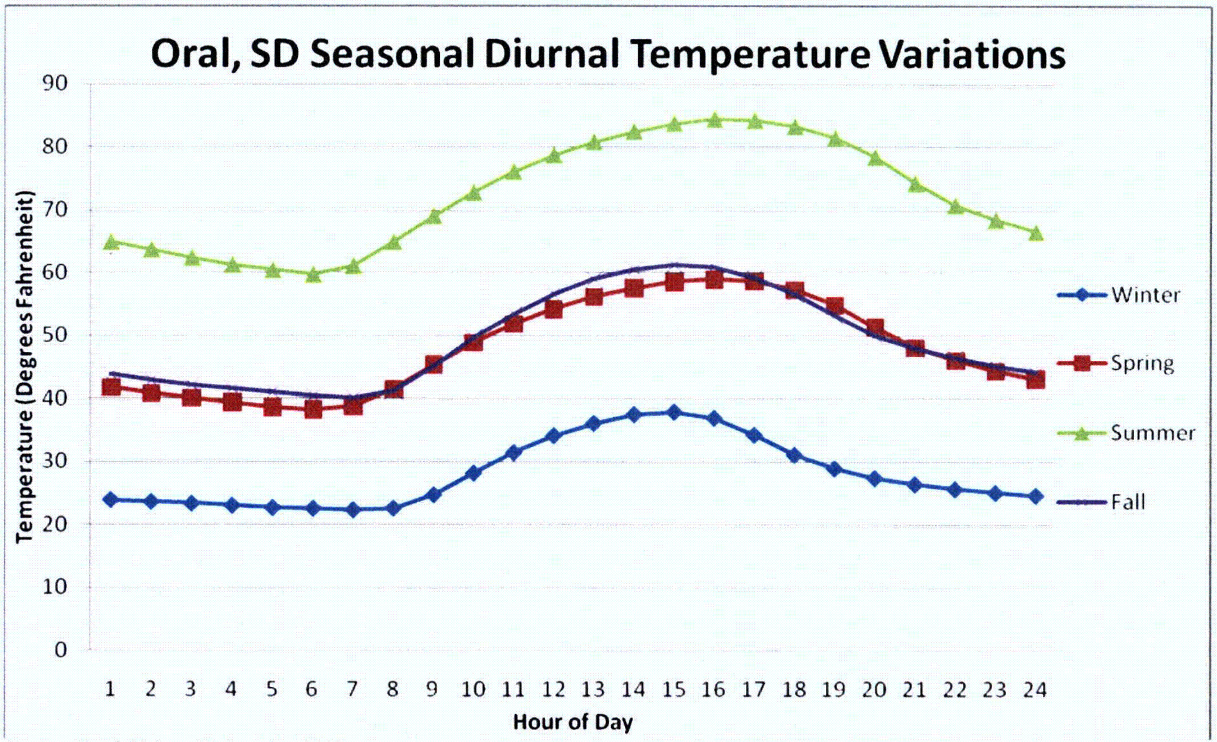
Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

Figures 2.5-6 and 2.5-7 display diurnal temperature variations by season for the Jewel Cave and Oral sites. These sites were used because they were the only sites that recorded hourly temperatures near the project. As the figures show, there are large variations in diurnal temperature, especially during the summer months.



Source: South Dakota University, 2008

Figure 2.5-6: Jewel Cave, South Dakota, Seasonal Diurnal Temperature Variations

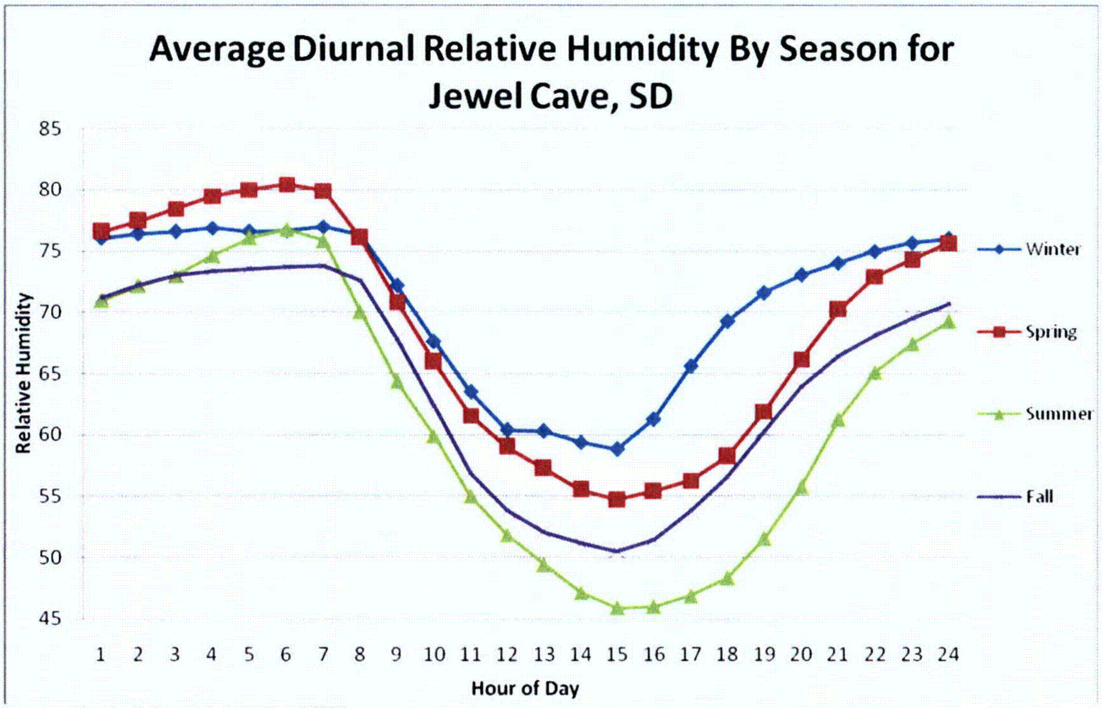


Source: South Dakota University, 2008

Figure 2.5-7: Oral, South Dakota, Seasonal Diurnal Temperature Variations

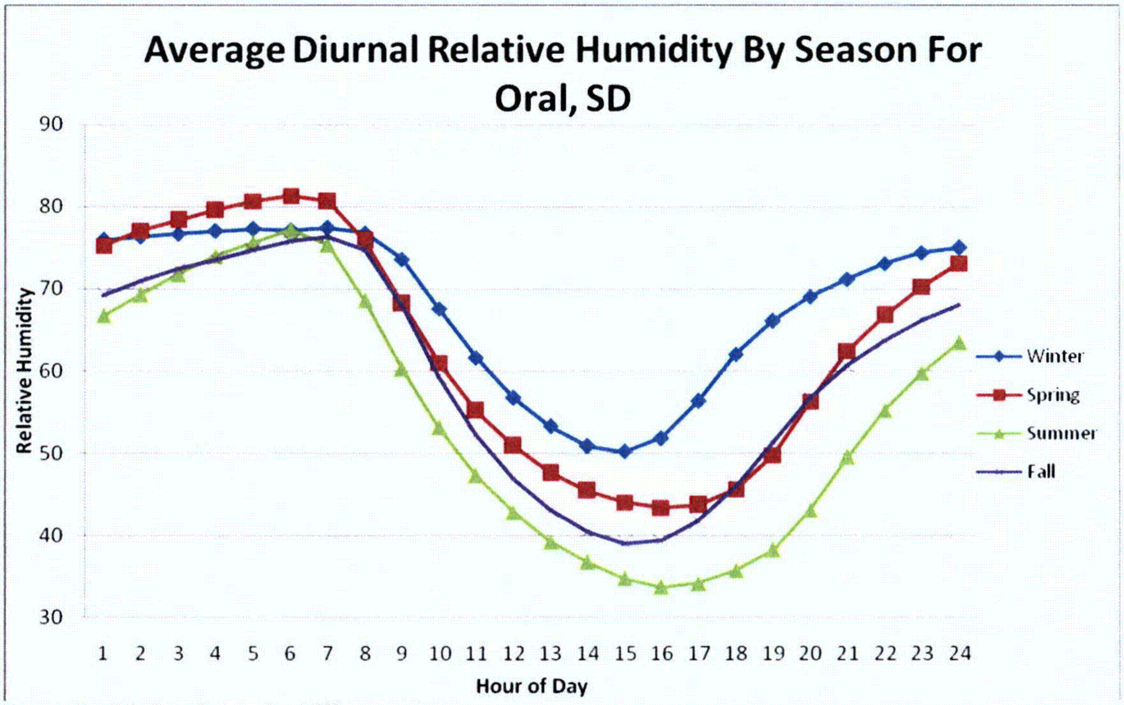
2.5.2.2 Relative Humidity

Relative humidity measures the fraction of moisture in the air to saturated moisture content at a certain temperature. This parameter was analyzed for both the Jewel Cave and Oral sites. Figures 2.5-8 and 2.5-9 display the relationship of relative humidity to the season and time of day for each site. The figures show that the summer has the lowest relative humidity, averaging 60 percent, while winter has the highest relative humidity, averaging 69 percent.



Source: South Dakota University, 2008

Figure 2.5-8: Average Diurnal Relative Humidity by Season for Jewel Cave, South Dakota



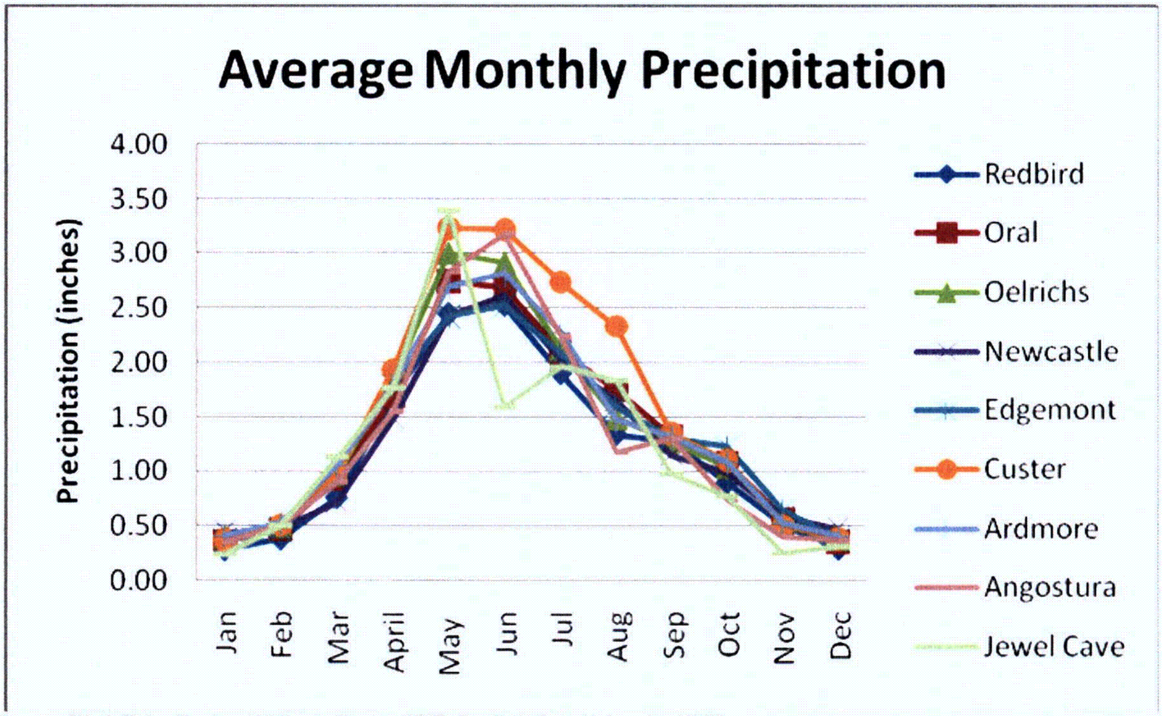
Source: South Dakota University, 2008

Figure 2.5-9: Average Diurnal Relative Humidity by Season for Oral, South Dakota

The relative humidity in this region peaks out in the morning at around 6 a.m. with the minimum falling in the afternoon around 3 p.m. The readings during the peak time average 77 percent at Jewel Cave and 78 percent at the Oral site. The readings with the lowest relative humidity during the day average 53 percent and 42 percent at Jewel Cave and Oral, respectively.

2.5.2.3 Precipitation

Figure 2.5-10 and Table 2.5-5 show that 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 accumulation of 2.8 inches. Winter receives roughly 8 percent of the annual accumulated precipitation. January is the driest month of the year with an average accumulation of 0.36 inch of precipitation.



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

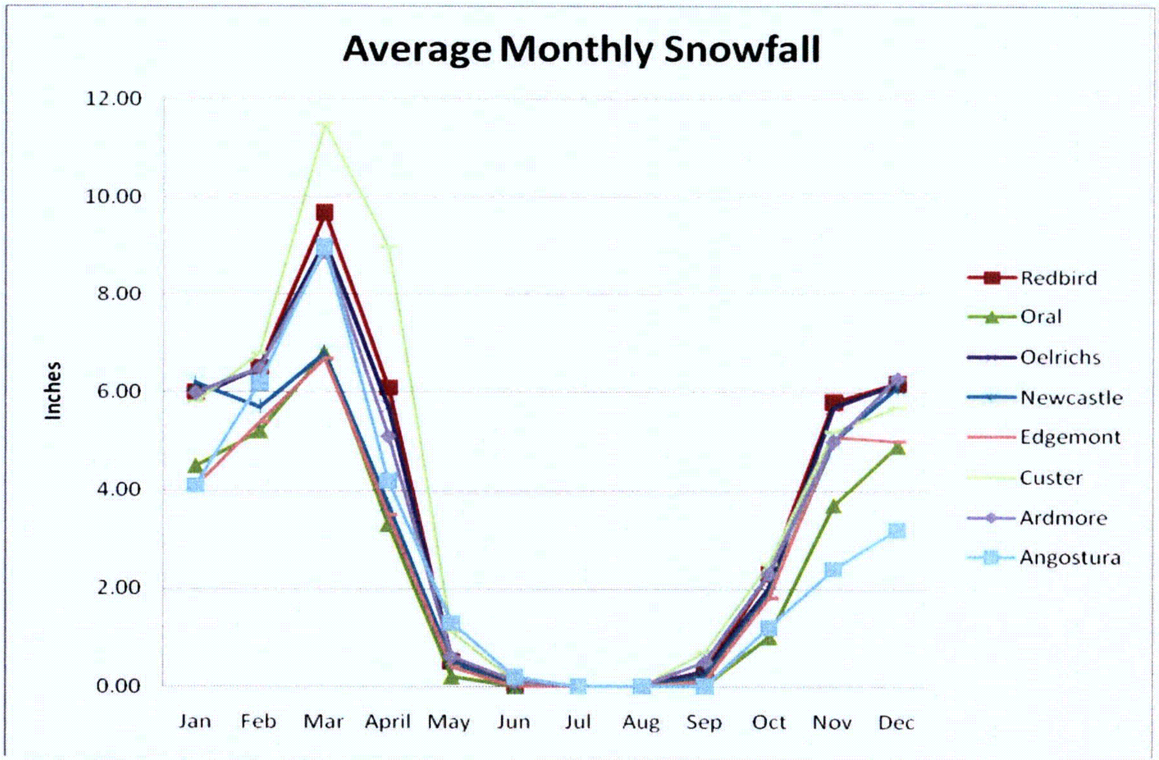
Figure 2.5-10: Average Monthly Precipitation for Regional Sites

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

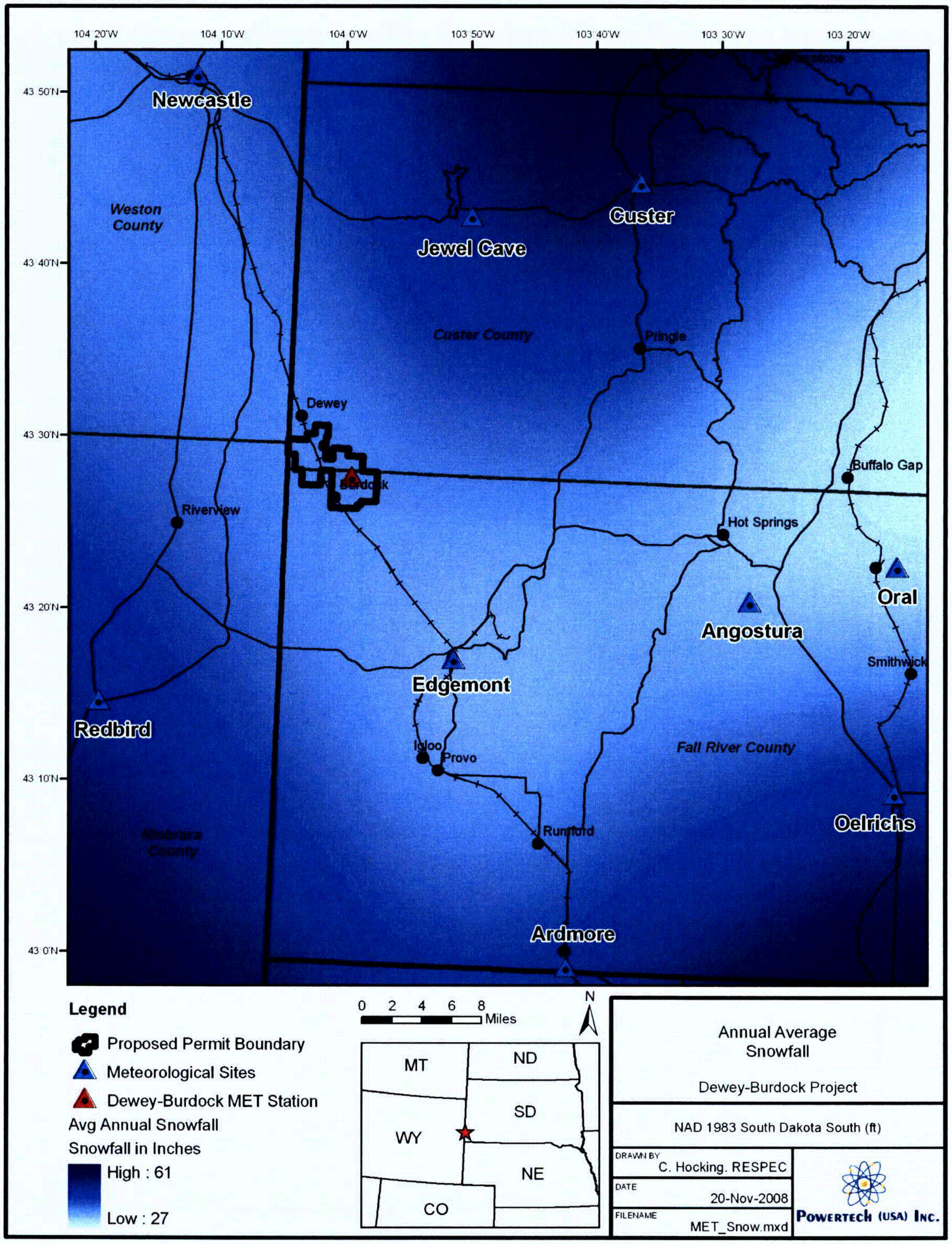
Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

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 Black Hills that surround it (Figure 2.5-12).



Source: South Dakota University, 2008

Figure 2.5-11: Average Monthly Snowfall at Regional Sites

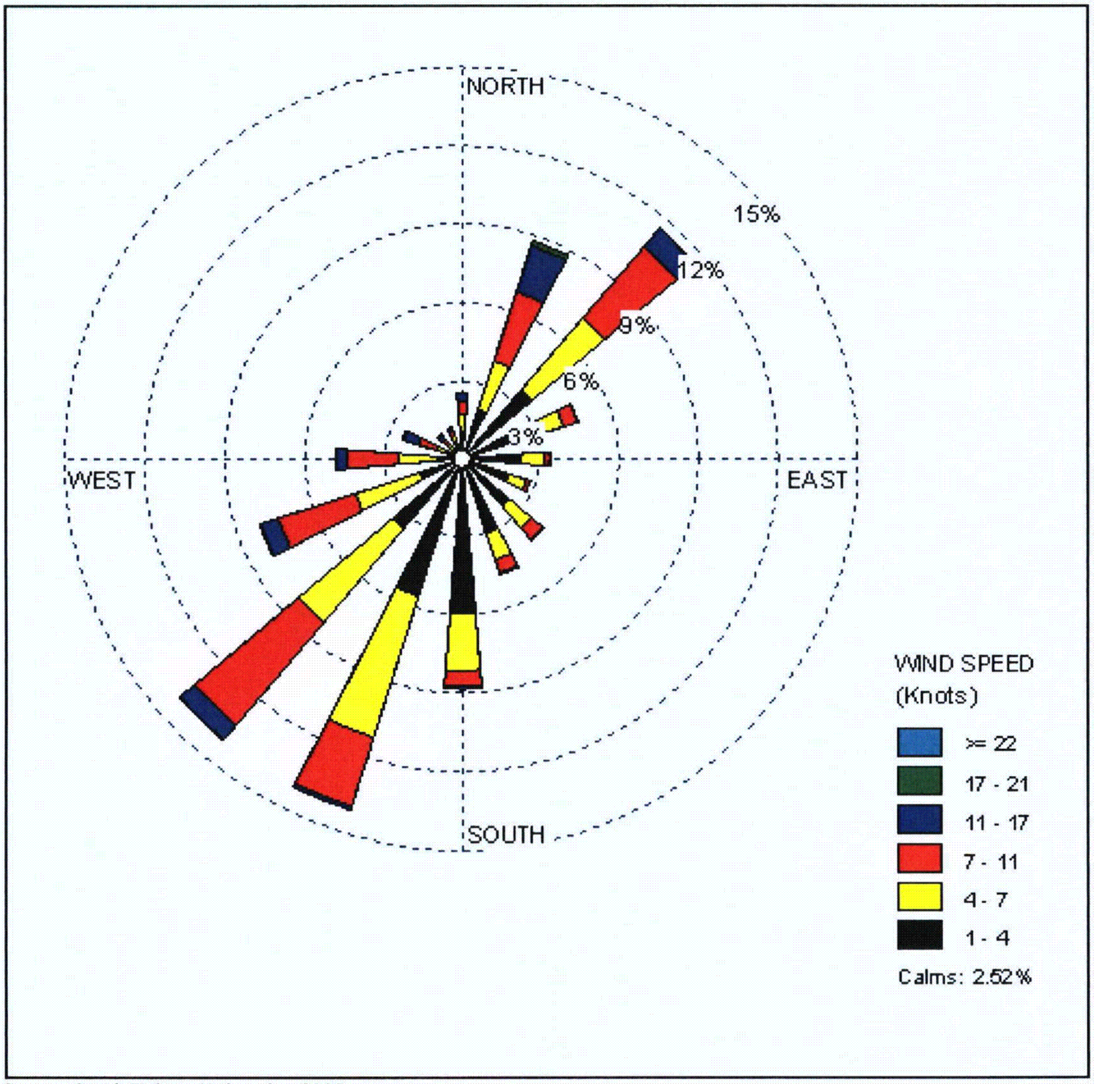


Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

Figure 2.5-12: Average Snowfall Accumulation throughout the Region

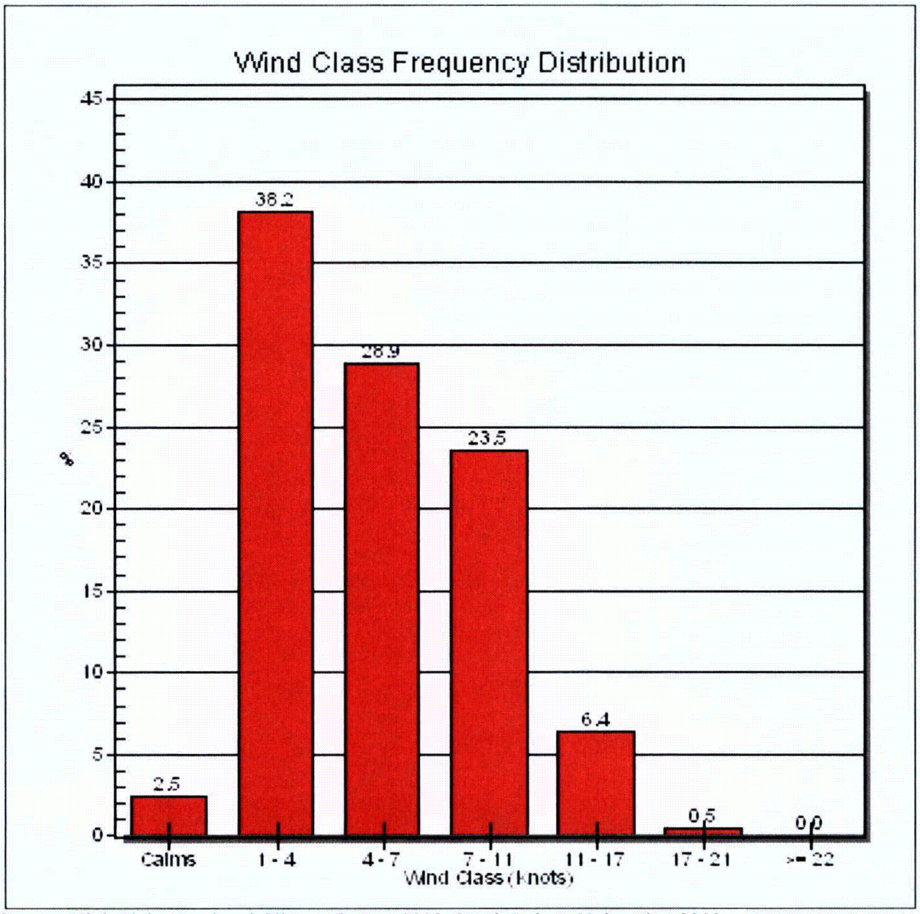
2.5.2.4 Wind Patterns

The Oral site was the only site in the region with representative data for wind speed and direction. The wind speed averaged 6.4 mph over the entire period of record with approximately 51 percent of the winds blowing from the southwest (Figure 2.5-13). Over 38 percent of the wind is between 1.2 and 4.6 mph (1 to 4 knots) with calm winds (less than 1.2 mph or 1 knot) occurring 2.5 percent of the time (Figure 2.5-14).



Source: South Dakota University, 2008

Figure 2.5-13: Wind Rose, Oral, South Dakota

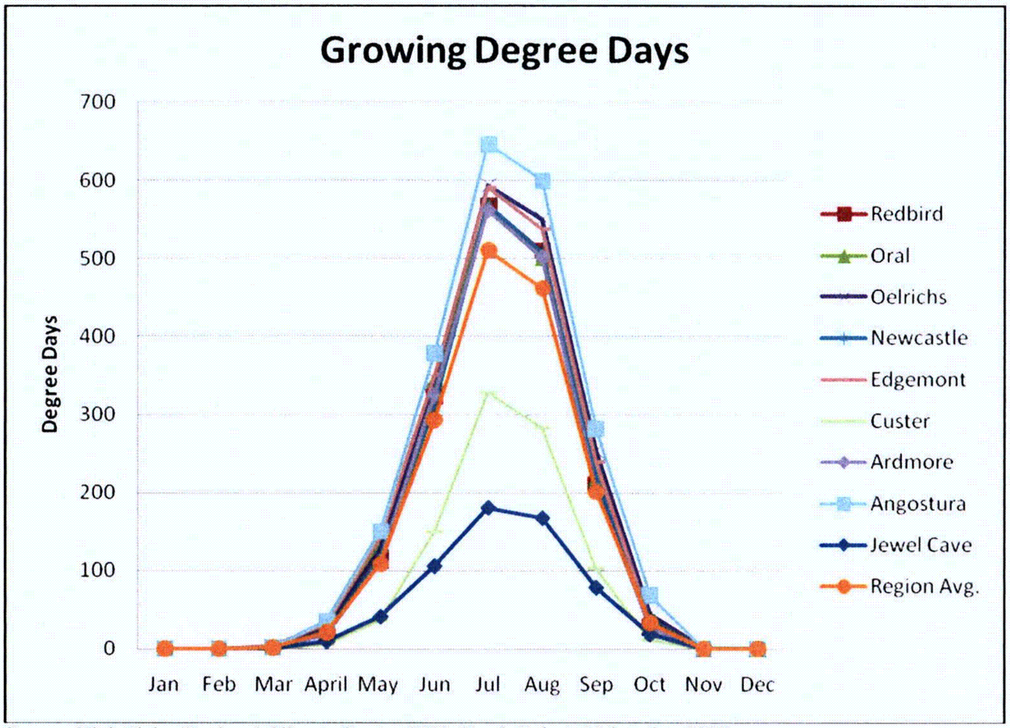


Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

Figure 2.5-14: Wind Class Frequency Distribution for Oral, South Dakota, From November 2002 – July 2008

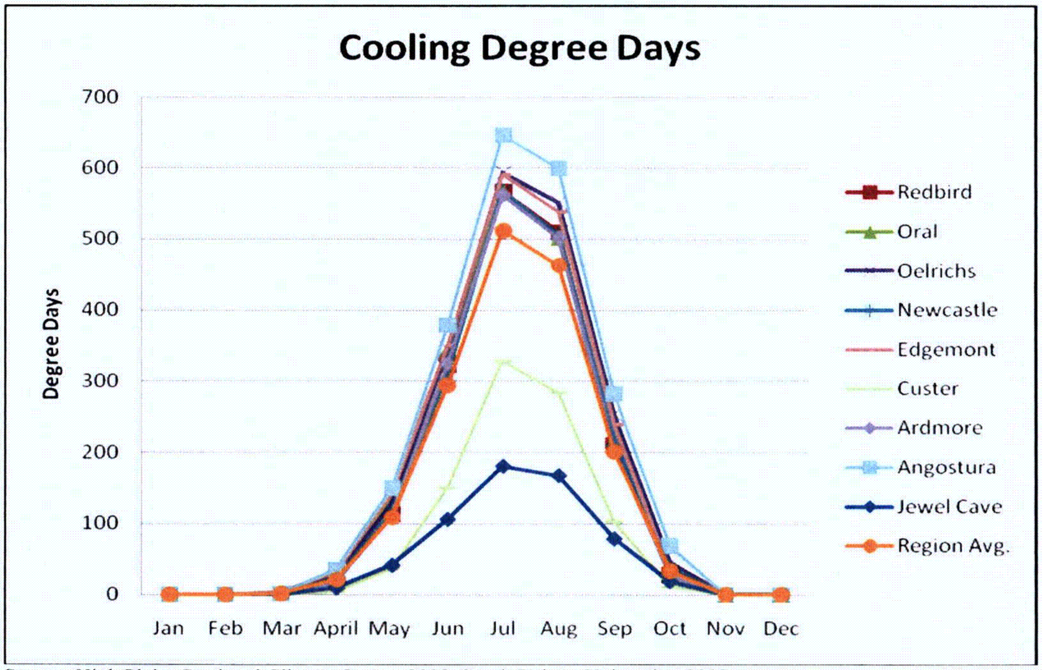
2.5.2.5 Cooling, Heating and Growing Degree Days

The graphs shown in Figures 2.5-15, 2.5-16, and 2.5-17 summarize the growing degree, cooling, and heating 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.



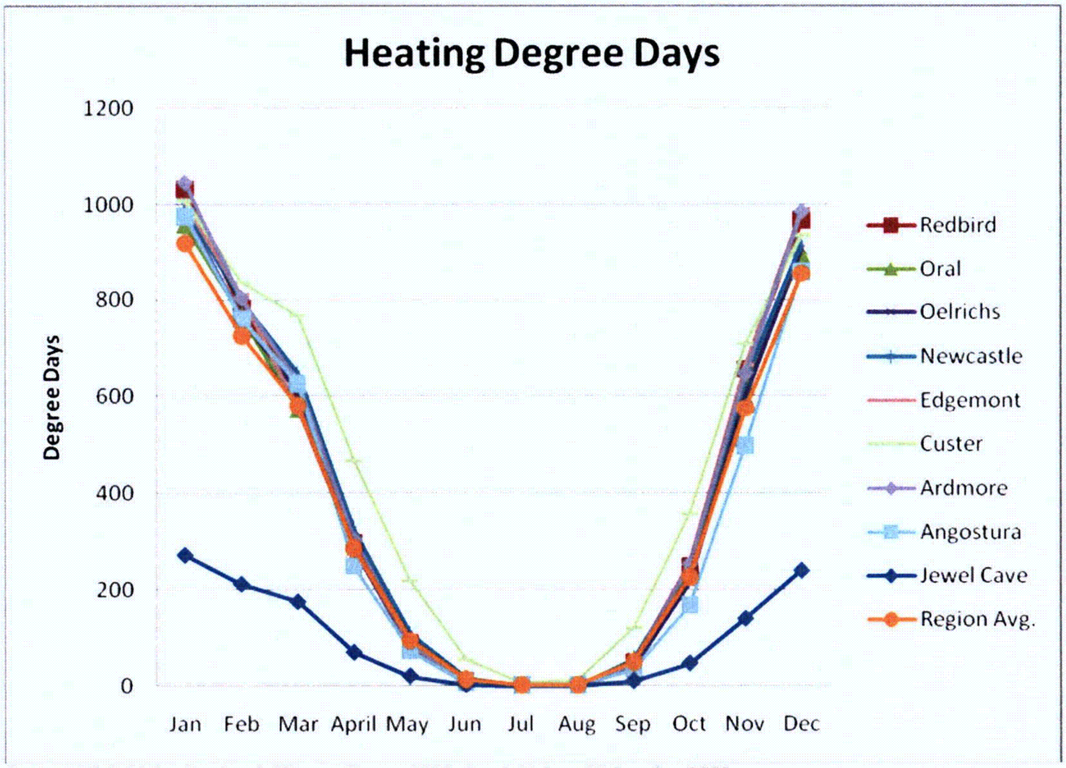
Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

Figure 2.5-15: Growing Degree Days for Regional Sites



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

Figure 2.5-16: Cooling Degree Days for Regional Sites



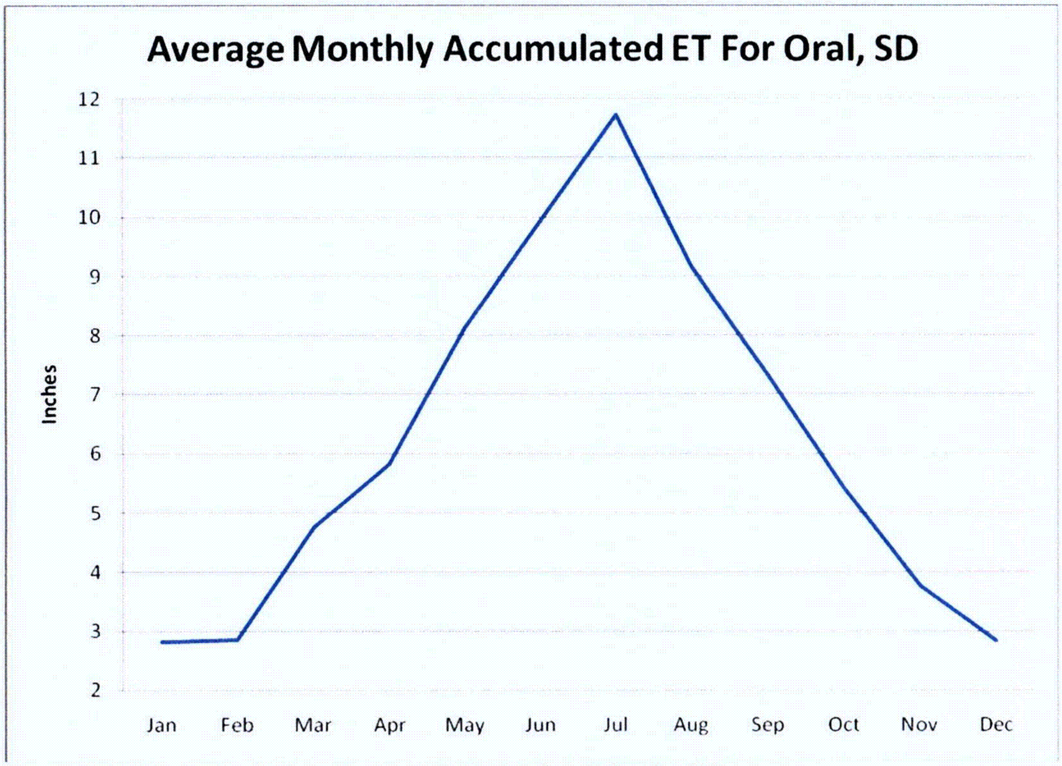
Source: High Plains Regional Climate Center, 2008; South Dakota University, 2008

Figure 2.5-17: Heating Degree Days for Regional Sites

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 2.5-18 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: High Plains Regional Climate Center, 2008; South Dakota University, 2008

Figure 2.5-18: Average Monthly Accumulated Evapotranspiration for Oral, South Dakota

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 proposed 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.

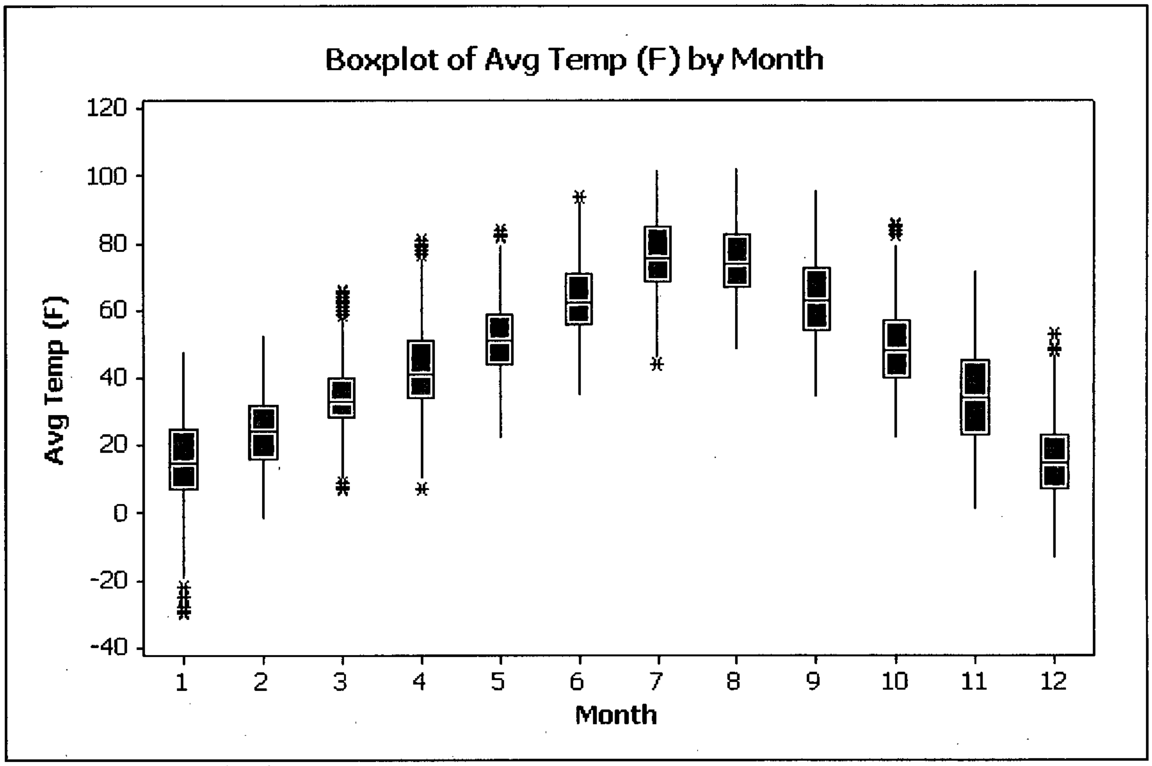
This site was installed in cooperation with the South Dakota State Climatology office according to the standards they use to install their Automatic Weather Data Network (AWDN) stations. The parameters being sampled at the site are air temperature, solar radiation, humidity, precipitation, and wind speed/direction at both 3- and 10-meter heights (9.8 and 32.8 feet). Table 2.5-6 lists the model number and specifications of the sensors that were installed. The accuracy of all the sensors used is within the standards required by the NRC. All results of the statistical analysis, completed using Minitab software version 14.0 for the parameters analyzed, are included in Appendix 2.5-B.

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

Measurement	Model	Manufacturer	Accuracy	Operating Temperature
Precipitation	VR6101	Vaisala	0.01 inch	–40°C to 60°C
Wind Direction	024A	Met-One	±5 degrees	–50°C to 70°C
Wind Speed	014A	Met-One	0.25 mph (0.11 m/s)	–50°C to 70°C
Temperature and RH	HMP45C	Vaisala	±2% for 10–90% RH; ±3% of 90–100% RH	–40°C to 60°C
Solar Radiation	L1200X	Lt-Cor	Absolute error in natural daylight is ±5% max; ±3% typical	–40°C to 65°C

2.5.3.1 Temperature

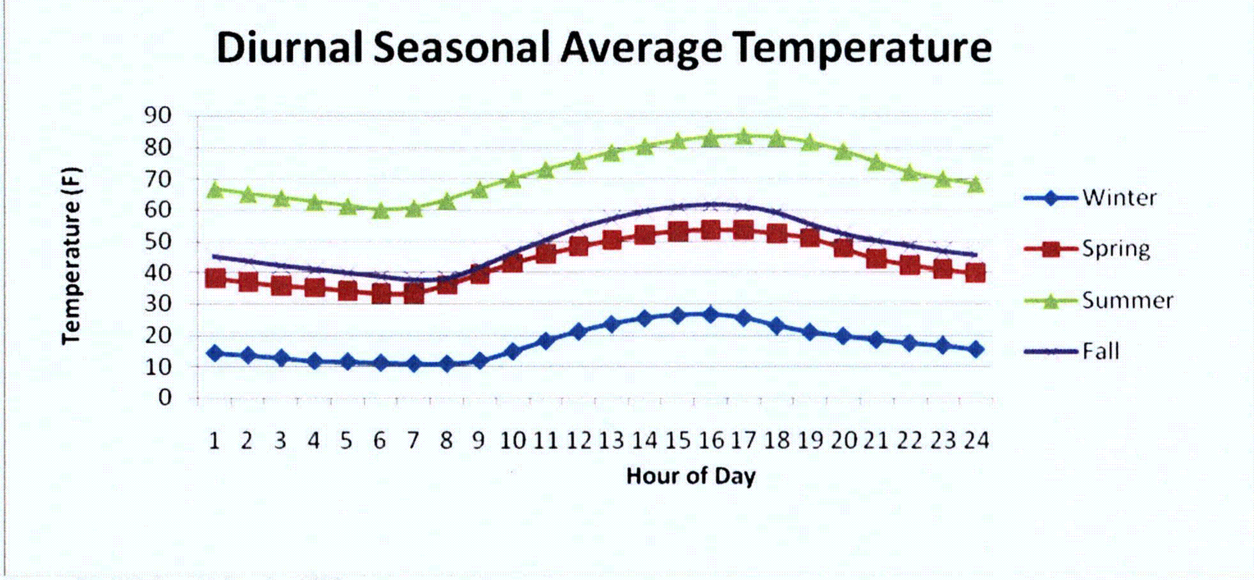
The average hourly temperature over the year for the site was 45.5°F. A maximum temperature of 104°F was reached on both July 21, 2007, and August 13, 2007, while the minimum temperature for the period of record was –28°F on January 22, 2008. A boxplot of the average temperature by month is shown in Figure 2.5-19. 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 University, 2008

Figure 2.5-19: Average Temperature (Degrees Fahrenheit) by Month from the Project Meteorological Site

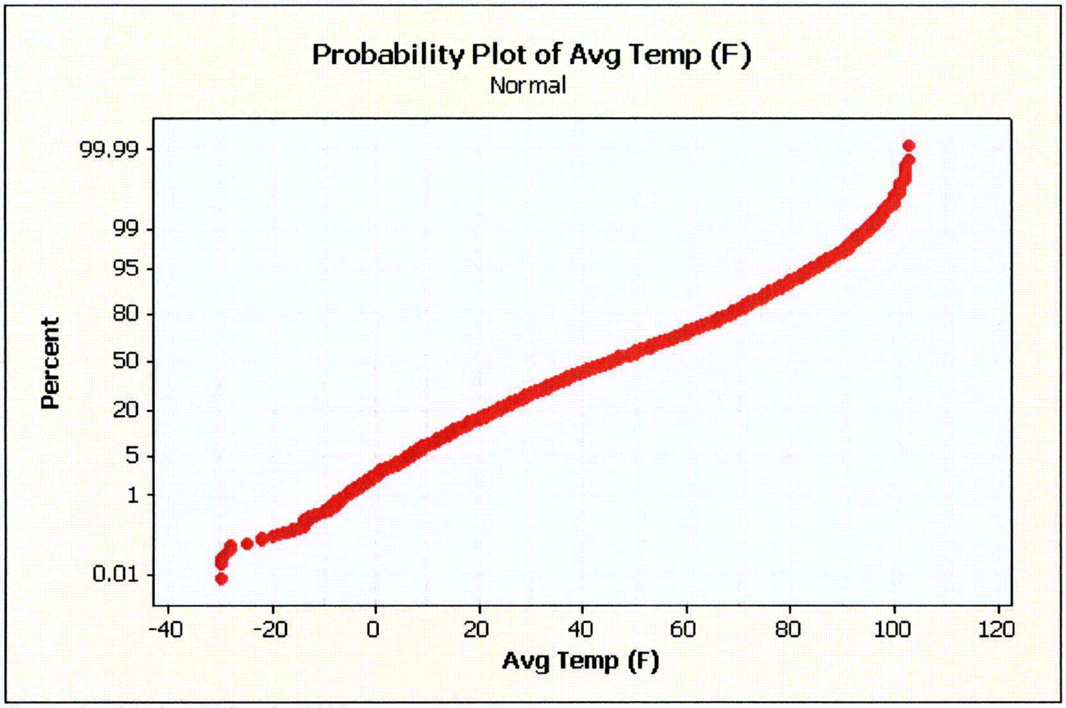
There were large variations in seasonal and diurnal temperature (Figure 2.5-20). In the summer season, average temperatures were as low as 60°F at 6 a.m. to 83.6°F at 5 p.m. In the winter season, temperatures varied from an average of 11°F between 7 a.m. and 8 a.m. and rose to nearly 27°F at 4 p.m. The 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 University, 2008

Figure 2.5-20: Diurnal Average Temperature for the Project Meteorological Site by Season

Figure 2.5-21 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 of 32°F 31 percent of the time.



Source: South Dakota University, 2008

Figure 2.5-21: Probability Plot of Average Temperature From the Project Meteorological Site

2.5.3.2 Wind Patterns

Wind speed and direction was measured in the field using Met-One 014A and 024A model sensors. Statistical analysis and visualization of wind data were performed using WRPLOT View Version 5.3 distributed by Lakes Environmental. All data analysis outputs are included in Appendix 2.5-C. The average wind speed over the period of record was approximately 5 mph, while calm winds occurred only 1.8 percent of the time.

As shown in Table 2.5-7, a majority of the winds (51 percent) come from the southeast and approximately 55 percent of all winds were less than 4.6 mph. December had the least amount of wind with 7.66 percent of the total winds being classified as calm and having an average wind speed of 2.8 mph. In contrast, May was the windiest month with only 0.41 percent of calm winds and an average wind speed of 6.9 mph. Southeasterly winds were prevalent in the winter months (38 percent of total shown in Figure 2.5-22) as well as the summer months (56 percent of total shown in Figure 2.5-23).

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

Frequency Distribution (Normalized)							
Wind Direction	Knots						
	1–4	4–7	7–11	11–17	17–21	≥ 22	Total
348.75–11.25	0.000345	0.000115	0.000000	0.000000	0.000000	0.000000	0.000459
11.25–33.75	0.002526	0.000804	0.000459	0.000115	0.000000	0.000000	0.003904
33.75–56.25	0.012517	0.003790	0.003790	0.000804	0.000230	0.000230	0.021360
56.25– 78.75	0.028250	0.016996	0.021475	0.003330	0.000459	0.000000	0.070510
78.75–101.25	0.057074	0.037322	0.018489	0.001263	0.000000	0.000000	0.114148
101.25– 123.75	0.069936	0.025609	0.011713	0.000000	0.000000	0.000000	0.107258
123.75–146.25	0.070740	0.022738	0.007350	0.000115	0.000115	0.000000	0.101056
146.25–168.75	0.071199	0.015618	0.001378	0.000345	0.000000	0.000000	0.088539
168.75–191.25	0.057533	0.004364	0.000459	0.000230	0.000000	0.000000	0.062586
191.25–213.75	0.035829	0.004364	0.000345	0.000115	0.000000	0.000000	0.040652
213.75–236.25	0.035140	0.005397	0.002182	0.001034	0.000000	0.000000	0.043753
236.25– 258.75	0.030202	0.006890	0.004593	0.001493	0.000115	0.000000	0.043294
258.75– 281.25	0.032269	0.014469	0.004364	0.001952	0.000000	0.000000	0.053055
281.25–303.75	0.027905	0.034566	0.019982	0.002986	0.000000	0.000000	0.085439
303.75–326.25	0.017570	0.040652	0.052710	0.015962	0.000230	0.000000	0.127124
326.25–348.75	0.004364	0.006546	0.006775	0.001263	0.000115	0.000000	0.019063
Subtotal	**0.553399**	**0.240239**	**0.156063**	**0.031006**	**0.001263**	**0.00023**	**0.973702**
Calms							**0.017646**
Missing/Incomplete							**0.008652**
Total							**1.000000**

Source: South Dakota University, 2008

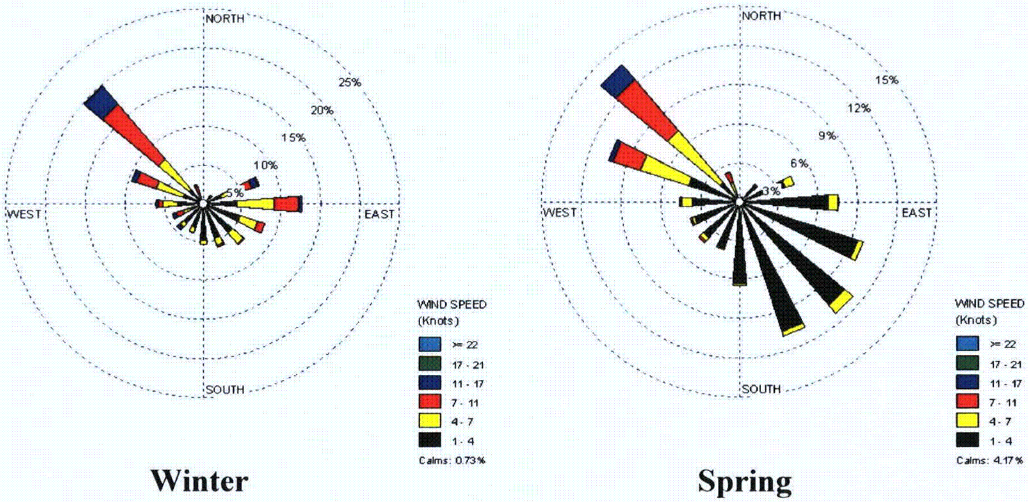


Figure 2.5-22: Winter and Spring Wind Roses

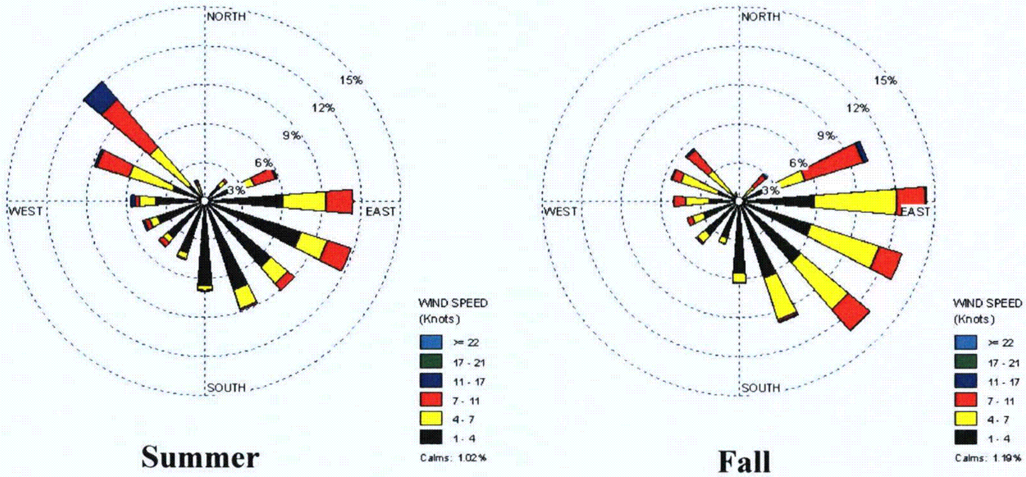
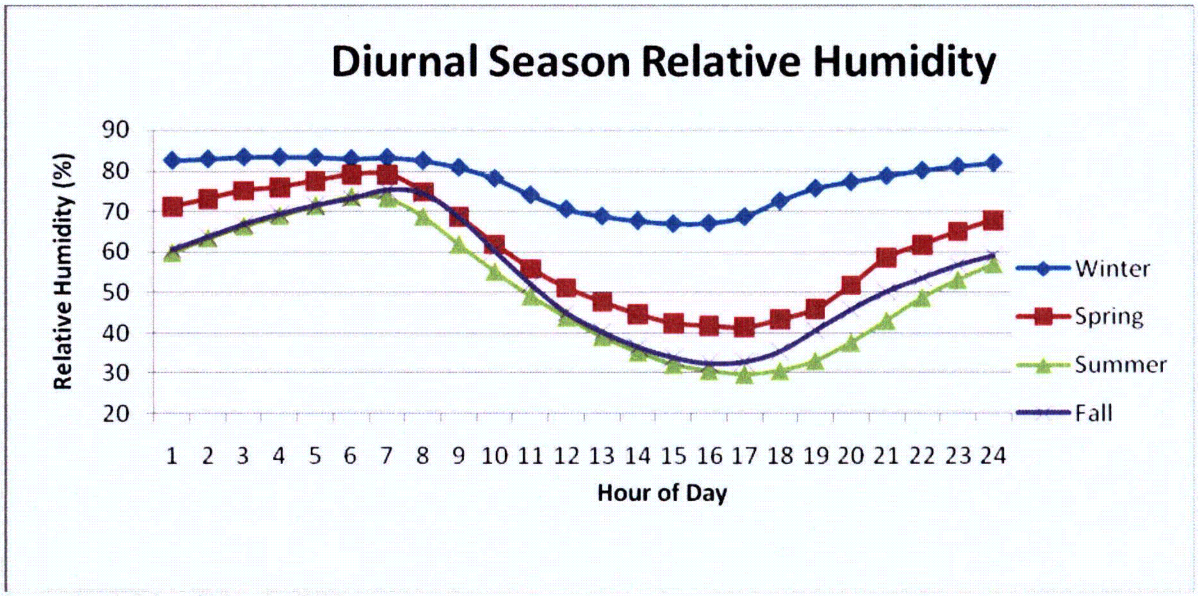


Figure 2.5-23: Summer and Fall Wind Roses

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 2.5-24). During the winter months, the diurnal relative humidity range was much less because of less intense and shorter duration solar radiation.

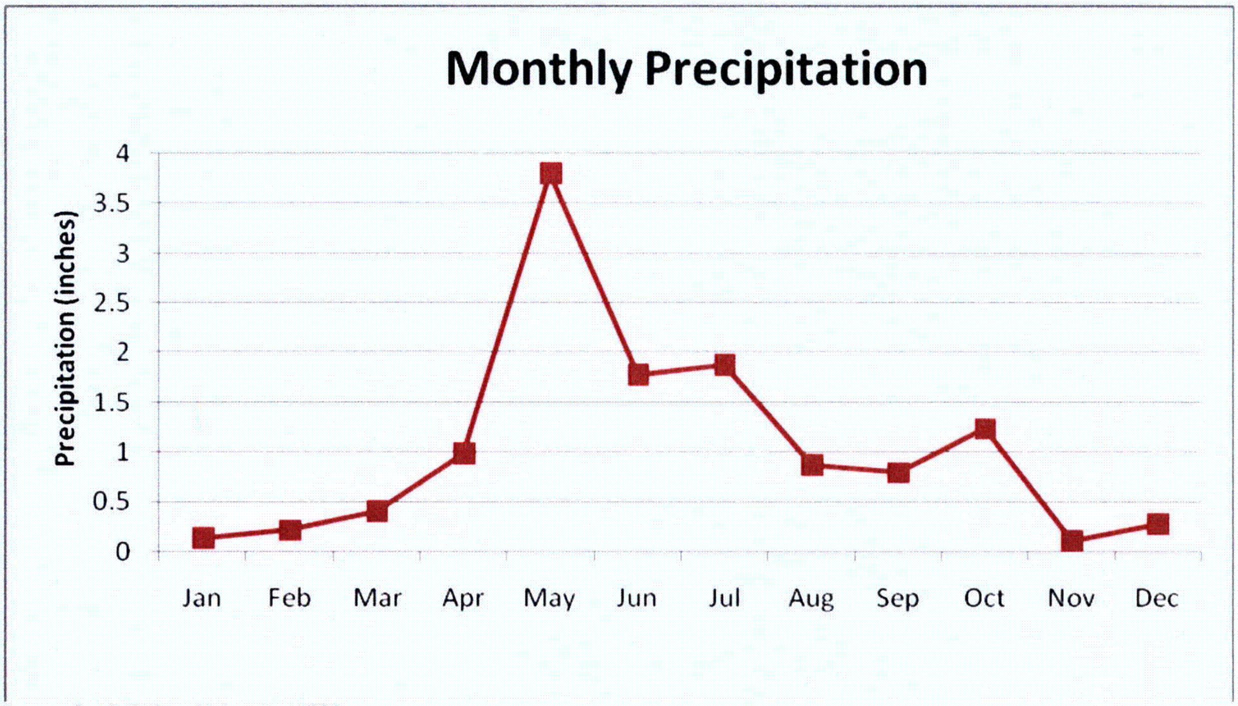


Source: South Dakota University, 2008

Figure 2.5-24: 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 2.5-25 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.

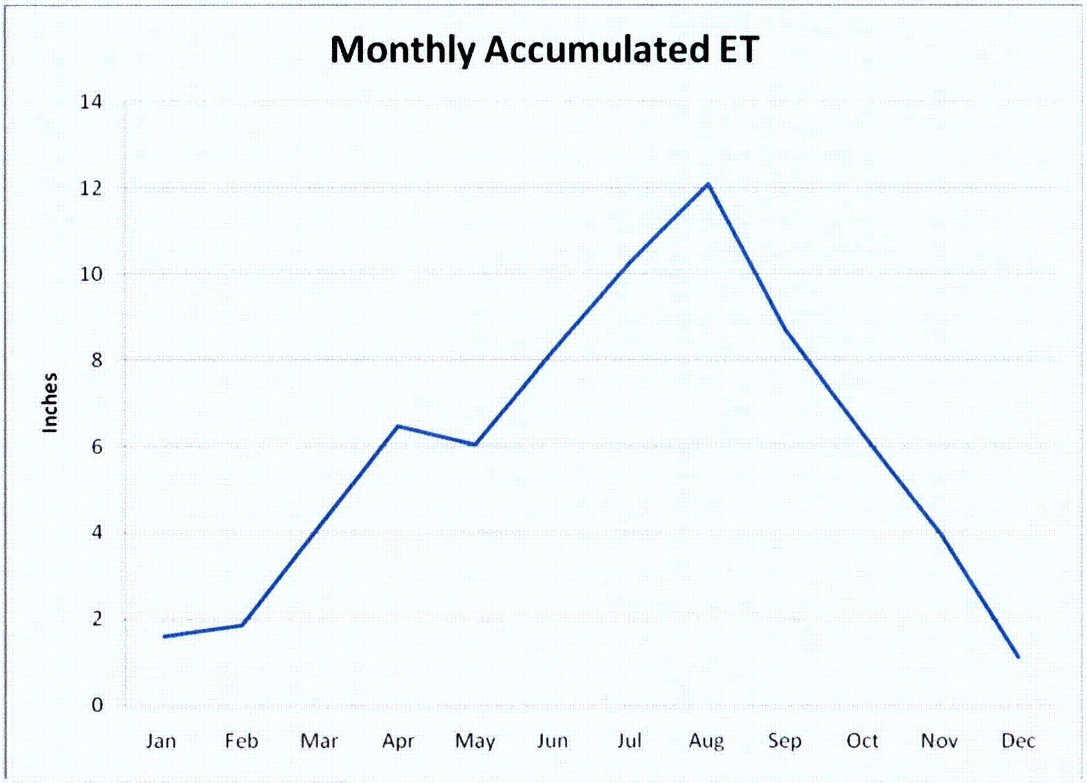


Source: South Dakota University, 2008

Figure 2.5-25: 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 2.5-26) 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 University, 2008

Figure 2.5-26: Estimated Evapotranspiration Calculated Using Weather Data Collected at the Project Meteorological Site

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/

South Dakota State University, 2008, "*South Dakota Climate and Weather*", retrieved August 2008 from South Dakota State University Web Site: http://www.climate.sdstate.edu/ climate_site/climate_page.htm

2.6 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 PAA is the Powder River Basin of Wyoming. The regional geologic map of this region is shown in Figure 2.6-1.

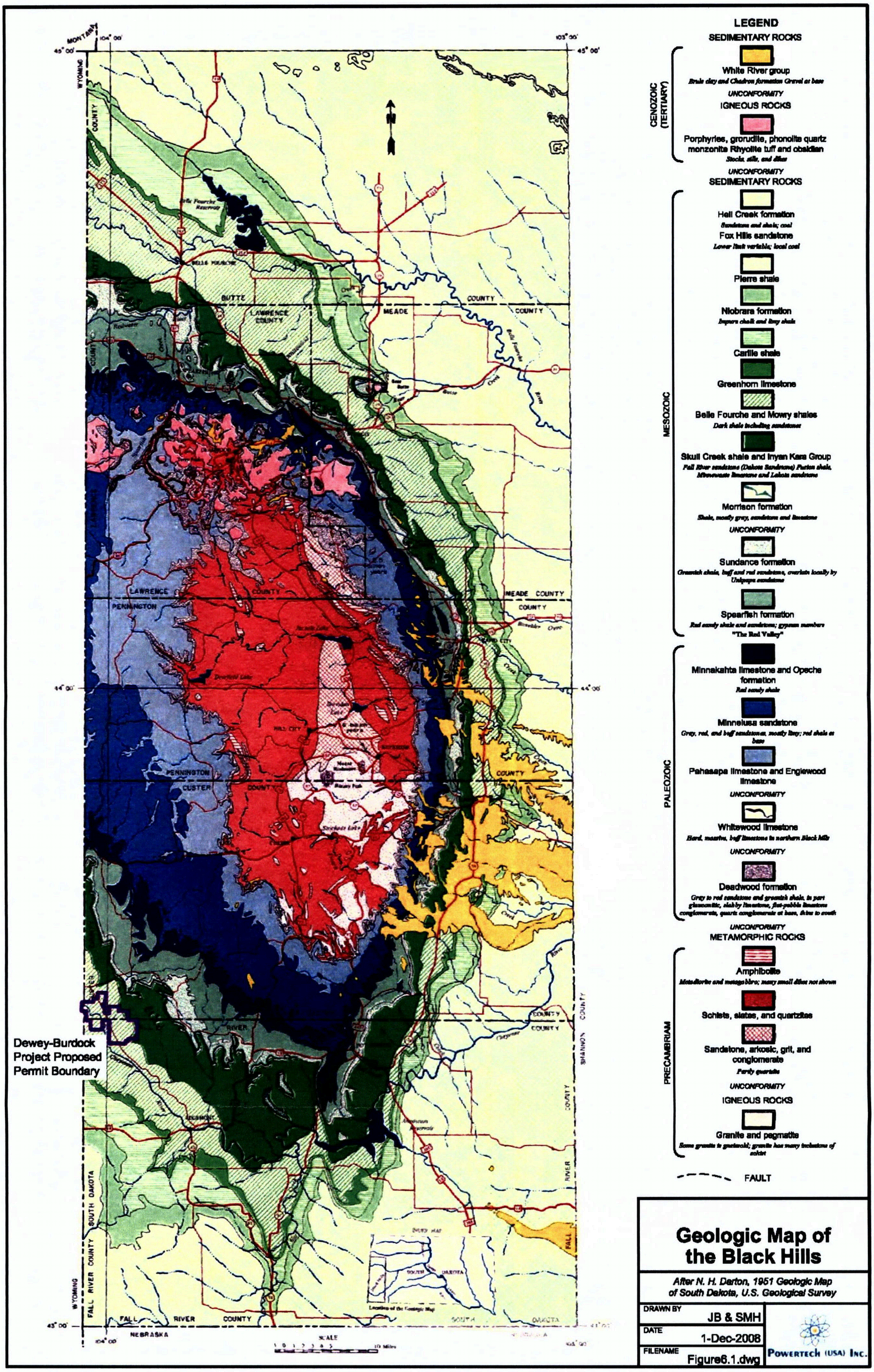


Figure 2.6-1: Geologic Map of the Black Hills

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, Unkpapa and Morrison Formations 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 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, Carlisle 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 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 and Mowry Shale outcrops across the western part of the project. The formations dip west and southwest at 2 to 6 degrees.

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. Plate 2.6-1 is an example of a "type log" from the project.

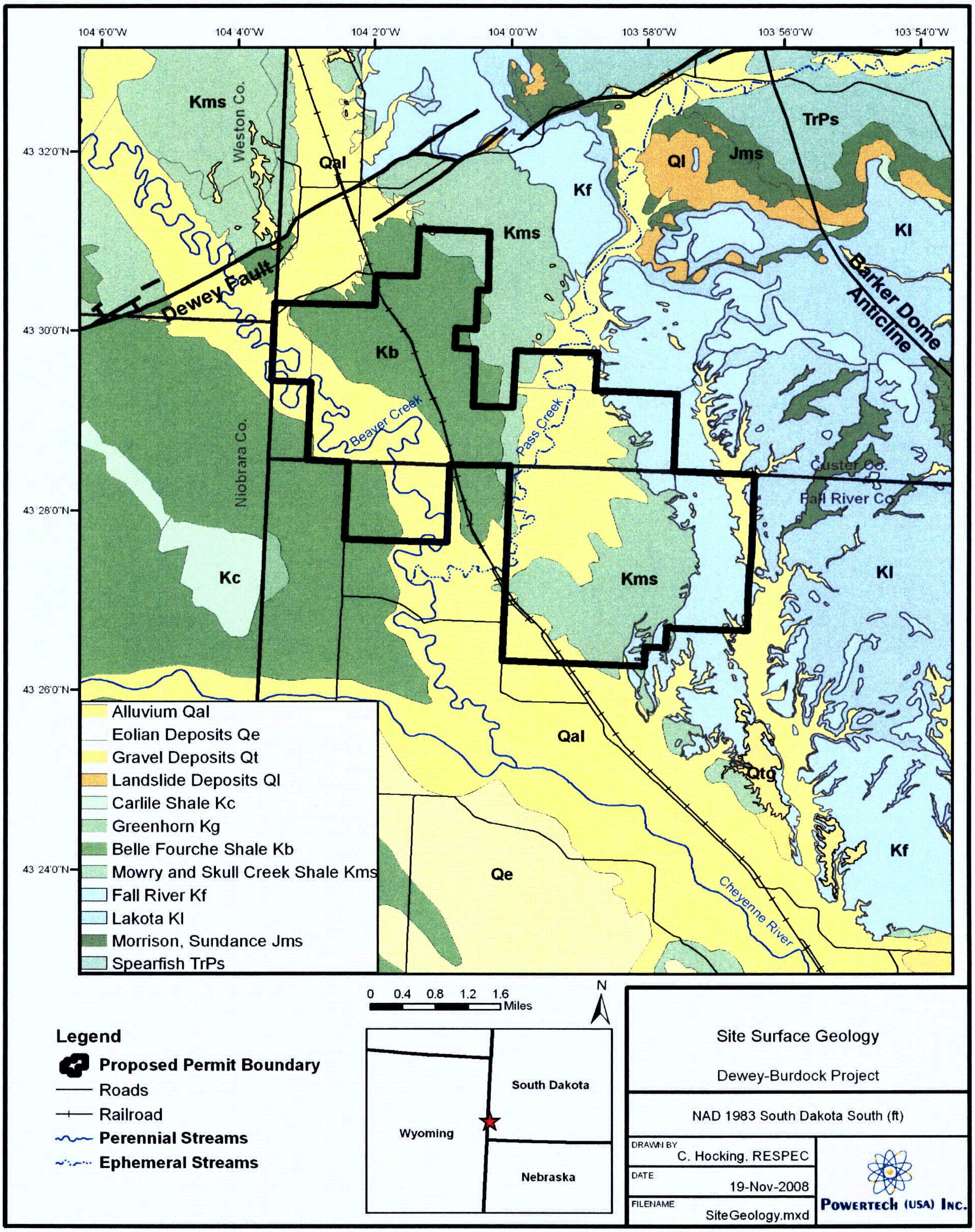


Figure 2.6-2: Site Surface Geology

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 a structure contour map on the tops of the Fall River Formation (Plates 2.6-2) the Chilson Member of the Lakota Formation (Plates 2.6-3) and the Unkpapa Formation (Plate 2.6-4).

The Dewey Fault, a northeast to southwest trending fault zone, is present approximately one mile north of the north and northwest parts of the PAA. 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 PAA.

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 Lower Confining Unit for the project. The uranium mineralization is contained within the Inyan Kara Group (Lakota and Fall River Formations). The Skull Creek Shale is the Upper Confining Unit. Plate 2.6-5 is a generalized cross section of the PAA, illustrating the relationship between these sedimentary units, as well as their position to underlying rocks, ranging in age from Jurassic to Precambrian.

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

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. Analyses of core samples demonstrate that the Morrison clays have extremely low vertical permeabilities, ranging from 3.9 x 10^{-9} cm/sec to 4.2 x 10^{-8} cm/sec (0.004 millidarcies to 0.043 millidarcies).

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 are the Chilson Member, the Minnewasta Limestone Member and the Fuson Member.

<u>The Minnewasta Limestone Member</u> is not present in the PAA.

<u>The Chilson Member</u> (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 x 10^{-3} cm/sec to 4.1 x 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. (Plate 2.6-6).

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. 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).

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 Member shows the thickness of the shale – siltstone unit ranging from 30 to 80 feet (Plate 2.6-7). It shows thinning of the shale under the overlying channel sandstones of the Fall River Formation.

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 PAA, this formation is exposed on the surface and erosion has taken place (Plate 2.6-8).

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 the Upper 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 and is also considered to be part of the Upper Confining Unit. Normally, the Newcastle Sandstone is present between the Skull Creek Shale and the Mowry Shale, but is absent across the PAA. 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 Skull Creek Shale – Mowry Shale reaches a thickness of 400 feet in the western part of the project. Plate 2.6-9 is an isopach map showing the combined thickness of these two shale units. In the northeastern portion of the PAA, these units outcrop 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 PAA 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.

Four site cross sections, based on exploration logs, were developed along each orebody to illustrate the relationship between mineralized Inyan Kara sands and their confining units. Plate 2.6-10 shows the locations of the four cross sections. The cross sections were generated in the MVS model and were hung on the elevation of each drill hole. Traces of electric logs of exploration holes were overlain on these cross sections to illustrate the data sources used in the preparation of these sections. Cross sections A-A'', F-F', H-H''', and J-J' show the project stratigraphy and mineralization across the PAA and are presented in Plates 2.6-11, 2.6-12, 2.6-13, and 2.6-14. The Skull Creek Shale thickens from the east to the west. The Fall River Formation is continuous across the area and dips to the west. The Fuson Member of the Lakota thickens and thins across the area. The Chilson Member of the Lakota is continuous across the area and thickens and thins due to channeling. The uranium mineralization in the Fall River occurs in the lower sandstone unit. The mineralized sands in the Chilson Member of the Lakota occur within individual sandstone lenses or channels.

2.6.3 Ore Mineralogy and Geochemistry

Uranium deposits within the project are classic, sandstone, roll-front type deposits, similar to those in Wyoming 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. Uranium minerals were emplaced in these deposits after migrating down gradient from the surface in oxygenated groundwater and precipitating 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. Reducing conditions are the result of a reductant in the sands these can be from organic material or from Hydrogen Sulfide (H_2S) or methane in the host sands.

There is a geochemical "footprint" associated with these roll-front deposits, resulting from the passage of oxygenated groundwater through subsurface sands. The typical alteration pattern associated with these oxidizing solutions consists of limonitic and hematitic staining of the sandstones. This is due to the alteration of naturally-occurring iron rich minerals (valence state of Fe^{+2}) to iron oxides (valence state of Fe^{+3}). On outcrop, most of the sandstones of the Inyan Kara Group exhibit trace to pervasive limonite staining of various shades of yellow and orange. Red hematite staining is less common and occurs as scattered streaks in most outcrops. Generally, the more porous and thicker the sandstone, the more pronounced the alteration. Reduced or unaltered sands have a medium to dark grey color. Alteration within the host sands has been mapped for distances of over 12 miles within the sandstones of the Inyan Kara Group in the PAA.

The primary uranium minerals in the project deposits are very fine-grained, opaque pitchblende and coffinite. This mineralization occurs as sand grain coatings in the host sand, and marginal to or as replacement of pyrite grains.

Mineralized sands within the project occur at depths of less than 100 feet in the outcrop area of Fall River Formation and at depths of up to 800 feet in the Lakota in the northwest part of the project. This mineralization occurs in three sandstones in the Fall River Formation and within six sandstones of the Lakota Formation. The uranium mineralization occurs along a large "U" shaped trend that is five miles long and three to four miles wide. The average thickness of this mineralization has been calculated to be 6.1feet and the average grade is 0.21 percent U_3O_8.

In 1988 in a Thesis for a Master of Science in Geology degree, Bonnie Janine Blake used scanning x-ray fluorescence supplemented by standard x-ray fluorescence, x-ray diffraction, electron microprobe, scanning electron microscopy, and atomic absorption to study core samples from the Burdock orebody. She did not identify any uranium or vanadium minerals but concluded that the uranium was in an amorphous or poorly-crystalline form or was associated with the clays or carbonaceous material. Bonnie Blake noted "quartz grains illustrated layered clay coatings in the paragenetic sequence of a smectite partially covered by kaolinite with remnants of possible illite on the kaolinite. The smectite coatings showed isolated concentrations of uranium and vanadium." This is to be expected where uranium cation exchanges with the clays. The uranium mineralization is probably uranphane and coffinite.

2.6.4 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 PAA, 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 PAA. 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 mode 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 includes a table summarizing all historical exploration drilling.

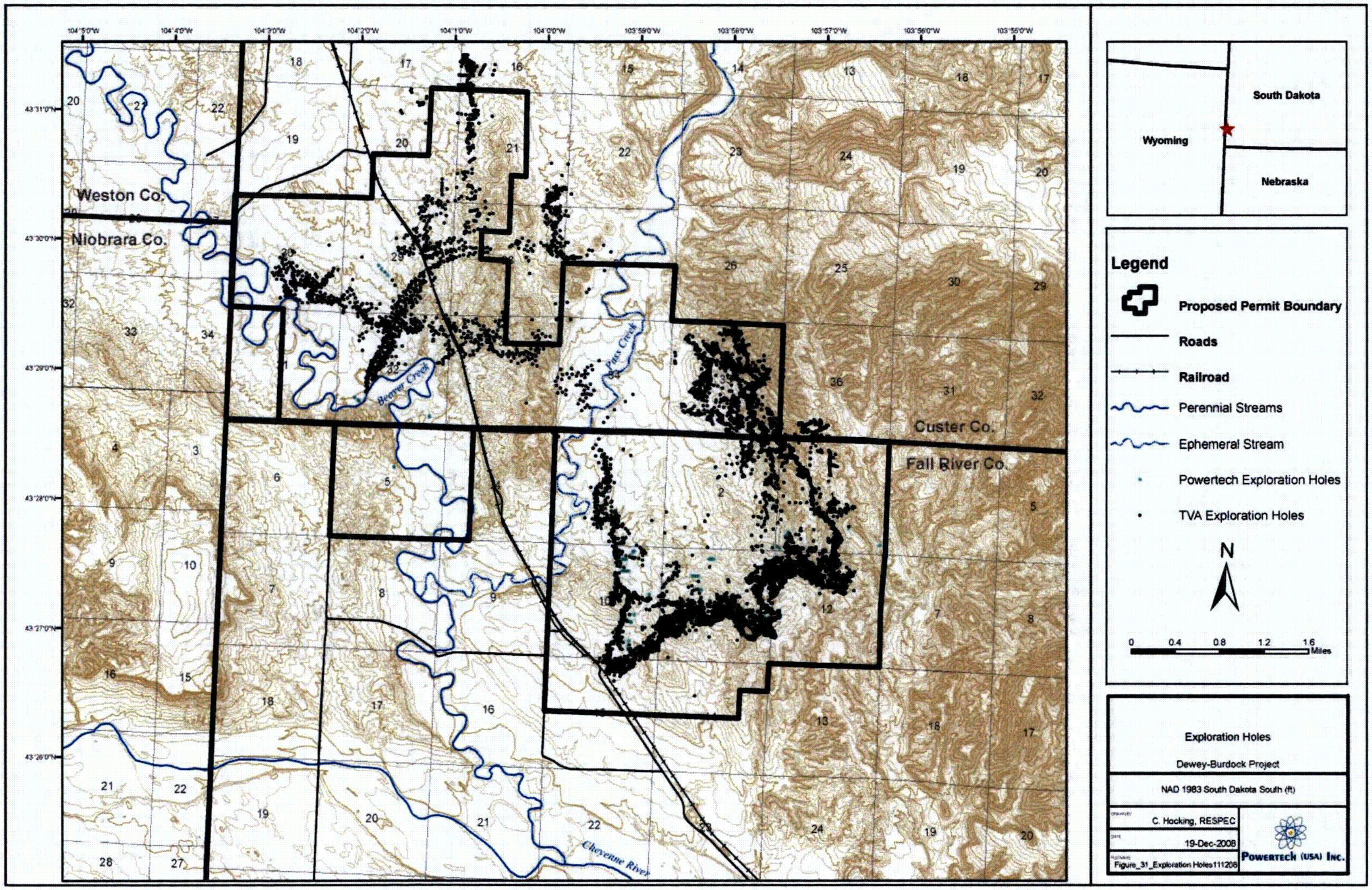


Figure 2.6-3: Location of all Known Exploration Drill Holes within the Proposed Project Site

2.6.5 Soils

Powertech (USA) conducted baseline soil sampling and mapping covering an estimated 7,964.26 acres as shown on Plate 2.6-15 in accordance with NUREG-1569 and RG-4.14.

Stripping depths for the PAA 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 proposed 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 PAA 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 PAA are electrical conductivity (EC), sodium adsorption ratio (SAR), calcium carbonates, and texture (clay percentage).

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

2.6.5.1 Methodology

2.6.5.1.1 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.

2.6.5.1.2 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.

2.6.5.1.3 Soil Survey

Construction of the PAA 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 PAA, in which 3,065.74 of those acres were located in disturbance areas. Refer to Table 2.6-1 for soil mapping unit designations and associated acreage within the PAA. Table 2.6-1 also describes the soil map units in terms of actual map designations and slope percentages.

Table 2.6-1: Proposed Action Area Soil Mapping Unit Acreages

Map Symbol	Map Unit Description	Permit Acreage	Disturbance Areas	% Total PAA
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**

2.6.5.1.4 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 augered 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 PAA 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 2.6-2: Soil Series Sample Summary for the Proposed Action Area [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: Proposed Action Area[1] Soil Sample Locations

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.

2.6.5.1.5 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, Original Laboratory Data Sheets.

2.6.5.2 Results and Discussion

2.6.5.2.1 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 PAA 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 PAA contained deep soils on level upland areas with shallow and very shallow soils located on hills, ridges and breaks.

2.6.5.2.2 Soil Mapping Unit Interpretation

The primary purpose of the 2007 fieldwork was to characterize the soils within the PAA 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 PAA. Refer to Appendix 2.6-B and Appendix 2.6-C for soil mapping unit descriptions and soil series descriptions, respectively.

2.6.5.2.3 Analytical Results

Analyzed parameters, as defined in WDEQ Guideline 1 (August 1994 Revision), are in Appendix 2.6-D, Original Laboratory Data Sheets. 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. 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.

2.6.5.2.4 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 PAA, 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: Proposed Action Area 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]Samples were taken within proposed disturbed area as defined by initial estimates of the orebody.

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

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: Proposed Action Area Summary of Marginal and Unsuitable Parameters within Sampled Profiles

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: Proposed Action Area 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

2.6.5.2.5 Topsoil Volume Calculations

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

2.6.5.2.6 Soil Erosion Properties and Impacts

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the PAA varies from negligible to severe. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the very fine and clayey texture of the surface horizons throughout the majority of the PAA, the soils are more susceptible to erosion from water than wind. See Table 2.6-7 for a summary of wind and water erosion hazards within the PAA.

Table 2.6-7: Proposed Action Area 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.

2.6.5.2.7 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 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.

2.6.5.2.8 References

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2.6.6 Seismology

2.6.6.1 Seismic Hazard Review

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

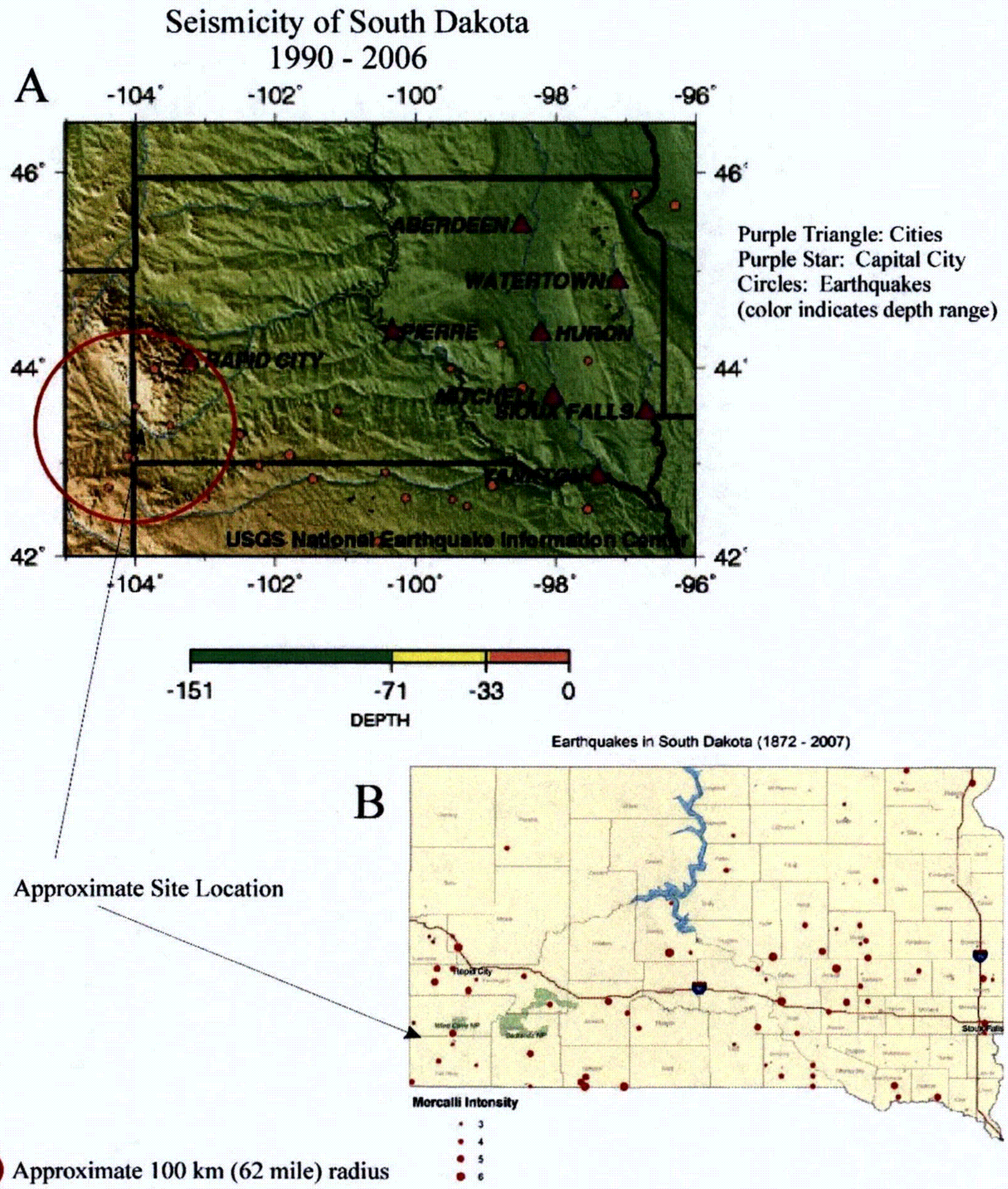
"The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term "capable fault" has the same meaning as defined in section III(g) of Appendix A 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 PAA, 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.

2.6.6.1.1 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 PAA 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).



Earthquake locations are from the USGS/DEIC PDE catalog.
Map Source A: USGS website (http://earthquake.usgs.gov/regional/states/south_dakota/seismicity.php)
Map Source B: USGS website (http://www.sdgs.usd.edu/digitalpubmaps/quakemap.html)

Michael W. West and Associates, Inc. *Consulting Engineers and Geologists*	*Seismicity Maps Dewey-Burdock Project southwestern South Dakota*	*BY: JMF*	*05/12/2008*
		Proj.: 08807	

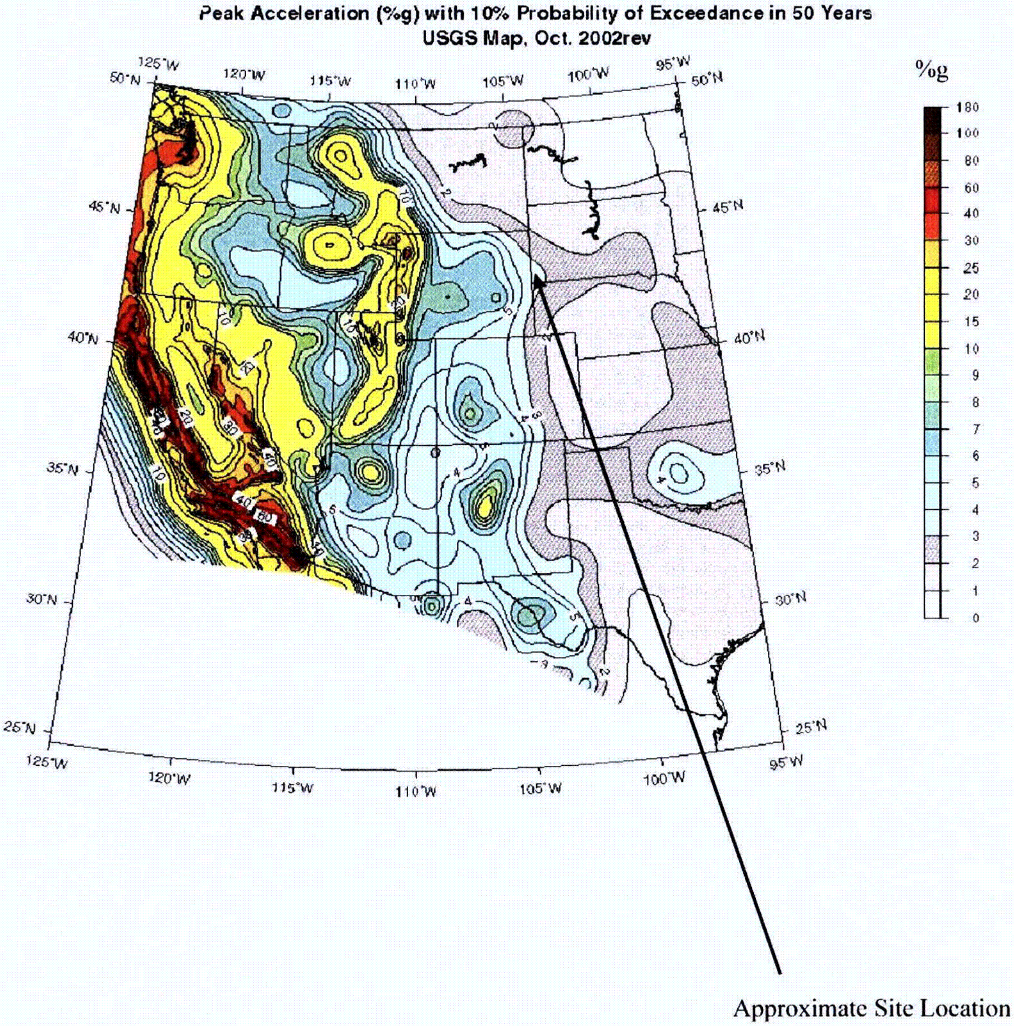
Figure 2.6-4: Seismicity of South Dakota, 1990 – 2006; and Earthquakes in South Dakota, 1872 - 2007

The U.S. Geological Survey Earthquake Database reports locations, times, and magnitudes for epicenters recorded since 1973. The database reports a total of 10 earthquakes with Richter magnitudes ranging from 2.3 to 3.7 within 100 km radius of the site (Appendix 2.6-G). This list includes epicenters in Wyoming and Nebraska. The closest historical earthquake to the project site (unknown magnitude) was recorded on May 16, 1975 approximately 19 km (12 miles) southeast of the site. The most recent earthquake recorded in the entire state of South Dakota took place on February 7, 2007, 35 miles east of Rapid City (approximately 80 miles northeast of the project site) and displayed a magnitude of 3.1.

According to the U.S. Geological Survey Earthquake Database (Appendix 2.6-G), two historical earthquakes, each exhibiting a magnitude of 3.7, represent the largest historical events recorded within 100 km (62 miles) of the project. These events occurred on February 6, 1996, and April 9, 1996, and were located 76 km (47 miles) to the north and 30 km (19 miles) to the southwest of the site, respectively. If the search radius was expanded to 200 km (124 miles), an earthquake with magnitude 5.50 occurring on October 18, 1984 approximately 180 km (112 miles) to the southwest of the site is the largest magnitude event near 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).

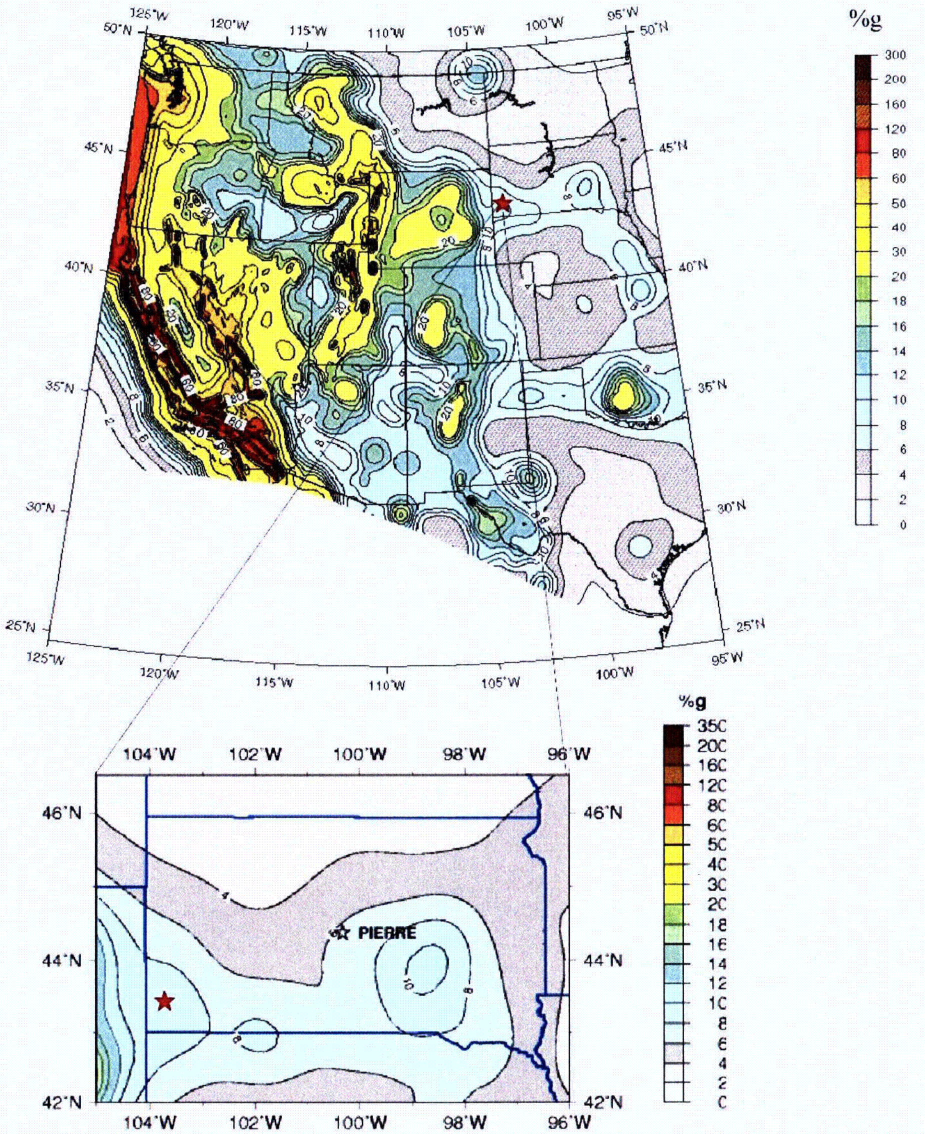


Map Source: USGS website (http://earthquake.usgs.gov/research/hazmaps/products_data/2002/wus2002.php)

Michael W. West and Associates, Inc. *Consulting Engineers and Geologists*	*PGA Map (10% Probability Exceedance 50 years) Dewey-Burdock Project southwestern South Dakota*	*BY: JMF*	*05/12/2008*
		Proj.: 08807	

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

Powertech (USA) Inc.



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
site: NEHRP B-C boundary
National Seismic Hazard Mapping Project

★ Approximate Site Location

Map Source: USGS website (http://earthquake.usgs.gov/research/hazmaps/products_data/2002/wus2002.php)

Michael W. West and Associates, Inc. *Consulting Engineers and Geologists*	*PGA Map* *(2% Probability Exceedance in 50 Years)* *Dewey-Burdock Project* *southwestern South Dakota*	*BY: JMF*	*05/12/2008*
		Proj.: 08807	

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

2.6.6.1.2 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.

2.6.6.1.3 Capable Faults

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

2.6.6.1.4 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 PAA 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.

2.6.6.2 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 PAA, 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 PAA. 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.

2.6.6.3 References

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L., and Bender, B.L., 1982, "*Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States*", U.S. Geological Survey, Open-File Report 82-1033.

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Martin, J.E., Sawyer, J.C., Fahrenbach, M.D., Tomhave, D.W., and Schulz, L.D., 2004, "*Geologic Map of South Dakota*", South Dakota Geological Survey, General Map 10.

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U.S. Geological Survey, 2002, "*Earthquake Hazards Program, Preliminary Conterminous States Probabilistic Maps & Data*", Accessed April 2008 <http://earthquake.usgs.gov/research/hazmaps/products_data/48_States/index.php

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 PAA is approximately 12 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 PAA 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).

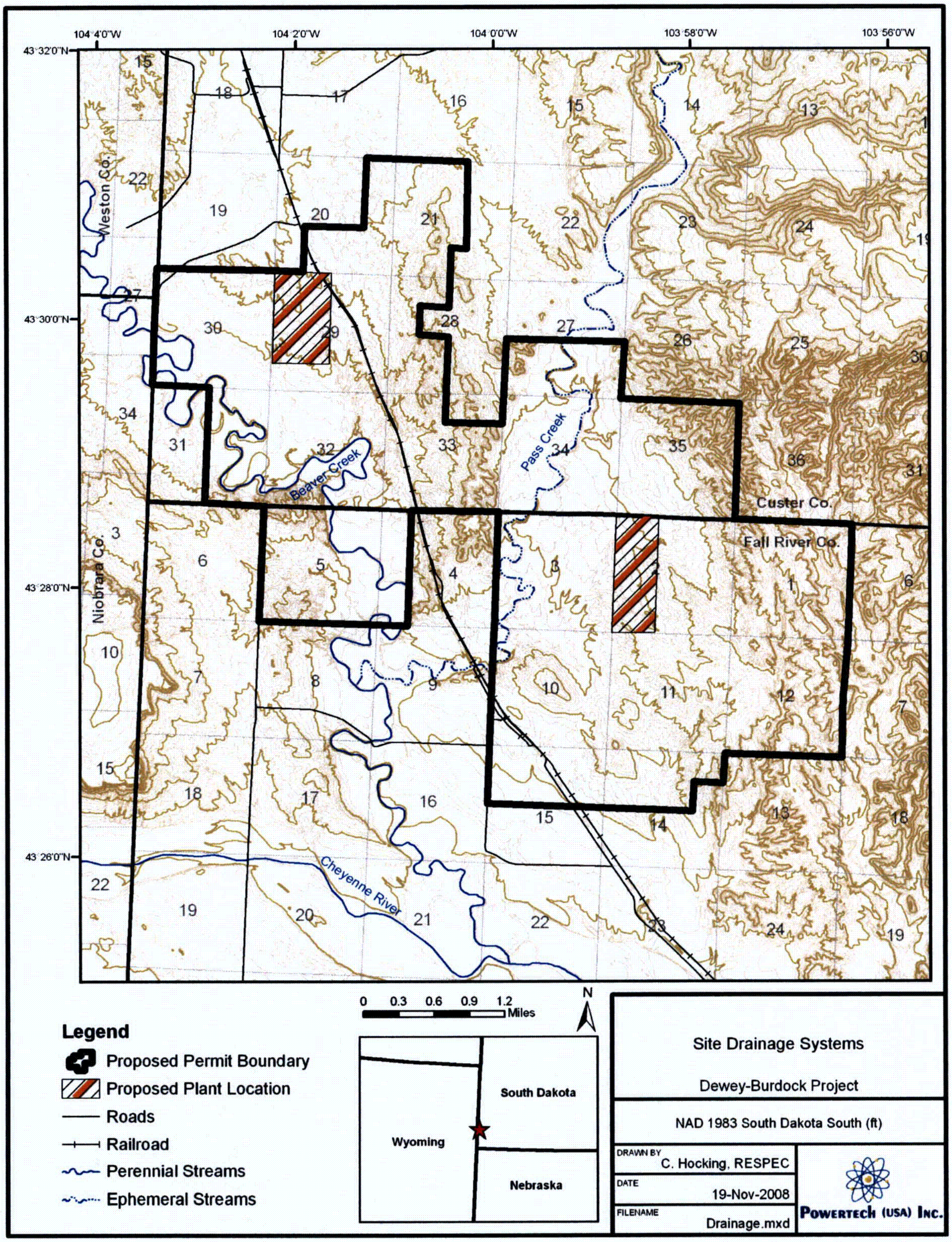


Figure 2.7-1: Site Drainage Systems

2.7.1.2 Site Hydrology

The local hydrology and surface water resources are described for the PAA 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 PAA is characterized by low to moderately sloping brush land with areas of moderately steep ridges. The elevation ranges from approximately 5190 feet to about 3310 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 PAA. Both the eastern and western facility zones have an average slope of nearly 3 percent.

2.7.1.3 Drainage Basins

The PAA 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 PAA from the northwest to the southeast. The Pass Creek system flows south through the central portion of the PAA and joins Beaver Creek southwest of the PAA. Three miles south of this confluence, Beaver Creek converges with the Cheyenne River (Figure 2.2-2) 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).

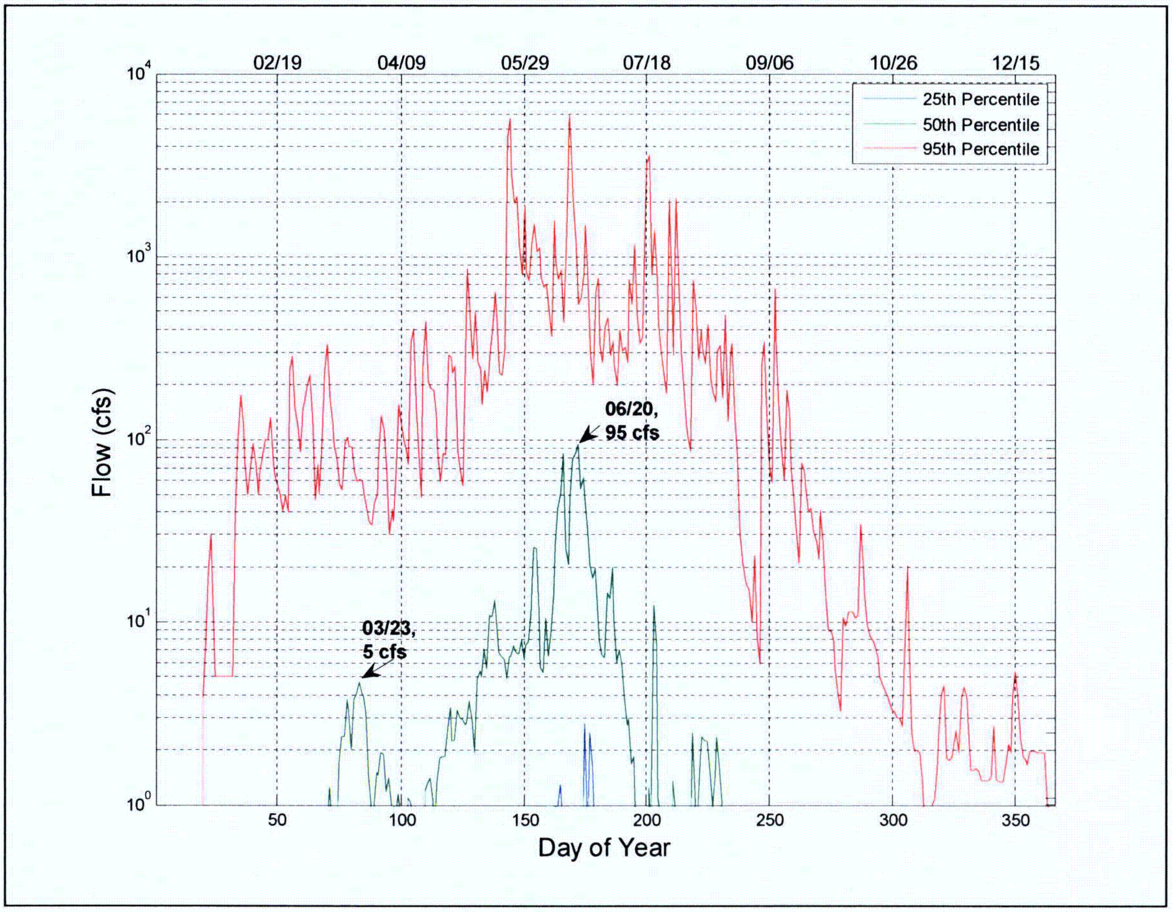


Figure 2.7-2: Annual Hydrograph for USGS Gage 06386500 on the Cheyenne River near Spencer, WY from 1948 to 2008

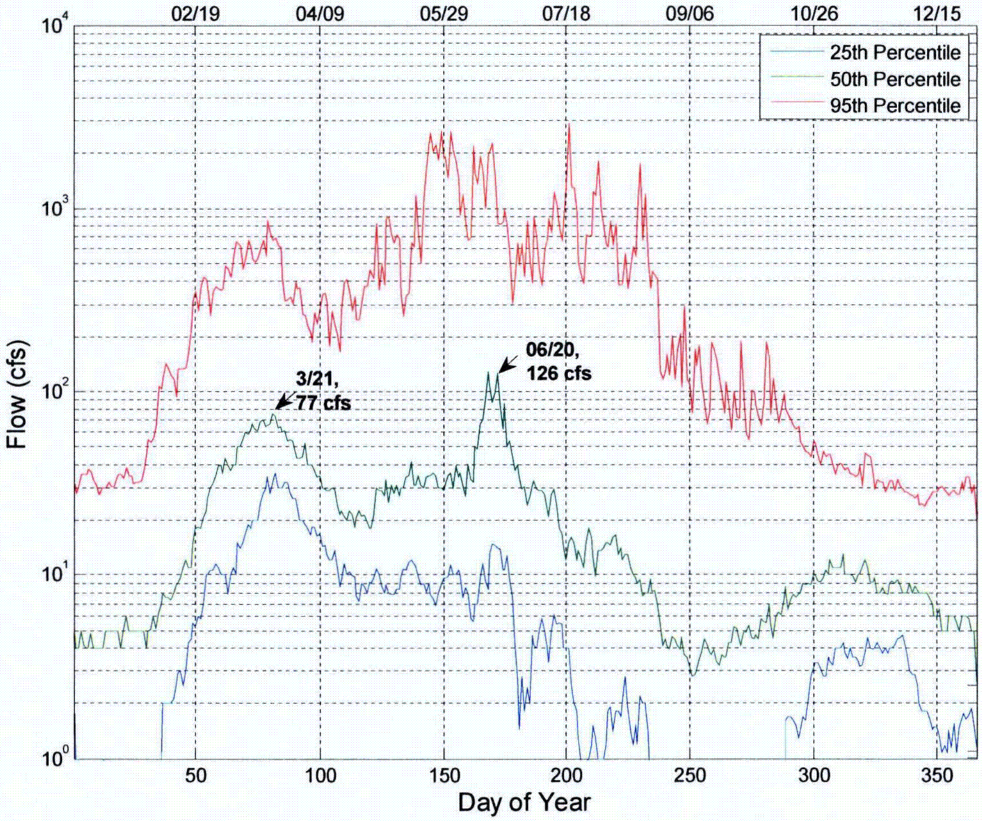


Figure 2.7-3: Annual Hydrograph for USGS Gage 06395000 on the Cheyenne River at Edgemont, SD from 1903 to 2008

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 2.2-2). 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.

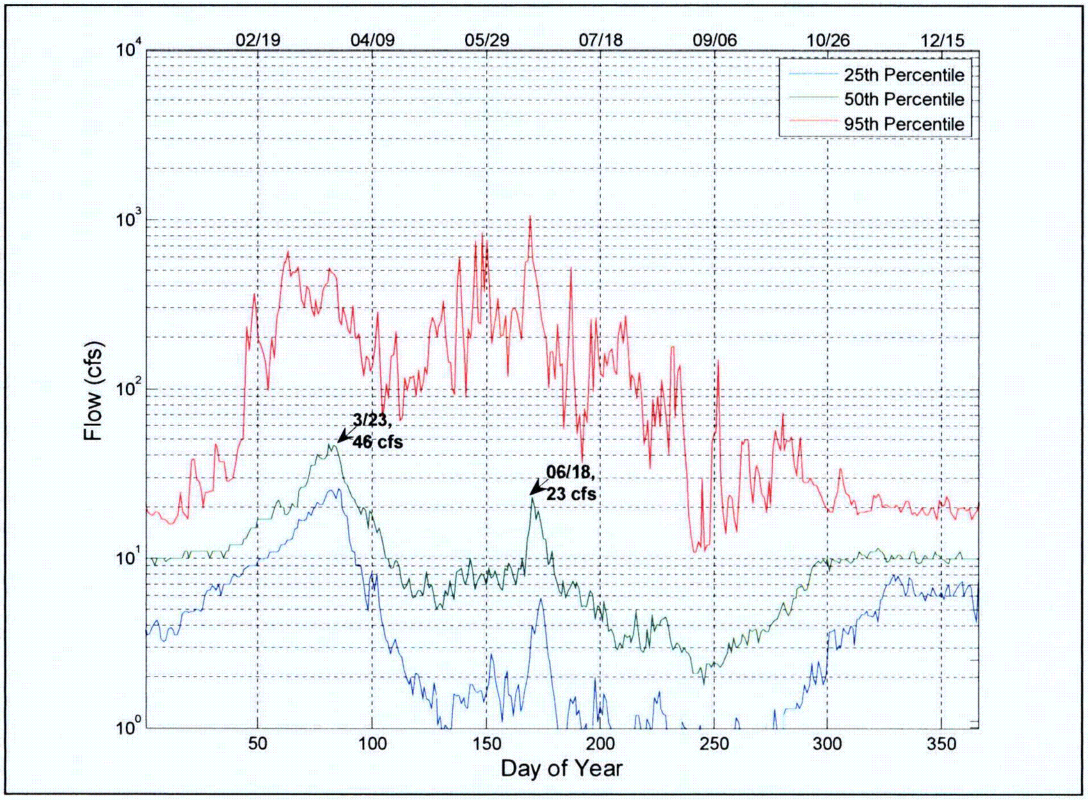


Figure 2.7-4: Annual Hydrograph for USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

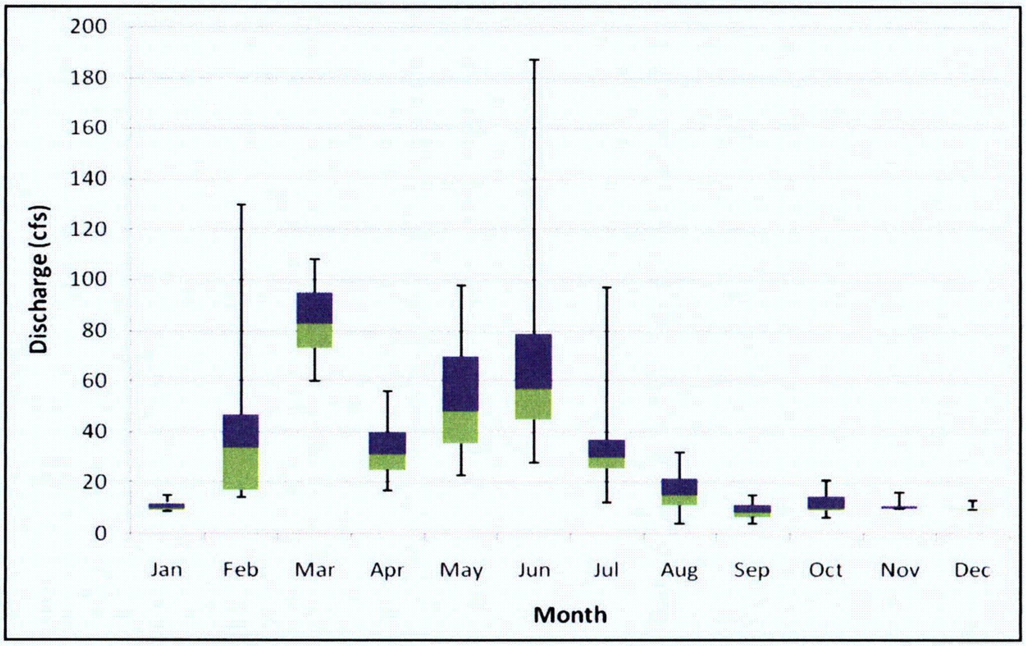


Figure 2.7-5: Monthly Average Flows at USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

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. There is no permanent stream flow gage stationed along Pass Creek.

2.7.1.3.3 Project Boundary

The northwestern section of the PAA drains to Beaver Creek via an intermittent tributary. The north-central and east-central section of the PAA is drained via Pass Creek and smaller, ephemeral tributaries. The southeast portion of the PAA is also part of the Cheyenne River Basin that drains into the Cheyenne River through East Bennett Canyon. The PAA 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 PAA. Most of the small impoundments that exist within the PAA are dry during most of the year (Plate 2.5-1). Many of these existing impoundments are found along ephemeral streams and tributaries, particularly in the eastern section of the PAA.

2.7.1.3.4 Proximity of Surface Water Features to Proposed ISL Facilities

Beaver Creek is the primary surface water resource in the PAA. There will be no ISL operations within 0.4 miles of the Beaver Creek channel, with the exception of two very small areas of known ore bodies that may involve in situ leach well installations and associated piping (Figure 2.7-1).

Pass Creek is a secondary surface water resource in the PAA, although the channel is almost always dry. There will be no in situ leach operations within 0.5 miles of the Pass Creek channel, with the exception of one small orebody that may involve in situ leach well installations and associated piping.

The remaining surface water resources in the PAA are small intermittent stream channels and small ponds which are used by livestock when water exists. With the exception of two ponds in the eastern section of the PAA, just south of the Custer-Fall River County line, no ponds are located in the PAA primary facility zones. Several small, local drainage channels pass through the primary facility zone of the eastern site. The buildings, surface impoundments, and other major facilities constructed in these areas will be located far enough away from these intermittent drainage channels so that no flooding of the facilities will occur, and so that the occasional overland flow hydrographs will not be changed by the presence of these facilities.

2.7.1.4 Surface Water Run Off

2.7.1.4.1 General Approach

The potential for flood or erosion damage in the PAA 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 PAA 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 PAA 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.

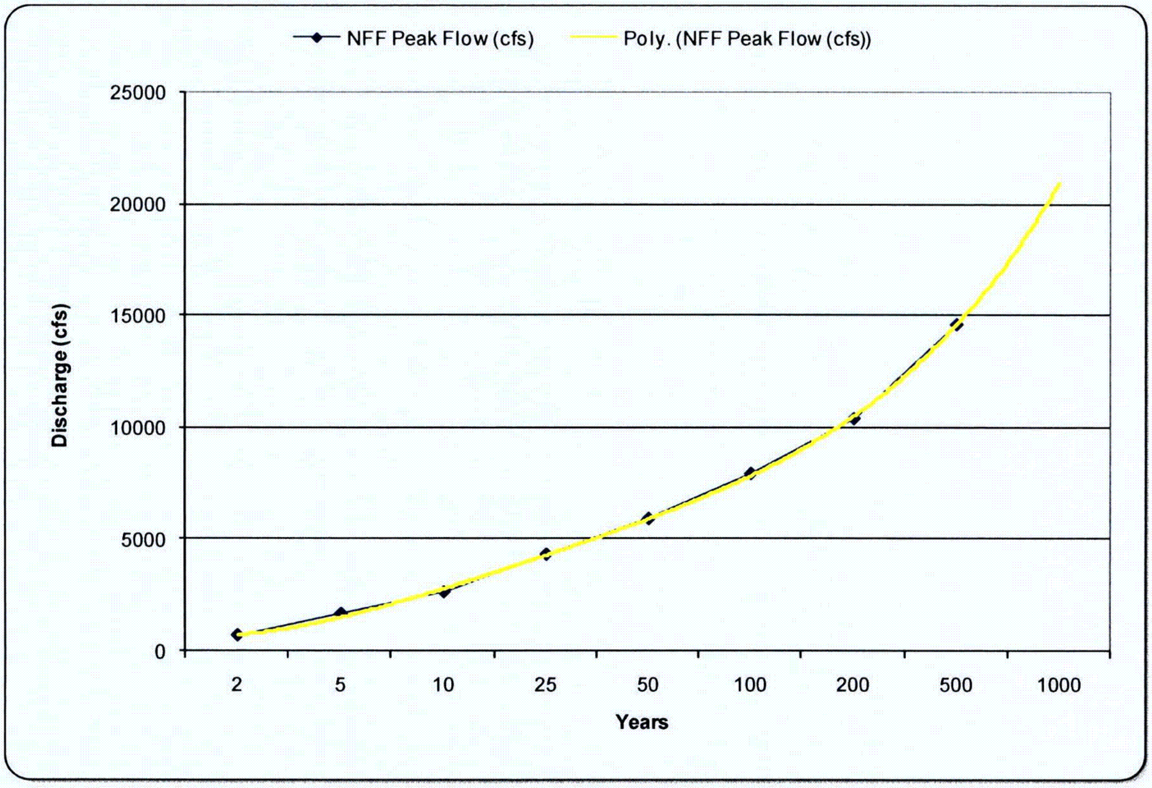
The 100-year flows were developed using hydrologic analyses for Beaver Creek and Pass Creek. These flows are then transformed to maximum water levels using a stream channel hydraulic model. Upper-bound flows, or extreme flows, were developed for each creek and used for comparison with the 100-year event. 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 2.7-2). 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 and extreme condition flood.

Figure 2.7-6: Beaver Creek Flood Estimates

Table 2.7-1: 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: 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 PAA, 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.

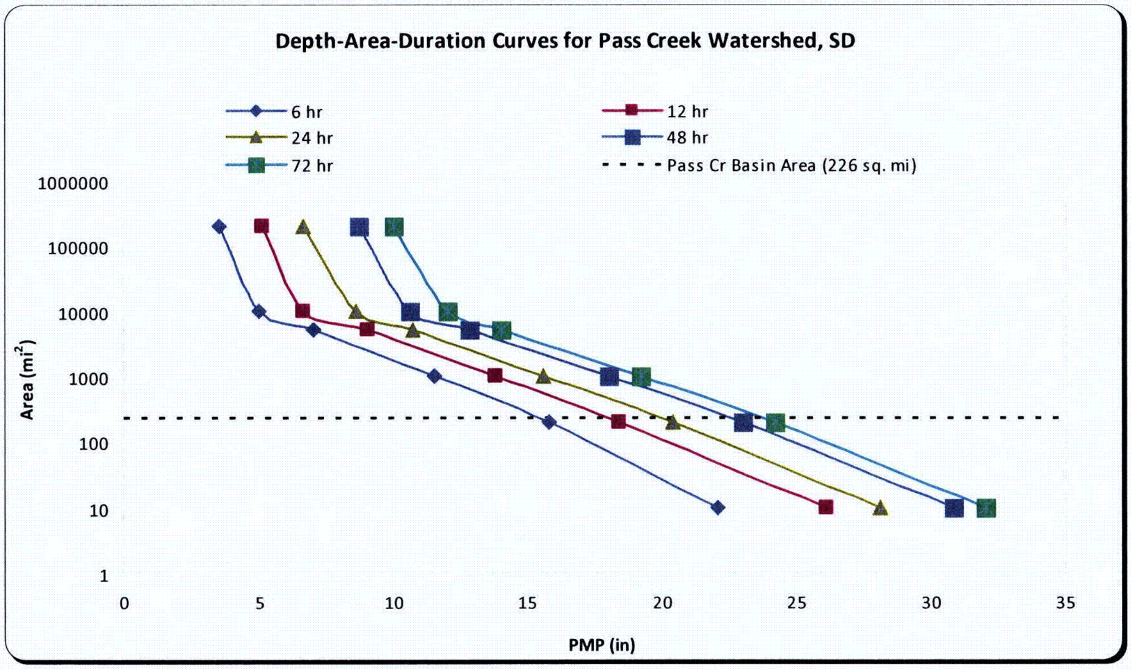
Table 2.7-5: Depth-Duration Data for the 100-Year Storm Event

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 (mi²)	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 (mi^2)	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 PAA. 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 PAA 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 PAA. 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 PAA. 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 PAA 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.

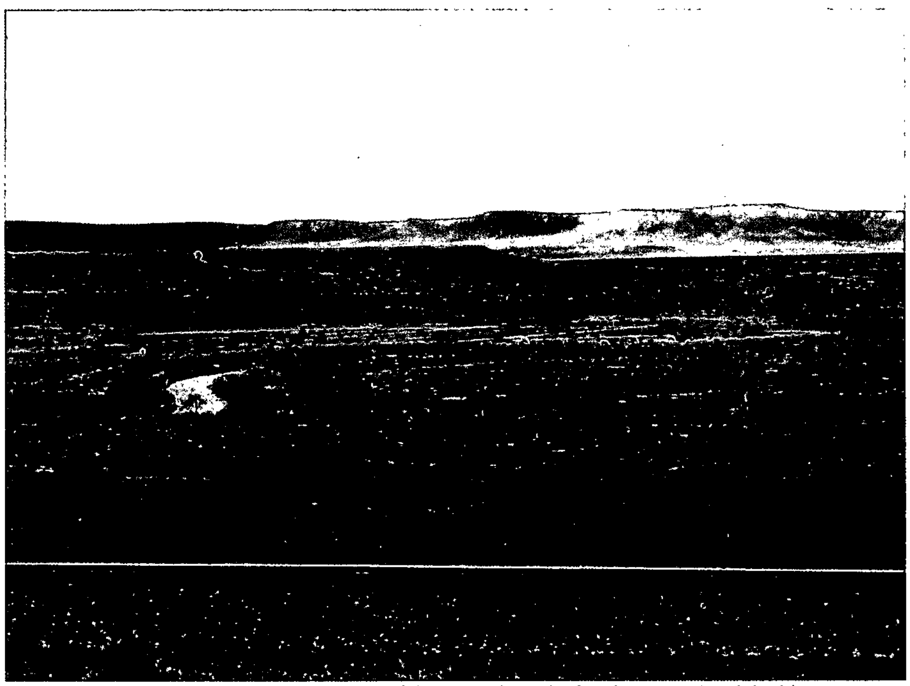
Data entry for the bridges in the downstream section of Pass Creek was manually performed. Low flow calculation methods for the road bridge and railroad bridge included the energy and momentum methods. Pressure and weir methods were used for high flow computation of the road bridge while energy only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

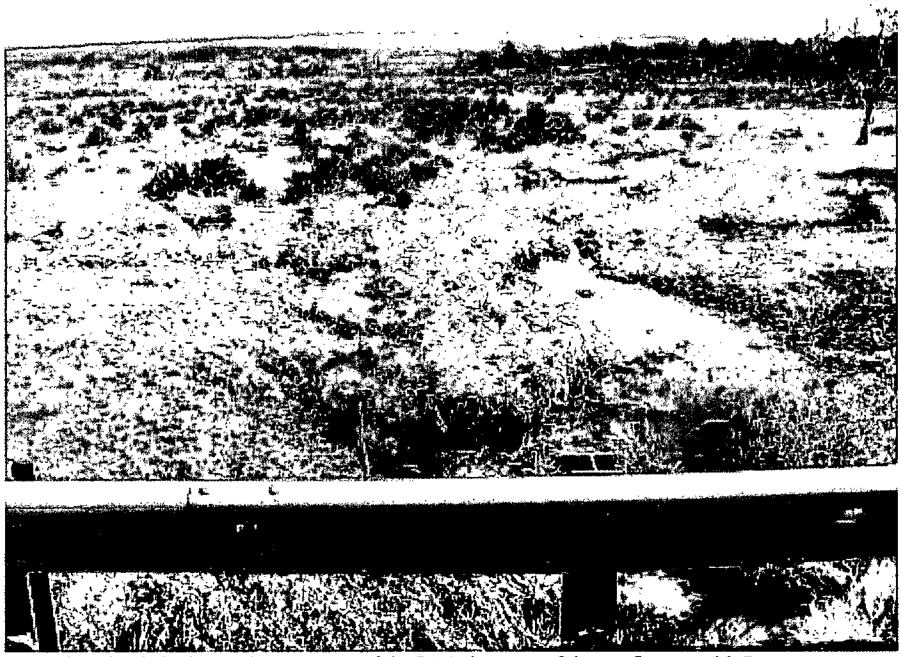
Note: based on field observations

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 PAA 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 PAA, 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 PAA are shown in Figures 2.7-10 and 2.7-11, respectively. The figures indicate the relationship of the maximum extent of the 100-year 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 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	2,190	32
	Ore Bodies	170	15
Pass			
	Facilities	2,180	30
	Ore Bodies	340	10

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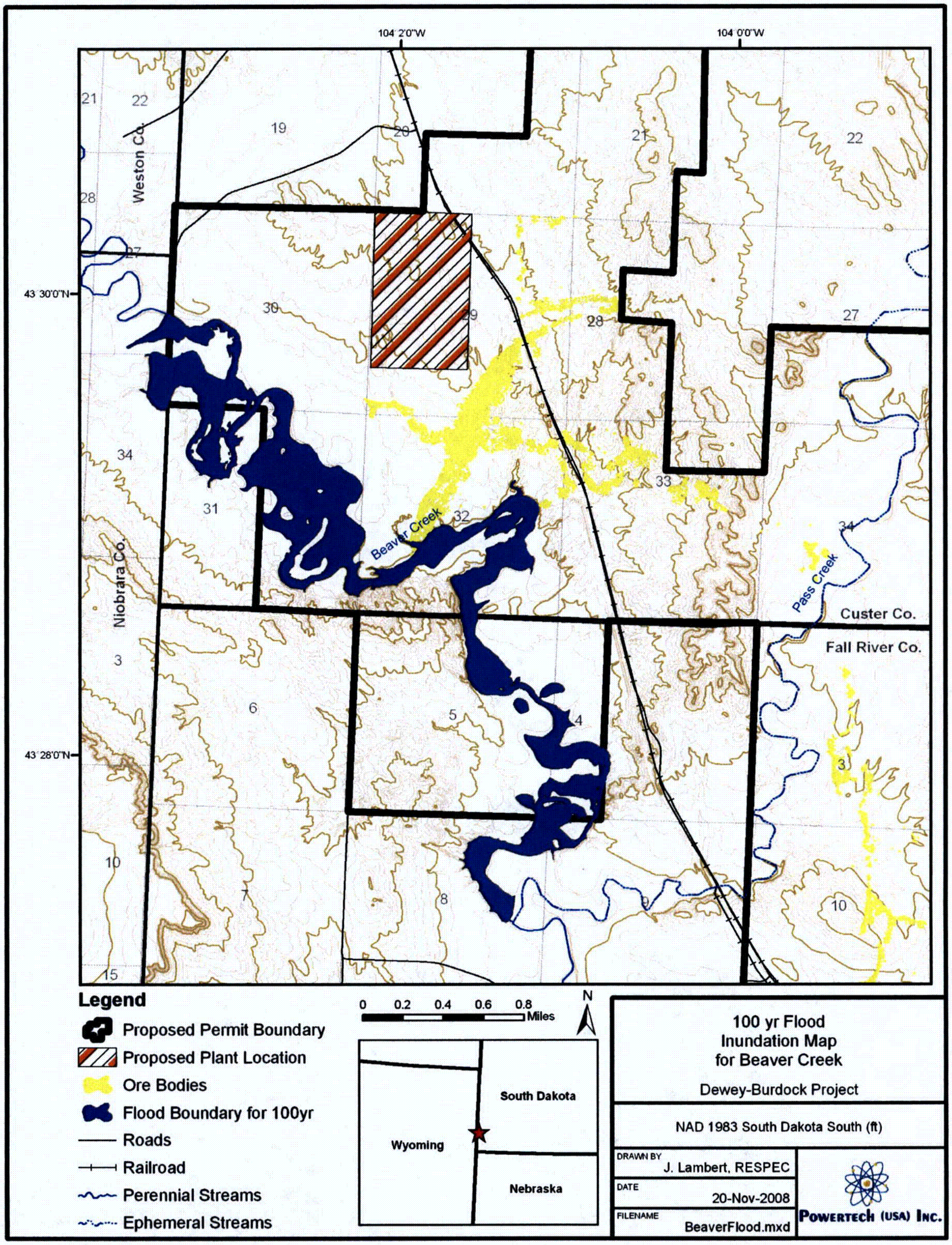

Figure 2.7-10: 100 Year Inundation Map for Beaver Creek

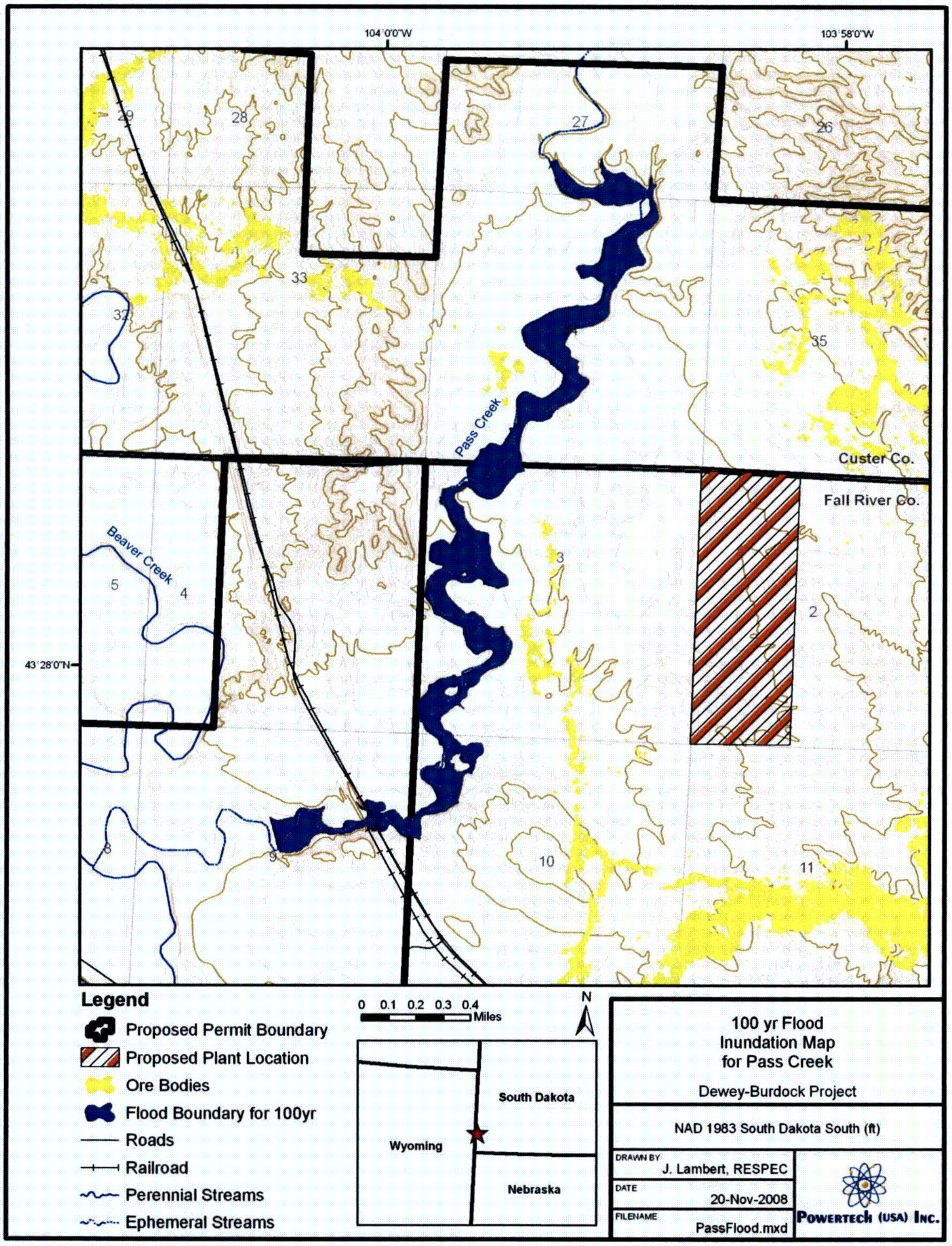

Figure 2.7-11: 100 Year Inundation Map for Pass Creek

The final model results for the spatial representation of the extreme condition floodplains for Beaver Creek and Pass Creek within the PAA 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 PAA facilities from Beaver and Pass Creeks is extremely low.

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.

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	2,180	27
	Ore Bodies	165	10
Pass			
	Facilities	1,960	25
	Ore Bodies	180	2

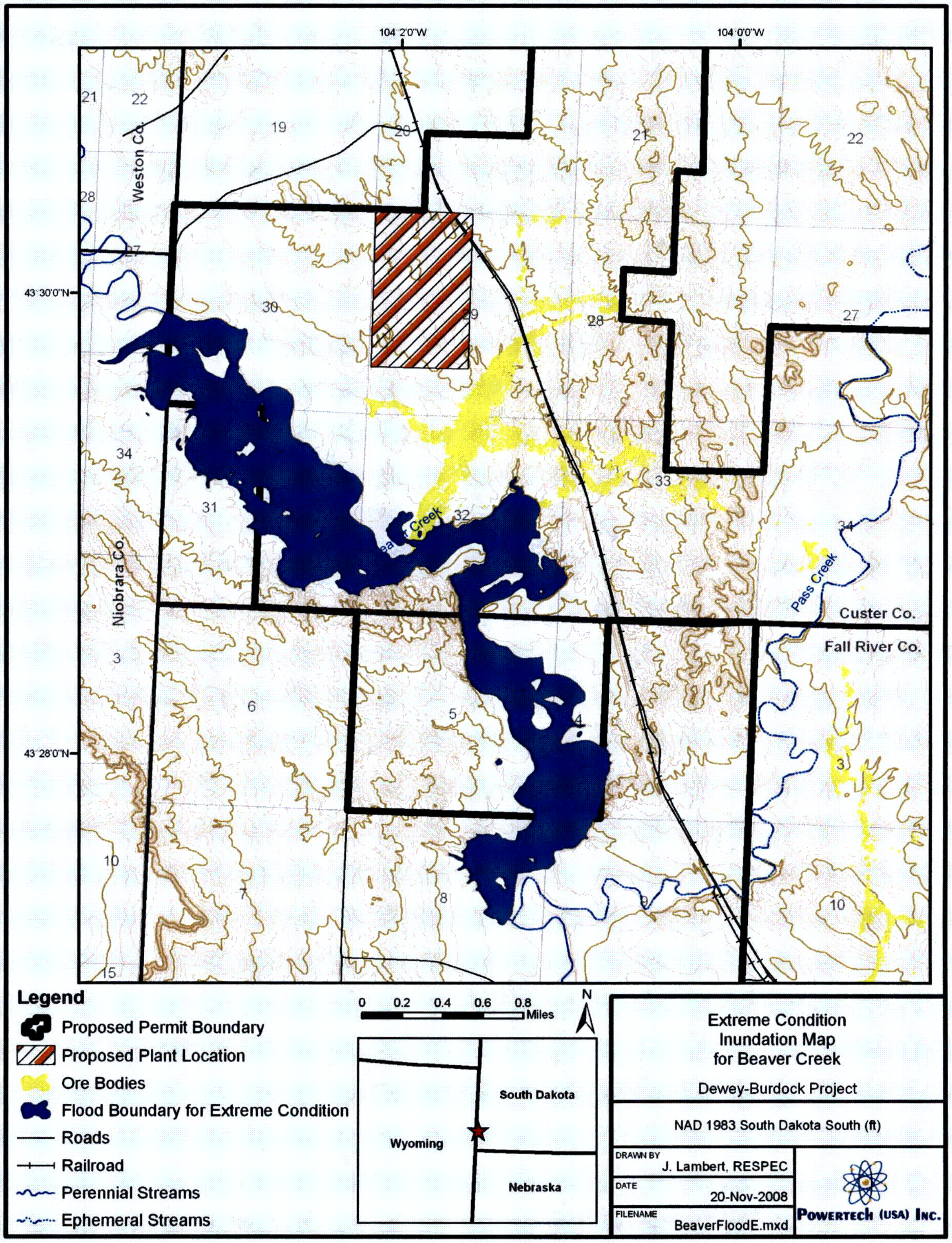

Figure 2.7-12: Extreme Condition Inundation Map for Beaver Creek

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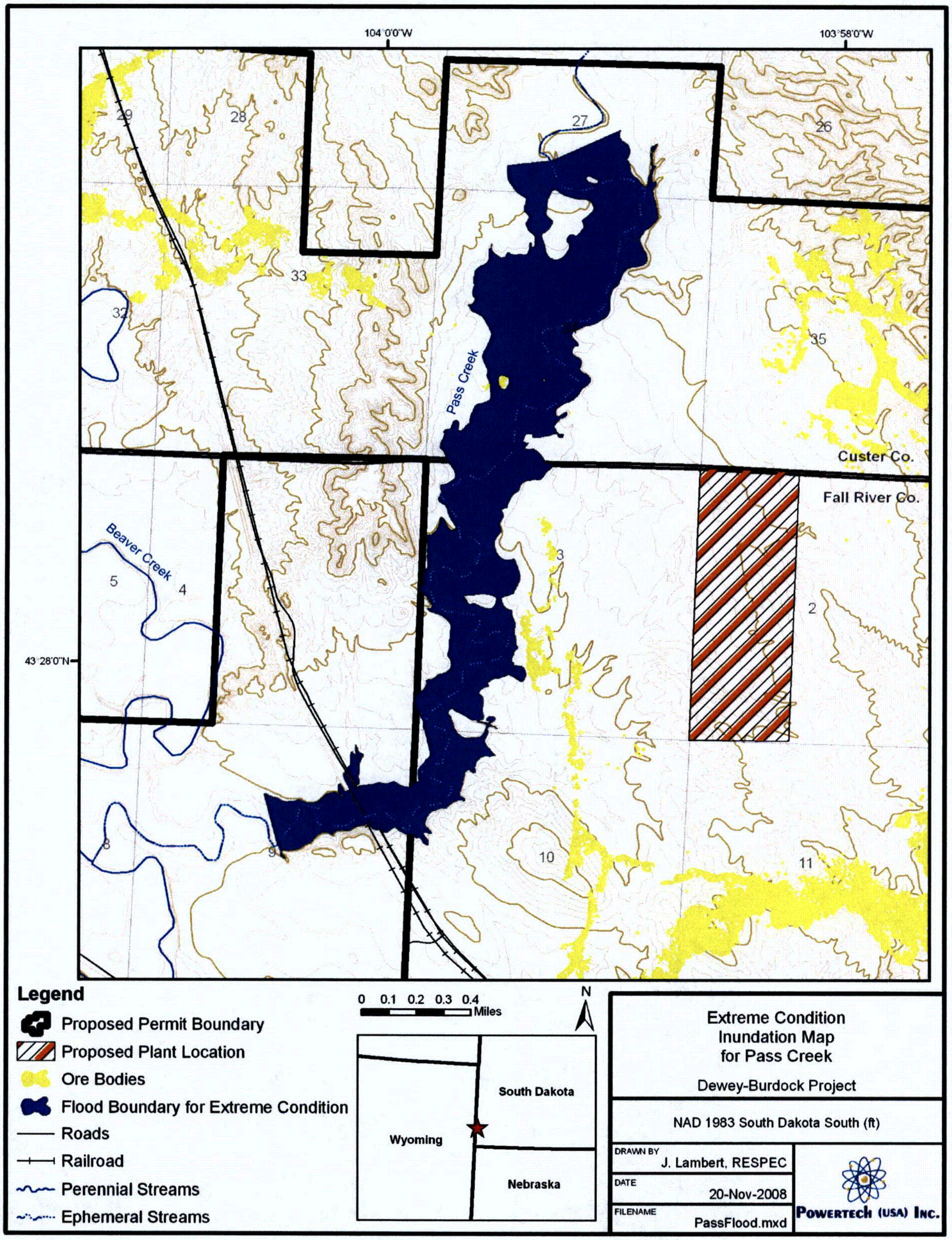

Figure 2.7-13: Extreme Condition Inundation Map for Pass Creek

2.7.1.4.5 Flooding and Erosion in Local Drainages

There are no significant local drainage systems that could impact the primary facility zone in the western area of the project site (e.g., buildings housing critical processes, or surface impoundments). There are several small, local drainage systems that could occasionally produce flow in small channels that pass through the primary facility zone in the eastern section of the PAA. The largest system drains a 0.5 square mile catchment (measured upstream of the eastern border of the proposed eastern primary facility zone, 0.2 miles south of the Custer-Fall River County line). The average slope of this watershed is 3 percent, and the channel slope just upstream of the primary facility zone is 2 percent. The maximum length of the drainage path from the primary facility zone upstream to the drainage divide is one mile. Several other drainage systems that could occasionally carry flow through the proposed site are similar to this system, but have smaller drainage areas.

These small catchments could occasionally produce floods with significant flow but relatively short duration. Velocities of concentrated flow created by the existing rainfall runoff processes are high enough to erode these channels. The project operations can be protected from impacts due to erosion and flooding related to these local systems by applying standard engineering methods associated with urban storm water management. Specific structures and facilities should be located out of the drainage paths of these catchments. Construction should not occur in areas where the structure could alter the existing runoff hydrograph or reduce the existing stability of the drainage channels. On-site runoff due to roofs, parking lots and other impervious areas constructed for the project should be managed so that it is released to the natural channel systems without increasing the erosion that would naturally occur due to runoff from the watersheds upstream of the project facilities.

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 PAA. Surface water bodies within the PAA 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 PAA. Further discussion about the interaction between ground water and surface water bodies is provided in the ground water report.

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 Groundwater

2.7.2.1 Regional Hydrogeology

Four major aquifers are utilized as groundwater resources in the Black Hills. These main aquifers are the Inyan Kara, Minnelusa, Madison, and Deadwood. The groundwater hydrology is influenced by distribution and variation in recharge, leakage between overlying and underlying hydrogeologic units, lateral flow within the aquifers, and discharge to pumping wells, artesian wells, and springs.

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.

Refer back to Figure 2.2-2, which provides an overview of the hydrologic setting and general hydrogeologic flow within the Black Hills.

2.7.2.1.1 Regional Hydrostratigraphic Units

This section summarizes the aquifers in the Black Hills, including general characteristics and hydraulic properties. Hydrologic units of interest within the Black Hills area are shown on the stratigraphic column in Figure 2.2-4. Additional information on the geologic units within the study area is provided in Section 2.6. Table 2.7-13 (from Driscoll et al., 2002) summarizes hydraulic properties of major aquifers determined in previous investigations.

Table 2.7-13: Estimates of Hydraulic Conductivity, Transmissivity, Storage Coefficient, and Porosity of Major Aquifers from Previous Investigations

[ft/d, feet per day; ft^2/d, feet squared per day; --, no data; <, less than]

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 Conductivity, Transmissivity, Storage Coefficient, and Porosity of Major Aquifers from Previous Investigations (concl.)

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

2.7.2.1.2 Inyan Kara Aquifer

On the prairie away from the central Black Hills, the Inyan Kara is typically the first significant aquifer encountered. The Inyan Kara aquifer is comprised of two sub-aquifers, the Lakota and the Fall River, which are separated by the Fuson shale confining unit. Regionally, the Inyan Kara ranges from 250 to 500 feet. The Inyan Kara is a very heterogeneous formation, which results in the two (2) aquifers exhibiting a large variation in local characteristics. Regionally, the Inyan Kara exhibits a large effective porosity (0.17) and the aquifer can yield considerable water from storage (Driscoll et al., 2002). Within the Black Hills, transmissivity of the Inyan Kara ranges from 1 to 6,000 ft^2/day. This high variability is an indication of the complex heterogeneity of the Inyan Kara formation. The Inyan Kara is confined below by the Morrison Formation (50-100 ft thick) and above by Cretaceous Graneros Group shale.

2.7.2.1.3 Minnelusa Aquifer

The Minnelusa Formation consists of interbedded siltstone, sandstone, anhydrite, and limestone (SDSM&T, 1963). 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 lower permeability layers at the base of the Minnelusa formation.

2.7.2.1.4 Madison Aquifer

Within the Black Hills, the Madison Limestone, also known as the Pahasapa Limestone, could be considered the most important aquifer because it is the source of municipal water in numerous communities including Rapid City and Edgemont. The hydraulic characteristics of the Madison Limestone aquifer have been studied for several decades in the region and Table 2.7-13 summarizes the regional findings. The Madison aquifer is mainly a dolomite unit 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 widely 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 a paleosol and low permeability layers within the overlying Minnelusa Formation act to confine the Madison. Locally, these confining layers may be absent or their hydraulic characteristics are higher such that intercommunication between the Madison and Minnelusa occurs. The Madison may be in connection with the underlying Deadwood aquifer when the Whitewood and Winnipeg confining units are absent.

2.7.2.1.5 Deadwood Aquifer

Overlying the Precambrian, the Cambrian Deadwood Formation consists of basal conglomerates, sandstone, limestone, and mudstone. The thickness of the Deadwood is between zero (0) and 500 feet (Driscoll et al., 2002). Rahn (1985) estimated the effective porosity of the aquifer to be 0.05. In the northern Black Hills the effective porosity is presumably lower, in areas where the formation has undergone extensive hydrothermal alteration. The transmissivity of the Deadwood within the region is 250 to 1,000 ft2/day (Table 2.7-13) (Downey, 1984). Regionally, "the Precambrian rocks act as a lower confining unit to the Deadwood aquifer," although local connection can exist (Williamson and Carter, 2001). The Deadwood aquifer is in contact with the overlying Madison aquifer except where the Whitewood and Winnipeg formations are present and act as semiconfining units (Strobel et al., 1999).

2.7.2.1.6 Minor Aquifers

In addition to the major aquifers, minor aquifers around the Black Hills include the Minnekahta Limestone, Sundance/Unkpapa, Newcastle Sandstone, and alluvium. Where present and saturated, these units may yield small amounts of water. Locally, beds within the confining units may also contain aquifers (Driscoll et al., 2002). Typically, these minor aquifers are not heavily utilized because of more reliable sources in adjacent aquifers.

2.7.2.1.7 Regional Hydraulic Connection of Aquifers

Because of the geologic variability across the Black Hills, several mechanisms can serve to create hydraulic connection between aquifers. Most interconnection appears to be associated with the thinning or absence of confining units between aquifers, which has been documented in local and regional geologic studies (Miller, 2005). Analyses of regional aquifer tests conducted around the Black Hills provide direct evidence of aquifer interconnection or separation. A few examples are mentioned below.

- Recent pumping tests within the Deadwood aquifer near Jewel Cave indicate that vertical leakage through a confining layer is occurring in that area (Valder, 2006).
- In Rapid City, Rahn (1989) points to different artesian pressures reported in Sioux Park wells, installed into different hydrogeologic units, as evidence that the units are hydraulically separated.
- Studies by Long and Putnam (2002) of paired Madison and Minnelusa wells at the City Quarry site indicate hydraulic connection between these units. The variation in yields between areas indicates that locally the interlaying layers may not provide hydraulic separation between the two units. Both well tests and outcrop observations show the variability of hydraulic connection between the Deadwood, Madison, and Minnelusa aquifers.
- Various sources have also suggested that breccia pipes serve as a path between aquifers. The majority of these features are believed to originate within the Minnelusa Formation and extend upward as high as the Inyan Kara (Gott et al., 1974). These breccia pipes are the result of dissolution of significant thicknesses of

anhydrite from the upper Minnelusa and subsequent collapse. The greatest concentration of these breccia pipes has been noted within a few miles of the outcrop, although groups of pipes can be concentrated along joints and may extend as "high in the stratigraphic section as the Lakota Formation" (Braddock, 1963). Gott, Wolcott, and Bowles (1974) believed that these breccia pipes allowed large quantities of water to migrate upwards from the Minnelusa into the Inyan Kara.

2.7.2.1.8 Regional Potentiometric Surfaces

As part of the Black Hills Hydrology Study, the USGS developed 1:100,000-scale potentiometric maps for five aquifers including the Inyan Kara, Minnekahta, Minnelusa, Madison, and Deadwood (Strobel et al, 2000). The purpose of these maps is to show the potentiometric surface of the aquifers and to serve as a tool for evaluating groundwater flow directions and hydraulic gradients in the Black Hills area. The potentiometric maps were created by contouring elevations of water levels in wells completed in their respective aquifers. Structural features such as folds and faults were also considered in the contouring of the potentiometric surfaces. In areas where the potentiometric contours have been inferred (dashed), deviations between the map and actual water levels may occur. The following conclusions can be drawn from analysis of the figures:

- Regional flow within the different units is consistent for all units. Flow is radially outward from the central highlands toward the plains.
- Near the outcrop, the aquifers are unconfined. With distance, the aquifers are confined and have water levels above the top of the formation, and locally above the land surface.

2.7.2.1.9 Regional Groundwater Recharge

Aquifers in the Black Hills are recharged by infiltrating precipitation, streamflow losses, and minor seepage from other aquifers. The relative contribution of each of these recharge components is variable in the Black Hills. For instance, recharge is dominated by precipitation on the western limestone plateau, while streamflow dominates in parts of the southern hills (Carter et al., 2000).

The Black Hills are relatively arid with rainfall ranging from 12 to 28 inches per year in the area. Most precipitation can be accounted for as surface runoff or evapotranspiration. Regionally, the percentage of precipitation that recharges the aquifers varies from 30 percent in the northwestern Black Hills to approximately 2 percent in the drier southwestern Black Hills.

Streamflow losses can contribute to aquifer recharge if connection between the stream and underlying aquifer exists. Generally, surface water recharge to groundwater is limited to relatively shallow alluvial aquifers in relatively close proximity to the streams. The exception to this rule occurs in areas where karstic features provide preferential pathways for recharge into the subsurface.

Other sources of recharge to individual units can occur from leakage between units. Regionally, water elevations increase with depth, which provides an upward potential for ground-water flow. This limits the potential for downward recharge. Locally these flow head relationships can be reversed due to pumping of wells, thus creating localized zones where the potential for downward leakage exists.

2.7.2.1.10 Regional Groundwater and Surface Water Interactions

Throughout the Black Hills there are numerous springs in both the Madison and Minnelusa formations. These springs provide the headwaters for many streams in the western hills (Long and Putnam, 2002). Where these streams cross aquifer outcrops along the eastern Black Hills they lose flow into the subsurface through sinkholes and re-emerge downstream in springs and wells (Rahn, 1971 and Long and Putnam, 2002).

In alluvial aquifers, flow is often exchanged between subsurface and surface water. Many of the streams in the Black Hills are losing streams from which stream water infiltrates into the alluvial aquifers. Streams also can be gaining streams, in which they have increased discharge due to inflow from an alluvial aquifer.

The maximum amount of streamflow loss that occurs is known as the loss threshold. When streamflows are less than the loss threshold, then the discharge is the maximum that can be absorbed as recharge. If streamflow is greater than (or equal to) the loss threshold, then recharge equals the loss threshold and the stream will flow over the entire outcrop area.

Hortness and Driscoll (1998) conducted a study of streamflow loses across the Black Hills. Several factors that have been theorized to affect loss rates include streamflow rate, duration of flow across a loss zone, or deposition of large amounts of sediment. These observations are consistent with factors known to influence recharge into the surface: volume of water available, the time period during which recharge can occur, and connectivity with the subsurface as represented by thickness of overlying sediments. Hortness and Driscoll (1998) found no evidence that loss thresholds were affected by upstream flow rates.

2.7.2.2 Site Hydrogeology

This section focuses on Site Hydrogeology in comparison to documented regional characteristics of hydrostratigraphic units, which are presented in Section 2.7.2.1.1. Only hydrogeologic units younger than and including the Spearfish Formation (Permo-Triassic age) are described here for two reasons:

- With the exception of the town of Edgemont, which has two Madison wells, deeper aquifers are not used as a source of water in this area.
- Federal and State permit guidance requires that this assessment focus on the mined unit (the Inyan Kara Group) and on the hydrogeologic units immediately above and below the proposed mined unit.

2.7.2.2.1 Site Hydrostratigraphic Units

The site hydrostratigraphic units are consistent with the regional units discussed above. The surficial geology and hydrostratigraphy at the site are shown in Figure 2.6-2, and Figure 2.2-3, respectively. Analyses of water quality data for the units are provided in Section 2.7.3.

2.7.2.2.2 Spearfish Formation Confining Unit

In general, the Spearfish Formation is characterized by a thick sequence (250 to 450 feet) of red shale and siltstone. Based on the few exploration holes that have penetrated the entire thickness of the formation in the PAA, the Spearfish is an average of 320 feet thick. This thick sequence of shale serves as a hydrologic barrier or confining unit preventing nearly all vertical flow between the Paleozoic aquifers and the Jurassic/Cretaceous aquifers.

2.7.2.2.3 Sundance and Unkpapa Aquifers

Overlying the Spearfish formation, the Sundance and Unkpapa aquifers are considered aquifers of minor importance within the Black Hills. These aquifers are a source of water within the PAA. 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 is 50 to 80 feet of well sorted, fine-grained, eolian sandstone. For the purpose of this study, the Sundance and Unkpapa aquifers are considered equivalent as there is no intervening confining unit separating the two.

2.7.2.2.4 Morrison Formation Confining Unit

Overlying the Sundance and Unkpapa aquifers is the Morrison Formation. The Morrison is a shale layer approximately 100 feet thick, which serves as an underlying confining unit between the Inyan Kara and the Sundance aquifers (and the Unkpapa where it exists). A core sample was collected from the upper Morrison; results of geotechnical testing indicate that the shale has a relatively low vertical permeability of about 6.0×10^{-5} feet/day.

2.7.2.2.5 Inyan Kara Aquifer

The Inyan Kara aquifer is the principal aquifer in the region. Locally, the Cretaceous Inyan Kara Group is consistent with its regional characteristics and is composed of two formations: the Lakota (Fuson and Chilson members) and Fall River. In general, the Inyan Kara consists of interbedded sandstone, siltstone, and shale. Based on several measured outcrop sections within the Dewey Quadrangle, the Inyan Kara Group averages 350 feet thick. The Fuson member of the Lakota, underlying the Fall River, varies in thickness from 40 to 70 feet. Throughout most of the region, the Fuson is expected to be an effective interaquifer confining unit. Locally, however, results of aquifer tests at the project site indicate that the Fuson Shale is not an effective barrier in some locations. It is possible that, "interaquifer connection here could result from as-yet-unidentified structural features or old open exploration holes". As such, the Inyan Kara is treated in this report as one aquifer with the Fall River and Lakota representing sub-aquifers. The Inyan Kara is confined above by the Graneros Group, a thick sequence of dark shale that varies in thickness from zero (0) feet where the Inyan Kara crops out to more than 500 feet thick in the plains, preventing the vertical migration of water between the Inyan Kara and alluvial aquifers.

2.7.2.2.6 Graneros Group Confining Unit

The Graneros Group is composed of several geologic formations including the Skull Creek, Newcastle, Mowry, and Belle Fourche. The group acts as a single unit that confines the Inyan Kara aquifer. In the PAA, the thickness of the Graneros is zero (0) at the outcrop but increases westward to more than 500 feet thick. A core sample was collected from the lower Skull Creek shale; results of geotechnical testing indicate that the shale has a very low vertical permeability of 1.5×10^{-5} ft/day.